CITY of TRAVERSE CITY MICHIGAN

CWSRF WASTEWATER IMPROVEMENTS PROJECT PLAN

PREPARED BY:

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CONSULTING ENGINEERS SINCE 1915

1925 Breton Road SE, Suite 100
Grand Rapids, Michigan 49506

MAY 2021

HRC Job Number 20210140

Versions:

Draft April 1, 2021 (Submittal to EGLE)

Draft April 15, 2021 (Submittal to Public)

Final May 26, 2021

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1 Executive Summary

1.1 Summary

The Project Plan for the City of Traverse City Wastewater Improvements Program has been prepared using the Project Plan Preparation Guidance of the Clean Water State Revolving Fund (CWSRF) Administrative Rules. While the rates have not been set yet for FY2022, the rate in 2021 is 1.875% for 20-year loans (note 2% is used for cost estimates). These rules call for compliance with the basic Federal Planning Requirements and the National Environmental Policy Act (NEPA). This Project Plan will serve as a basis for project prioritization and must be submitted to the Michigan Department of Environment, Great Lakes, & Energy (EGLE) by June 1, 2021, to be on the project priority list for the fiscal year of 2022.

The proposed projects listed herein as part of this CWSRF Project Plan are the Lower Boardman River Wall Sanitary Sewer, Primary Treatment Improvements, UV Disinfection Update, I&I Removal, East Front Sewer Improvements, and a US-31 Utility Replacement. These projects were a result of the conditions found during the recent Stormwater, Asset Management, and Wastewater System (SAW) Program and other evaluations completed. Several of the sanitary sewer collection system projects are long overdue and are needed to ensure the sanitary collection system and WWTP can operate properly. Inflow and Infiltration (I/I) was also a concern that needs to be addressed as part of this project plan to address Sanitary Sewer Overflows (SSOs) that have occurred.

1.2 Conclusions

The following is a summary of the existing issues identified by the City of Traverse City:

- Improvements to the Headworks and Primary Treatment necessary to improve the reliability of treatment and address the system deficiencies
- New UV system constructed and installed to replace the aged system, minimize the potential for flow surges and minimize interruption of the disinfection process
- Restoration and management of the lower Boardman River wall sanitary sewer to reinitiate the support for the sewer service connections and avoid the release of raw sewage into the river
- Completion of sewer rehabilitation to address sources of infiltration and inflow and continued flow monitoring
- East Front Street updates including 720 feet of 24-inch sewer lining, 300 feet of force main replacement with a 20-inch pipe, and 40 lateral replacement subject to high infiltration and inflow to address high dry weather flow
- Removal of existing 8-inch sanitary sewer on the north side of US-31 and extend all laterals from the north side to the south 24-inch sanitary sewer in US-31 from Garfield to Hope Street.

1.3 Recommendations

The selected projects identified in this Plan are the most cost-effective and environmentally sound alternatives. The following recommendations are therefore made:

- The City Commission should pass a resolution formally adopting this Plan.
- The City should apply for low-interest loans under the CWSRF program.

2 Project Background

2.1 Study Area Description

2.1.1 General

The City of Traverse City is in Grand Traverse County, Michigan. The total City area is approximately 8.66 square miles. The Traverse City Regional Wastewater Treatment Plant (TCRWWTP) is located at 606 Hannah Avenue, Traverse City, MI 49686. The Traverse City Regional WWTP treats the wastewater discharges from the entire City as well as portions of Acme, Blair, East Bay, Elmwood, Garfield, and Peninsula Townships. The sanitary sewer system map is shown in Figure 2-1.

Wastewater from the City's collection system is conveyed to the Traverse City Regional WWTP located in the City of Traverse City along Franklin Street on the northern end of Boardman Lake. Conveyance of wastewater to the Traverse City Regional WWTP is accomplished by a sanitary sewer collection system and nine remote pumping stations. This network of collection and transmission infrastructure is spread throughout the City of Traverse City and portions of East Bay, Garfield, Peninsula, and Elmwood Townships. A map showing the sanitary sewer collection system is provided in Figure 2-2.

2.1.2 Land Use

The largest land-use types within the City of Traverse City (excluding open spaces and utilities) are residential and commercial. A map with the current zoning districts within the City of Traverse City can be seen in the attached Figure 2-3. A map of the future land use within the City of Traverse City can be seen in the attached Figure 2-4. Future land use for the City was obtained from the City of Traverse City Master Plan.

2.1.3 Population Data

Population numbers and projections for Grand Traverse County and the City of Traverse City came from the United States Census Bureau database. The U.S. 2010 Census Bureau data estimated the average household size in the City at 2.18 people per household. The population projections for the City of Traverse City and Grand Traverse County are shown below in Table 2-1. The City services wastewater for a total of approximately 30,623 people.

Table 2-1. Population Projections

Year	Population		Served by City Wastewater System		
	Traverse City	Grand Traverse County	Traverse City	Grand Traverse County	Total
2010	14,674	86,986	14,674	14,129	28,803
2014	14,736	91,701	14,736	14,895	29,631
2019	14,805	97,380	14,805	15,818	30,623
2024	14,870	103,121	14,870	16,750	31,620
2029	14,924	108,314	14,924	17,594	32,518
2034	14,968	112,734	14,968	18,311	33,279

*Census projections: https://www.census.gov/quickfacts/fact/table/traversecitycitymichigan,grandtraversecountymichigan/PST045219 & https://milmi.org/datasearch/popproj

Recent projections show the 2019 population has increased slightly since the 2010 Census in the City of Traverse City and Grand Traverse County. Projections predict the population will continue to increase through 2034.

Forecast from the Census Bureau projects population in 2034 to be approximately 14,968. This increase in population may also cause an increase in sanitary waste; however, the sanitary sewer collection system was built to handle larger populations and therefore higher flow than it is currently experiencing or will experience based on the projected 2034 population.

2.1.4 Economic Characteristics

The major industries in the City of Traverse City are Health Care & Social Assistance (1,396 people), Retail Trade (1,008 people), and Accommodation & Food Services (844 people). The median household income for the City of Traverse City was $57,076 in 2019. The median household income is approximately 0.11% lower than the median Michigan household income and 9.18% less than the U.S. median household income. Table 2-2 shows the City of Traverse City, Grand Traverse County, and Leelanau County median household income comparison below.

Table 2-2. Study Area Household Income

Municipality	Median Annual Household Income
City of Traverse City	$57,076
Grand Traverse County	$61,485
Leelanau County	$63,575

*Source: https://www.census.gov/quickfacts/fact/table/MI,traversecitycitymichigan,grandtraversecountymichigan/PST045219

2.1.5 Cultural and Environmental Settings

Cultural Setting:

The City of Traverse City has 4 historical districts and 5 historical properties listed under the National Register of Historic Places. However, none are within the project limits and will not be impacted by the proposed project. If the I/I Alternative 2 is selected (described below for future evaluation) the State Historic Preservation Office (SHPO) will be contacted to aid in the identification of significant historical and archeological sites which may be affected by the project

Air Quality:

Mobile source emissions, mainly from automobiles, are the primary source of outdoor air pollution in this area. The area has the noise pollution characteristics of a typical, tourist-driven community. No noise pollution problems exist in residential areas, other than from traffic noise from adjacent major roadways. Commercial and business areas experience only normal traffic noise.

Air quality is not anticipated to be an issue for this project, apart from temporary dust and debris from construction and minimal odors from the CIPP curing material. All necessary notifications will be distributed to the public when this occurs and all regulations for this odor will be followed.

Wetlands:

There are no localized wetlands associated with the existing project footprint where the work is anticipated. For the final design, any wetlands that may be impacted would be flagged and the appropriate EGLE and USACE permits will be applied for. However, it is not anticipated to be an issue for this project. Wetland maps are shown in Figure 2-5.

Great Lake Coastal Zones:

The major body of water north of the City of Traverse City is Grand Traverse Bay, which is approximately 0.5 miles north of the WWTP. The WWTP is located on the North end of Boardman Lake which leads into the Boardman River. The Boardman River carries on for approximately 2 miles until it hits the Grand Traverse Bay which then leads out into Lake Michigan. For this project plan, no impacts will be made to the Bay or tributary areas.

Floodplains & Surface Waters:

The study area is located entirely in the Grand Traverse Bay Watershed. The watershed encompasses 976 square miles with nine sub-watersheds that drain directly into the Grand Traverse Bay.

The City of Traverse City is located along the Grand Traverse Bay. Area groundwater is not used as a source of drinking water within the City. Water supply for the City is obtained via the City of Traverse City Water Treatment Plant. There will be no major impacts to the great lake coastal zones, floodplains, and surface waters, however, proper permits will be acquired, and steps will be taken to avoid any damage or permanent disruption which could affect the nearby floodplain. Any work which impacts the floodplain will only be undertaken after first contacting EGLE and obtaining the appropriate permits.

FEMA floodplain maps are shown in Figure 2-6.

Natural or Wild and Scenic Rivers:

The scope of this project is scattered throughout the City of Traverse City, surrounding Townships, and at the WWTP. Kids Creek is located within the City. The WWTP is located along the shoreline of the Boardman River. The location of these improvements and construction will be planned to not occur or impact the nearby Rivers.

The proposed work will also decrease the amount of TSS discharged to the Boardman River during wet weather events, improving the water quality of the effluent to the river. See Appendix A for attached documentation of the Nationwide Rivers Inventory, showing that no Nationwide Rivers will be impacted by the proposed project.

Recreation Facilities:

The City of Traverse City owns 34 parks and recreational properties, ranging from a small downtown parcel to the larger Hickory Hills Ski Area, Grand Traverse Commons, and Brown Bridge Quiet Area. Much of the park land is heavily concentrated along the Boardman River and along the shoreline of the West Grand Traverse Bay. In total, over 1,600 City-owned acres are currently dedicated to recreational pursuits including Hickory Hills Ski Area and Grand Traverse Commons that are each approximately 125 acres and Brown Bridge Quiet Area, located 10 miles southeast of the City, has nearly two square miles (1,310 acres) of natural area along the Boardman River. The proposed work will limit all impacts to parks or other publicly owned facilities by ensuring pedestrian access if maintained and maintaining quality aesthetics of facilities.

Topography:

The terrain within the City of Traverse City is characterized as relatively flat but has relatively low spots near the Grand Traverse Bay. The lowest point at about 582 feet above sea level is in the north region of the City on the bay along the shoreline. The highest point is about 950 feet above sea level in the western hillier extents of the City.

A set of United States Geological Survey (USGS) topography maps of the City and surrounding townships are shown in Figure 2-7 through Figure 2-11.

Geology:

The City of Traverse City is typified by eolian, lake, and glacial deposits. The lake sand deposits make up the larger portion of the City of Traverse City. Two types of bedrock make up the bedrock surface in the City of Traverse City, Ellsworth Shale and Coldwater Shale.

Soils:

According to the USDA Natural Resources Conservation Service Web Soil Survey, the City of Traverse City the 3 main soils located within the City are Loamy Sand (27.53%), Sandy Loam (14.78%), and Sand (39.73%). See Appendix B for documentation of the Web Soil Survey results.

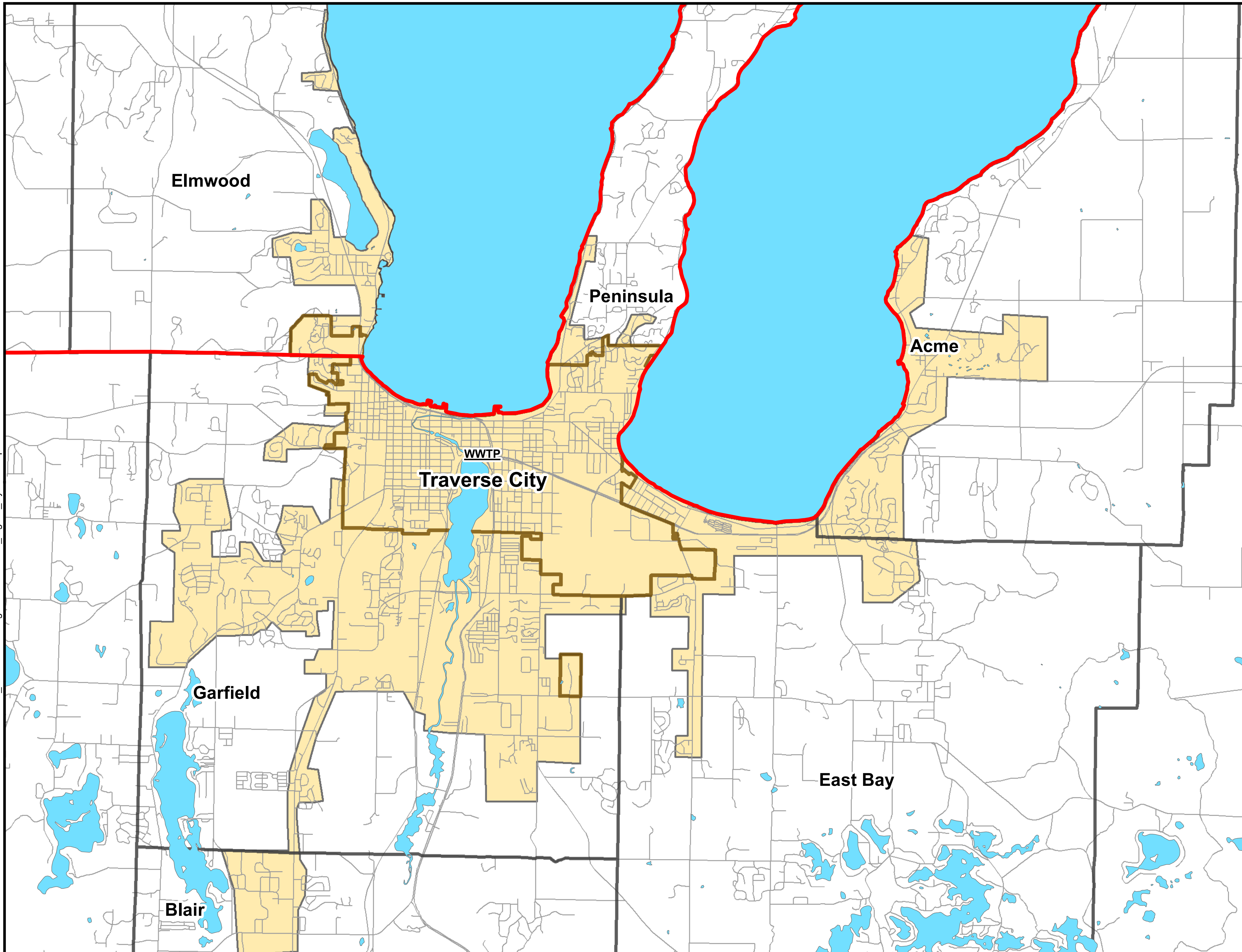
As part of the final design process, soil borings will be taken near the proposed work areas to determine if any special construction methods will be needed.

Agricultural Resources:

There is no agricultural land located within the project limits. The project area is within developed and human use land cover; therefore, no agricultural resources will be impacted by the proposed work.

Existing Plant and Animal Communities:

Wildlife within the study area includes animals and birds normally associated with urban or agricultural environments. However, EGLE will be coordinating with Michigan Natural Feature Inventory (MNFI) and U.S Fish and Wildlife (USFW) Information for Planning and Consultation (IPaC) for an official review of federally or state listed threatened and endangered species within this proposed project area.



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LEGEND

- County Boundary
- Traverse City
- Other Townships
- Sanitary Sewer System Extents
- Roads

N
W E
S

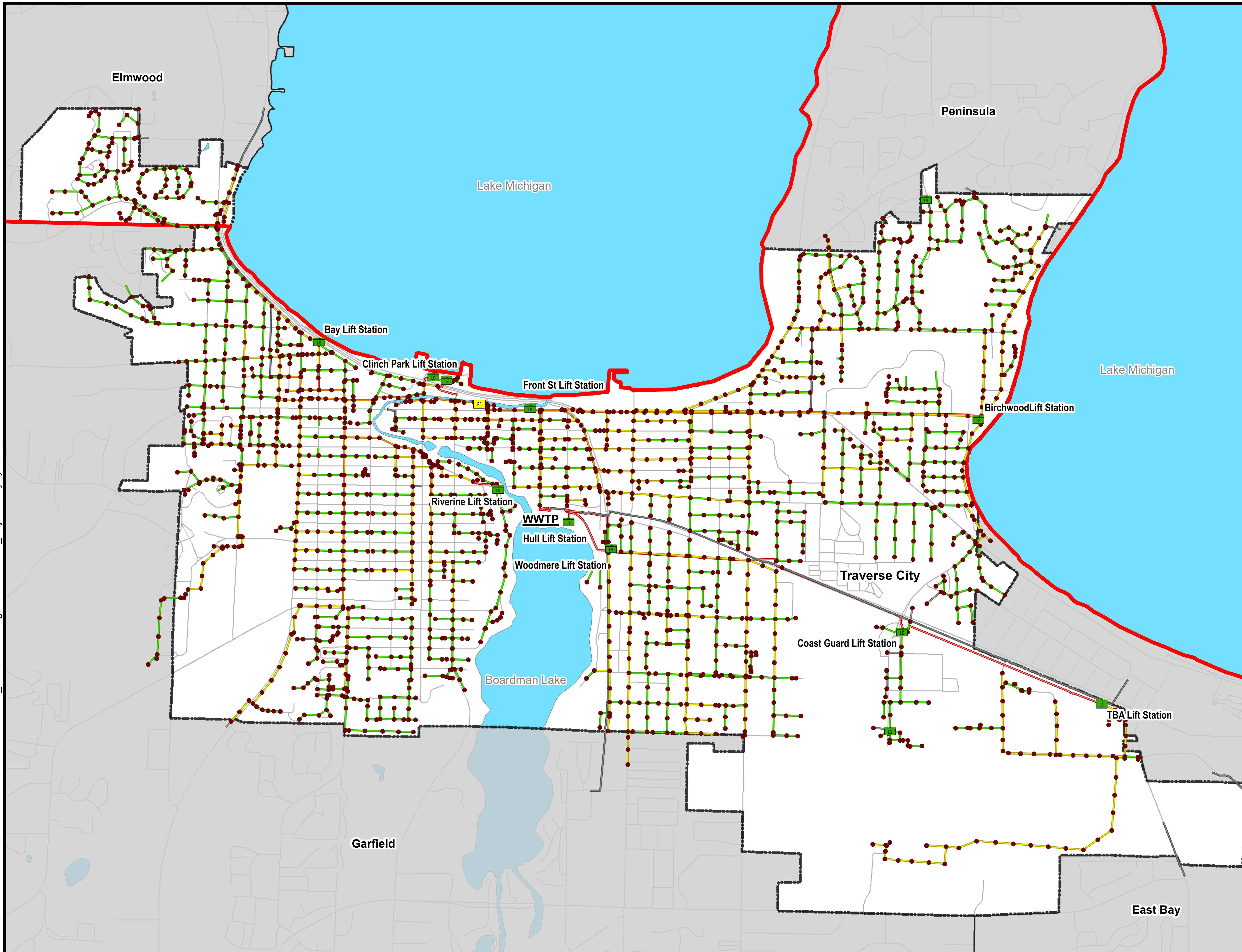
0 0.5 1 2 Miles

DRAWN: DRM/NAC CHECKED: DIU

CWSRF PROJECT PLAN SANITARY SEWER SYSTEM MAP

HRC JOB NO: 20210140	SCALE: AS SHOWN
MAY 2021	**FIGURE 2.1**

Date: 4/1/2021 Document Path: Y:\202101\20210140\03_Studies\Working\GIS\20210316_Figure_SystemMap.mxd



Date: 3/30/2021 Document Path: Y:\202101\20210140\03_Studies\Working\GIS\20210316_CitySanitarySystem.mxd

CITY of TRAVERSE CITY MICHIGAN

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LEGEND

- County
- City of Traverse City
- Townships
- Roads
- Lift Station
- Pump Station
- Sanitary Sewer Manholes

Sewer Gravity Mains Diameter (in.)

- Unknown
- 4" - 8"
- 9" - 15"
- 16" - 36"

Sewer Force Mains

- Traverse City Owned
- Maintained by Others

N W E S

0 0.175 0.35 0.7 Miles

DRAWN: DJM/NAC CHECKED: DIU

CWSRF PROJECT PLAN

CITY OF TRAVERSE CITY SANITARY SEWER COLLECTION SYSTEM

HRC JOB NO: 20210140	SCALE: AS SHOWN
MAY 2021	FIGURE 2.2

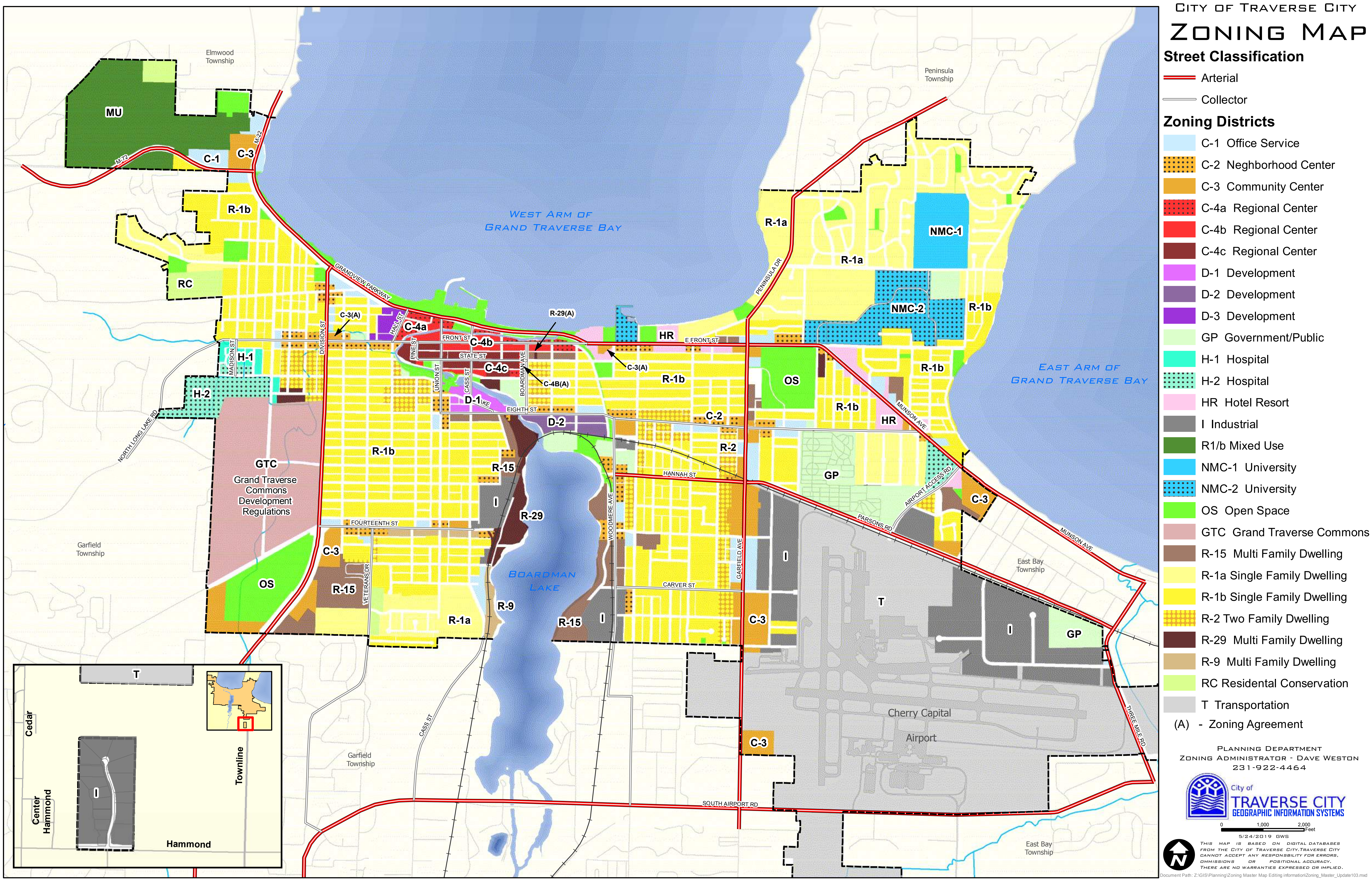


Figure 2-3 City of Traverse City Current Zoning Districts

*Courtesy of City of Traverse City

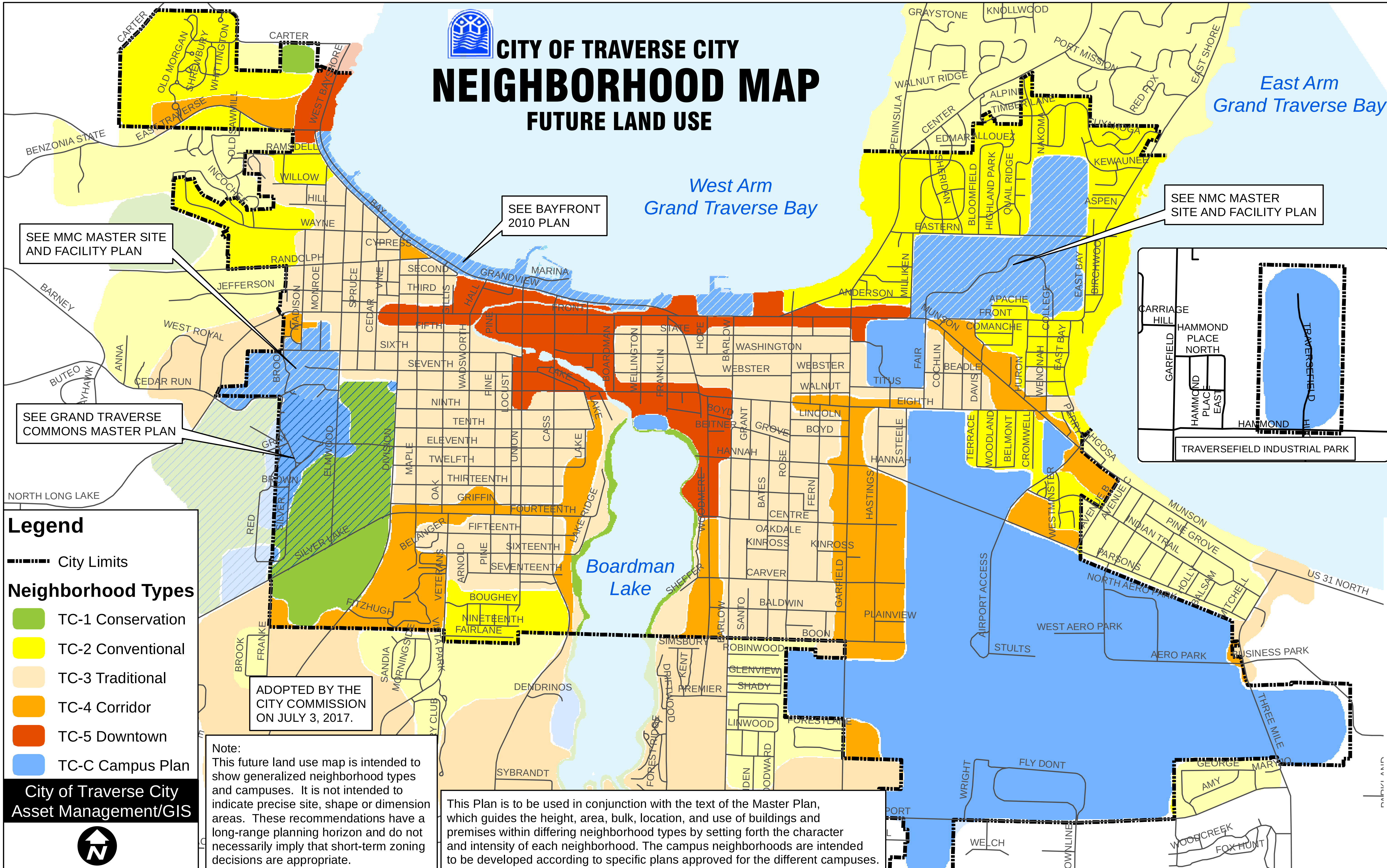


Figure 2-4 City of Traverse City Future Land Use

**Courtesy of City of Traverse City*

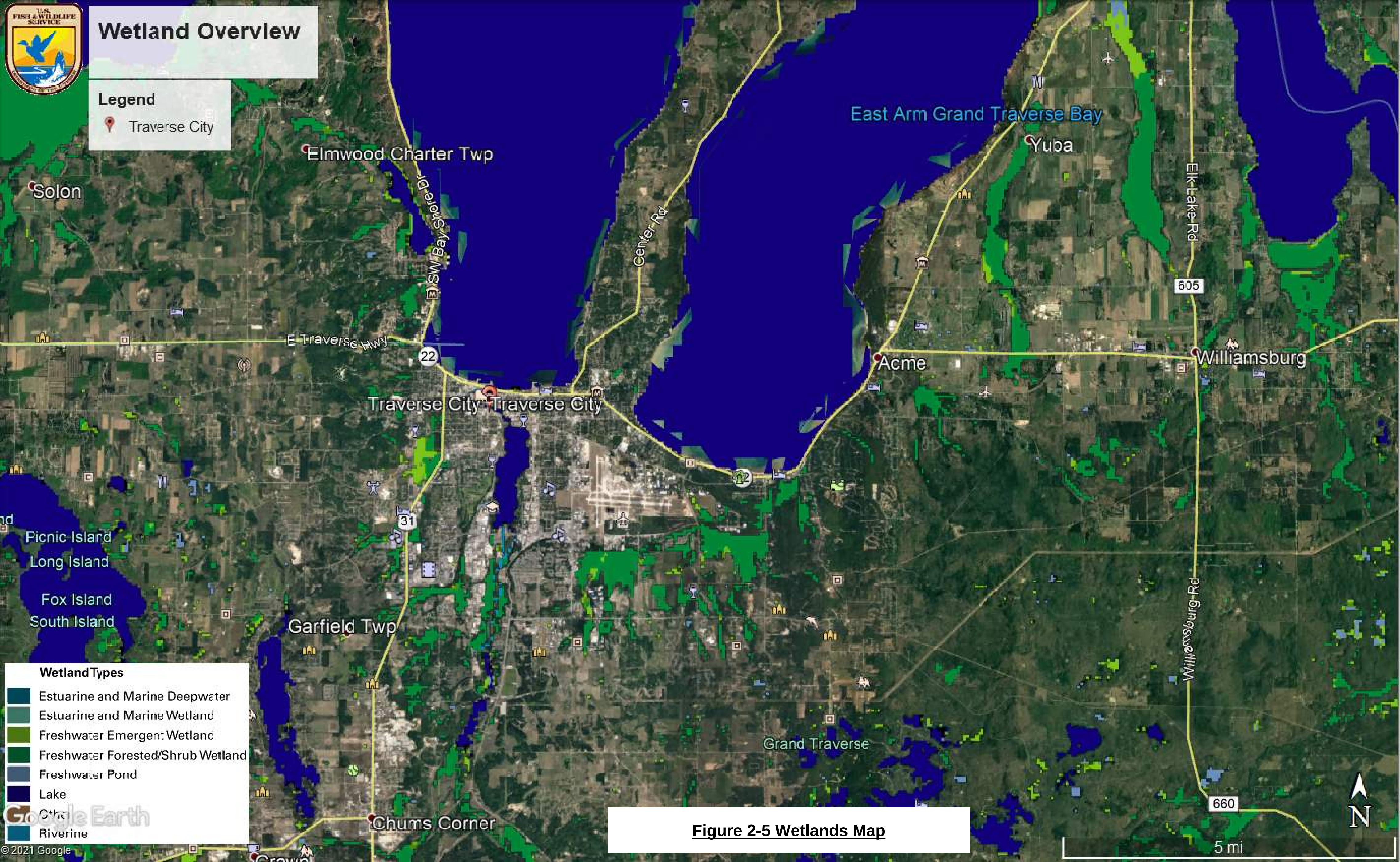


Figure 2-5 Wetlands Map

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 16. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by the National Agricultural Imagery Program (NAIP). This information was photogrammetrically compiled at a scale of 1:12,000 from aerial photography dated 2007 or later.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map,** how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

Figure 2-6 FEMA Floodplain Map

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% Annual Chance Floodplain Boundary

0.2% Annual Chance Floodplain Boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.

~~~ 513 ~~~ Base Flood Elevation line and value; elevation in feet*

(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A Cross section line

23 - - - 23 Transect line

45° 02' 08", 93° 02' 12" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere

$^{49}89^{000m}$ N 1000-meter Universal Transverse Mercator grid values, zone 16

DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)

• M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
August 28, 2018

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0113C

FIRM

FLOOD INSURANCE RATE MAP

GRAND TRAVERSE COUNTY, MICHIGAN

(ALL JURISDICTIONS)

PANEL 113 OF 425

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PENINSULA, TOWNSHIP OF	260747	0113	C
TRAVERSE CITY, CITY OF	260082	0113	C

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 26055C0113C

EFFECTIVE DATE AUGUST 28, 2018

Federal Emergency Management Agency
~~~

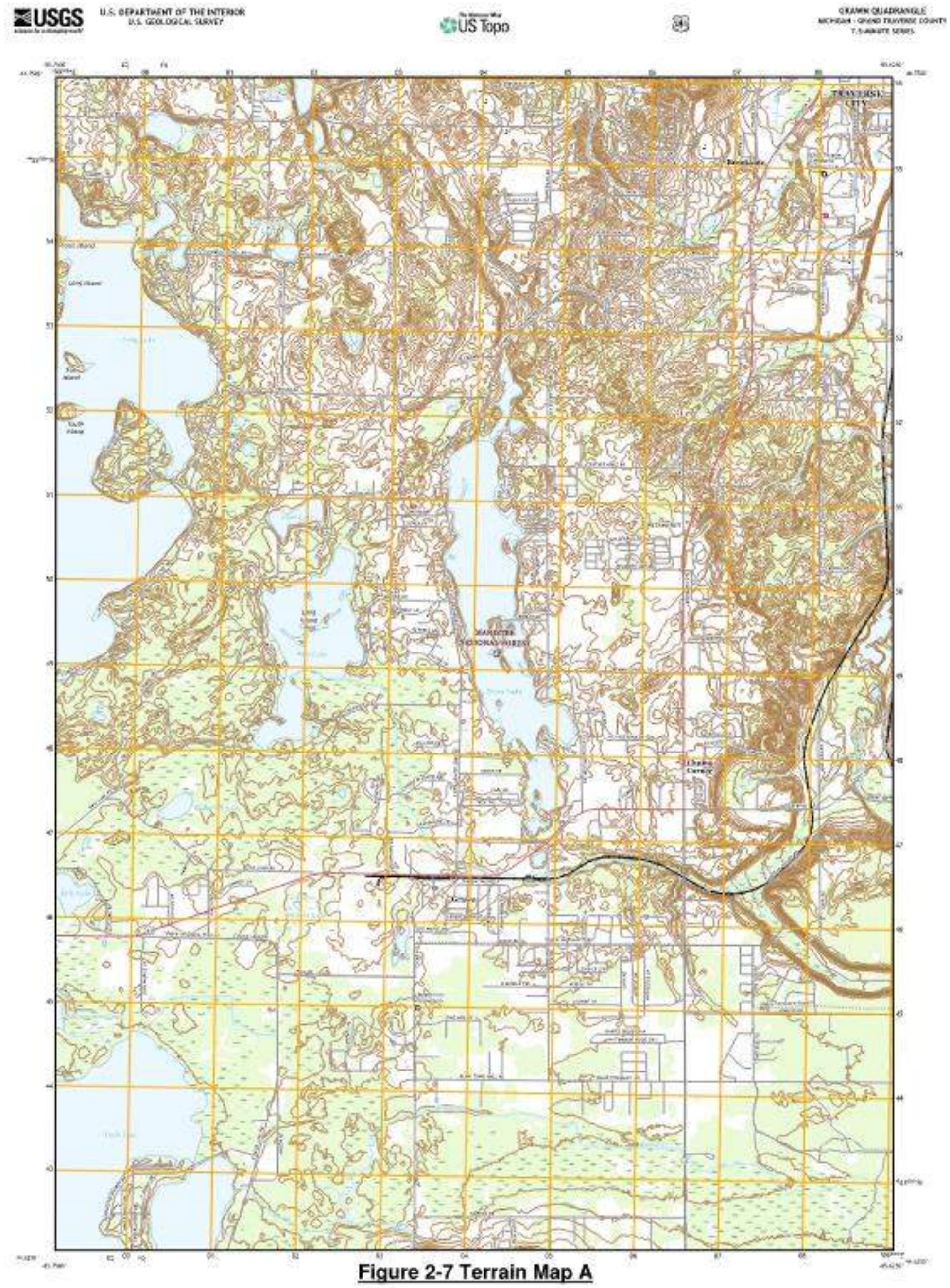
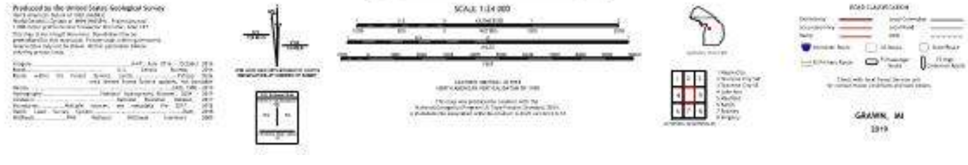


Figure 2-7 Terrain Map A



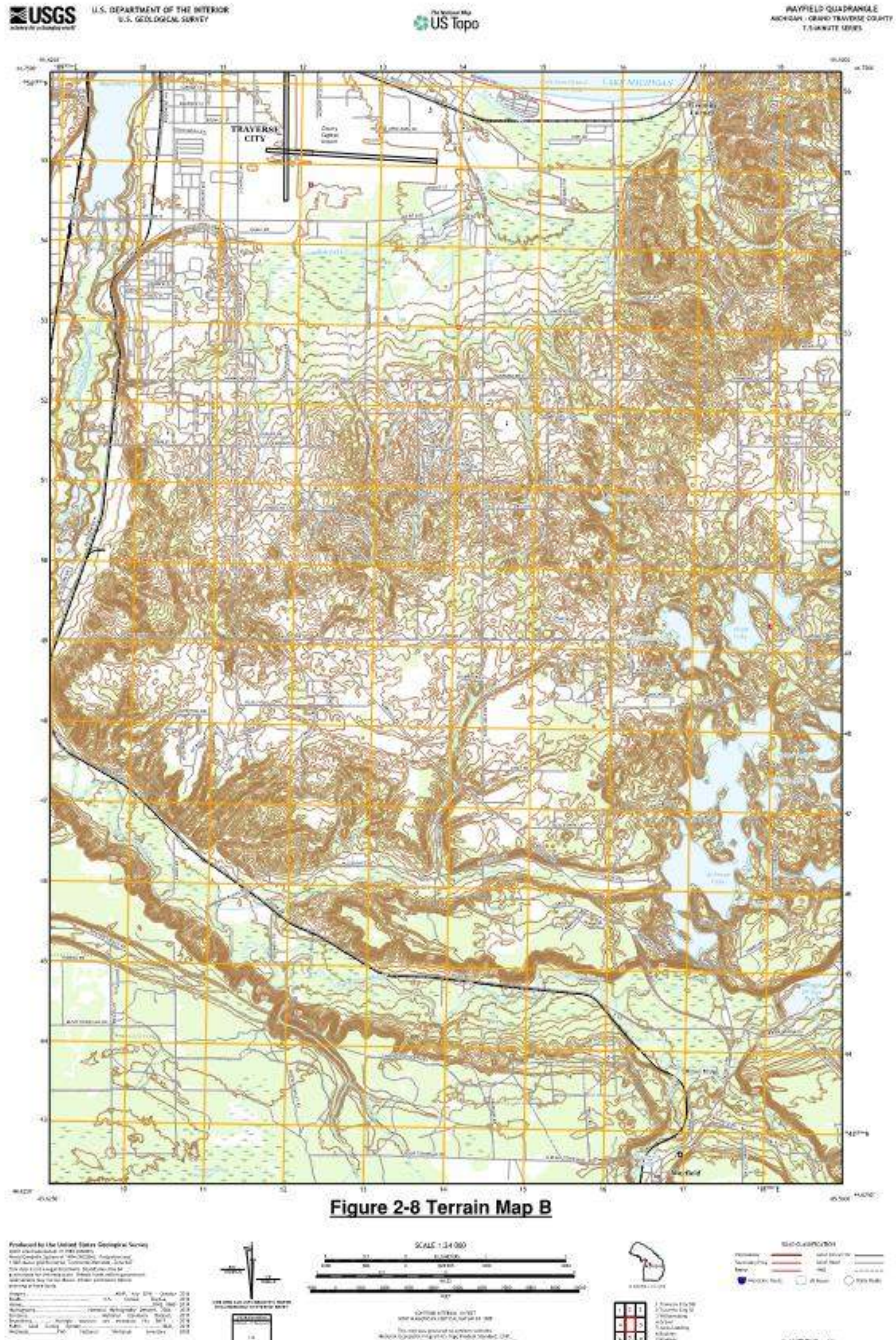


Figure 2-8 Terrain Map B

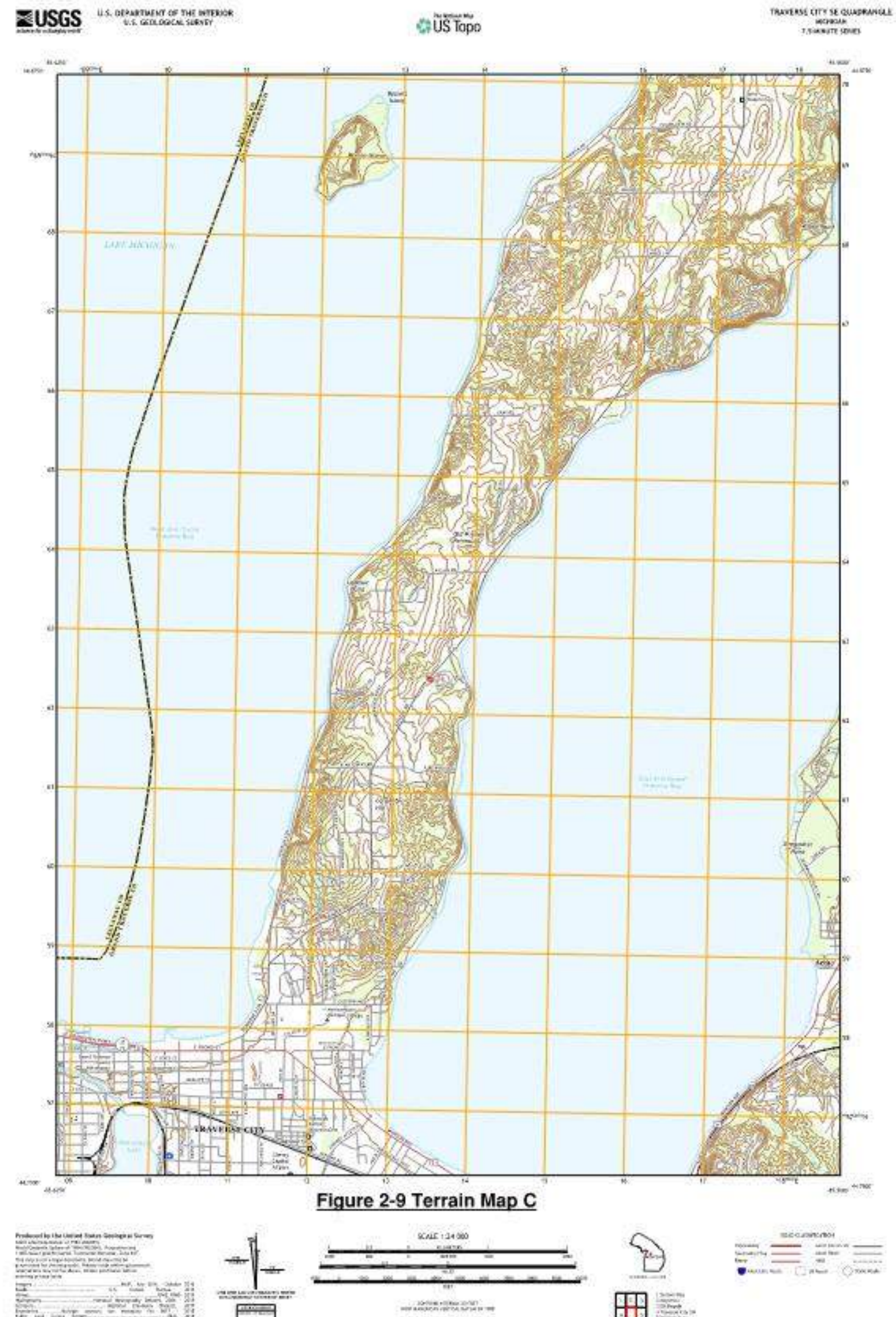


Figure 2-9 Terrain Map C

Figure 2-10 Terrain Map D

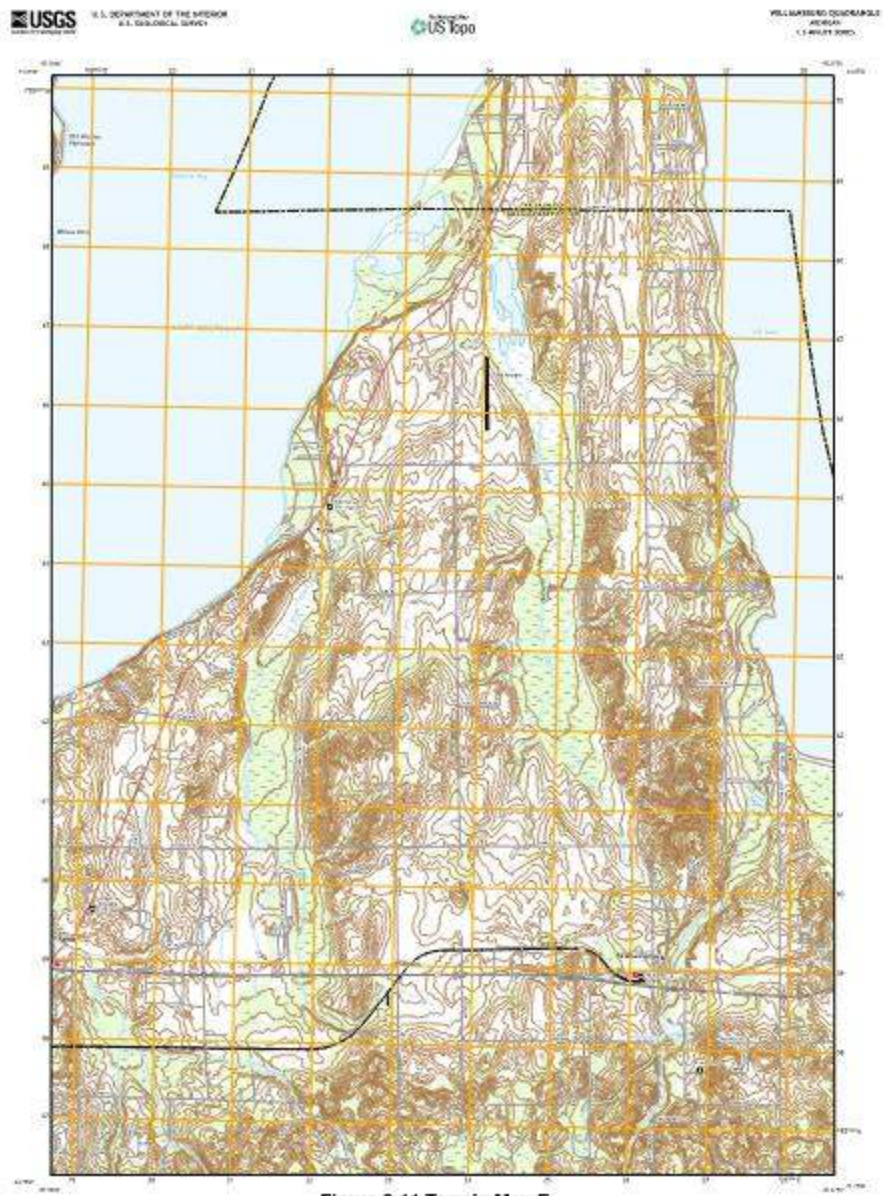
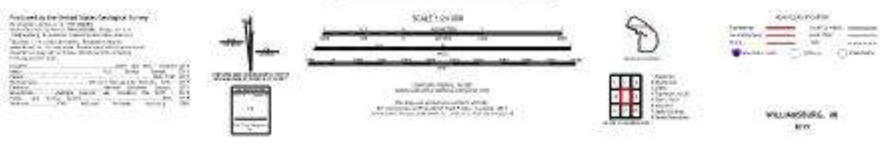


Figure 2-11 Terrain Map E



2.2 *Existing Facilities – General*

The City of Traverse City sewer and wastewater collection, transmission, and treatment infrastructure are critical assets for conveying and treating waste and preventing the introduction of pollutants into Boardman Lake, Boardman River, and the Grand Traverse Bay. A description of the City's wastewater collection and treatment infrastructure is provided in the following sections.

2.2.1 Sewer Collection System and Lift Stations

Conveyance of wastewater to the TCRWWTP is accomplished by a sanitary sewer collection system with nine lift stations. The network of collection and transmission infrastructure collects and treats wastewater from the City of Traverse City, Garfield Township, Acme Township, Blair Township, East Bay Township, Peninsula Township in Grand Traverse County, and Elmwood Township in Leelanau County.

The City owns and maintains its sanitary sewer collection system, which is comprised of approximately 1,902 manholes, 81 miles of sanitary sewer pipeline, 4.7 miles of public force mains, and 9 lift stations. Flow collected via the collection system can have significant infiltration and inflow contributions to the collection system and WWTP. Wet weather contributions throughout the collection system cause the delivery of low strength waste to the WWTP but simultaneously provide a flushing effect which resuspends settled grit and solids allowing them to travel to the WWTP for treatment. Table 2-3 below lists the locations and capacities of the City of Traverse City lift stations.

Each lift station was constructed with ancillary support systems, such as telemetry, cathodic protection, and emergency power. These systems ensure maintenance staff can respond to alarms and emergencies in a timeframe that keeps the City from violating its level of service goals and protects the buried metal housing from corrosion. Backup emergency power for lift stations is provided through either a standby generator onsite or portable power generation equipment.

Table 2-3. City of Traverse City Lift Stations

	Lift Station	Location	Pump Station	Pumping Capability (gpm at ft TDH)
1	Birchwood	2060 East Front Street	Non-clog dry pit Hydrodynamic (2)	800 gpm at 40 ft TDH
2	Bay Street	580 Bay Street	4-inch submersible 9.4 HP (2)	430 gpm at 32 ft TDH
3	Clinch Park	111 East Grandview Parkway	Submersible 3 inch 2.4 HP Flygt (2)	260 gpm at 17 ft TDH
4	Coast Guard	911 Airport Access Road	Submersible 4 inch 17.5 HP ABS (2)	400 gpm at 70 ft TDH
5	Hull Park	660 Hannah Avenue	Submersible 1 ¼ inch 2.0 HP Hydromatic Grinder (1)	-
6	Front Street	429 East Front Street	Dry Pit VFD ITT A-C (3)	2600 gpm/Ea
7	Riverine	318 East Eight Street	Nonclog Dry Pit 4-inch 7.5 HP (2)	350 gpm at 37 ft TDH
8	Woodmere	643 Woodmere Avenue	Submersible 4 inch 6.4 HP Flygt (2)	450 gpm at 25 ft TDH
9	Ind. Park (TBA)	880 Parsons Road	Dry Pit 5-inch 15 HP	700 gpm at 35 ft TDH

2.2.2 Infiltration and Inflow

Infiltration and inflow have been a concern in the City which can cause the TCRWWTP to treat low strength waste at a higher cost to rate payers. In addition, the substantial volumes of wastewater during wet weather events which reach the plant are difficult to manage. Nine (9) temporary sewer flow meters and one rain gauge were installed for a period of five months, from April – August 2015. The flow meters were used to identify areas for future condition assessment, to assess the system capacity, as an indicator of current system function, and to help capture the amount of infiltration and inflow in the system. Infiltration and inflow mitigation efforts have been completed on portions of the collection system including sump pump disconnections, sealing manholes, and additional inspections.

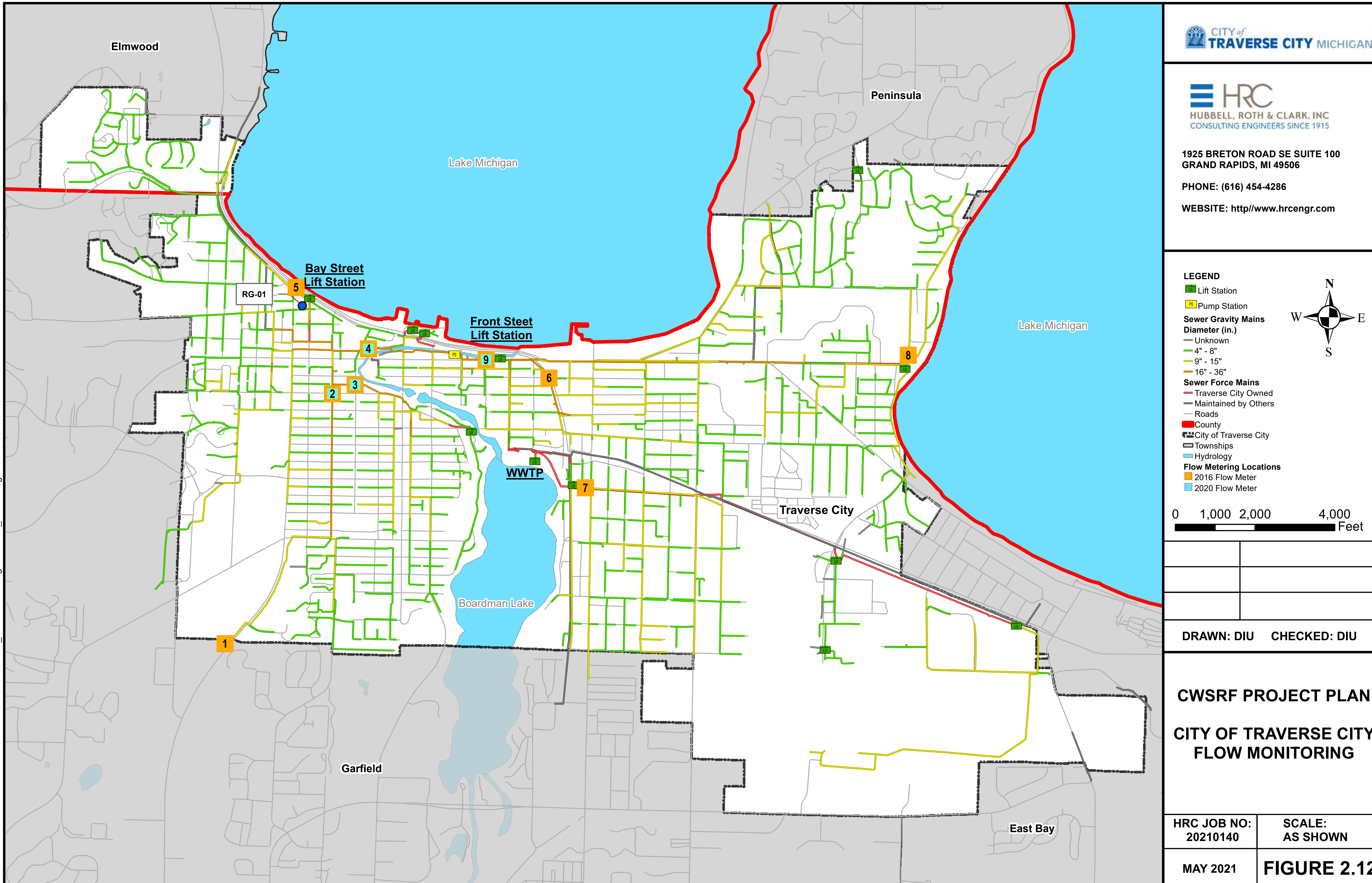
During the spring/summer of 2020, the City of Traverse City (City) experienced three major storm events with >50-year frequency which resulted in sanitary sewer overflows (SSOs) at the downstream end of the Boardman River sanitary sewer siphon. To better understand the sources of high flows, the City purchased four area velocity laser flow meters and installed August 31st, 2020, to further evaluate the flows in the West Front. Flow monitoring locations from the 2015 and 2020 monitoring are shown in Figure 2-12.

High dry weather infiltration in the meter district M09 (West Front; 100 feet west of Front Street Lift Station in SSM-1414) and M04 (Parking Lot; at the corner of the building, CCM-1387) has resulted in increased daily flows. These flows are directly correlated with the high groundwater levels due to the high levels in West Grand Traverse Bay specifically in sewers below the levels of the bay (582.9' NAVD88). CCTV inspections of sewers near Bay Street in August 2020 identified high sources of infiltration from sanitary sewer leads.

The wet weather flows that occurred before this flow monitoring effort appears to have occurred as a result of flooding from Kids Creek in meter district M04. Flooding at Munson hospital recorded peak flows as a result of flooding on May 28th, 2020, in the lower levels to drains connected to the City's gravity sewers. Subsequent storm events did not produce these flows at Munson Hospital.

An initial hydraulic model simulation of the West Front Street Sewer was developed using SewerGEMS, using the City's GIS shapefiles of the sewers and manholes. The estimated design flows from the flow monitoring study completed as part of the Wastewater AMP in addition to the increased dry weather flows from these events as a result of the high groundwater elevations predict SSOs downstream of this siphon in manholes SSM-1395, SSM-1396, and SSM-1397. This modeling effort confirmed the high wet weather flows over the capacity of the sewer downstream of the Boardman River siphon from the three major storm events caused the overflows at the location of the siphon were due to:

1. High infiltration from the elevated water levels of Lake Michigan (WSL 580.5 to 582.9' NAVD88) during these summer events relative to the past monitoring in 2015 (WSL 579.5' to 580.0' NAVD88)
2. Significant rainfall events exceeded the capacity of the sanitary sewer downstream of this siphon causing the surcharging and overflow events. The three storms were 50-yr and 150-yr events.



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CWSRF PROJECT PLAN

CITY OF TRAVERSE CITY FLOW MONITORING

HRC JOB NO: 20210140

SCALE: AS SHOWN

MAY 2021

FIGURE 2.12

Date: 3/31/2021 Document Path: Y:\202101\20210140\03_Studies\Working\GIS\Flow_Monitoring.mxd

2.3 Existing WWTP Facilities

All wastewater received at the facility is treated and discharged to the Boardman River, in accordance with its National Pollutant Discharge Elimination System (NPDES) permit (MI0027481). Appendix C contains a copy of the City's current NPDES permit. The design and permitted annual average daily flows are 8.5 MGD, with a design peak flow of approximately 17 MGD. An overall site plan of the WWTP is shown in Figure 2-13. The WWTP facilities can be broken up into four sectors: preliminary and primary treatment, secondary treatment, disinfection, and solids handling. A complete hydraulic flow schematic of the WWTP is shown in Figure 2-14.

The TCRWWTP effluent discharges into the Boardman River and ultimately Grand Traverse Bay. The facility has been designed to comply with the EGLE requirements for wastewater treatment including monthly average effluent five-day biochemical oxygen demand (BOD5) and total suspended solids (TSS) of 25 mg/L and 30 mg/L respectively. The current discharge permit also establishes a seasonal effluent limit for ammonia nitrogen (NH3-N) of 11 mg/L and an effluent total phosphorus (TP) limit of 1 mg/L. The Traverse City effluent objectives have been established as 4 mg/L for BOD5 and TSS, 1 mg NH3-N /L, and 0.5 mg TP/L.

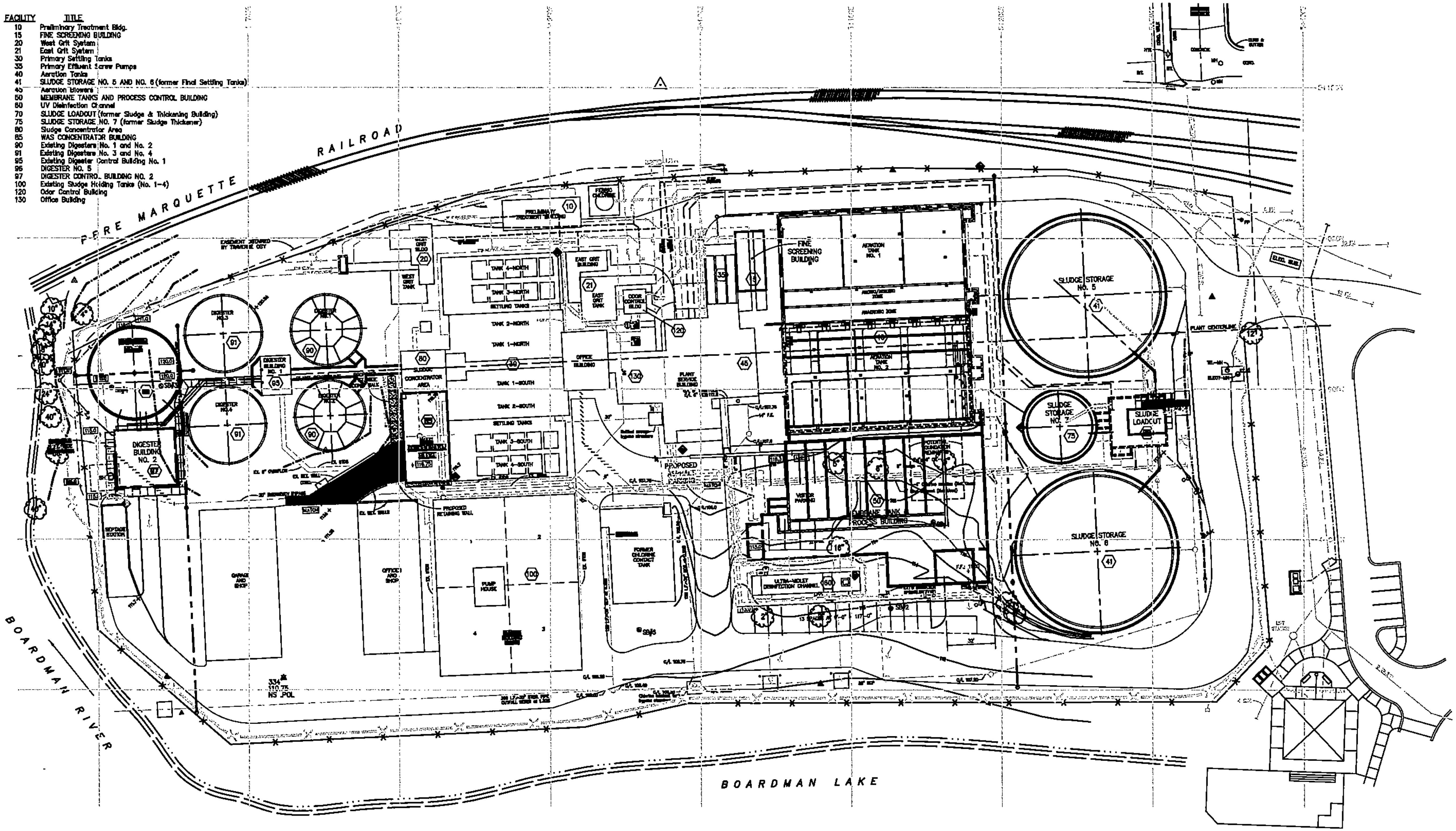


Figure 2-13 Overall Site Plan

**Courtesy of City of Traverse City*

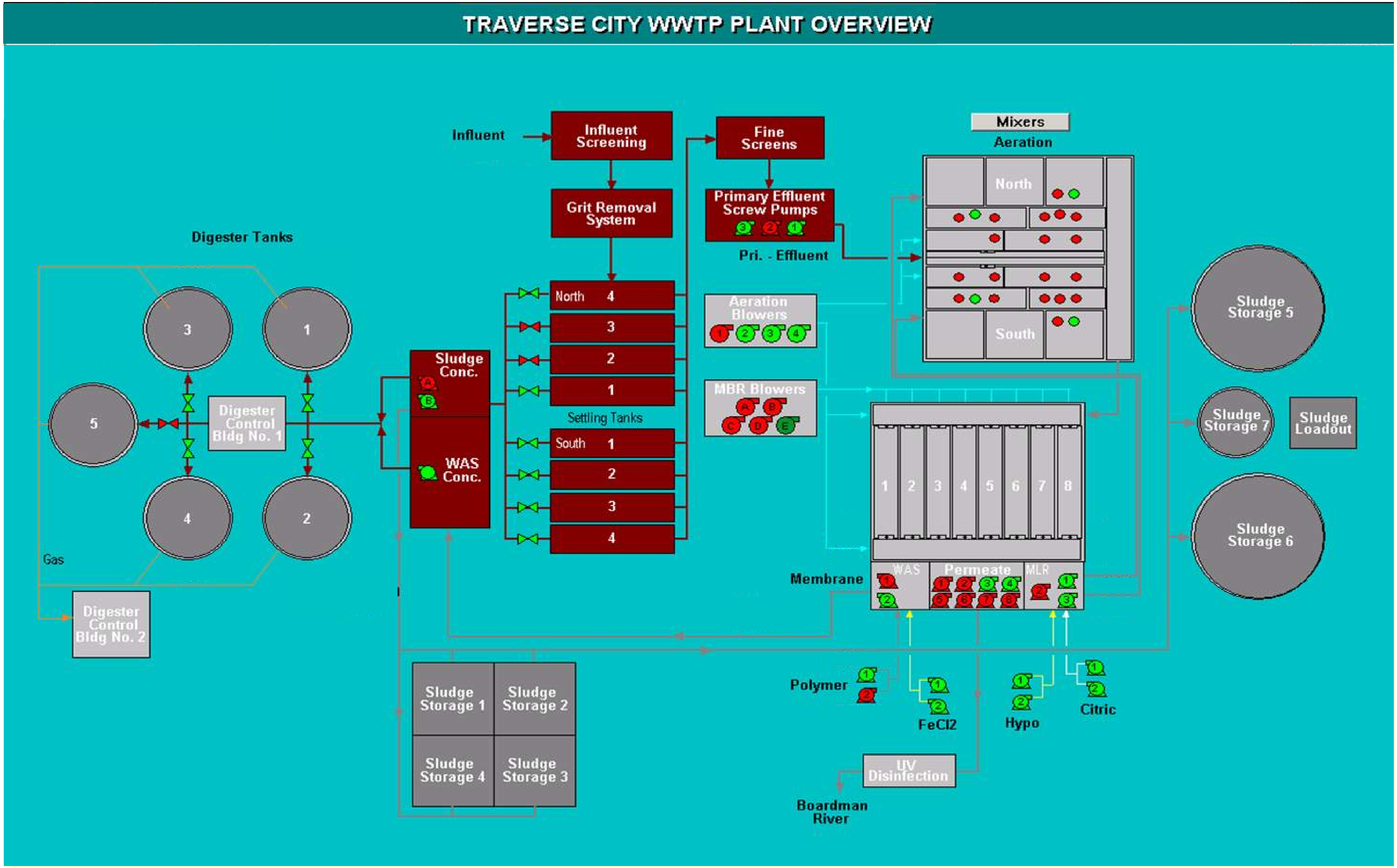


Figure 2-14 Process Flow Schematic

**Courtesy of City of Traverse City*

2.3.1 Primary Treatment

Preliminary Screening

Currently, raw sewage enters the TCRWWTP through four force mains which flow into the influent channel of the Preliminary Treatment Building. The influent channel directs the wastewater through a Rotary (Lakeside Rotamat) Semi-Fine Screen (3/8-inch +/- openings). The screened wastewater then flows by gravity through two 24-inch pipes to the two separate grit removal systems (East and West). The influent wastewater flow is measured through two 24-inch Parshall Flumes located upstream of both grit tanks each with a range of 0–10 MGD. The design capacity of the WWTP is 8.5 MGD with a peak flow capacity of 17 MGD.

If the flow is in excess of the rotary screen's capacity, it can overflow a slide gate and proceed through a bypass channel that is equipped with a manually cleaned coarse bar screen with 1-inch openings. Since it is a manually cleaned screen, it can become blinded rather quickly and result in problematic overflows of both of the channels or bypassing around the rotary screen since the rotary screen has points of overflow that are below the top of the channel walls. It has been indicated that equipping the overflow channel with a fine screen mechanism would be desirable.

Grit Removal

Grit removal is achieved using two 18' x18' square Detritor Style grit chambers (East and West Grit Tanks). The effluent from the West Grit Tank then flows through three cast iron sluice gates to the Primary Settling Tanks: one 24-inch diameter sluice gate/pipe and one 18-inch diameter sluice gate/pipe to the North Primary Settling Tanks and one 24-inch diameter sluice gate/pipe to the South Primary Settling Tanks. The effluent from the East Grit Tank flows through one 24-inch diameter sluice gate/pipe to the South Primary Settling Tanks and through one 24-inch diameter sluice gate/pipe to the North Primary Settling Tanks. The existing gates from each grit tank are nearly inoperable and the TCRWWTP is unable to isolate flows downstream of each grit chamber.

Primary Settling

The eight rectangular Primary Settling Tanks (each 66.5 feet long) are used to remove suspended solids and organics via gravity settling. The inner tanks are the original Primary Settling Tanks and located closest to the center plant walkway (original plant axis) are each 14 feet wide and was originally constructed in the 1930s. The newer tanks are each 16-ft wide and were constructed in the 1950s. The primary setting tank effluent discharges via overflow weirs and then flows to the Secondary Influent Screw pumps which then lifts the flow to the secondary biological process. The primary settling tanks are entirely covered with fiberglass covers supported by fiberglass beams that are anchored to the concrete walls with mild steel hardware that has indications of severe corrosion.

The sludge that settles to the bottom of the primary settling tanks is collected using chain and flight sludge removal mechanisms. Reportedly there is some grit carryover from the grit tanks that end up in the primary sludge and has accumulated in the digesters.

Most of the influent pipe between the grit tanks and both sets of Primary Settling Tanks is spiral welded steel pipe. This pipe also has several points of connection that were completed using bolted flexible connections (BFC's or "Dresser Couplings"), some are exposed but most were buried. The buried BFC's were likely coated with an asphaltic material before burying. A significant section of this piping adjacent to the south primary settling tanks has since ended up under the Sludge Thickening Building and is thus not easily accessible for any maintenance or repairs.

The section of these 24-inch pipes from the buried section outside of the south and north ends of the pipe gallery to the 18-inch pipe inside is a high point and not vented. At these locations, air tends to accumulate in this piping at the headspace. In wastewater, this air gap allows hydrogen sulfide to off-gas and collect in the pipe headspace.

Bacteria in the biofilm of the pipe oxidize hydrogen sulfide to form corrosive acids (typically sulfuric acid) which cause crown corrosion at the top of the metal pipe. Visual inspection of this steel pipe exterior at the south end of the gallery indicates severe corrosion and exposed holes. Also, the noticeable sound of the pipe "gulping" was present at the south end of the pipe gallery indicating that the trapped bubble at the larger diameter section of the buried pipe outside was periodically being released into the pipe within the building. At the pipe gallery sump pump discharge pipe connection, a severe leak developed previously. This leak almost resulted in a catastrophic failure of the entire pipe system but was averted by the TCRWWTP maintenance personnel. At the north end of the pipe gallery, any accumulated air in the pipe can also relieve itself through the 24-inch pipe section that connects to the West Grit tank provided that the sluice gate at the west grit tank is open. However, there could still be small sections of air pockets since pipes are never perfectly level, and bubbles in level pipes move very slowly so acids could still accumulate at the top of the pipe.

Likely, most of the primary influent piping is submerged given that the pipe centerline is typically at centerline elevation 112.0 (from the East Grit) or 113.0 (from the West Grit) at the point where it leaves the grit tanks and then rises to the centerline elevation 113.0 for tanks. The older tanks are all at a lower centerline elevation, 111.50. Given that the water surface elevation in the primary settling tanks is usually always at or above the weir elevation of 116.0, the pipes should be submerged except at the location in the south pipe gallery entrance where the pipe transitions from 24 to 18-inch diameter where the top air (or off gas generated within the pipe) gets trapped. As mentioned above, the air at the north end is not trapped since it can relieve itself to the north grit tank which is relatively close to this location. Installing vents at the north and south ends of the pipe gallery would help serve to eliminate any potential gas bubble buildup.

Fine Screening

Fine screen equipment provides for the screening of primary settling tank effluent, before conveyance to the secondary treatment system. Two screening channels, each 2 feet wide, are provided with a mechanically cleaned band screen rated at 10 MGD. The channels have a design water surface depth of approximately 3 feet. The channel depth is controlled by a fixed weir, installed in the effluent channel of each screen. The screened effluent discharges to the influent bay of the screw pumps. The screens have perforated openings of 2 mm, which is the opening size preferred by the membrane system manufacturer. Material collected on the screen is lifted out of the channel by the rotating screen and removed using a rotating brush and spray water. Each screen discharges the collected screenings to a screenings flume. Effluent water flushes the screenings from the screen and serves as sluicing water to convey the screenings, via the flume, to a screening compactor for removal of excess water. The compacted or dewatered screenings are bagged to prevent excessive odors with a screening bagger for periodic removal.

Primary Effluent Pumping

Screened primary effluent is conveyed by gravity from the fine screens to the screw pump influent well. Spiral screw pumps lift the screened primary effluent to the level of the Aeration Tanks. The pump discharge is hydraulically split into two parallel Aeration Tank inlet channels. A motorized slide gate is located in each channel and positioned to adjust the desired flow split between the north and south Aeration Tanks. The secondary influent flow is monitored downstream of the motorized slide gates via Parshall flumes.

2.3.2 Membrane Bioreactor Secondary Treatment

The influent to the Membrane Bioreactor (MBR) is pumped from the primary effluent screening facility to two secondary influent channels, each with a Parshall flume and individual sluice gates that are controlled to split the flow to the in-service Aeration Tanks.

The Aeration Tanks are arranged into two parallel trains. The tanks are configured in three passes: an anaerobic zone representing a percentage of the first pass, an anoxic zone for the remainder of the first and all the second pass (with swing zone capabilities), and the final pass an aerated zone. The secondary influent and mixed liquor recycle containing biological solids are introduced into the anaerobic zone. The combined wastewater is referred to as mixed liquor because of the presence of biological solids flows through the anaerobic zone, anoxic zones, and aerated zones of the Aerations Tanks. The flow pattern is generally plug flow through the individual Aeration Tank zones. The ML ultimately overflows from the discharge end of the aerated zone into a common Membrane Tanks influent channel.

The mixed liquor (ML) from the Aeration Tanks is channeled to the in-service Membrane Tanks. The membrane equipment effectively separates the solids from the liquid phase of the ML by applying suction to the inside of individual membranes with large centrifugal pumps. The separated solids from the ML side (outside) of the membranes, referred to as activated sludge, overflows adjustable gates at the discharge site of the Membrane Tanks. Most of the activated sludge (AS) is recirculated to the front of the aerated zones in the Aeration Tanks as return activated sludge (RAS) and the remaining portion of the activated sludge is directed to the solids handling processes as waste active sludge (WAS).

The membranes require cleaning on a routine basis. Two methods of in-tank cleaning, also referred to as Clean-In-Place (CIP), has been provided. Separate chemical systems are in place to feed sodium hypochlorite or citric acid to the membranes without removing the membrane cassettes from their respective tanks. The citric acid cleaning system is presented first followed by the sodium hypochlorite system.

The Membrane Building contains a chemical storage area and feed systems used for all membrane cleaning operations. Citric acid is fed to the membranes via a system of pumps and delivery piping. Two (2) citric acid dosing pumps are available and operate as duty-standby to deliver chemicals as required. The bulk chemical is delivered in totes to the chemical storage area and transferred to a storage tank in the storage area. Concrete curbs provide containment in the event of a spill.

Biological phosphorus removal is the main mechanism for phosphorus removal, but the chemical may be added to the MBR to supplement the phosphorus removal process.

The process air blower system consists of four (4) inlet throttled constant speed drive centrifugal multistage process air blowers, a low-pressure air piping system, and fine bubble diffusers to supply process air to the aerated zones of the Aeration Tanks. The process air blower output is varied by pneumatic butterfly valves, one valve located on the inlet side of each process air blower, to maintain a pressure set point in the air header.

2.3.3 Ultraviolet Disinfection

Wastewater from the membrane permeate pump enters the UV channel inlet wet well. The inlet wet well splits the flow into two channels. Normally, both UV channels are in service, but isolation gates are available if one channel requires service. Isolation gates are also available to stop the flow to the UV channel and divert it directly to the outfall.

The existing UV disinfection system is achieved using a low-pressure, low-output Aquaray 40 model by Infilco Degremont, Inc. (IDI), now a subsidiary of Suez Environmental (Suez). Suez UV equipment is marketed under the brand name Ozonia. The UV modules contain multiple lamps in a vertical arrangement. The system was designed in 1995 and included two channels with six modules per channel and space for an additional module in each. Design peak flow for the UV system was 11 to 12.2 million gallons per day (mgd) with final effluent. In 1998, two additional modules were added to the available spaces, resulting in up to 14 in-service UV modules.

2.3.4 Sludge Digestion and Solids Handling

WAS Concentration

The waste-activated sludge (WAS) is pumped from the WAS Box to the Gravity Belt Concentrator (GBC). The GBC consists of a permeable, continuous belt that travels horizontally across a series of rollers. Polymer is injected into the WAS in the pump discharge header upstream of the GBC to flocculate the activated sludge solids. Conditioned activated sludge fills a floc tank at the head of the GBC, which is designed to provide adequate mixing and reaction time of the polymer with the sludge solids. The conditioned activated sludge fills the tank and overflows onto the traveling belt. The belt travel speed is operator adjustable to optimize the retention time of the conditioned sludge on the belt to allow maximum water release and, therefore, maximize the concentration of the activated sludge at the end of the belt travel. The lateral position of stationary plows or chicanes along the belt is manually adjustable to create furrows and open clear sections of the belt to aid in free water release and belt drainage. A polyethylene doctor blade, with an adjustable tensioning arm, removes the thickened sludge from the belt at the discharge end of the machine. Concentrated waste activated sludge (CWAS) is discharged to a thickened sludge hopper that directly feeds an open throat progressive cavity pump. From there it is pumped to the Anaerobic Digestion system. The liquid released from the sludge drains through the belt to a filtrate collection box. Ferric chloride can be added to the WAS upstream or the CWAS downstream of the GBC to chemically fix the phosphorus that was taken up biologically in the activated sludge system.

Anaerobic Digestion

The anaerobic digestion system consists of five anaerobic digesters, complete with sludge recirculation, sludge heating system, sludge mixing, and digester gas handling. The digesters are equipped with recirculation pumps. The recirculation pumps are used to provide digester mixing by pumping the sludge through mixing nozzles located throughout Digesters 1, 2, and 5. Digester 4 uses gas lift mixers for primary mixing, and their sludge recirculation pump provides secondary mixing. The efficiency of the gas lift mixing is limited and the mixing in Digester 3 was replaced with a linear motion mixer installed in 2020.

Digested sludge is stored in the sludge holding tanks before being transported by tanker truck to be land applied. The thickening of the digested sludge is to both reduce the volume of biosolids to be hauled from the plant, as well as provide a suitable product for land application.

Digested sludge is normally concentrated via two sieve drum concentrators (SDCs). Four digested sludge transfer pumps are used to transfer the digested sludge to the SDCs. Polymer is added upstream of the SDCs to assist the thickening process. The concentrated digested sludge, CDS, is pumped to the sludge storage tanks.

Sludge Storage and Offloading

The sludge storage recirculation and loading system are operated manually. Sludge flows to storage from the sieve drum concentrators are monitored with a flow meter. In the event, that both sieve drum concentrators are out of service and the gravity belt concentrator is processing digested sludge, the concentrated digested sludge is conveyed to the sludge storage tanks using a different metered line.

In the Sludge Loadout Building, the piping and recirculation pumps are arranged such that either of the two pumps can be used for any one of the three tanks. Normally, only one pump is in service, mixing one tank at any given time. The incoming concentrated sludge can be directed to the suction line of the operating recirculation pump or conveyed directly to a storage tank without using the recirculation pump.

In the Sludge Storage Facility, sludge is directed to one of the four sludge storage tanks (Tanks 1 to 4) by opening the appropriate inlet valve. Recirculating mixers are available to mix the sludge if needed. Telescoping valves are available for each tank to decant supernatant. Each sludge storage tank is provided with high-level float switches, which will initiate an alarm when the tank liquid level reaches a high level.

2.3.5 Odor Control

Foul air is generated at several locations at the plant. Two odor control systems are provided to capture and treat foul air to control odors. One system uses activated carbon to remove hydrogen sulfide and other odor-producing compounds. The other system uses the aerated zones of the Aeration Tanks to treat foul air. The activated carbon system (Phoenix system) treats foul air from the east and west grit buildings, the primary settling tanks, the sludge concentrator building, and the WAS thickening building. Air is drawn from these buildings by a blower, located outside of the odor control building. Foul air is delivered to the Phoenix system and flows through the activated carbon canisters and is discharged to the atmosphere.

2.4 Need for Project

The WWTP is generally in compliance with the requirements of their NPDES permit. An order of enforcement is in place for the UV replacement. However, numerous issues need to be addressed immediately due to the age and condition of the plant to ensure the reliability of continued operation. An Asset Management Plan for the plant, which rates the condition of existing assets, was recently completed. It concluded that numerous assets at the plant need immediate replacement or refurbishment largely due to hydraulic limitations and aging equipment. The most critical needs are addressed in this Plan. These problems are prioritized according to Fiscal Years. The UV Disinfection Report completed by CH2M (Jacobs) in 2017 can also be noted in Appendix D.

Without the design, construction, and implementation of these projects, the water quality of the Boardman River, Boardman Lake, and Grand Traverse Bay will eventually degrade because the plant will not be able to continue to provide adequate treatment as mandated by its NPDES permit.

3 Alternative Analysis

3.1 Alternatives Considered

Each project was assessed to follow one of the following alternate classifications. Each upgrade or rehabilitative method was chosen on a technical basis and cost comparisons are presented for each alternative analysis, where applicable.

3.2 No Action

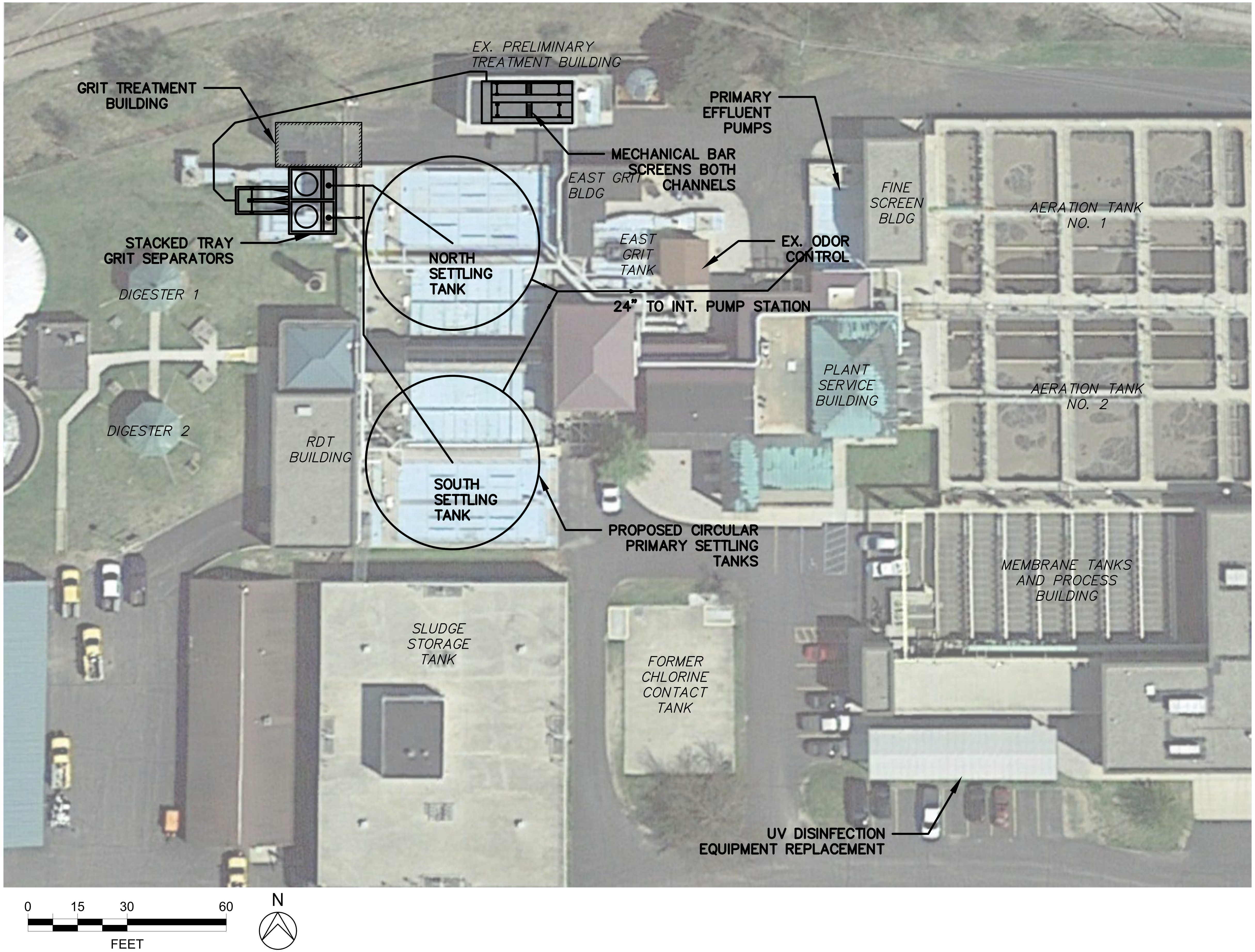
As previously indicated, if no action is taken, the existing plant equipment and structures will continue to degrade to the point that they will not be able to treat wastewater to a degree which complies with NPDES permit requirements or adequately protects public health and the environment. Besides, there are several projects which will mitigate or eliminate the potential for harm to employees and inhabited environs. All projects listed as part of this plan are of absolute necessity and should be implemented as soon as possible to avoid harm to workers, nearby residents, unnecessary upsets at the plant, and failures to the facility.

3.3 Headworks and Primary Treatment Improvements

Improvements to the Headworks and Primary Treatment are necessary to improve the reliability of treatment and address the system deficiencies. Figure 3-1 shows the overall locations of these projects located at the wastewater treatment plant. The Headworks and Primary Treatment Options Study is provided in Appendix E.

The Primary Influent Distribution Piping is in severely distressed condition and requires corrective action as it is reportedly on the verge of failure and has already exhibited leaks that have been arrested but almost caused disastrous flooding of the lower level of the TCRWWTP. Another issue is the manual bar screen used in the bypass channel for flow that is more than the rotary screen's capacity. Since it is a manually cleaned screen, it can become blinded rather quickly and result in problematic overflows of both channels or bypassing around the rotary screen since the rotary screen has points of overflow that are below the top of the channel walls. Within the grit removal process, the existing gates from each grit tank are nearly inoperable and the TCRWWTP is unable to isolate flows downstream of each grit chamber. This poor grit removal has led to grit settling in the primary sludge and accumulating in the anaerobic digesters.

Several alternatives were evaluated to address the headworks and primary treatment which are described below.



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PRELIMINARY AND
PRIMARY TREATMENT
IMPROVEMENTS

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3.3.1 Preliminary Screening

3.3.1.1 Mechanically Raked Bar Screen in Bypass Channel, Band Screen in Primary Channel

This alternative would include the installation of a mechanically raked bar screen on a fixed bar rack in the current bypass channel and the installation of motorized gate actuators to regulate the flow to the grit removal processes downstream similar to Alternative S1 and the installation of a mechanical traveling band screen in the current primary channel.

There would likely be minimal changes in Operation Cost since the additional periodic operation of the bypass channel screen would likely be offset by fewer problems resulting from bypassing of excess flows with lower levels of screenings as well as the cost of labor of tending to the manual screen bypass. This alternative would address the need for mechanical screening of all flows. The overall screen capacity during high plant flows would also be increased since the band screen has a higher capacity than the Rotamat.

3.3.1.2 Mechanically Raked Bar Screen in both Bypass Channel and Primary Channels

This alternative would include the installation of a 3/8" mechanically raked bar screen on a fixed bar rack in the current bypass channel similar to Alternative S1. In addition, the existing Rotamat screen would be replaced with a fixed bar rack mechanically cleaned screen.

There would likely be minimal changes in operating costs since the additional periodic operation of the bypass channel screen would likely be offset by fewer problems resulting from bypassing of excess flows with lower levels of screenings as well as the cost of labor of tending to the manual screen bypass. This alternative would address the need for mechanical screening of all flows. The overall screen capacity during high plant flows would also be increased since the mechanically cleaned bar screen has a higher capacity than the Rotamat.

3.3.2 Grit Removal

3.3.2.1 Rehabilitate the Existing Grit Removal Treatment Process (Detritors)

This alternative assumes the two existing Detritor grit removal tanks continued to be used. The existing tanks would be rehabilitated, and new covers would be installed. The mechanisms and grit classifiers would be replaced to match the existing ones. The two existing flumes are also old and should be replaced or modified to ensure their accuracy. A concern has been expressed on this alternative over the lack of adequate flow control to the Grit removal since there is currently no means to limit flow to one grit tank versus the other. A motor actuator on the channel gates downstream of the primary screen channel could be placed. If the actuator were set to limit the flow to one of the grit systems, the other channel could be used for the excess flow. Specific programming would be required to control the actuator.

3.3.2.2 Replace the Existing Grit Removal Using Stacked Tray System

This alternative assumes the grit system would be replaced with two stacked tray grit removal units (Hydro HeadCell). For this evaluation, two 9-foot diameter stacked tray systems would be installed in grit removal tanks. A grit classifier/washer would be installed in a new building adjacent to the tanks for final grit disposal to achieve greater than 95% grit removal with less and 5% volatile solids. The building would be equipped with foul air odor control and connected to the existing odor control system. Flow splitting to each grit tank would be achieved using a splitter box and flow metering using Parshall flumes.

3.3.3 Primary Settling

3.3.3.1 New Circular Primary Settling Tanks

The first alternative includes two new circular settling tanks that would be installed to provide a similar capacity as the existing rectangular units. Circular settling tank mechanisms are easier to maintain, and this is consistent with industry practices. With only two tanks there would only be two mechanisms versus the current four collector mechanisms and significantly fewer moving parts since there would be no chains and flights. Settling rates using two 70 feet diameter units would be approximately the same as the existing 8 rectangular tanks, existing as the settling area is 7,702 SF and the proposed settling area would be 7,693 SF. For this alternative, the circular primary treatment tanks could be paired with one either the east or west grit tanks (either the existing or new ones) with flow control occurring upstream of these tanks. Doing so would equally distribute the hydraulic capacity between the two primary settling tanks. Covering the circular tanks for odor containment would be more challenging but still feasible. Odor control treatment of the foul air would also still be required like existing practices.

3.3.3.2 Upgrade Existing Primary Settling Tanks and Influent Piping

Alternative 2 includes the complete replacement of the four dual chain and flight primary settling tanks including drive mechanisms, chains, flights scrapers, and scum trough actuators, replacement of critical primary influent distribution piping – mainly in the primary pipe gallery and just beyond the wall to facilitate removal of all parallel pipe paths and the installation of all twelve 12-inch influent valves, three redundant 24-inch knife gate valves (all except the path from West Grit to North Primary since it is so short), cleaning of 24-inch piping between the East Grit Tank and the South Primary Settling Tanks and the installation of slide gates at the location of four of the inoperable sluice gates downstream of both grit tanks (the fifth one – 18-inch from West Grit Tank would be removed and this pipe abandoned). Odor control would still be required similar to existing practices.

3.3.4 Primary Effluent Pumping

3.3.4.1 Primary Effluent Pumping Using Submersible Pumps

Primary effluent currently flows through one of two existing fin mesh opening band screens and then into one of four screw pumps for pumping to the secondary treatment process. These screw pump bays could be reconfigured to accept a submersible pump that can operate at low levels. This alternative would include a screw centrifugal pump with a pre-rotation basin installed in each bay along with a discharge pipe that would extend up to the level of the existing screw pumps and would fit nicely into the existing screw pump bays with a slight alteration of the floor in each bay.

3.3.4.2 Primary Effluent Pumping Using Existing Screw Pumps

This alternative includes the replacement of the existing screw pumps in kind. In addition, replacement of some of the concrete on the discharge channels with sulfide-resistant concrete is recommended due to the extensive corrosion which has been experienced in this area due to the sulfide release and eventual acid deposition on the wall, which has seriously degraded the existing concrete.

3.3.5 Evaluation of Headworks and Primary Treatment Alternatives

To get a reasonable comparison of alternatives for Preliminary and Primary Treatment, the improvement alternatives suggested for both Preliminary and Primary Treatment were compared between each equivalent alternative so that a complete Capital and Operating Cost impact could be determined and compared.

The Opinion of Probable Project Cost for the lowest PW alternatives is shown in Table 3-1 below along with a proportional amount of Annual Operation & Maintenance (O&M) cost for each. This comparison included various differential components such as an allowance for the HV costs based on the relative volumes of the additional building volumes that would need to be ventilated and heated on an annual basis, the cost of dealing with grit carryover from the existing grit removal process as opposed to improved grit removal from a more efficient process, the relative cost of screenings removal versus improved screenings equipment, as well as the relative cost of operation of rectangular settling equipment versus circular clarifier equipment. A Present Worth factor was applied to the relative Annual O&M cost (3.5% at 20 years) in each case to determine a 20-year Present Worth of the O&M costs to develop an Equivalent Present Worth Cost for each of the alternatives being considered. This provides a baseline economic comparison upon which each of these alternative combinations was compared. The table below summarizes the results of this economic comparison.

Table 3-1. Comparison of Headworks and Primary Treatment Alternatives

DESCRIPTION	PROJECT AMOUNT	ANNUAL O&M [4]	20 YEAR PW OF O&M [1.]	TOTAL PW
Preliminary Screening				
Mech. Fine Bar Screen in Bypass Ch, Band Screen in Exist Ch.	$1,739,000	$202,368	$2,876,137	$4,615,137
Mech. Fine Bar Screen in Both Channels	$1,662,000	$202,368	$2,876,137	**$4,538,137**
Grit Removal				
Ex. Grit Removal [2]	$900,000	$270,471[3]	$6,094,039	$6,994,039
New Grit Removal – Stacked Tray	$4,820,000	$42,909	$609,838	**$5,429,838**
Primary Settling				
Primary Settling and Influent Piping/Valves Replacements[3]	$3,550,000	$63,932	$3,408,631	$6,958,631
Two new 70' diam circular Primary Settling Tanks	$6,340,000	$12,416	$176,463	**$6,516,463**
Primary Effluent Pumping				
New Submersible Primary Effluent Pumps	$1,533,000	$49,724	$706,698	**$2,239,698**
Rehab Exist Primary Effluent Screw Pumps	$2,420,000	$180,843	$2,570,207	$4,990,207

1. Assumes 3.5% Interest Rate over 20 years.
2. Annual O&M includes future tank replacements – West Grit Tank in 20 years and East Grit Tank in 40 years*
3. Annual O&M includes the future tank replacements as a percentage of the future cost.
4. A portion of the total O&M Cost most relevant to each alternative and utilized for comparison of the alternatives.

The most cost-effective alternative for preliminary screening is for two new mechanical fine bar screens. Improved flow splitting before the grit removal is also recommended to equally distribute the flow to each grit removal unit. The rehabilitation of the existing grit tanks would also require their eventual complete replacement. New, more efficient, stacked tray grit removal would provide significantly less wear on downstream equipment.

Re-using the existing primary settling tanks represents the lowest capital cost and based on the structural analysis, the existing primary sludge tanks are in sound condition if concrete repairs are completed. However, given their age, the tanks would likely need to be replaced in the next 40 to 60 years. Replacement of the existing primary settling tanks with circular tanks provides a lower 20-year present worth mainly due to the lower estimated

O&M costs and the anticipated replacement cost of the existing tanks (one pair in 40 years and one pair in 60 years). The O&M and potential safety risks of continuing to work in the crowded primary piping gallery (both very difficult to quantify) also contribute to recommending replacement of the primary tanks at this time.

Preliminary Effluent Pumping Alternative using new submersible pumps in the existing screw pump bays represents the most cost-effective alternative versus continued reliance on the screw pumps.

3.4 UV Disinfection Upgrades

In September 2016, surge flow events damaged the electronics in the ultraviolet (UV) modules. Instrumentation and controls, spare UV modules, and operation procedures have been implemented to minimize the potential for flow surges and to minimize interruption of UV disinfection should surges or peak wet-weather flows occur. Hydraulic limitations and aging equipment also led to the need for an updated disinfection system.

3.4.1 UV System Modification

In accordance with the Administrative Consent Order (ACO) issued by EGLE to the City on July 3rd, 2019, all UV system modifications required were completed by the deadline of no later than one year after the Part 41 Permit was issued. These modifications included the following:

- Raising the UV system electrical equipment out of the wastewater flow channel and sealing the electrical components. Non-watertight electrical equipment will be raised at least 12 inches above the top of the UV channel concrete. The electrical equipment for at least six UV modules or lamp banks will be raised.
- Raising the electrical conduits associated with the raised UV modules at least 12 inches above the top of the UV channel concrete.
- Relocating the weir plates in the UV channel (that function to maintain upstream levels and prime on the membrane bioreactor back pulse pumps) to the permeate discharge structure.
- Raising the permeate discharge structure rim or top of concrete (TOC) at least 1.1 feet above its current elevation.

3.4.2 UV System Replacement

In accordance with the ACO issued, the new UV system must be constructed/installed and fuller operational no later than July 1st, 2026. Additionally, the existing UV equipment has reached the end of its useful life, and new UV equipment along with a raised UV channel hydraulic grade level, a raised UV channel invert, and a replacement modulating weir gate is recommended. The new UV equipment will be designed not to be damaged at 100-year flood levels and provide full disinfection at 25-year flood levels.

3.4.2.1 Evaluation of UV System Replacement Alternatives

Two alternatives were evaluated for the replacement UV technology: open-channel UV systems (both horizontal and vertically oriented) and in-vessel systems. The existing UV technology employed at the Traverse City Regional WWTP is low-pressure, low output. WWTPs typically replace these systems with low-pressure, high-output systems when they have reached the ends of their useful lives. The high-output systems require significantly fewer lamps than the low-output systems. They also offer modulation of lamp output in addition to the ability to turn banks or modules on and off. This will provide significant energy savings due to flow and water quality variability typical of WWTPs. And most relevant to the flooding events that occurred at the TCRWWTP, the electronics in this next generation of UV equipment are better protected from flooding.

The alternative of horizontally oriented lamps has the best benefit-to-cost ratio and is recommended. Retrofitting existing channels with vertically oriented lamps was ranked second. This alternative offered modest savings but less protection from damage at high water levels, and the cost savings versus the lowest budgetary estimate of the horizontally oriented lamps were small. The in-vessel alternatives provide a robust solution to address flooding and would eliminate the need for additional hydraulic improvements provided the permeate pumps are not impacted by the head loss through the in-vessel equipment. However, due to the high cost of constructing a new building, this technology had the lowest benefit-to-cost ratios, was ranked third in the evaluation, and therefore not recommended.

As UV equipment offerings continue to change, a similar review and evaluation of alternatives may be required. The 25-year flood elevation at the WWTP discharge may be reduced below the FEMA elevation noted herein as a result of the planned Union Street Dam replacement. Therefore, the 25-year flood elevation should be determined after the dam replacement at the time of UV replacement and the new UV channel HGL set accordingly.

3.5 Lower Boardman River Sanitary Sewer Replacement

The existing 24-inch sanitary sewer main along the frontage of the Lower Boardman River in the 100 and 200 blocks of Front Street is supported by a concrete retaining wall. The sewer and retaining walls were built in the 1930s. This wall is a cantilevered retaining wall, itself supported by a series of timber piles. In recent years it has become apparent that the river was scouring out the soil underneath the wall footing risking failure of the 24-inch gravity sewer.

The loss of soils is problematic to the community and the river as the support for the sanitary sewer and service leads is lost and/or weakened, potentially contributing to the release of raw sewage into the river. In addition, the impact to the sewer system pipes and connections encourages ground water infiltration into the sewer pipes which increases the community costs to treat sewage on typical days and contributes to the failure of the sanitary sewer on larger storm event days.

Several improvements to the sanitary sewer were assessed as the best and most feasible approaches for the restoration and management of the shoreline of the river. With these projects, potentially 50 gallons per minute of infiltration from wet laterals will be removed as a result of this project. Figure 3-2 shows the overall locations of this project as well as other projects located in the collections system.

In the 100 blocks, replacement of the sewer and addressing the risk of undermining the sewer is recommended. During the sewer replacement, the existing retaining wall would be replaced to allow for a natural shoreline and restoration of habitat along the riverfront. The existing stem and footing of the wall would be removed with the existing piles to remain. Riprap would be placed along the river bottom and up the shoreline to protect the shoreline from erosion and scouring while creating habitat for fish and other aquatic and riparian wildlife. Planting, trees, grasses, and other landscape items will be added to protect the new bank from erosion and promote habitat. Other landscaping would include the construction of a rain garden for stormwater management. It is recommended to remove only the vertical stem of the existing concrete wall, leaving the horizontal footing of the old wall in place as a sheltered habitat for fish. Methods of creating a stable, scour-resistant toe of the slope near the wall foundation will require further consideration during the final design.

The existing 24-inch sanitary sewer line behind the wall would be rerouted further south within the alley. This section of sanitary sewer has many sanitary leads that need to be replaced and this rerouting would provide the opportunity to fix and stabilize the leads, which will reduce the infiltration of ground water into the sewer system.

Date: 4/14/2021 Document Path: Y:\202101\20210140\03_Studies\Working\GIS\Sewer_Alternatives.mxd

CITY of TRAVERSE CITY MICHIGAN

HRC
HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

1925 BRETON ROAD SE SUITE 100
GRAND RAPIDS, MI 49506

PHONE: (616) 454-4286

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LEGEND
Lift Station
Pump Station
Sanitary Sewer Manholes
Sewer Gravity Mains
Diameter (in.)
Unknown
4" - 8"
9" - 15"
16" - 36"
Sewer Force Mains
Traverse City Owned
Maintained by Others
Roads
City of Traverse City
Townships
Hydrology
2020 Flow Meter

N W E S

0 500 1,000 2,000 Feet

DRAWN: DIU CHECKED: DIU

CWSRF PROJECT PLAN

CITY OF TRAVERSE CITY
COLLECTION SYSTEM
IMPROVEMENTS

HRC JOB NO: 20210140	SCALE: AS SHOWN
MAY 2021	FIGURE 3-2

For the sewer replacement in the 200-block alley, the installation of a sheet pile wall on the river side of the wall is recommended to prevent the loss of sewer support. A sheet pile wall would be driven into the earth on the river side of the retaining wall. The top of the sheet pile would coincide with the top of the wall footing. Once the sheet pile is driven into the river bottom, concrete would be pumped between the sheet pile and the existing retaining wall and fill under the existing footer as well to fill the gap. The sheet pile would protect the wall from further scour. Rip rap could be placed into the river to provide some fisheries habitat benefit.

The sanitary leads in this block were replaced about 10 years ago. As a precaution, removing the asphalt behind the concrete wall to locate any signs of soil subsidence and backfill with compacted aggregate material, as well as excavating and repairing any storm or sanitary sewer service leads that appear compromised is recommended. This option may be constructed with a temporary dam in the river and dewatering between the dam and the existing retaining wall.

3.6 Infiltration and Inflow Removal

Several alternatives for removing infiltration and inflow (I/) were considered to be completed together with long-term sewer rehabilitation in West Front Sewer System and are presented as follows.

3.6.1 Sanitary Sewer Evaluation Study and Hydraulic Modeling

Flow monitoring completed in 2015 and 2020 demonstrated the need for further investigation of two-meter districts, M03 and M09 which indicated high wet infiltration and inflow. This investigation would be a sanitary sewer evaluation study (SSES) and include field investigations for infiltration and inflow. This may include additional manhole inspections, CCTV inspections, smoke testing, and/or dye testing. Specifically, for Meter District M09 this would involve cleaning and CCTV inspection of the 24-inch sewer from the Front Street Lift Station to the Boardman River siphon (excluding the 100 and 200 block sewers). This inspection will also help identify the quantity and severity of the lateral connections adjacent to the Boardman River as sources of infiltration.

Meter district M04 represents a large collection area with increased dry weather flows. Based on the flow monitoring results, subdividing and re-metering this district would allow the City to capture more rainfall events and prepare the necessary unit hydrographs for the hydraulic modeling of these sewers and best target the areas for sewer rehabilitation and I/I removal.

3.6.2 Rehabilitation or Sewer Main Replacement (I/I Alternative 1)

Completion of sewer rehabilitation to address sources of infiltration and inflow is typically the most sustainable and lowest maintenance alternatives. The rehabilitation includes sewer, manhole, and lateral rehabilitation to address infiltration and inflow as well as the removal of footing drains, roof leads, sump pumps, and other sources of inflow. Overflows can be removed by reducing wet weather flows. Effective infiltration and inflow removal programs can take years to develop and implement and the evaluation of the other alternatives may be required considering this schedule.

In the development of the wastewater AMP, sanitary sewers and manholes were inspected per the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) and Manhole Assessment Certification Program (MACP) grading systems. Rehabilitation will address sewer segments and manholes with at least one PACP or MACP defect rating of 4 or 5 will be addressed.

3.6.3 Interceptor Lift Station and FM (I/I Alternative 2)

To address the hydraulic limitations in the West Front street sewer, an interceptor pump station was evaluated at Fifth Street and Wadsworth at the western end of Hannah Park. This option would capture the flows from meter districts M02 and M03 and reduce the peak wet weather flows limited by the hydraulic capacity of the sewer downstream of the Boardman River siphon. This alternative would include a new lift station, approximately 4,500 LF of 8-inch force main, and 1,000 LF of gravity sewer to separate these district flows from the Front Street Lift Station. Results from this project would potentially eliminate overflows downstream by diverting flow from the East Front Street lift station. The proposed force main would be located along City streets and cross the Boardman River under the 8th Street Bridge or by trenchless technology.

The pump station would have approximately 3.0 mgd capacity to convey the average and peak flows contributing to this meter district and constructed either below grade or in an above-grade structure. As this pump station would be located at the western portion of Hannah Park, the pump station would be designed to ensure above-grade structures provide both aesthetic architectural features and ensure all pedestrian traffic is not impacted.

3.6.4 Retention Basin (I/I Alternative 3)

The alternative for the construction of a retention basin in the location of the City's Lot X was also considered. This basin would be assumed to be 500,000 gallons and collect wet weather flows in excess of the hydraulic capacity of the sewer downstream of the Boardman River siphon and prevent sewer overflows downstream. The equalized wastewater would be pumped back to the gravity sewer following the wet weather event using a pump station. The equalization basin would be constructed with adequate level controls gates, flushing devices, and sloped floors to minimize the maintenance and cleaning associated with the tank. This tank would be installed to maintain above-grade parking.

3.6.5 Evaluation of Alternatives

The Front Street Lift Station has sufficient capacity to convey the peak flows and the Boardman River siphon can convey peak flows greater than 25-year, 24-hour wet weather events, this alternative is recommended to be completed after completion and evaluation of the I/I removal through sewer rehabilitation. I/I removal is more cost-effective over a 40-year life due to the reduced maintenance requirements, electrical energy usage, and treatment costs associated with removing these flows. However, due to the frequency of the events that occurred in 2020 and variable levels of Lake Michigan, sewer rehabilitation and targeted I/I removal may require additional measures to prevent SSOs. I/I alternatives 2 or 3 should be considered using a hydraulic model simulation to determine the required pump station capacity or retention basin equalization volume to effectively prevent downstream SSOs.

3.7 East Front Sewer Improvements

Most of the 24-inch and 18-inch sewer in Front Street both east and west of the Front Street Lift Station has been CIPP lined or replaced to address infiltration and inflow issues as well as structural defects. However, two sections of 24-inch concrete sewer constructed in the 1940s should be rehabilitated. Additionally, old leaking sewer laterals continue to contribute to high dry weather flows as a result of the increased groundwater levels and high-water levels of Grand Traverse Bay (Lake Michigan).

The Front Street Lift Station discharges to a 16-inch cast-iron force main. This pipe is more than 65 years old and is incurring high friction losses due to age and condition. This alternative includes 500 feet of force main replacement with the 20-inch pipe as well as 720 feet of 24-inch sewer lining, and 40 lateral replacement subject to high infiltration and inflow in East Front Street. Infiltration from the leaking laterals will be removed as a result of this project. This project would be completed in concurrence with the Front Street Streetscape project.

3.8 US-31 Reconstruction – Utility Replacement

The Michigan Department of Transportation (MDOT) has designed the reconstruction of US-31 from Murchie Bridge East to Garfield Avenue in Grand Traverse County approximately 4,560 feet long. Portions of the City of Traverse City's MDOT project will occur in the road rights-of-way under the jurisdiction of the MDOT. The City of Traverse City is working with the MDOT to incorporate the removal of approximately 3,200 LF of 8-inch sewer, transferring 38 sewer leads by extending to the southern 24-inch sanitary sewer, and the replacement of 350-feet of the 8-inch sewer during the reconstruction. These sewers are clay and concrete constructed in the 1950s and structural defects and infiltration were identified during the wastewater AMP No rehab of the 24" san is planned with this project, but it could be lined at a later date if needed. When construction plans are prepared, the necessary MDOT permit for working in the rights-of-way will be applied for.

3.9 Cost of Alternatives

The costs of the improvements detailed previously are shown in Table 3-2 by Fiscal Year.

3.10 Impacts of Alternatives

The improvements listed in the above projects are a mixture of work at the Wastewater Treatment Plant (WWTP) and Collection System. The long and short-term impacts of the alternatives are described in Section 5.

Table 3-2. Summary of SRF Projects (by Fiscal Year)

	Projects	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
1	Lower Boardman River Wall Sanitary Sewer	$2,853,000				
2	SSES		$200,000			
3	Sanitary Sewer Rehabilitation		$430,000	$430,000	$430,000	$430,000
4	Primary Treatment Improvements		$14,544,000			
5	US-31 Reconstruction - Utility Replacement			$416,000		
6	East Front Sewer Improvements			$860,000		
7	UV Disinfection Upgrades				$2,699,000	
8	Wet Weather Equalization/Diversion					$4,200,000
	Total FY Project Cost	**$2,853,000**	**$15,174,000**	**$1,706,000**	**$3,129,000**	**$4,630,000**
	Total SRF Projects Cost	**$27,492,000**				

4 Selected Alternatives

4.1 Proposed Facilities

The following projects noted in Table 4-1 are proposed under this SRF Project Plan.

Table 4-1. Fiscal Year of SRF Projects

Project	Fiscal Year
Lower Boardman River Wall Sanitary Sewer	2022
SSES	2023
Sanitary Sewer Rehabilitation	2023
Headworks and Primary Treatment Improvements	2023
UV Disinfection Update	2024
US-31 Reconstruction – Utility Replacement	2024
East Front Sewer Improvements	2024
Lift Station and Force Main	2025

The projects proposed in this Project Plan will begin construction within the next year starting the 2022 fiscal year. It is anticipated that these projects will encompass the needed capital improvements over the next 20-year period. Project locations, including the extents of disturbance, for all projects, have been included in Figure 3.1 for a WWTP projects overview and Figure 3.2 for a collection system projects overview. Detailed cost estimates for each project have been included in Appendix F.

4.2 *Proposed Schedule*

Table 4-2 below shows the completed SRF Project Plan submittal task dates.

Table 4-2. SRF Project Plan Task Schedule

Project Plan Task	Scheduled Date
Public Hearing Notice	April 15, 2021
Place Draft Project Plan on Public Records	April 15, 2021
Formal Public Hearing	May 17, 2021
City Commission Resolution of Project Plan Adoption	May 17, 2021
Submit Final Project Plan to EGLE	June 1, 2021

4.3 *Cost Estimate*

The estimated total project cost for the proposed project is $27,492,000. A cost summary for the wastewater collection system improvements and a detailed opinion of probable project cost for the WWTP improvements are both shown in Appendix F.

4.4 *User Costs and Cost Sharing*

The estimated costs for all proposed projects and fiscal years are presented below. Table 4-3 presents a summary of the estimated user costs by Fiscal year. The total estimated cost for the project is $11.68 per residential connection.

Table 4-3. Estimated User Cost Summary by Phase

Descriptions	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
Total Phase Project Cost	$2,853,000	$15,174,000	$1,706,000	$3,129,000	$4,630,000
Interest Rate	2.0%	2.0%	2.0%	2.0%	2.0%
Term (years)	20	20	20	20	20
No. of Residential Connections	9,299	12,197	6,446	12,197	9,805
Total Annual Debt Repayment	$174,500	$928,000	$104,400	$191,400	$283,200
Total Annual Debt Repayment (Residential)	$157,050	$835,200	$93,960	$172,260	$254,880
Total Monthly Cost for Project per Residential Connection	$1.42	$5.71	$1.21	$1.18	$2.17
Total Cost of Loan	$3,490,000	$18,560,000	$2,088,000	$3,828,000	$5,664,000
Interest Paid	$637,000	$3,386,000	$382,000	$699,000	$1,034,000

Notes:

1.Assumes interest rate of 2.0%
2.Assumes 90% residential contribution to fund
3.As of April 2021, 5,870 residential connections in Traverse City and an estimated 6,327 residential connections from Townships

4.5 Authority to Implement Selected Alternative

Implementation of the proposed project assumes that the project will be financed by a low-interest loan from the SRF program. The City of Traverse City has the necessary legal, institutional, financial, and managerial resources available to ensure the construction, operation, and maintenance of the proposed facilities.

5 Fiscal Sustainability Plan

A fiscal sustainability plan will be developed for those facilities which are installed, replaced, or rehabilitated under this project. This will be done by building on the Plant's existing asset management plan. The City's asset inventory is a key part of its asset management plan and is provided in Appendix G.

The existing asset registry will be updated with information on facilities impacted by the project. Data for existing equipment will be updated with new model numbers and rehabilitation dates. The new equipment will be added to the inventory. At the conclusion of the projects, the inventory will be fully updated to accurately reflect the equipment that is currently installed at the site.

Condition and performance data will be updated as well. New pumps and blowers will have their duty points recorded during startup. This will provide a benchmark to judge future performance by. Other critical mechanical equipment will have data such as full load amp draws recorded for this purpose as well. Condition information for existing items will be updated to reflect any rehabilitation work that was completed.

Useful life estimates will be updated for rehabilitated assets and solicited from manufacturers of newly installed assets. These estimates will be used to plan for future service and replacement costs. Operations and Maintenance manuals will be provided for all new equipment, along with onsite training. This will ensure that Plant staff has the knowledge necessary to perform maintenance and repairs. Water and energy conservation efforts will be implemented as a part of the fiscal sustainability plan as well.

6 Environmental Impacts

6.1 General

The anticipated environmental impacts resulting from the construction of the selected plan include beneficial & adverse, short-term & long-term, and irreversible impacts. The following is a discussion of the environmental impacts of the selected plan.

6.1.1 Beneficial and Adverse Impacts

The Traverse City Regional Wastewater Treatment Plant (TCRWWTP) is the City of Traverse City's municipal wastewater treatment facility. The TCRWWTP provides treatment to all industrial, commercial, and domestic (residential) wastewater. Wastewater from homes, businesses, and industries is pumped from two pump stations and nine lift stations to the head of the TCRWWTP for treatment in accordance with its NPDES permit with subsequent discharge to the Boardman River. Without the diligent work of TCRWWTP employees to operate and maintain the facilities, the polluted water (sewage) would be discharged into the Boardman River, Boardman Lake, Kids Creek, and the Grand Traverse Bay.

Construction activities associated with the proposed improvements will take place on the existing facilities. Construction and equipment manufacturing-related jobs would be generated, and local contractors would have an equal opportunity to bid on the construction contracts.

Implementation of the Project Plan would create temporary disruption due to required construction. This includes noise & dust generated by the work and possible erosion of spoils from open excavation. The assessment of alternate solutions and sites for the proposed project included identification of any important resources of either historic or environmental value which are protected by law and should be avoided. No registered contamination sites were found within the project area using the EGLE site contamination online mapper tool. Documentation of the research and results can be found in Appendix A.

6.1.2 Short-Term and Long-Term Impacts

The short-term adverse impacts associated with construction activities would be minimal, and mitigatable, in comparison to the resulting long-term beneficial impacts. Short-term impacts include traffic disruption, dust, noise, and temporary partial enclosures. No long-term negative impacts are anticipated.

The long-term positive impacts include improved efficiency at the plant, increased treating capacity, decreased complaints of odor, and the ability to continue providing adequate treatment to protect water quality. These impacts also include improved processing at the plant and reduced wear on the plant equipment.

6.1.3 Irreversible Impacts

The investment in non-recoverable resources committed to the Project Plan would be traded off for the improved performance of the facilities during the life of the system. The commitment of resources includes public capital, energy, labor, and unsalvageable materials. These non-recoverable resources would be foregone for the provision of the proposed improvements.

Construction accidents associated with this project may cause irreversible bodily injuries or death. Accidents may also cause damage to or destruction of equipment and other resources.

6.2 Analysis of Impacts

6.2.1 Direct Impacts

Local Air Quality

There will be minimal direct impacts on local air quality during the construction phases of these projects. Any effects on air quality will be due to dust and emissions from construction equipment and minimal possible styrene emissions from the CIPP curing material.

Archeological, Historical, or Cultural Resources

There are no impacts on archaeological, tribal, historical, or cultural resources due to this project.

Impacts Upon the Existing or Future Quality of Local Groundwater and Surface Waters

Construction will occur on the WWTP site, which is on the north shoreline of Boardman Lake and adjacent to the Boardman River. Additionally, work will take place within the connections systems through Grand Traverse County, the City of Traverse City, and the associated Township: Bair, Acme, East Bay, Elmwood, Garfield, and Peninsula. No impact will be made to the River, but appropriate measures will be taken during construction to avoid impact to these neighboring bodies of water. All necessary permits will be obtained before the proposed activities. There are no impacts anticipated to the local groundwater.

A detailed topographical survey will be conducted before construction to determine if the floodplain will be impacted by the project where construction of the oxidation tank will take place. All other construction and improvements will be made within existing facilities

Impacts Upon Sensitive Features

Since the work is expected to take place within the existing wastewater collection system facilities, the construction will take place outside of the designated floodplain, wetland areas, or other sensitive areas. Any work that takes place within floodplain limits, proper mitigation measures, and permits will be obtained before the proposed activities.

Impacts Upon People and The Local Economy

Short-term impacts on people will occur during the construction phase. Increased construction traffic will occur in the localized project areas of the connection system. All sanitary sewer users will experience beneficial long-term impacts due to the level of service to which they expect to be maintained by these improvements. The local economy will be stimulated for contractors and suppliers of the materials, labor, and equipment necessary to construct the project.

Operational Impacts

The proposed project will improve the operational efficiency of the WWTP and lower future operation and maintenance (O&M) costs for the wastewater collection system.

6.2.1 Indirect Impacts

Changes in Rate, Density, Or Type of Residential, Commercial, or Industrial Development and the Associated Transportation Changes

No changes are anticipated to the above.

Changes in Land Use

No changes are anticipated to the above. All improvements to the WWTP and the wastewater collection system will be completed on the existing WWTP site and to existing system structures.

Changes in Air or Water Quality Due to Facilitated Development

There will be no changes to air quality due to development. The proposed work will decrease the amount of total suspended solids discharged to the Boardman River during wet weather events, improving the water quality of the effluent to the river.

Changes to The Natural Setting or Sensitive Features Resulting from Secondary Growth

There should be no changes to the natural setting or sensitive features resulting from secondary growth.

Impacts on Cultural, Human, Social and Economic Resources

No changes are anticipated to the above.

Impacts of Area Aesthetics

All the proposed WWTP work will be completed on the existing sites which are largely isolated from public view.

Resource Consumption Over the Useful Life of the Treatment Works, Especially the Generation of Solid Wastes

No changes are anticipated to the above.

6.2.1 Cumulative Impacts

Siltation

Siltation may occur during the construction phase of the project. Proper soil erosion and sedimentation control practices will be followed to reduce the impacts of siltation on surrounding areas.

Water Quality Impacts from Direct Discharges and Non-Point Sources

The proposed work will decrease the amount of total suspended solids and biological solids discharged to the Boardman River during SSOs caused by wet weather events, improving the water quality of the effluent to the river.

Indirect Impacts from Development

There should no impacts on development as a result of this project.

The Impacts from Multiple Public Works Projects Occurring in the Same Vicinity

There will only be short-term traffic impacts during the construction phase of this project and proper traffic control measures will be followed.

7 Mitigation

7.1 Short-Term, Construction Related Mitigation

Environmental disruption will occur during construction. Guidelines will be established for cover vegetation removal, dust control, traffic control, and accident prevention. Once construction is completed those short-term effects will stop and the area will be returned to the original conditions.

The soil erosion impact would be mitigated through the contractor's required compliance with a program for control of soil erosion and sedimentation as specified in Part 91 of Michigan Act 451, P.A. of 1994. The use of soil erosion and sedimentation controls (i.e., straw bales, sedimentation basins, catch basin inserts, silt fencing, etc.) will protect the Boardman River, Boardman Lake, Kids Creek, and the Grand Traverse Bay.

Careful considerations will be taken during the construction planning process to ensure that the plant remains in service while the improvements are underway. Construction equipment will be maintained in good condition to decrease noise. All access roads will be swept as necessary to avoid tracking sediment onto public roads.

7.2 Mitigation of Long-Term Impacts

General construction activities will prohibit the disposal of soils in wetlands, floodplains, or other sensitive areas. Catch basins will be protected where earthwork activities will take place.

7.3 Mitigation of Indirect Impacts

The current trend in Grand Traverse County and the City of Traverse City is that the land use is largely dominated by residential properties. According to the City of Traverse City's master planning for land use, this will not change. Considering that a vast majority of the residents within the City limits are connected to the wastewater system, a substantial increase in flow is not expected from within the City limits.

The City of Traverse City's Master Plan and ordinances can also be found on their websites.

8 Public Participation

8.1 General

The Project Plan was advertised in the local newspaper April 15, 2021 (refer to Appendix H for all public participation documentation.) A copy of the Project Plan was placed at the following location for review:

- City Hall
- Online at the City of Traverse City's Website

A formal public hearing was held on May 17, 2021, to review the work associated with the proposed Project Plan. The hearing reviewed the information presented in the Project Plan, including estimated user costs, and receive comments and views of interested persons. Copies of correspondence related to agency notifications, as well as other relevant correspondence, will also be included in Appendix H.

8.2 Public Hearing

Appendix H includes a transcribed copy of the public hearing, commission members attendance list, the Project Plan resolution, and a photocopy of the slides presented at the hearing. No comments were received.

8.3 Resolution

The City Commission made a formal resolution regarding this Plan at a Commission meeting following the public hearing scheduled for May 17, 2021. The resolution is included in Appendix I.

APPENDIX A: AGENCY CORRESPONDANCE

HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

STREET: 1925 Breton Road SE
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Grand Rapids, MI 49506
PHONE: 616-454-4286
WEBSITE: hrcengr.com

May 14, 2021

NESHAP Asbestos Program
Department of Environment, Great Lakes & Energy – Air Quality Division
P.O. Box 30260
Lansing, MI 48909-7760

Attn: Ms. Karen Kajiya-Mills, Program Manager

Re: Impact Review
Wastewater Improvements Program
City of Traverse City, Michigan

HRC Job No. 20210140

Dear Ms. Kajiya-Mills:

The City of Traverse City is submitting a Project Plan to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for acceptance into the Clean Water State Revolving Fund (CWSRF) Loan Program. The Project plan requires a review to determine any potential impacts due to removal of building materials containing asbestos in the vicinity of the project.

On behalf of the City of Traverse City, we are requesting information regarding the impacts of the above referenced proposed project upon National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. The project work will involve the following:

- Improvements to the wastewater treatment plant including:
  - New preliminary screening system
  - Modifications to the grit removal process
  - Upgraded primary settling tanks
  - Replacement of effluent pumps
  - Repairs to the UV disinfection process
- Sewer main replacement/rehabilitation along Lower Boardman River
- Sewer Main replacement along US-31
- Sewer main rehabilitation along Bay Street
- Force main installment west of the wastewater treatment plant

Conveyance of wastewater to the TCRWWTP is accomplished by a sanitary sewer collection system with nine lift stations. The network of collection and transmission infrastructure collects and treats wastewater from the City of Traverse City, Garfield Township, Acme Township, Blair Township, East Bay Township, Peninsula Township in Grand Traverse County and Elmwood Township in Leelanau County. The City owns and maintains its sanitary sewer collection system, which is comprised of approximately 1,902 manholes, 81 miles of sanitary sewer pipeline, 4.7 miles of public force mains, and 9 lift stations. The service area location of the WWTP that will be impacted is provided in the attached figures.

Since the proposed project does not plan for the removal of any building materials containing asbestos, no impacts are expected from the proposed project upon any NESHAP regulations. On behalf of the City of Traverse City, we are requesting a review to confirm that the above referenced project will not cause an impact to NESHAP regulations in the project vicinity.

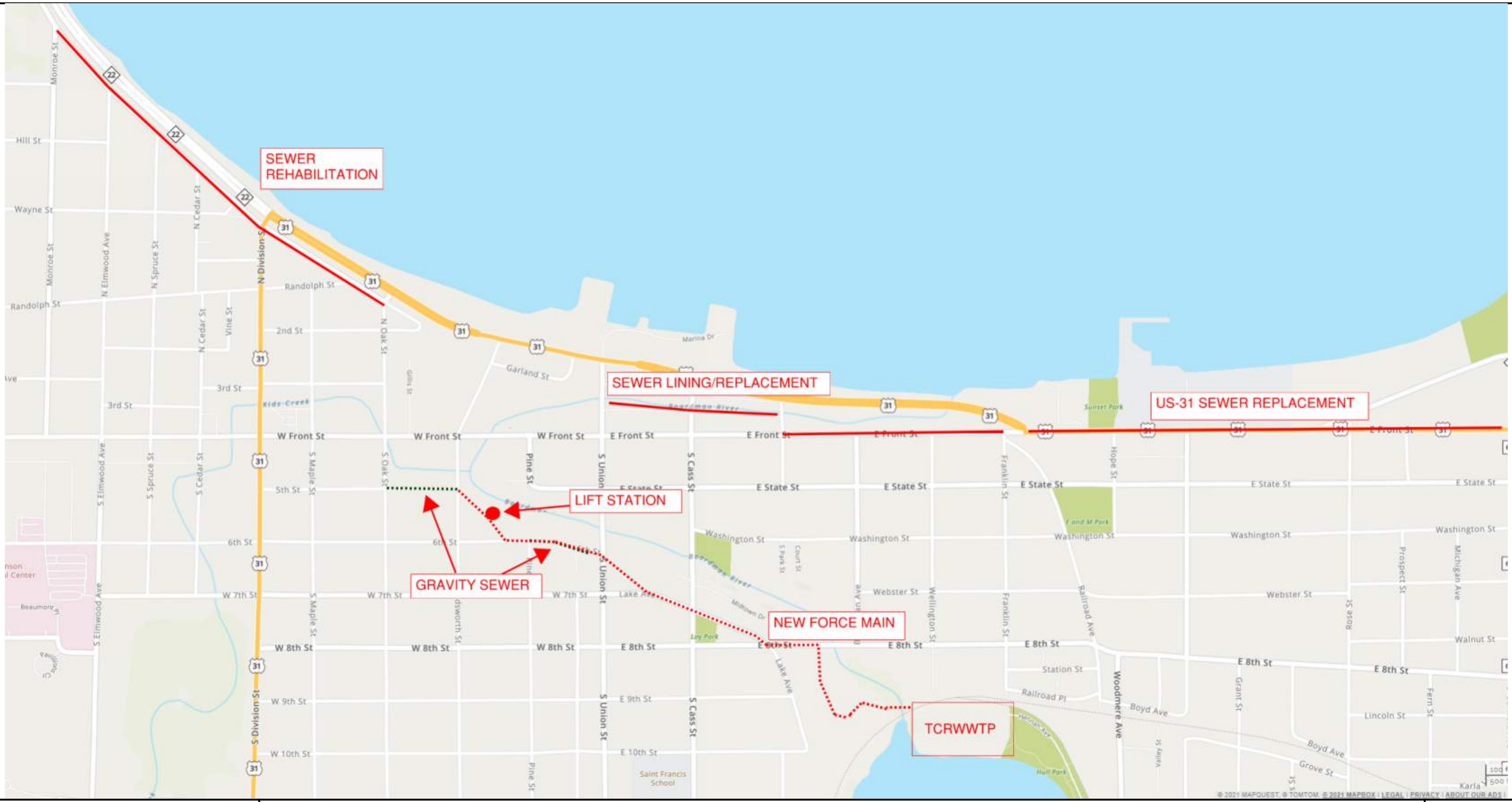
We request, on behalf of the City of Traverse City, your concurrence with this determination. We appreciate your review and would be grateful for a response as soon as possible so that we may meet program deadlines. If you have any questions or require any additional information, please contact the undersigned.

Very truly yours,

HUBBELL, ROTH & CLARK, INC.

Joshua Cole
Graduate Engineer I

Attachment
Project Map

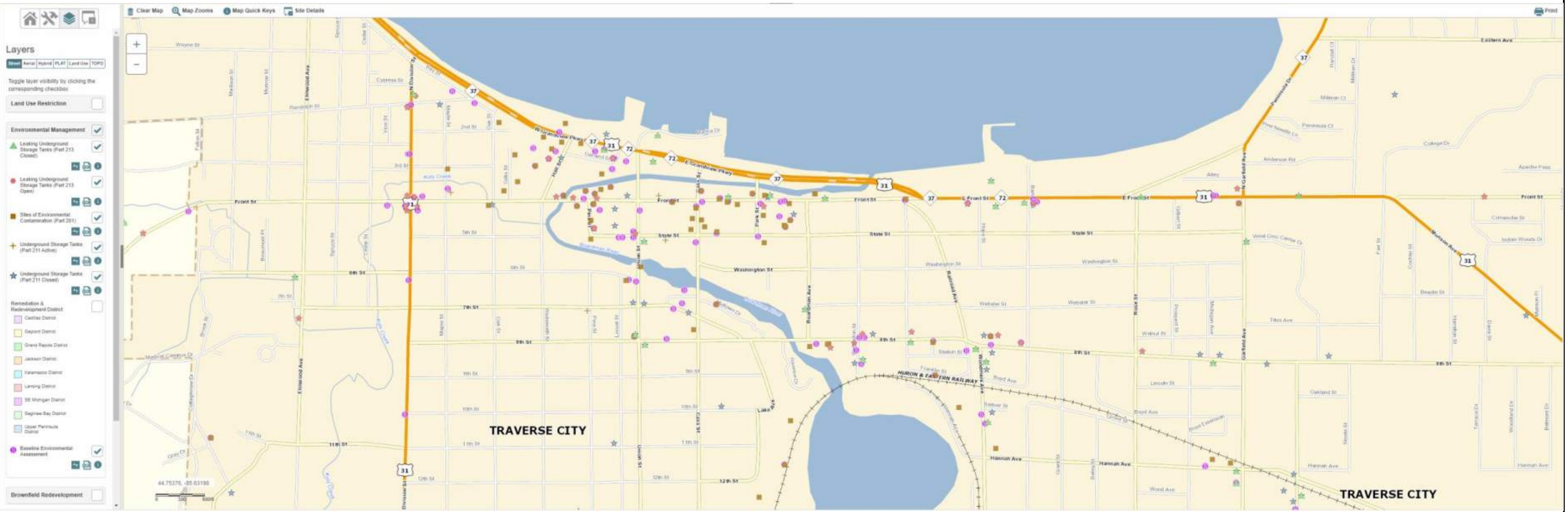


Traverse City Wastewater Improvements

Project Map

Date
5/14/2021

Figure No.
1



Traverse City Wastewater Improvements

EGLE RRD Listed Facilities Map

Date
5/14/2021

Figure No.
2

HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

STREET: 1925 Breton Road SE
Suite 100
Grand Rapids, MI 49506
PHONE: 616-454-4286
WEBSITE: hrcengr.com

May 14, 2021

Michigan Department of Environment, Great Lakes, & Energy
Office of Waste Management and Radiological Protection Division
P.O. Box 30473
Lansing, MI 48909-7973

Re: Impact Review HRC Job No. 20210140
Wastewater Improvements Program
City of Traverse City, Michigan

To Whom it May Concern:

The City of Traverse City is submitting a Project Plan to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for acceptance into the Clean Water State Revolving Fund (CWSRF) Loan Program. The Project plan requires a review to determine any potential impacts due to the disposal of waste materials in accordance with Michigan's Natural Resources and Environmental Protection Act (NREPA) as a result of the project.

On behalf of the City of Traverse City, we are requesting information regarding the potential impacts of the above referenced project based on Part 111, Part 115 and Part 121 of Michigan's Natural Resources and Environmental Protection Act (NREPA) and the Hazardous Materials Transportation Act. The project work will involve the following:

- Improvements to the wastewater treatment plant including:
  - New preliminary screening system
  - Modifications to the grit removal process
  - Upgraded primary settling tanks
  - Replacement of effluent pumps
  - Repairs to the UV disinfection process
- Sewer main replacement/rehabilitation along Lower Boardman River
- Sewer Main replacement along US-31
- Sewer main rehabilitation along Bay Street
- Force main installment west of the wastewater treatment plant

Conveyance of wastewater to the TCRWWTP is accomplished by a sanitary sewer collection system with nine lift stations. The network of collection and transmission infrastructure collects and treats wastewater from the City of Traverse City, Garfield Township, Acme Township, Blair Township, East Bay Township, Peninsula Township in Grand Traverse County and Elmwood Township in Leelanau County. The City owns and maintains its sanitary sewer collection system, which is comprised of approximately 1,902 manholes, 81 miles of sanitary sewer pipeline, 4.7 miles of public force mains, and 9 lift stations. The service area location of the WWTP that will be impacted is provided in the attached figures.

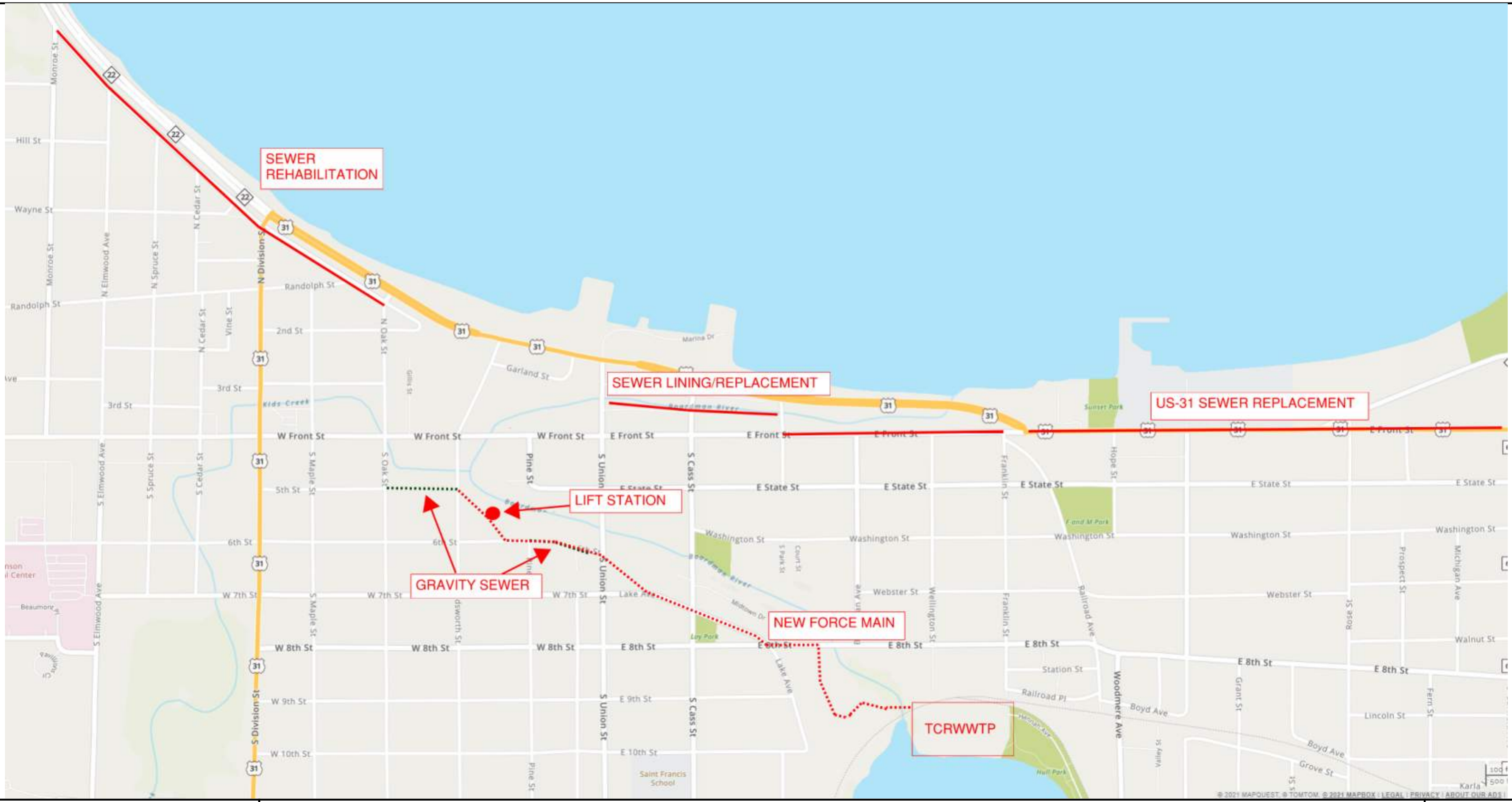
The proposed project involves replacement of existing facilities. No removal or disposal of building materials which contain lead, mercury, PCBs, or similar contaminants is expected. There may be existing facilities that were constructed during a period when lead paint was being used. However, in any case contaminants are discovered on the premises during construction, precaution and proper disposal will be implemented to follow regulations. We are requesting a review to confirm that the above referenced project will not impact Part 111, Part 115, or Part 121 of the NREPA.

We request, on behalf of the City of Traverse City, your concurrence with this determination. We appreciate your review and would be grateful for a response as soon as possible so that we may meet program deadlines. If you have any questions or require any additional information, please contact the undersigned.

Very truly yours,

HUBBELL, ROTH & CLARK, INC.
Josh Cole
Joshua Cole
Graduate Engineer I

<u>Attachment</u>
Project Map
EGLE RRD Listed Facilities Map

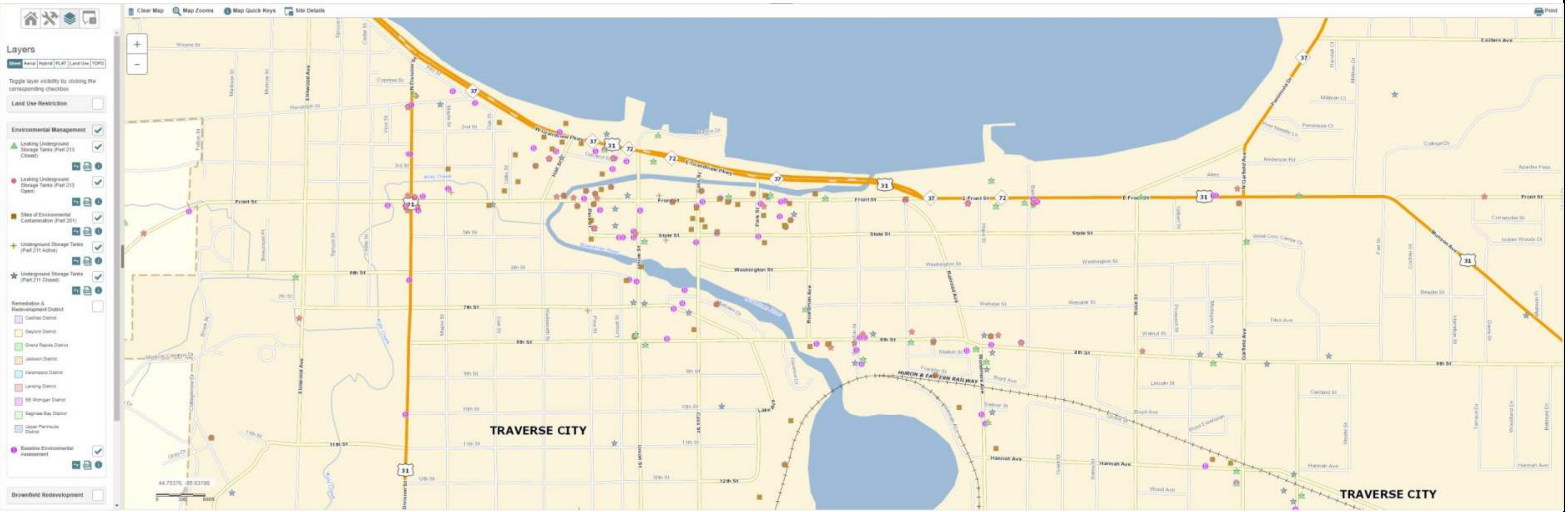


Traverse City Wastewater Improvements

Project Map

Date
5/14/2021

Figure No.
1



Traverse City Wastewater Improvements

EGLE RRD Listed Facilities Map

Date
5/14/2021

Figure No.
2

STREET: 1925 Breton Road SE
Suite 100
Grand Rapids, MI 49506
PHONE: 616-454-4286
WEBSITE: hrcengr.com

May 14, 2021

Networks Northwest
600 East Front Street, Suite 104
PO Box 506
Traverse City, MI 49685-0506

Re: Regional Environmental Planning Review
Wastewater Improvements Project
City of Traverse City, Michigan

HRC Job No. 20210140

To Whom It May Concern:

The City of Traverse City is submitting a Project Plan to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for acceptance into the Clean Water State Revolving Fund (CWSRF) Loan Program. The Project Plan requires a review to determine any potential impacts on any local development plans, area wide waste treatment management plans and/or regional water quality management plans.

On behalf of the City of Traverse City, we are requesting information regarding the impacts of the above referenced proposed project upon any local development plans, area wide waste treatment management plans and/or regional water quality management plans in the vicinity of the project. The project work will involve the following:

- Improvements to the wastewater treatment plant including:
    - New preliminary screening system
    - Modifications to the grit removal process
    - Upgraded primary settling tanks
    - Replacement of effluent pumps
    - Repairs to the UV disinfection process
- Sewer main replacement/rehabilitation along Lower Boardman River
- Sewer Main replacement along US-31
- Sewer main rehabilitation along Bay Street
- Force main installment west of the wastewater treatment plant

Conveyance of wastewater to the TCRWWTP is accomplished by a sanitary sewer collection system with nine lift stations. The network of collection and transmission infrastructure collects and treats wastewater from the City of Traverse City, Garfield Township, Acme Township, Blair Township, East Bay Township, Peninsula Township in Grand Traverse County and Elmwood Township in Leelanau County. The City owns and maintains its sanitary sewer collection system, which is comprised of approximately 1,902 manholes, 81 miles of sanitary sewer pipeline, 4.7 miles of public force mains, and 9 lift stations. The service area location of the WWTP that will be impacted is provided in the attached figures.

All population figures and projections referenced in the project plan will be collected from the Networks Northwest Website.

We request, on behalf of the City of Traverse City, notification if an alternative source for the population data is recommended.

Since the proposed project involves improvements to existing facilities, no impacts are expected from the proposed project upon local development plans, area wide waste treatment management plans and/or regional water quality management plans. On behalf of the City of Traverse City, we are requesting a review to confirm that the above referenced project will not cause an impact to any local development plans, area wide waste treatment management plans and/or regional water quality management plans.

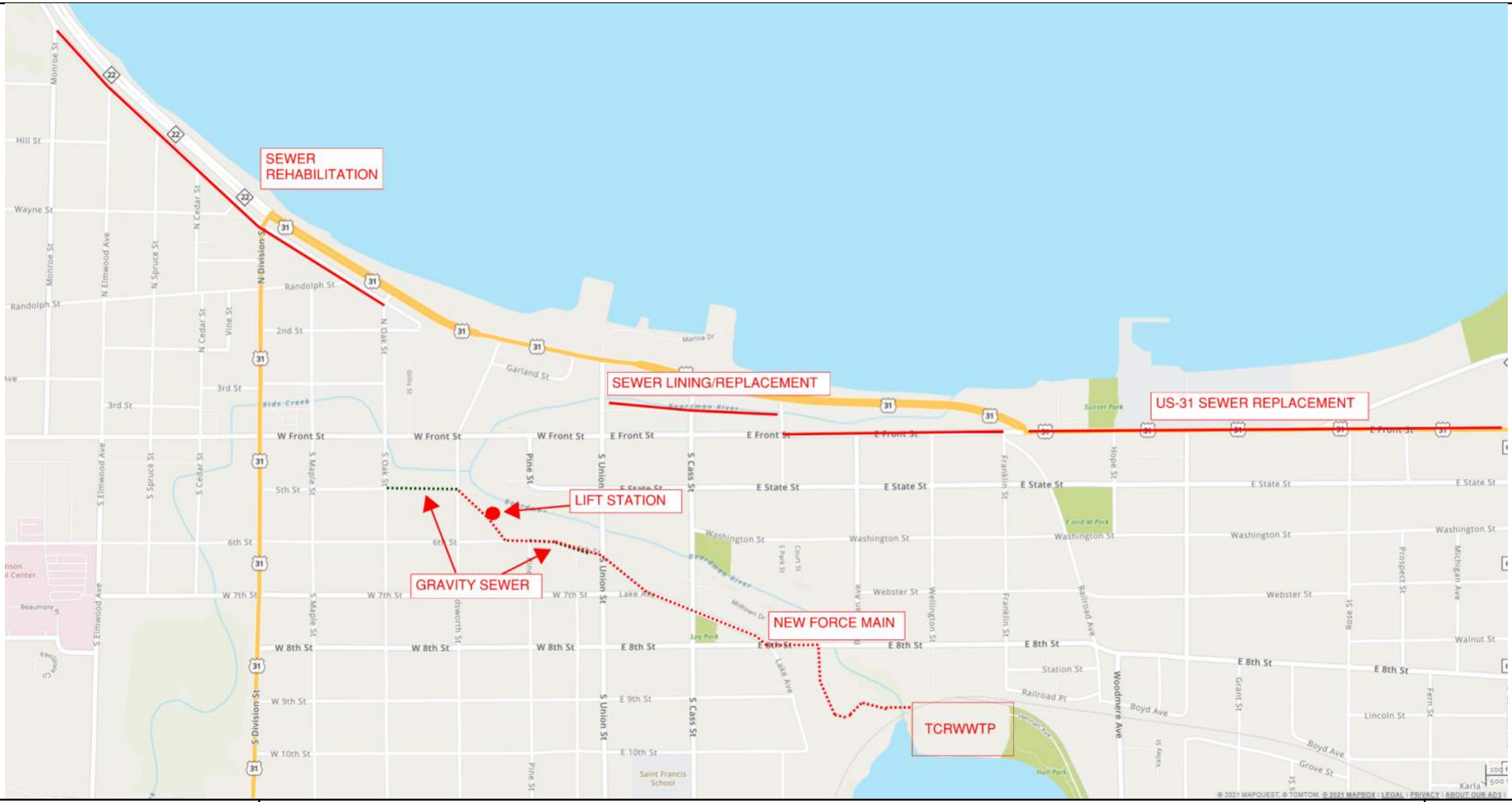
We request, on behalf of the City of Traverse City, your concurrence with this determination. We appreciate your review and would be grateful for a response as soon as possible so that we may meet program deadlines. If you have any questions or require any additional information, please contact the undersigned.

Very truly yours,

HUBBELL, ROTH & CLARK, INC.

Joshua Cole
Graduate Engineer I

Attachment
Project Map



Traverse City Wastewater Improvements

Project Map

Date
5/14/2021

Figure No.
1

HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

STREET: 1925 Breton Road SE
Suite 100
Grand Rapids, MI 49506
PHONE: 616-454-4286
WEBSITE: hrcengr.com

May 14, 2021

Farmland Preservation Program
USDA Natural Resources Conversation Service
3001 Coolidge Road, Suite 250
East Lansing, MI 48823-6362

Re: Impact Review
Wastewater Improvements Project
City of Traverse City, Michigan

HRC Job No. 20210140

To Whom it May Concern:

The City of Traverse City is submitting a Project Plan to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for acceptance into the Clean Water State Revolving Fund (CWSRF) Loan Program. The Project Plan requires a review to determine any potential impacts on prime and unique farmland in the vicinity of the project.

On behalf of the City of Traverse City, we are requesting information regarding the impacts of the above referenced proposed project upon the Farmland Protection Policy Act regulations. The project work will involve the following:

- Improvements to the wastewater treatment plant including:
  - New preliminary screening system
  - Modifications to the grit removal process
  - Upgraded primary settling tanks
  - Replacement of effluent pumps
  - Repairs to the UV disinfection process
- Sewer main replacement/rehabilitation along Lower Boardman River
- Sewer Main replacement along US-31
- Sewer main rehabilitation along Bay Street
- Force main installment west of the wastewater treatment plant

Conveyance of wastewater to the TCRWWTP is accomplished by a sanitary sewer collection system with nine lift stations. The network of collection and transmission infrastructure collects and treats wastewater from the City of Traverse City, Garfield Township, Acme Township, Blair Township, East Bay Township, Peninsula Township in Grand Traverse County and Elmwood Township in Leelanau County. The City owns and maintains its sanitary sewer collection system, which is comprised of approximately 1,902 manholes, 81 miles of sanitary sewer pipeline, 4.7 miles of public force mains, and 9 lift stations. The service area location of the WWTP that will be impacted is provided in the attached figures.

The proposed project site covers only urban areas, mainly zoned as single family residential or commercial. All excavated land will be restored to pre-construction condition. Since the proposed project involves improvements to existing facilities, no conversions of farmland to nonagricultural uses are expected. Please see attached map which shows a lack of existing significant farmlands in the project area. On behalf of the City of Traverse City, we are requesting a review to confirm that the above referenced project will not cause an impact to any significant farmland or agricultural lands in the project vicinity.

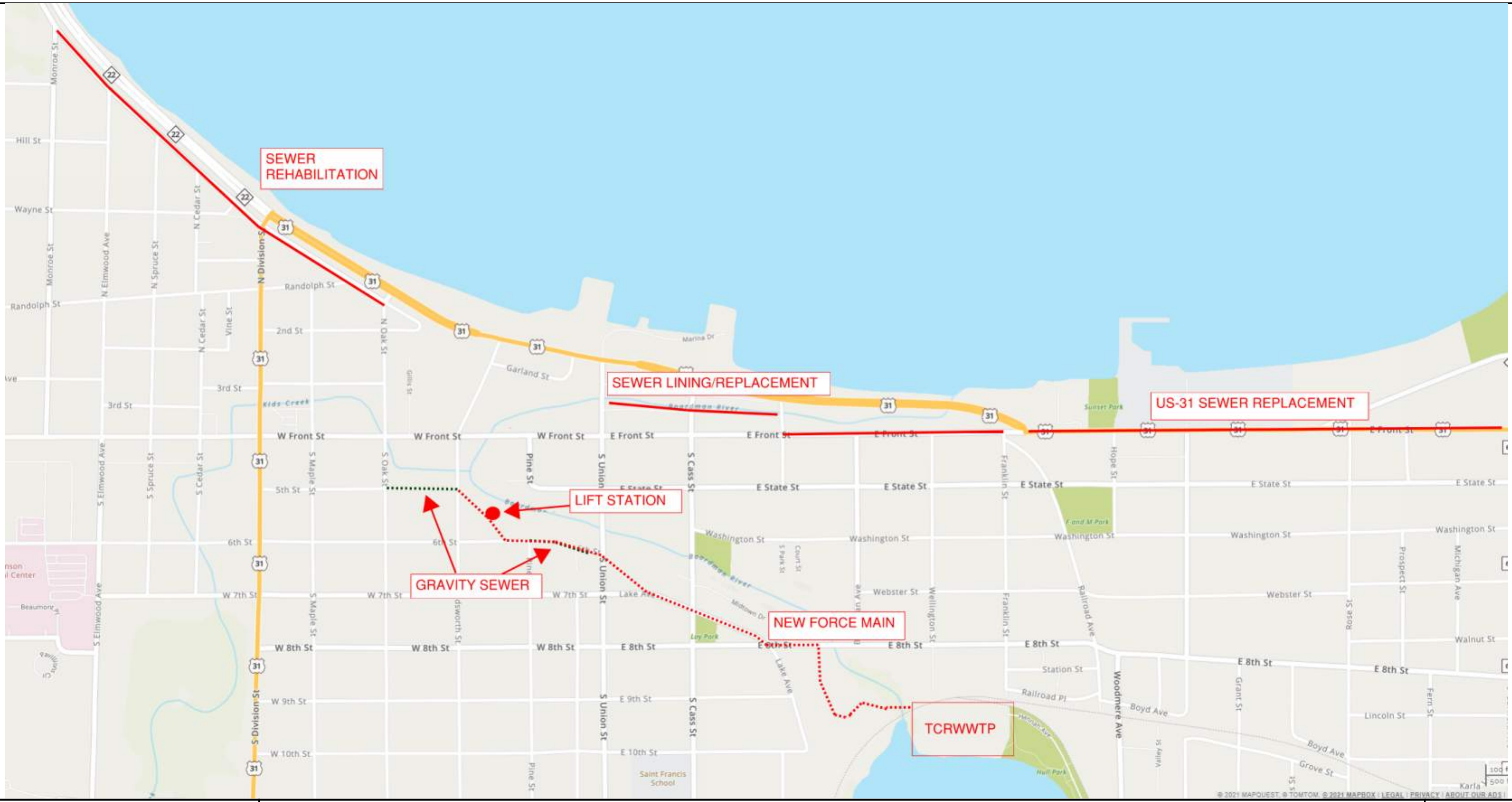
We request, on behalf of the City of Traverse City, your concurrence with this determination. We appreciate your review and would be grateful for a response as soon as possible so that we may meet program deadlines. If you have any questions or require any additional information, please contact the undersigned.

Very truly yours,

HUBBELL, ROTH & CLARK, INC.

Joshua Cole
Graduate Engineer I

<u>Attachment</u>
Project Map



HRC

Traverse City Wastewater Improvements

Project Map

Date
5/14/2021

Figure No.
1

USDA

United States Department of Agriculture

Natural Resources Conservation Service

Michigan State Office

3001 Coolidge Road
Suite 250
East Lansing, MI
48823-6321

Telephone:
(517) 324-5270
Fax:
(855) 701-4363

www.mi.nrcs.usda.gov

May 18, 2021

Joshua Cole
Hubble, Roth & Clark, Inc.
1925 Breton Road SE
Suite 100
Grand Rapids, Michigan 49506

RE: Traverse City Waste-Water Improvements Project

Dear Mr. Cole:

The Natural Resources Conservation Service (NRCS) under Part 523 of the Farmland Protection Policy Act has reviewed the proposed Traverse City Waste-Water Improvements Project. This review was conducted with respect to the effect(s) that the proposal may have on prime and/or unique farmland. Since the proposed project involves improvements to existing facilities, we have concluded that this proposal will have no negative impact on prime and/or unique farmland.

Should the scope of the project change to where expansion will occur, please resubmit the proposal for our review.

Sincerely,

GARRY LEE

Digitally signed by GARRY LEE
Date: 2021.05.18 12:18:14 -04'00'

GARRY LEE
State Conservationist

cc:
William Elder, Area Conservationist, NRCS, Gaylord, MI
Jason Kimbrough, District Conservationist, NRCS, Traverse City, MI

HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

STREET: 1925 Breton Road SE
Suite 100
Grand Rapids, MI 49506
PHONE: 616-454-4286
WEBSITE: hrcengr.com

May 17, 2021

Michigan Department of Environment, Great Lakes, and Energy (EGLE)
Cadillac District Office
120 West Chapin Street
Cadillac, MI 49601-2158

Re: Regional Environmental Planning Review
Wastewater Improvements Program
City of Traverse City, Michigan

HRC Job No. 20210140

To Whom it May Concern:

The City of Traverse City is submitting a Project Plan to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for acceptance into the Clean Water State Revolving Fund (CWSRF) Loan Program. The Project plan requires a review to determine any potential impacts on land-water interfaces, including Inland Lakes and Streams, Floodplains, Wetlands, Great Lakes Shorelands, Navigable Waters and Army Corps of Engineers (ACE) Regulated Activities.

On behalf of the City of Traverse City, we are requesting information regarding the impacts of the above referenced proposed project upon the previously detailed land-water interfaces in the vicinity of the project. The project work will involve the following:

- Improvements to the wastewater treatment plant including:
  - New preliminary screening system
  - Modifications to the grit removal process
  - Upgraded primary settling tanks
  - Replacement of effluent pumps
  - Repairs to the UV disinfection process
- Sewer main replacement/rehabilitation along Lower Boardman River
- Sewer Main replacement along US-31
- Sewer main rehabilitation along Bay Street
- Force main installment west of the wastewater treatment plant

Conveyance of wastewater to the TCRWWTP is accomplished by a sanitary sewer collection system with nine lift stations. The network of collection and transmission infrastructure collects and treats wastewater from the City of Traverse City, Garfield Township, Acme Township, Blair Township, East Bay Township, Peninsula Township in Grand Traverse County and Elmwood Township in Leelanau County. The City owns and maintains its sanitary sewer collection system, which is comprised of approximately 1,902 manholes, 81 miles of sanitary sewer pipeline, 4.7 miles of public force mains, and 9 lift stations. The service area location of the WWTP that will be impacted is provided in the attached figures.

The proposed project plan site encompasses pre-existing sewer pipeline beneath paved roadways or along bridges, as well as a brief segment through a wooded area near a residential area. In addition to this, construction will take place within the existing Wastewater Treatment Plant.

Based on the attached FEMA Floodplain Maps, it can be concluded that the portion of construction crossing the Lower

Boardman River will be within the 100-year Floodplain. Because the construction will take place along the existing bridge, it is expected that the construction will not have any effect on the floodplain. All proper permits and precautions will be implemented during this construction. On behalf of the City of Traverse City, we are requesting a review to confirm that the above referenced project will not cause any long-term impacts to any floodplains in the project vicinity.

The proposed project locations are mainly within previously attained easements. Since the work will be primarily within existing structures in these easements, no impacts to any existing wetland areas are expected. However, if project work is required within an existing wetland, necessary mitigation measures will be undertaken to protect the wetlands influenced by the project. On behalf of the City of Traverse City, we are requesting a review to confirm that the above referenced project will not cause an impact to any wetlands in the project vicinity.

Since the proposed project involves improvements to existing facilities located along a shoreline or within navigable waters of the United States, no impacts are expected from the proposed project upon Great Lakes Shorelands, Navigable Waters or ACE Regulated Activities. On behalf of the City of Traverse City, we are requesting a review to confirm that the above referenced project will not cause an impact to any Great Lakes Shorelands, Navigable Waters or ACE Regulated Activities.

If not already obtained, the appropriate joint permit applications will be completed, and the necessary permits obtained prior to any construction activities in this project area.

We request, on behalf of the City of Traverse City, your concurrence with this determination. We appreciate your review and would be grateful for a response as soon as possible so that we may meet program deadlines. If you have any questions or require any additional information, please contact the undersigned.

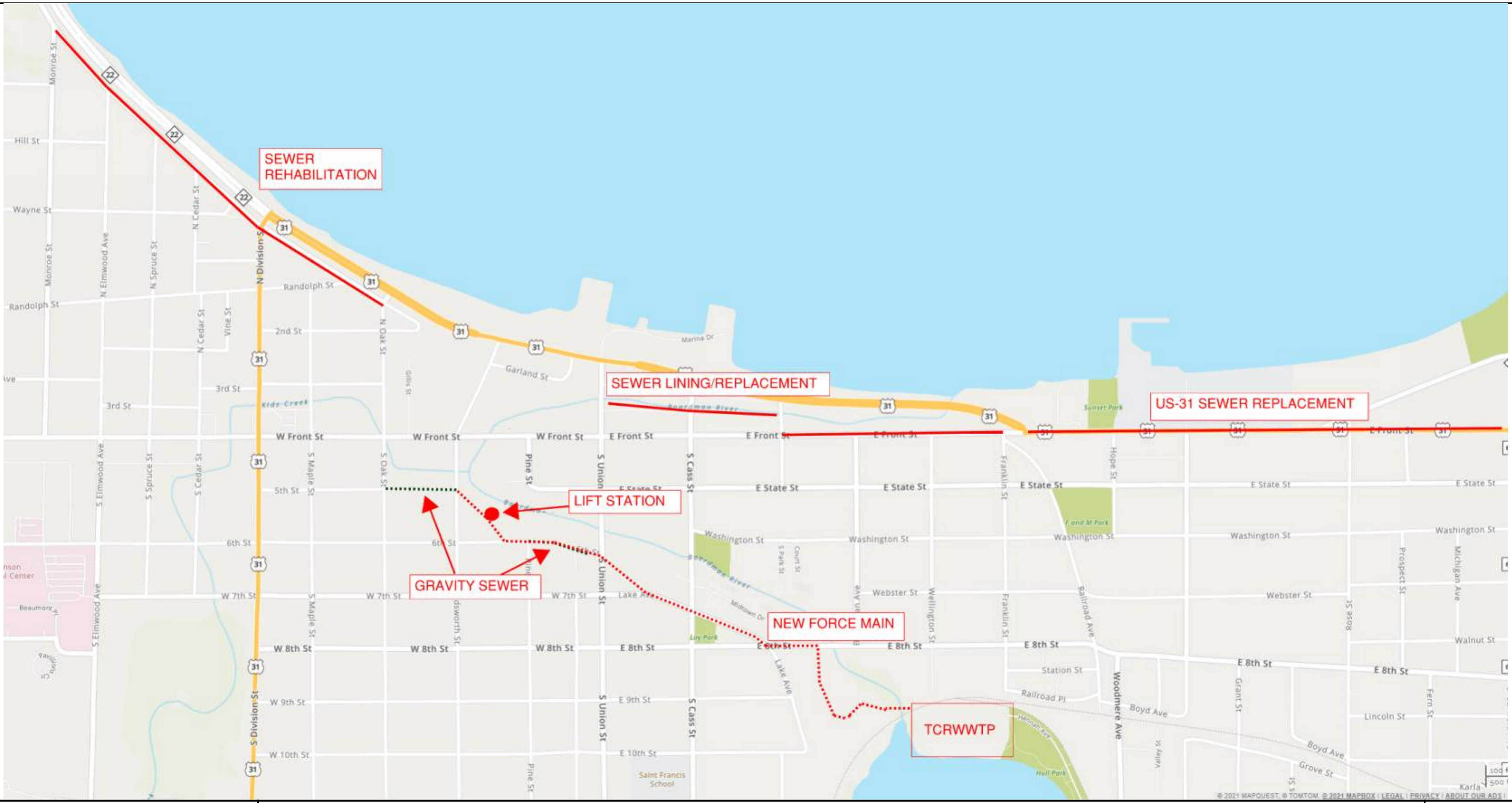
Very truly yours,

HUBBELL, ROTH & CLARK, INC.

Josh Cole

Joshua Cole
Graduate Engineer I

Attachment
Project Map
FEMA Floodplain



Traverse City Wastewater Improvements

Project Map

Date
5/14/2021

Figure No.
1

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 16. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by the National Agricultural Imagery Program (NAIP). This information was photogrammetrically compiled at a scale of 1:12,000 from aerial photography dated 2007 or later.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map,** how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% Annual Chance Floodplain Boundary
- 0.2% Annual Chance Floodplain Boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

- A — A: Cross section line
- 23 - - - - - 23: Transect line
- 45° 02' 08", 93° 02' 12": Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
- $^{49}89^{000m}$ N: 1000-meter Universal Transverse Mercator grid values, zone 16
- DX5510 ×: Bench mark (see explanation in Notes to Users section of this FIRM panel)
- • M1.5: River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
August 28, 2018

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0113C

FIRM
FLOOD INSURANCE RATE MAP

GRAND TRAVERSE COUNTY, MICHIGAN (ALL JURISDICTIONS)

PANEL 113 OF 425
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PENINSULA, TOWNSHIP OF	260747	0113	C
TRAVERSE CITY, CITY OF	260082	0113	C

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 26055C0113C

EFFECTIVE DATE AUGUST 28, 2018

Federal Emergency Management Agency

Figure 2-6 FEMA Floodplain Map

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 16. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by the National Agricultural Imagery Program (NAIP). This information was photogrammetrically compiled at a scale of 1:12,000 from aerial photography dated 2007 or later.

The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map,** how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

Figure 2-6 FEMA Floodplain Map

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% Annual Chance Floodplain Boundary

0.2% Annual Chance Floodplain Boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.

513 — Base Flood Elevation line and value; elevation in feet*

(EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A Cross section line

23 - - - - - 23 Transect line

45° 02' 08", 93° 02' 12" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere

$^{49}89^{000m}$ N 1000-meter Universal Transverse Mercator grid values, zone 16

DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)

• M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
August 28, 2018

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NATIONAL FLOOD INSURANCE PROGRAM

NFIP

PANEL 0113C

FIRM

FLOOD INSURANCE RATE MAP

GRAND TRAVERSE COUNTY, MICHIGAN

(ALL JURISDICTIONS)

PANEL 113 OF 425

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PENINSULA, TOWNSHIP OF	260747	0113	C
TRAVERSE CITY, CITY OF	260082	0113	C

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
26055C0113C

EFFECTIVE DATE
AUGUST 28, 2018

Federal Emergency Management Agency

HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

STREET: 1925 Breton Road SE
Suite 100
Grand Rapids, MI 49506
PHONE: 616-454-4286
WEBSITE: hrcengr.com

May 14, 2021

Natural River Administrator
DNR Fisheries Division
PO Box 30446
Lansing, MI 48909-7946

Re: Wild and Scenic Rivers Review
Wastewater Improvements Project
City of Traverse City, Michigan

HRC Job No. 20210140

To Whom It May Concern,

The City of Traverse City is submitting a Project Plan to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for acceptance into the Clean Water State Revolving Fund (CWSRF) Loan Program. The Project Plan requires a review to determine any potential impacts on state or federally designated wild, scenic, or natural rivers or tributaries in the vicinity of the project.

On behalf of the City of Traverse City, we are requesting information regarding the impacts of the above referenced proposed project upon protected state or federally designated wild, scenic, natural rivers, or tributaries. The project work will involve the following:

- Improvements to the wastewater treatment plant including:
  - New preliminary screening system
  - Modifications to the grit removal process
  - Upgraded primary settling tanks
  - Replacement of effluent pumps
  - Repairs to the UV disinfection process
- Sewer main replacement/rehabilitation along Lower Boardman River
- Sewer Main replacement along US-31
- Sewer main rehabilitation along Bay Street
- Force main installment west of the wastewater treatment plant

Conveyance of wastewater to the TCRWWTP is accomplished by a sanitary sewer collection system with nine lift stations. The network of collection and transmission infrastructure collects and treats wastewater from the City of Traverse City, Garfield Township, Acme Township, Blair Township, East Bay Township, Peninsula Township in Grand Traverse County and Elmwood Township in Leelanau County. The City owns and maintains its sanitary sewer collection system, which is comprised of approximately 1,902 manholes, 81 miles of sanitary sewer pipeline, 4.7 miles of public force mains, and 9 lift stations. The service area location of the WWTP that will be impacted is provided in the attached figures.

The proposed project site covers primarily commercial and residential areas, although construction of a sewer force main will take place across the Lower Boardman River. Apart from this area, excavations will be made in paved areas, primarily where sewer mains are preexisting. All land will be returned to pre-construction condition.

Although this project spans the Lower Boardman River, it is not designated by any state or federally as a wild, scenic, or natural river. Additionally, any construction spanning this river will take place on the pre-existing bridge. Therefore, we are requesting on behalf of the City of Traverse City for a review to confirm that the above referenced project will not cause an impact to any state or federally designated wild, scenic, or natural rivers or tributaries.

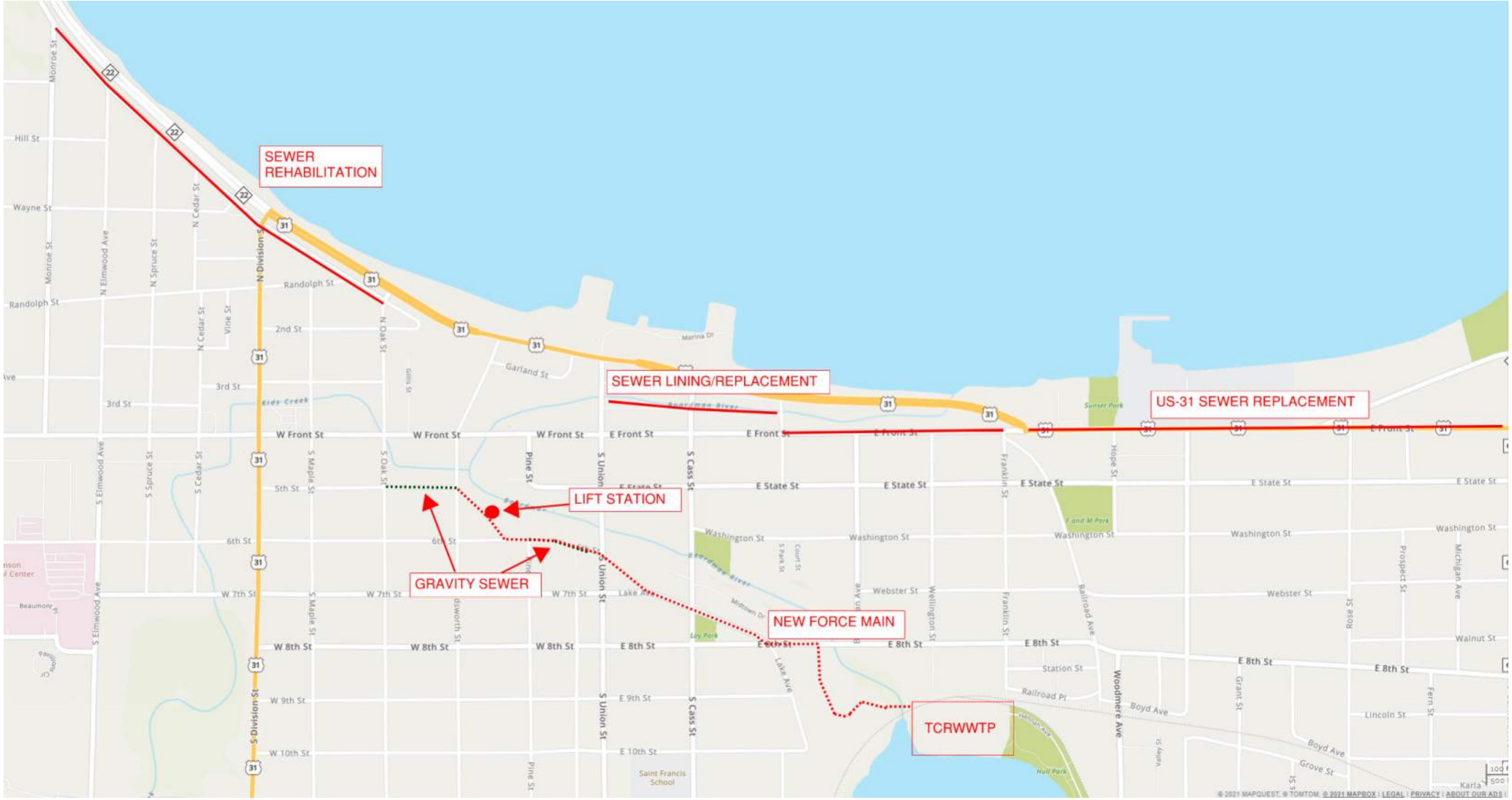
We request, on behalf of the City of Traverse City, your concurrence with this determination. We appreciate your review and would be grateful for a response as soon as possible so that we may meet program deadlines.

If you have any questions or require any additional information, please contact the undersigned.

Very truly yours,

HUBBELL, ROTH & CLARK, INC.
Josh Cole
Joshua Cole
Graduate Engineer I

Attachments:
Project Map
National Wild and Scenic Rivers System with Project Location
Nationwide Rivers Inventory with Site Location



HRC

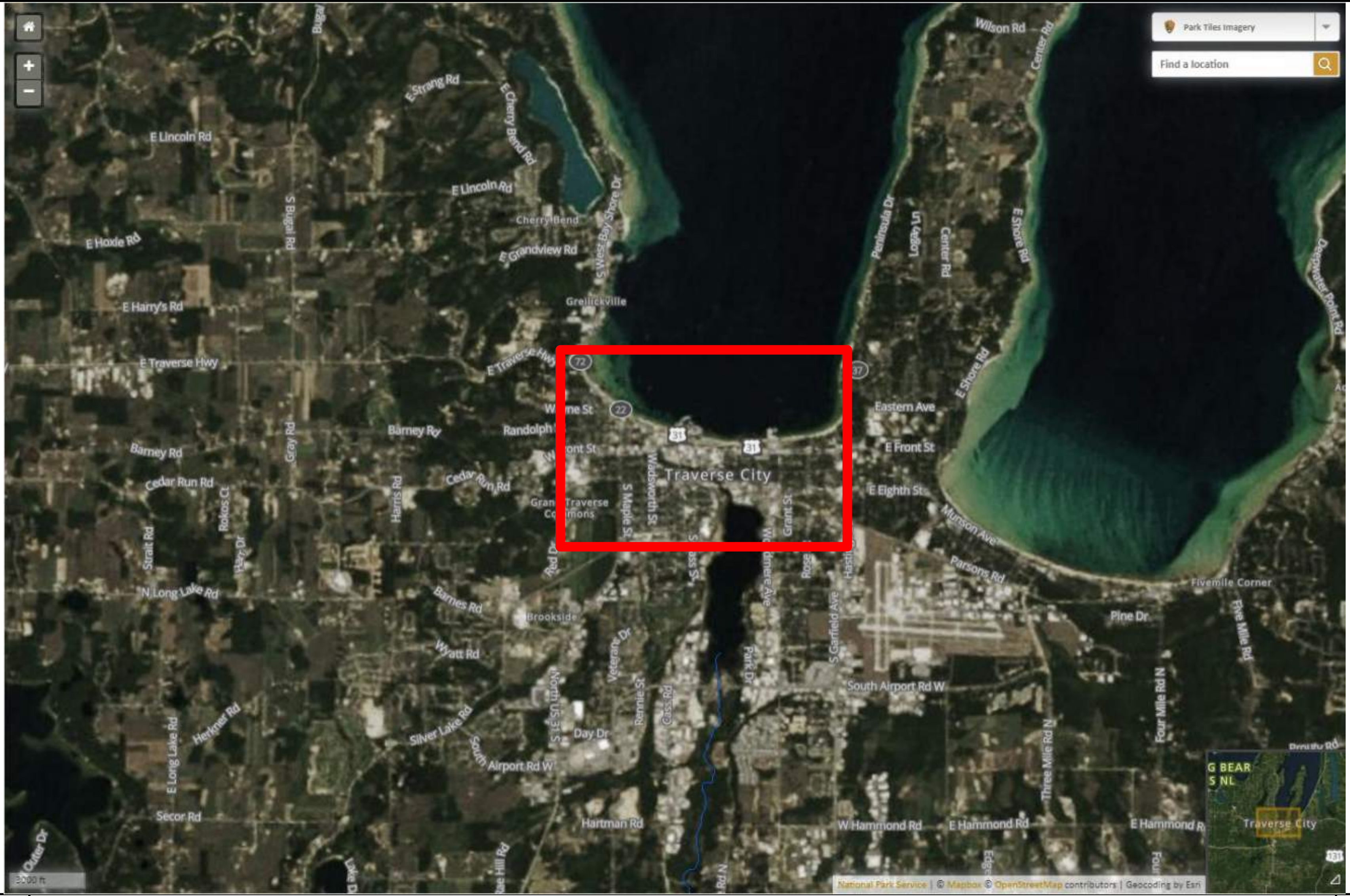
Wild and Scenic Rivers Review: Traverse City Sanitary Sewer Rehabilitation

Project Map

Date
4/15/2021

Figure No.
1

HRC	Wild and Scenic Rivers Review: Traverse City Sanitary Sewer Rehabilitation	Date 4/15/2021
	National Wild and Scenic Rivers System with Project Location	Figure No. 2

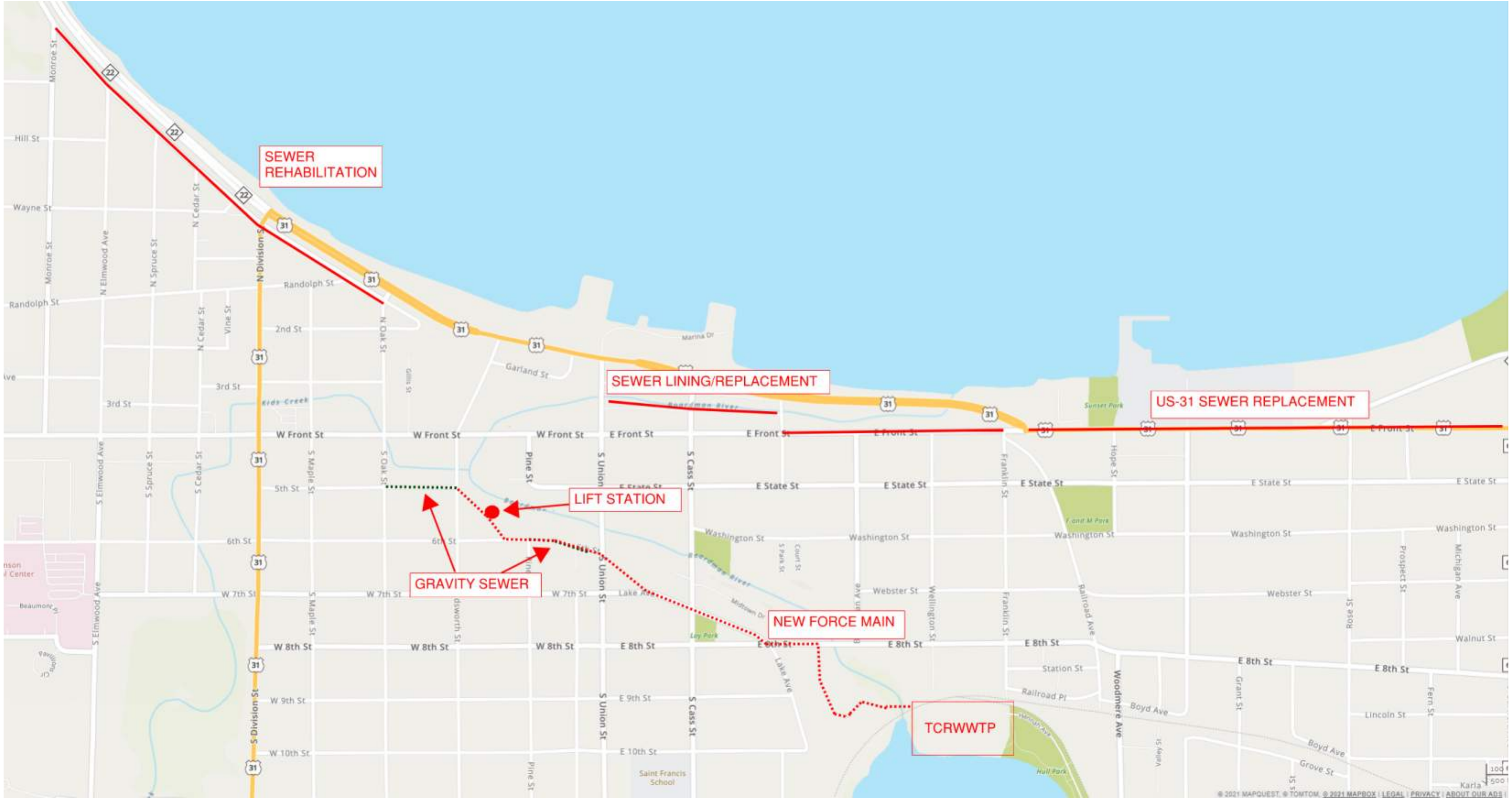


Wild and Scenic Rivers Review: Traverse City Sanitary Sewer Rehabilitation

Nationwide Rivers Inventory with Site Location

Date
4/15/2021

Figure No.
3



HRC

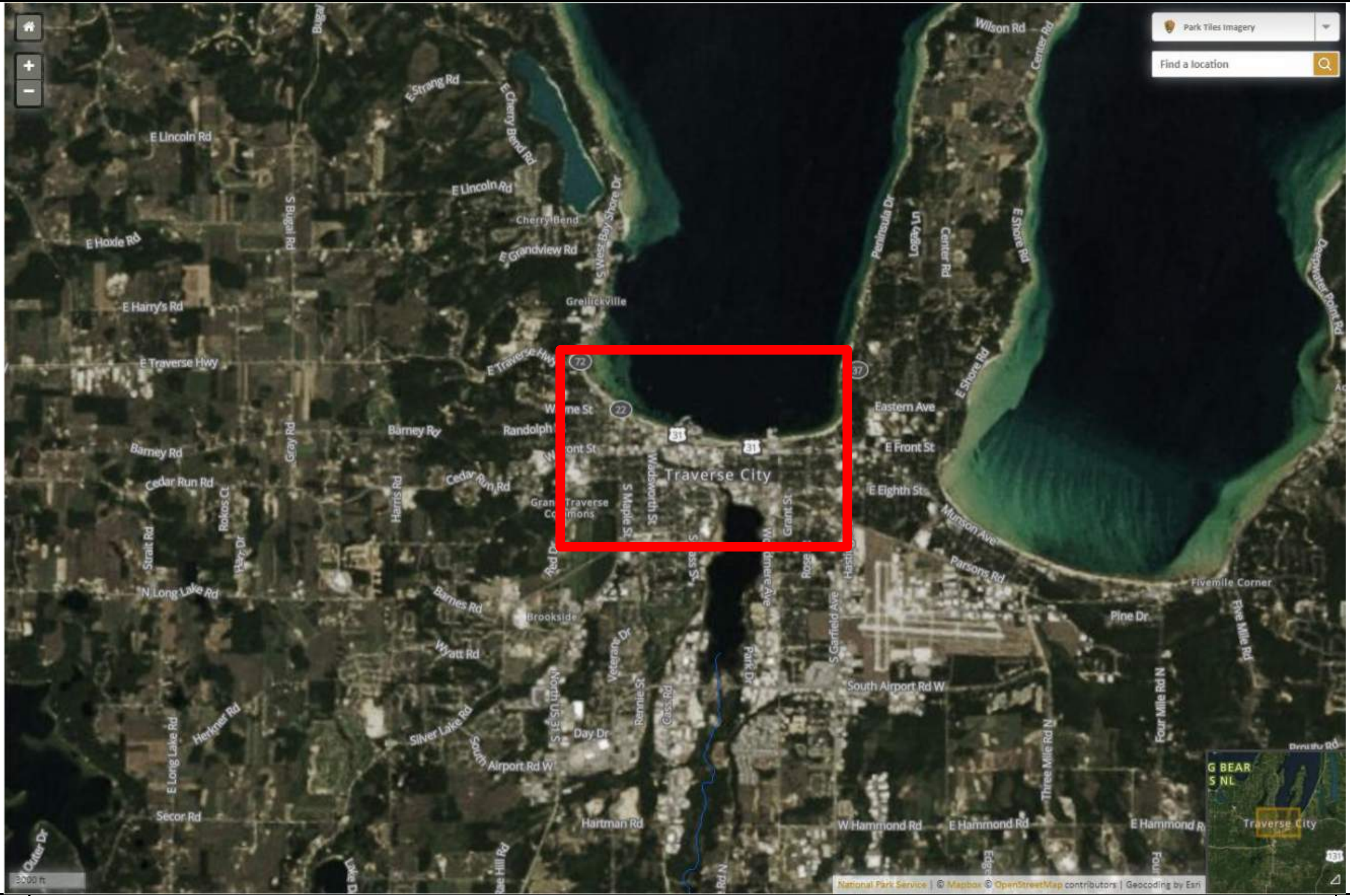
Wild and Scenic Rivers Review: Traverse City Sanitary Sewer Rehabilitation

Project Map

Date
4/15/2021

Figure No.
1

HRC	Wild and Scenic Rivers Review: Traverse City Sanitary Sewer Rehabilitation	Date 4/15/2021
	National Wild and Scenic Rivers System with Project Location	Figure No. 2



HRC	Wild and Scenic Rivers Review: Traverse City Sanitary Sewer Rehabilitation	Date 4/15/2021
	Nationwide Rivers Inventory with Site Location	Figure No. 3

APPENDIX B: WEB SOILS SURVEY RESULTS

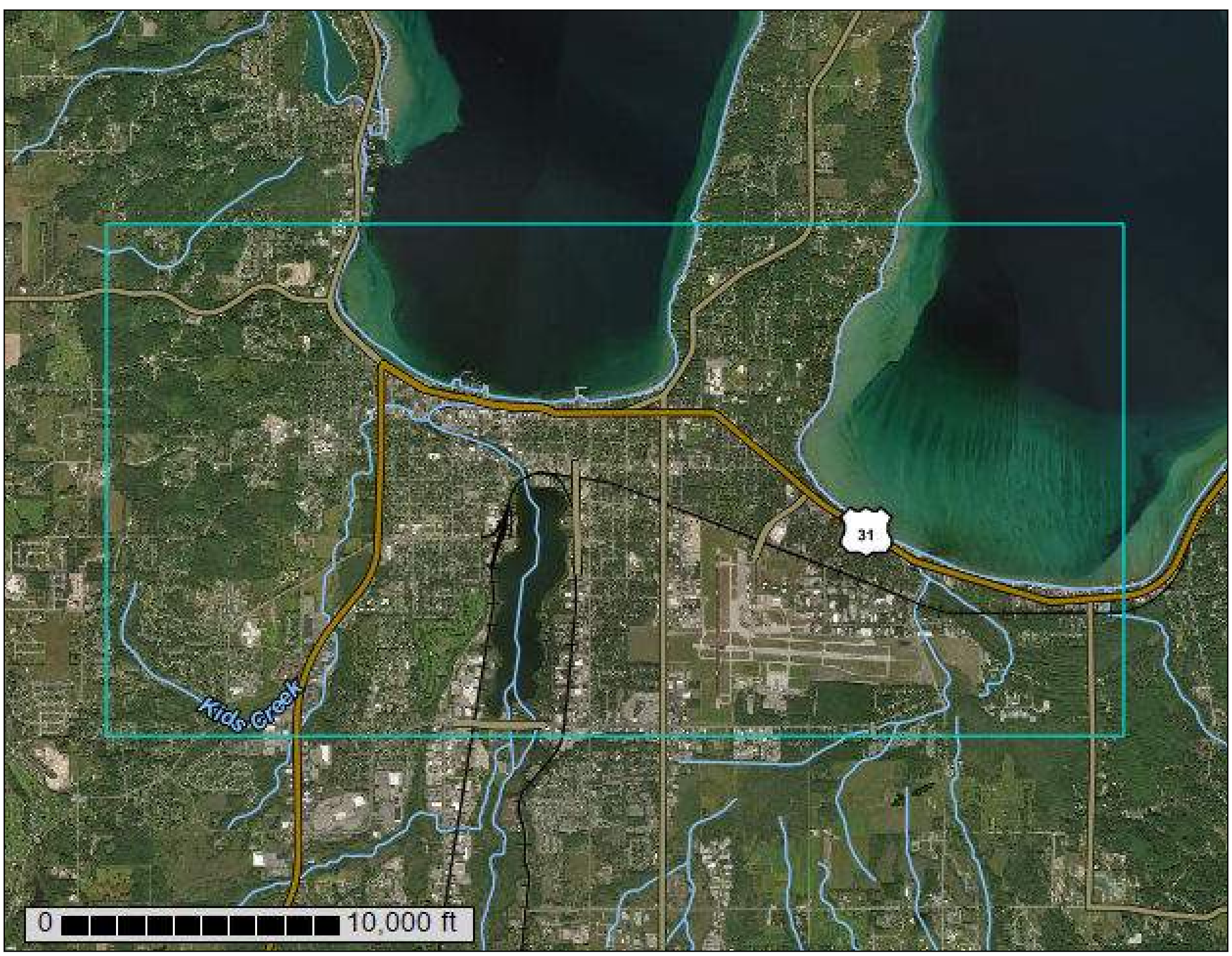
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Grand Traverse County, Michigan, and Leelanau County, Michigan



March 31, 2021

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

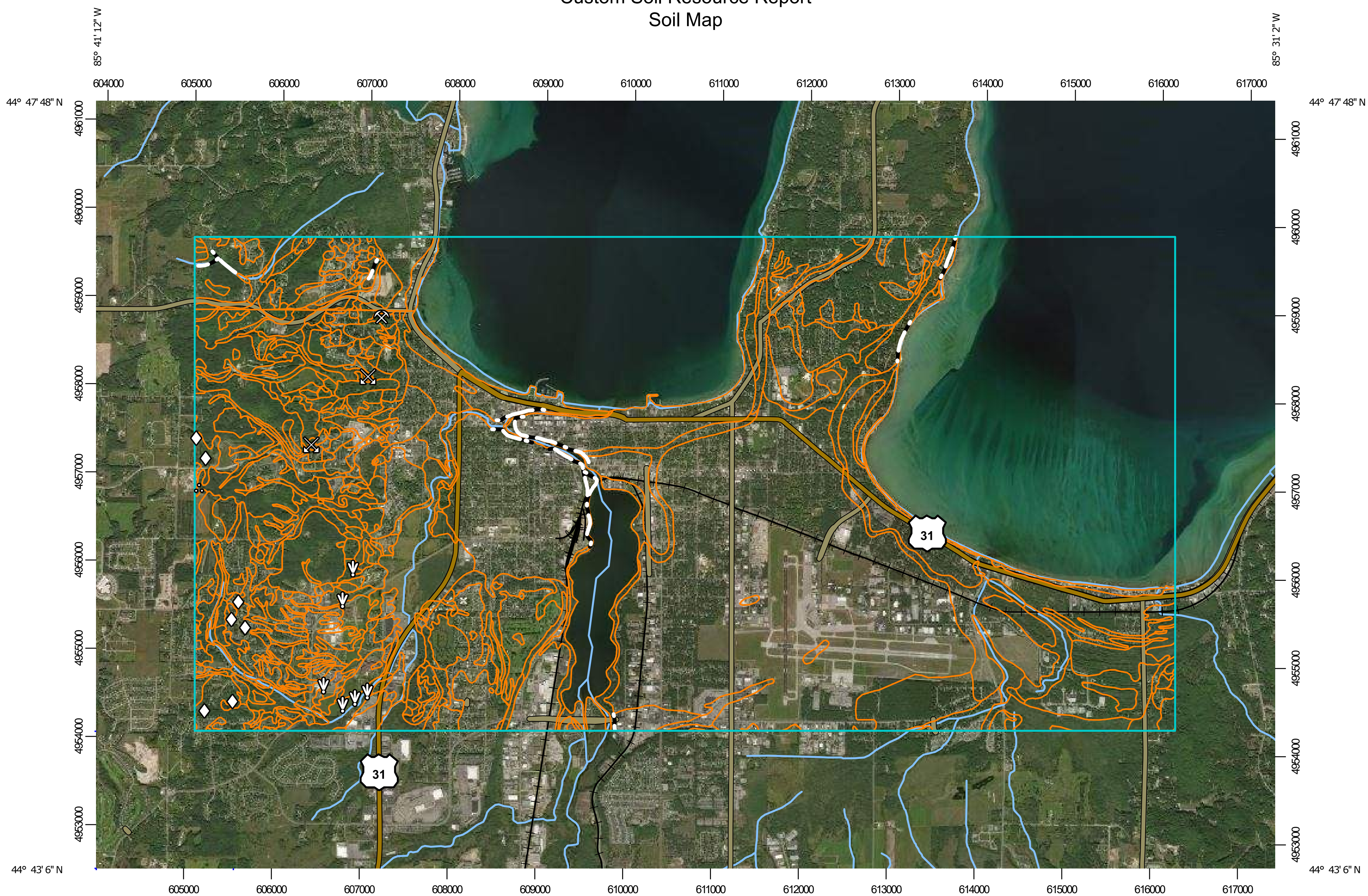
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:61,300 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 2500, 5000, 10000, 15000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
Area of Interest (AOI)

Soils
Soil Map Unit Polygons
Soil Map Unit Lines
Soil Map Unit Points

Special Point Features
Blowout
Borrow Pit
Clay Spot
Closed Depression
Gravel Pit
Gravelly Spot
Landfill
Lava Flow
Marsh or swamp
Mine or Quarry
Miscellaneous Water
Perennial Water
Rock Outcrop
Saline Spot
Sandy Spot
Severely Eroded Spot
Sinkhole
Slide or Slip
Sodic Spot
Spoil Area
Stony Spot
Very Stony Spot
Wet Spot
Other
Special Line Features

Water Features
Streams and Canals

Transportation
Rails
Interstate Highways
US Routes
Major Roads
Local Roads

Background
Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:15,800 to 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Grand Traverse County, Michigan
Survey Area Data: Version 14, Jun 8, 2020

Soil Survey Area: Leelanau County, Michigan
Survey Area Data: Version 14, Jun 3, 2020

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Dec 31, 2009—Jun 19, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
AeA	Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes	2.7	0.0%
AeB	Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes	15.7	0.1%
AeC	Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes	3.9	0.0%
AsA	Au Gres-Saugatuck sands, 0 to 2 percent slopes	15.7	0.1%
CoA	Croswell loamy sands, 0 to 2 percent slopes, overwash	86.4	0.6%
CoB	Croswell loamy sands, 2 to 6 percent slopes, overwash	12.3	0.1%
CpA	Croswell loamy sands, 0 to 2 percent slopes	58.3	0.4%
CpB	Croswell loamy sands, 2 to 6 percent slopes	7.0	0.0%
CrA	Croswell-Rubicon sands, 0 to 2 percent slopes	590.1	3.8%
EmA	East Lake-Mancelona loamy sands, 0 to 2 percent slopes	701.8	4.5%
EmB	East Lake-Mancelona loamy sands, 2 to 6 percent slopes	325.0	2.1%
EmC	East Lake-Mancelona loamy sands, 6 to 12 percent slopes	46.9	0.3%
EmE	East Lake-Mancelona loamy sands, 18 to 25 percent slopes	28.4	0.2%
ErA	Eastport-Roscommon sands, 0 to 2 percent slopes	213.0	1.4%
Es	Edwards muck, 0 to 1 percent slopes	285.3	1.8%
ExA	Emmet gravelly sandy loam, 0 to 2 percent slopes	28.8	0.2%
ExB	Emmet gravelly sandy loam, 2 to 6 percent slopes	182.9	1.2%
ExC	Emmet gravelly sandy loam, 6 to 12 percent slopes	146.9	0.9%
ExD	Emmet gravelly sandy loam, 12 to 18 percent slopes	67.6	0.4%
ExD2	Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded	31.7	0.2%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
ExE	Emmet gravelly sandy loam, 18 to 25 percent slopes	69.8	0.5%
ExE2	Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded	17.4	0.1%
ExF	Emmet gravelly sandy loam, 25 to 45 percent slopes	266.8	1.7%
ExF2	Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded	267.4	1.7%
EyA	Emmet sandy loam, 0 to 2 percent slopes	7.5	0.0%
EyB	Emmet sandy loam, 2 to 6 percent slopes	54.7	0.4%
EyC	Emmet sandy loam, 6 to 12 percent slopes	95.5	0.6%
EyC2	Emmet sandy loam, 6 to 12 percent slopes, moderately eroded	21.0	0.1%
EyD	Emmet sandy loam, 12 to 18 percent slopes	16.3	0.1%
EyD2	Emmet sandy loam, 12 to 18 percent slopes, moderately eroded	3.6	0.0%
EyE	Emmet sandy loam, 18 to 25 percent slopes	9.1	0.1%
EyE2	Emmet sandy loam, 18 to 25 percent slopes, moderately eroded	36.2	0.2%
EyF	Emmet sandy loam, 25 to 45 percent slopes	44.5	0.3%
EyF2	Emmet sandy loam, 25 to 45 percent slopes, moderately eroded	53.1	0.3%
Fm	Fresh water marsh	7.3	0.0%
GrA	Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes	8.0	0.1%
GrB	Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes	26.3	0.2%
GsE	Gravelly land, moderately steep	6.6	0.0%
GsF	Gravelly land, steep	11.1	0.1%
Gt	Gravel pits	15.0	0.1%
GxA	Guelph-Nester loams, 0 to 2 percent slopes	2.5	0.0%
GxB2	Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded	3.3	0.0%
GxC2	Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded	7.3	0.0%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
GxD2	Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded	6.2	0.0%
GxE2	Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded	4.8	0.0%
GxF2	Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded	4.3	0.0%
Gy	Gullied land	0.8	0.0%
Ho	Houghton muck, 0 to 1 percent slopes	33.2	0.2%
IlB	Iosco loamy sand, 2 to 6 percent slopes	19.0	0.1%
IlC	Iosco loamy sand, 6 to 12 percent slopes	7.6	0.0%
IsA	Iosco-Ogemaw loamy sands, 0 to 2 percent slopes	44.1	0.3%
IsB	Iosco-Ogemaw loamy sands, 2 to 6 percent slopes	10.6	0.1%
KaA	Kalkaska loamy sand, 0 to 2 percent slopes	356.7	2.3%
KaB	Kalkaska loamy sand, 2 to 6 percent slopes	90.8	0.6%
KaC	Kalkaska loamy sand, 6 to 12 percent slopes	102.7	0.7%
KaD	Kalkaska loamy sand, 12 to 18 percent slopes	16.7	0.1%
KaE	Kalkaska loamy sand, 18 to 25 percent slopes	74.4	0.5%
KaE2	Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded	48.9	0.3%
KaF	Kalkaska loamy sand, 25 to 45 percent slopes	33.8	0.2%
KaF2	Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded	10.8	0.1%
KbB	Kalkaska sand, 0 to 6 percent slopes	34.1	0.2%
KbD	Kalkaska sand, 6 to 18 percent slopes	3.4	0.0%
KbF	Kalkaska sand, 35 to 60 percent slopes	113.0	0.7%
KlF	Karlin loamy sand, 25 to 45 percent slopes	30.7	0.2%
Kt	Kerston muck	155.9	1.0%
LeB	Lake beach and Eastport sand, 0 to 6 percent slopes	524.3	3.4%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
LkA	Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes	1.5	0.0%
LkB	Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes	51.8	0.3%
LkC	Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes	119.6	0.8%
LkD	Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes	22.9	0.1%
LkE	Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes	232.3	1.5%
LkE2	Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded	37.9	0.2%
LkF	Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes	142.4	0.9%
LkF2	Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded	97.2	0.6%
Lu	Carlisle muck, 0 to 2 percent slopes, cool	255.9	1.7%
MaA	Mancelona gravelly sandy loam, 0 to 2 percent slopes	1.0	0.0%
MaC	Mancelona gravelly sandy loam, 6 to 12 percent slopes	2.9	0.0%
MaC2	Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded	3.1	0.0%
MaD	Mancelona gravelly sandy loam, 12 to 18 percent slopes	1.0	0.0%
MeA	Mancelona-East Lake loamy sands, 0 to 2 percent slopes	91.4	0.6%
MeE	Mancelona-East Lake loamy sands, 18 to 25 percent slopes	16.0	0.1%
Mk	Adrian muck, 0 to 1 percent slopes	1.7	0.0%
RcA	Richter loams, 0 to 2 percent slopes, overwash	75.2	0.5%
RcB	Richter loams, 2 to 6 percent slopes, overwash	31.7	0.2%
RhA	Richter loams, 0 to 2 percent slopes	82.7	0.5%
RpA	Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash	18.9	0.1%
RrA	Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes	141.7	0.9%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
RrC	Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes	5.0	0.0%
Rs	Rifle peat	99.3	0.6%
Ru	Roscommon mucky loamy sand	124.9	0.8%
RwA	Rubicon sand, 0 to 2 percent slopes	2,420.0	15.6%
RwB	Rubicon sand, 0 to 6 percent slopes	219.3	1.4%
SrB	Sanilac-Richter loams, 0 to 6 percent slopes	1.5	0.0%
Ta	Tawas-Roscommon complex	33.5	0.2%
Tm	Tonkey mucky sandy loam	6.9	0.0%
Tn	Tonkey sandy loam, overwash	7.9	0.1%
To	Tonkey sandy loam	38.8	0.3%
Tp	Tonkey-Hettinger-Pickford loams, overwash	15.9	0.1%
Tr	Tonkey-Hettinger-Pickford loams	6.1	0.0%
UnA	Ubly-Nester complex, 0 to 2 percent slopes	0.8	0.0%
UnB	Ubly-Nester complex, 2 to 6 percent slopes	9.1	0.1%
UnD2	Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded	3.1	0.0%
UnE	Ubly-Nester complex, 18 to 25 percent slopes	3.9	0.0%
UnE2	Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded	0.3	0.0%
W	Water	346.7	2.2%
WdD	Wind eroded land, strongly sloping	77.7	0.5%
Subtotals for Soil Survey Area		**10,477.2**	**67.6%**
Totals for Area of Interest		**15,504.2**	**100.0%**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
ArA	Alcona-Richter sandy loams, 0 to 2 percent slopes	8.8	0.1%
ArB	Alcona-Richter sandy loams, 2 to 6 percent slopes	1.6	0.0%
AuA	Au Gres-Kalkaska sands, 0 to 4 percent slopes	10.1	0.1%
EdB	Eastport sand, 0 to 6 percent slopes	25.7	0.2%
EnB	Emmet-Leelanau complex, 2 to 6 percent slopes	7.0	0.0%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
EnC	Emmet-Leelanau complex, 6 to 12 percent slopes	2.1	0.0%
EnD	Emmet-Leelanau complex, 12 to 18 percent slopes	1.6	0.0%
EnE	Emmet-Leelanau complex, 18 to 25 percent slopes	2.4	0.0%
EnF	Emmet-Leelanau complex, 25 to 50 percent slopes	11.3	0.1%
EoC	Emmet-Mancelona gravelly sandy loams, 4 to 12 percent slopes	16.9	0.1%
EoE	Emmet-Mancelona gravelly sandy loams, 18 to 35 percent slopes	2.5	0.0%
Hm	Hettinger-Muck complex	1.3	0.0%
KaB	Kaleva sand, 0 to 6 percent slopes	16.0	0.1%
KaC	Kaleva sand, 6 to 12 percent slopes	9.7	0.1%
KeB	Kalkaska-East Lake loamy sands, 0 to 6 percent slopes, lake moderated	0.2	0.0%
LlB	Leelanau-East Lake loamy sands, 0 to 6 percent slopes	13.2	0.1%
LlC	Leelanau-East Lake loamy sands, 6 to 12 percent slopes	40.3	0.3%
LlD	Leelanau-East Lake loamy sands, 12 to 18 percent slopes, lake moderated	24.7	0.2%
LlE	Leelanau-East Lake loamy sands, 18 to 25 percent slopes, lake moderated	25.7	0.2%
LlF	Leelanau-East Lake loamy sands, 25 to 45 percent slopes	191.9	1.2%
Lm	Lupton-Markey mucks	94.9	0.6%
MrB	Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes	2.6	0.0%
NtF3	Nester silty clay loam, 20 to 50 percent slopes, severely eroded	3.6	0.0%
Pt	Pits, gravel	1.5	0.0%
TmA	Tonkey-Munuscong-Iosco sandy loams, 0 to 2 percent slopes	2.6	0.0%
TmB	Tonkey-Munuscong-Iosco sandy loams, 2 to 6 percent slopes	5.3	0.0%
WlD	Wind eroded land, steep	19.3	0.1%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Subtotals for Soil Survey Area		**543.1**	**3.5%**
Totals for Area of Interest		**15,504.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Grand Traverse County, Michigan

AeA—Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c25
Elevation: 600 to 1,000 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 43 to 45 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Alpena and similar soils: 60 percent
East lake and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alpena

Setting

Landform: Outwash plains, lakeshores, kames
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 4 to 10 inches of sandy and loamy material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 12 inches: gravelly loamy sand
H2 - 12 to 60 inches: very gravelly sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (1.98 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Outwash plains, beach ridges, lake terraces
Landform position (three-dimensional): Rise

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

AeB—Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c26
Elevation: 600 to 1,000 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 43 to 45 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Alpena and similar soils: 60 percent
East lake and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alpena

Setting

Landform: Outwash plains, lakeshores, kames
Landform position (three-dimensional): Rise
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: 4 to 10 inches of sandy and loamy material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 12 inches: gravelly loamy sand
H2 - 12 to 60 inches: very gravelly sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (1.98 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Outwash plains, beach ridges, lake terraces
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

AeC—Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c27
Elevation: 600 to 1,000 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 43 to 45 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Alpena and similar soils: 60 percent
East lake and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alpena

Setting

Landform: Outwash plains, kames, lakeshores
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave, linear
Parent material: 4 to 10 inches of sandy and loamy material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 12 inches: gravelly loamy sand
H2 - 12 to 60 inches: very gravelly sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (1.98 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Very low (about 2.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Outwash plains, beach ridges, lake terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

AsA—Au Gres-Saugatuck sands, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c2b
Elevation: 600 to 1,800 feet

Mean annual precipitation: 22 to 40 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Au gres and similar soils: 55 percent
Saugatuck and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Au Gres

Setting

Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 4 inches: sand
H2 - 4 to 22 inches: sand
H3 - 22 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: A/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Saugatuck

Setting

Landform: Till plains, outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits cemented with ortstein

Typical profile

H1 - 0 to 2 inches: sand
H2 - 2 to 12 inches: sand

H3 - 12 to 26 inches: sand
H4 - 26 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Very low (about 0.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: B/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Minor Components

Roscommon

Percent of map unit: 5 percent
Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

CoA—Croswell loamy sands, 0 to 2 percent slopes, overwash

Map Unit Setting

National map unit symbol: 6c2h
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Croswell and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Croswell

Setting

Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 5 inches: loamy sand
H2 - 5 to 12 inches: sand
H3 - 12 to 30 inches: sand
H4 - 30 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

CoB—Croswell loamy sands, 2 to 6 percent slopes, overwash

Map Unit Setting

National map unit symbol: 6c2j
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Croswell and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Croswell

Setting

Landform: Lake plains, outwash plains

Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 5 inches: loamy sand
H2 - 5 to 12 inches: sand
H3 - 12 to 30 inches: sand
H4 - 30 to 60 inches: sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

CpA—Croswell loamy sands, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c2k
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Croswell and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Croswell

Setting

Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 5 inches: loamy sand
H2 - 5 to 12 inches: sand
H3 - 12 to 30 inches: sand
H4 - 30 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

CpB—Croswell loamy sands, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c2m
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Croswell and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Croswell

Setting

Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 5 inches: loamy sand
H2 - 5 to 12 inches: sand
H3 - 12 to 30 inches: sand

H4 - 30 to 60 inches: sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

CrA—Croswell-Rubicon sands, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c2p
Elevation: 600 to 1,800 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 80 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Croswell and similar soils: 50 percent
Rubicon and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Croswell

Setting

Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 5 inches: sand
H2 - 5 to 12 inches: sand
H3 - 12 to 30 inches: sand
H4 - 30 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 24 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Rubicon

Setting

Landform: Moraines, lake plains, outwash plains, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 5 inches: sand
H2 - 5 to 34 inches: sand
H3 - 34 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Eastport

Percent of map unit: 5 percent
Landform: Beach ridges, outwash plains

Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

East lake
Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Au gres
Percent of map unit: 5 percent
Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

EmA—East Lake-Mancelona loamy sands, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 6c2s
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition
East lake and similar soils: 55 percent
Mancelona and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of East Lake

Setting
Landform: Outwash plains, beach ridges, lake terraces
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile
H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand

H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of Mancelona

Setting

Landform: Outwash plains, moraines, kames, lake plains, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Croswell

Percent of map unit: 5 percent
Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

EmB—East Lake-Mancelona loamy sands, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c2t
Elevation: 600 to 1,000 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

East lake and similar soils: 60 percent
Mancelona and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of East Lake

Setting

Landform: Outwash plains, beach ridges, lake terraces
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of Mancelona

Setting
Landform: Kames, lake plains, beach ridges, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile
H1 - 0 to 6 inches: loamy sand
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities
Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

EmC—East Lake-Mancelona loamy sands, 6 to 12 percent slopes

Map Unit Setting
National map unit symbol: 6c2v

Elevation: 600 to 1,000 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

East lake and similar soils: 60 percent
Mancelona and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of East Lake

Setting

Landform: Lake terraces, outwash plains, beach ridges
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of Mancelona

Setting

Landform: Outwash plains, moraines, kames, lake plains, beach ridges
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest

Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

EmE—East Lake-Mancelona loamy sands, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6c2y
Elevation: 600 to 1,000 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

East lake and similar soils: 60 percent
Mancelona and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of East Lake

Setting

Landform: Outwash plains, beach ridges, lake terraces

Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile
H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities
Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of Mancelona

Setting
Landform: Kames, lake plains, beach ridges, outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile
H1 - 0 to 6 inches: loamy sand
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities
Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained

Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

ErA—Eastport-Roscommon sands, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 6c31
Elevation: 600 to 1,800 feet
Mean annual precipitation: 22 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition
Eastport and similar soils: 50 percent
Roscommon and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Eastport

Setting
Landform: Dunes, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy eolian deposits

Typical profile
H1 - 0 to 5 inches: sand
H2 - 5 to 26 inches: sand
H3 - 26 to 60 inches: sand

Properties and qualities
Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible

Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of Roscommon

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 3 inches: sand
H2 - 3 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 4.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: F096XA011MI - Snowy Wet Sandy Depression
Hydric soil rating: Yes

Minor Components

Croswell

Percent of map unit: 5 percent
Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Au gres

Percent of map unit: 5 percent
Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Es—Edwards muck, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2rfgx
Elevation: 580 to 1,230 feet
Mean annual precipitation: 31 to 41 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 125 to 205 days
Farmland classification: Farmland of local importance

Map Unit Composition

Edwards and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Edwards

Setting

Landform: Lakebeds (relict) on glacial drainage channels, lakebeds (relict) on outwash plains, lakebeds (relict) on moraines
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Herbaceous organic material over marl

Typical profile

Oa1 - 0 to 9 inches: muck
Oa2 - 9 to 26 inches: muck
Lma - 26 to 80 inches: marly silt loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent

Calcium carbonate, maximum content: 100 percent
Gypsum, maximum content: 4 percent
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Very high (about 20.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F098XA006MI - Mucky Depressions
Hydric soil rating: Yes

Minor Components

Adrian

Percent of map unit: 3 percent
Landform: Lakebeds (relict) on moraines, lakebeds (relict) on glacial drainage channels, lakebeds (relict) on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

Houghton

Percent of map unit: 3 percent
Landform: Lakebeds (relict) on glacial drainage channels, lakebeds (relict) on outwash plains, lakebeds (relict) on moraines
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

Palms

Percent of map unit: 2 percent
Landform: Depressions on outwash plains, depressions on outwash plains, drainageways on moraines, depressions on moraines, drainageways on glacial drainage channels, drainageways on moraines, drainageways on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Gilford

Percent of map unit: 2 percent
Landform: Lakebeds (relict) on moraines, lakebeds (relict) on glacial drainage channels, lakebeds (relict) on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

ExA—Emmet gravelly sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c33
Elevation: 600 to 1,200 feet
Mean annual precipitation: 28 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 100 to 140 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Emmet and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Moraines, till plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

ExB—Emmet gravelly sandy loam, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c34
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Mancelona

Percent of map unit: 10 percent
Landform: Beach ridges, lake plains, outwash plains, kames, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

ExC—Emmet gravelly sandy loam, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c35
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Mancelona

Percent of map unit: 10 percent
Landform: Moraines, beach ridges, lake plains, outwash plains, kames
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

ExD—Emmet gravelly sandy loam, 12 to 18 percent slopes

Map Unit Setting

National map unit symbol: 6c36
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear

Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile
H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities
Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Mancelona
Percent of map unit: 10 percent
Landform: Kames, moraines, beach ridges, lake plains, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

ExD2—Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded

Map Unit Setting
National map unit symbol: 6c37
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days

Farmland classification: Farmland of local importance

Map Unit Composition

Emmet, moderately eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Mancelona

Percent of map unit: 10 percent
Landform: Beach ridges, lake plains, outwash plains, kames, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

ExE—Emmet gravelly sandy loam, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6c38
Elevation: 600 to 1,200 feet
Mean annual precipitation: 28 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Emmet and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Moraines, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till

Hydric soil rating: No

ExE2—Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c39
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Emmet, moderately eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e

Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Mancelona

Percent of map unit: 10 percent
Landform: Beach ridges, lake plains, outwash plains, kames, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

ExF—Emmet gravelly sandy loam, 25 to 45 percent slopes

Map Unit Setting

National map unit symbol: 6c3b
Elevation: 600 to 1,200 feet
Mean annual precipitation: 28 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Emmet and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 25 to 45 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

ExF2—Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c3c
Elevation: 600 to 1,200 feet
Mean annual precipitation: 28 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Emmet, moderately eroded, and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

EyA—Emmet sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c3d
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 140 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 0 to 2 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau

Percent of map unit: 10 percent
Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

EyB—Emmet sandy loam, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c3f
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 140 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau

Percent of map unit: 10 percent
Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

EyC—Emmet sandy loam, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c3h
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 140 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau

Percent of map unit: 10 percent
Landform: Moraines
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope, summit
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

EyC2—Emmet sandy loam, 6 to 12 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c3j
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 140 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet, moderately eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet, Moderately Eroded

Setting

Landform: Moraines, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B

Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau

Percent of map unit: 10 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

EyD—Emmet sandy loam, 12 to 18 percent slopes

Map Unit Setting

National map unit symbol: 6c3k
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 12 to 18 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

EyD2—Emmet sandy loam, 12 to 18 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c3l
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days

Farmland classification: Farmland of local importance

Map Unit Composition

Emmet, moderately eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Moraines, outwash plains, beach ridges, lake terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Leelanau

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

EyE—Emmet sandy loam, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6c3m
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Lake terraces, moraines, outwash plains, beach ridges
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Leelanau

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

EyE2—Emmet sandy loam, 18 to 25 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c3n
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Emmet, moderately eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet, Moderately Eroded

Setting

Landform: Moraines, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

EyF—Emmet sandy loam, 25 to 45 percent slopes

Map Unit Setting

National map unit symbol: 6c3q
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Emmet and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau
Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

East lake
Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

EyF2—Emmet sandy loam, 25 to 45 percent slopes, moderately eroded

Map Unit Setting
National map unit symbol: 6c3r
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Emmet, moderately eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 38 inches: sandy clay loam
H4 - 38 to 60 inches: sandy loam

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Leelanau

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

East lake

Percent of map unit: 5 percent
Landform: Moraines, outwash plains, beach ridges, lake terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Fm—Fresh water marsh

Map Unit Composition

Fresh water marsh: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

GrA—Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c3v
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 160 days
Farmland classification: Farmland of local importance

Map Unit Composition

Gladwin and similar soils: 60 percent
Richter and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gladwin

Setting

Landform: Beach ridges, lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 14 inches: loamy sand
H3 - 14 to 20 inches: sandy loam
H4 - 20 to 60 inches: gravelly sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: A/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Richter

Setting

Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 39 inches: very fine sandy loam
H3 - 39 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

GrB—Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c3w
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 160 days
Farmland classification: Farmland of local importance

Map Unit Composition

Gladwin and similar soils: 60 percent
Richter and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Gladwin

Setting

Landform: Lake plains, outwash plains, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 14 inches: loamy sand
H3 - 14 to 20 inches: sandy loam
H4 - 20 to 60 inches: gravelly sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: A/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Richter

Setting

Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 39 inches: very fine sandy loam
H3 - 39 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

GsE—Gravelly land, moderately steep

Map Unit Composition

Gravelly land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

GsF—Gravelly land, steep

Map Unit Composition

Gravelly land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Gt—Gravel pits

Map Unit Composition

Gravel pits: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

GxA—Guelph-Nester loams, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c43
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 140 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Guelph and similar soils: 60 percent
Nester and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Guelph

Setting

Landform: Moraines, till plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy till

Typical profile

H1 - 0 to 6 inches: loam
H2 - 6 to 21 inches: clay loam
H3 - 21 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: C

Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester

Setting

Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

GxB2—Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c45
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 140 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Guelph, moderately eroded, and similar soils: 60 percent

Nester, moderately eroded, and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Guelph, Moderately Eroded

Setting

Landform: Moraines, till plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy till

Typical profile

H1 - 0 to 6 inches: loam
H2 - 6 to 21 inches: clay loam
H3 - 21 to 60 inches: silt loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester, Moderately Eroded

Setting

Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

GxC2—Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c46
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Farmland of local importance

Map Unit Composition

Guelph, moderately eroded, and similar soils: 60 percent
Nester, moderately eroded, and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Guelph, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: Loamy till

Typical profile

H1 - 0 to 6 inches: loam
H2 - 6 to 21 inches: clay loam
H3 - 21 to 60 inches: silt loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained

Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

GxD2—Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c48
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Farmland of local importance

Map Unit Composition

Guelph, moderately eroded, and similar soils: 60 percent
Nester, moderately eroded, and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Guelph, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: Loamy till

Typical profile

H1 - 0 to 6 inches: loam
H2 - 6 to 21 inches: clay loam
H3 - 21 to 60 inches: silt loam

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C

Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

GxE2—Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c49
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 140 days

Farmland classification: Not prime farmland

Map Unit Composition

Guelph, moderately eroded, and similar soils: 50 percent
Nester, moderately eroded, and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Guelph, Moderately Eroded

Setting

Landform: Moraines, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: Loamy till

Typical profile

H1 - 0 to 6 inches: loam
H2 - 6 to 21 inches: clay loam
H3 - 21 to 60 inches: silt loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Ubly

Percent of map unit: 5 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Iosco

Percent of map unit: 5 percent
Landform: Outwash plains, till plains
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

GxF2—Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c4b
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Guelph, moderately eroded, and similar soils: 50 percent
Nester, moderately eroded, and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Guelph, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: Loamy till

Typical profile

H1 - 0 to 6 inches: loam
H2 - 6 to 21 inches: clay loam
H3 - 21 to 60 inches: silt loam

Properties and qualities

Slope: 25 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 25 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Iosco

Percent of map unit: 5 percent
Landform: Outwash plains, till plains
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Ubly

Percent of map unit: 5 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Gy—Gullied land

Map Unit Composition

Gullied land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Ho—Houghton muck, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2rfgy
Elevation: 580 to 1,360 feet
Mean annual precipitation: 31 to 41 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 125 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Houghton and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Houghton

Setting

Landform: Depressions on outwash plains, depressions on moraines on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Herbaceous organic material

Typical profile

Oa1 - 0 to 12 inches: muck
Oa2 - 12 to 35 inches: muck
Oa3 - 35 to 80 inches: muck

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 3 percent
Maximum salinity: Nonsaline to very slightly saline (0.4 to 2.7 mmhos/cm)
Sodium adsorption ratio, maximum: 0.8
Available water capacity: Very high (about 23.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F098XA006MI - Mucky Depressions
Hydric soil rating: Yes

Minor Components

Adrian

Percent of map unit: 4 percent
Landform: Depressions on moraines on outwash plains, depressions on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: F098XA006MI - Mucky Depressions, F097XA030MI - Mucky Depression, F096XA014MI - Snowy Mucky Depression, F096XB027MI - Mucky Depression
Hydric soil rating: Yes

Edwards

Percent of map unit: 3 percent
Landform: Depressions on moraines on outwash plains, depressions on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Linear, concave
Across-slope shape: Linear
Hydric soil rating: Yes

Palms

Percent of map unit: 2 percent
Landform: Depressions on outwash plains, depressions on till plains, swamps on outwash plains, swamps on till plains, depressions on moraines, swamps on moraines, drainageways on till plains, drainageways on moraines, drainageways on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave

Across-slope shape: Linear, concave
Ecological site: F098XA006MI - Mucky Depressions, F097XA030MI - Mucky Depression
Hydric soil rating: Yes

Gilford, gravelly subsoil

Percent of map unit: 1 percent
Landform: Glacial drainage channels, glacial drainage channels
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

IIB—Iosco loamy sand, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c4h
Elevation: 600 to 1,400 feet
Mean annual precipitation: 28 to 32 inches
Mean annual air temperature: 41 to 45 degrees F
Frost-free period: 90 to 140 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Iosco and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iosco

Setting

Landform: Till plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy glaciofluvial deposits over loamy till or glacialacustrine deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 37 inches: sandy clay loam
H4 - 37 to 60 inches: silty clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)

Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

IIC—Iosco loamy sand, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c4j
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 140 days
Farmland classification: Farmland of local importance

Map Unit Composition

Iosco and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iosco

Setting

Landform: Till plains, outwash plains
Landform position (two-dimensional): Backslope, shoulder, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, crest, nose slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: 20 to 40 inches of sandy glaciofluvial deposits over loamy till or glacialacustrine deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 37 inches: sandy clay loam
H4 - 37 to 60 inches: silty clay loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 30 to 48 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Minor Components

Montcalm

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Ubly

Percent of map unit: 5 percent
Landform: Moraines, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

IsA—Iosco-Ogemaw loamy sands, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c4l
Elevation: 600 to 1,500 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 80 to 140 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Iosco and similar soils: 60 percent
Ogemaw and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iosco

Setting

Landform: Till plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy glaciofluvial deposits over loamy till or glacialacustrine deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 37 inches: sandy clay loam
H4 - 37 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Ogemaw

Setting

Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material with ortstein over loamy till

Typical profile

H1 - 0 to 10 inches: loamy sand
H2 - 10 to 20 inches: loamy sand
H3 - 20 to 26 inches: loamy sand
H4 - 26 to 60 inches: sandy clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.57 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Very low (about 1.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

IsB—Iosco-Ogemaw loamy sands, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c4m
Elevation: 600 to 1,500 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 80 to 140 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Iosco and similar soils: 60 percent
Ogemaw and similar soils: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Iosco

Setting

Landform: Till plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy glaciofluvial deposits over loamy till or glacialacustrine deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 37 inches: sandy clay loam

H4 - 37 to 60 inches: silty clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 9.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Ogemaw

Setting

Landform: Lake plains, moraines, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material with ortstein over loamy till

Typical profile

H1 - 0 to 10 inches: loamy sand
H2 - 10 to 20 inches: loamy sand
H3 - 20 to 26 inches: loamy sand
H4 - 26 to 60 inches: sandy clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.57 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Very low (about 1.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression, F094AA007MI - Snowy Acidic Sandy Depression

Hydric soil rating: No

KaA—Kalkaska loamy sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c4n
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Moraines, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

KaB—Kalkaska loamy sand, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c4q
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Moraines, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

KaC—Kalkaska loamy sand, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c4s
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

KaD—Kalkaska loamy sand, 12 to 18 percent slopes

Map Unit Setting

National map unit symbol: 6c4w
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

KaE—Kalkaska loamy sand, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6c4y
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift

Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

KaE2—Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c4z
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska, moderately eroded, and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska, Moderately Eroded

Setting

Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 18 to 25 percent

Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

KaF—Kalkaska loamy sand, 25 to 45 percent slopes

Map Unit Setting

National map unit symbol: 6c50
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Moraines, outwash plains

Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift, F094AA005MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

KaF2—Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c51
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska, moderately eroded, and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska, Moderately Eroded

Setting

Landform: Moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Lake terraces, outwash plains, beach ridges
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

KbB—Kalkaska sand, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2zgp3
Elevation: 580 to 1,680 feet
Mean annual precipitation: 28 to 36 inches
Mean annual air temperature: 41 to 48 degrees F
Frost-free period: 90 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Flats, moraines, lake plains, valley trains
Landform position (two-dimensional): Summit, backslope, shoulder
Landform position (three-dimensional): Side slope, interfluve, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Sandy outwash

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 2 inches: sand
E - 2 to 9 inches: sand
Bhs - 9 to 15 inches: sand
Bs - 15 to 31 inches: sand
BC - 31 to 56 inches: sand
C - 56 to 80 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F094AA005MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Blue lake

Percent of map unit: 3 percent
Landform: Flats, valley trains, moraines, lake plains
Landform position (two-dimensional): Summit, backslope, shoulder
Landform position (three-dimensional): Side slope, interfluve, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Ecological site: F094AA006MI - Snowy Sandy Drift
Hydric soil rating: No

Halfaday

Percent of map unit: 1 percent
Landform: Moraines, lake plains, flats, valley trains
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Au gres

Percent of map unit: 1 percent
Landform: Flats, moraines, lake plains, valley trains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear
Ecological site: F094AA007MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

KbD—Kalkaska sand, 6 to 18 percent slopes

Map Unit Setting

National map unit symbol: 2zgp4
Elevation: 580 to 1,710 feet
Mean annual precipitation: 28 to 36 inches
Mean annual air temperature: 41 to 48 degrees F
Frost-free period: 90 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 98 percent
Minor components: 2 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Moraines, valley trains, rises
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Sandy drift

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 2 inches: sand
E - 2 to 9 inches: sand
Bhs - 9 to 15 inches: sand
Bs - 15 to 31 inches: sand
BC - 31 to 56 inches: sand
C - 56 to 80 inches: sand

Properties and qualities

Slope: 6 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F094AA005MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Blue lake

Percent of map unit: 2 percent
Landform: Moraines, valley trains, rises
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Ecological site: F094AA006MI - Snowy Sandy Drift
Hydric soil rating: No

KbF—Kalkaska sand, 35 to 60 percent slopes

Map Unit Setting

National map unit symbol: 2zgp6
Elevation: 580 to 1,690 feet
Mean annual precipitation: 28 to 36 inches
Mean annual air temperature: 41 to 48 degrees F
Frost-free period: 90 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Kalkaska and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Moraines, glacial drainage channels
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Parent material: Sandy drift

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 2 inches: sand
E - 2 to 9 inches: sand
Bhs - 9 to 15 inches: sand
Bs - 15 to 31 inches: sand
BC - 31 to 56 inches: sand
C - 56 to 80 inches: sand

Properties and qualities

Slope: 35 to 60 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F094AA005MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Blue lake

Percent of map unit: 5 percent
Landform: Glacial drainage channels on moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, nose slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Ecological site: F094AA006MI - Snowy Sandy Drift
Hydric soil rating: No

KlF—Karlin loamy sand, 25 to 45 percent slopes

Map Unit Setting

National map unit symbol: 6c5n
Elevation: 600 to 1,950 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 36 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Karlin and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Karlin

Setting

Landform: Moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: Loamy and/or sandy surface over sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 32 inches: loamy fine sand
H3 - 32 to 60 inches: sand

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift, F094AA006MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Newaygo

Percent of map unit: 5 percent
Landform: Outwash plains, lake terraces
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Side slope, base slope, interfluve, nose slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Kalkaska

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest

Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Mancelona

Percent of map unit: 3 percent
Landform: Outwash plains, moraines, kames, beach ridges, lake plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

Coventry

Percent of map unit: 2 percent
Landform: Outwash plains, lake terraces
Landform position (two-dimensional): Toeslope, footslope, backslope, shoulder
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

Kt—Kerston muck

Map Unit Setting

National map unit symbol: 6c5t
Elevation: 670 to 1,600 feet
Mean annual precipitation: 22 to 33 inches
Mean annual air temperature: 36 to 45 degrees F
Frost-free period: 88 to 145 days
Farmland classification: Not prime farmland

Map Unit Composition

Kerston and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kerston

Setting

Landform: Flood plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 16 to 40 inches of organic deposits over stratified mineral alluvium

Typical profile

Oa - 0 to 5 inches: muck
C - 5 to 10 inches: stratified sand to fine sandy loam

O'a - 10 to 21 inches: muck
C' - 21 to 60 inches: stratified sand to muck

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 5.95 in/hr)
Depth to water table: About 0 to 24 inches
Frequency of flooding: FrequentNone
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: F096XA013MI - Snowy Wet Floodplain
Hydric soil rating: Yes

LeB—Lake beach and Eastport sand, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c5v
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Eastport and similar soils: 50 percent
Lake beach: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Eastport

Setting

Landform: Beach ridges, dunes
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy eolian deposits

Typical profile

H1 - 0 to 5 inches: sand
H2 - 5 to 26 inches: sand
H3 - 26 to 60 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of Lake Beach

Interpretive groups

Land capability classification (irrigated): None specified
Ecological site: R096XY001MI - Coastal Dune Complex
Hydric soil rating: Unranked

Minor Components

Alpena

Percent of map unit: 5 percent
Landform: Outwash plains, kames, lakeshores
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Kalkaska

Percent of map unit: 5 percent
Landform: Moraines, outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

LkA—Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c5w
Elevation: 600 to 1,900 feet

Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Leelanau and similar soils: 55 percent
Kalkaska and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska

Setting

Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, moraines, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

LkB—Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c5y
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Leelanau and similar soils: 55 percent
Kalkaska and similar soils: 40 percent
Minor components: 5 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska

Setting

Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible

Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Beach ridges, lake terraces, moraines, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

LkC—Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c60
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Leelanau and similar soils: 55 percent
Kalkaska and similar soils: 35 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear

Across-slope shape: Linear, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska

Setting

Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Mancelona

Percent of map unit: 5 percent
Landform: Kames, moraines, beach ridges, lake plains, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

LkD—Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes

Map Unit Setting

National map unit symbol: 6c62
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Leelanau and similar soils: 50 percent
Kalkaska and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Moraines
Landform position (two-dimensional): Footslope, toeslope, summit, shoulder, backslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Mancelona

Percent of map unit: 10 percent
Landform: Beach ridges, lake plains, outwash plains, kames, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

LkE—Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6c64
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches

Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Leelanau and similar soils: 55 percent
Kalkaska and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest

Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

LkE2—Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c65
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches

Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Leelanau, moderately eroded, and similar soils: 55 percent
Kalkaska, moderately eroded, and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest

Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

LkF—Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes

Map Unit Setting

National map unit symbol: 6c66
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days

Farmland classification: Not prime farmland

Map Unit Composition

Leelanau and similar soils: 55 percent
Kalkaska and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 25 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex

Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

LkF2—Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c67
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days

Farmland classification: Not prime farmland

Map Unit Composition

Leelanau, moderately eroded, and similar soils: 55 percent
Kalkaska, moderately eroded, and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 25 to 40 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of Kalkaska, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex

Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 8 inches: sand
H3 - 8 to 36 inches: sand
H4 - 36 to 60 inches: sand

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, beach ridges, lake terraces, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Lu—Carlisle muck, 0 to 2 percent slopes, cool

Map Unit Setting

National map unit symbol: 2w5mg
Elevation: 580 to 1,180 feet
Mean annual precipitation: 30 to 36 inches
Mean annual air temperature: 41 to 48 degrees F
Frost-free period: 110 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

Carlisle, cool, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Carlisle, Cool

Setting

Landform: Depressions on outwash plains, depressions on till plains, depressions on moraines, depressions on glacial drainage channels
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Parent material: Woody organic material

Typical profile

Oa1 - 0 to 13 inches: muck
Oa2 - 13 to 37 inches: muck
Oa3 - 37 to 80 inches: muck

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum: 0.6
Available water capacity: Very high (about 23.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F094AA013MI - Snowy Mucky Depression, F096XA014MI - Snowy Mucky Depression
Hydric soil rating: Yes

Minor Components

Adrian

Percent of map unit: 5 percent
Landform: Depressions on outwash plains, drainageways on glacial drainage channels, drainageways on outwash plains, depressions on outwash plains, drainageways on moraines, depressions on moraines, drainageways on moraines
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

Kingsville

Percent of map unit: 3 percent
Landform: Nearshore zones (relict), outwash plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Wallkill

Percent of map unit: 2 percent
Landform: Depressions on till plains, depressions on glacial drainage channels, depressions on moraines
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: Yes

MaA—Mancelona gravelly sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c69
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Mancelona and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mancelona

Setting

Landform: Kames, moraines, beach ridges, lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: gravelly sandy loam
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F094AA006MI - Snowy Sandy Drift, F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Newaygo

Percent of map unit: 5 percent
Landform: Outwash plains, lake terraces, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

MaC—Mancelona gravelly sandy loam, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c6c
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Mancelona and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mancelona

Setting

Landform: Kames, outwash plains, beach ridges, lake plains, moraines

Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: gravelly sandy loam
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Newaygo

Percent of map unit: 5 percent
Landform: Lake terraces, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

MaC2—Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c6d
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Mancelona, moderately eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mancelona, Moderately Eroded

Setting

Landform: Beach ridges, lake plains, moraines, kames, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: gravelly sandy loam
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Alpena

Percent of map unit: 5 percent
Landform: Kames, lakeshores, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear, concave
Hydric soil rating: No

Newaygo

Percent of map unit: 5 percent
Landform: Outwash plains, lake terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

MaD—Mancelona gravelly sandy loam, 12 to 18 percent slopes

Map Unit Setting

National map unit symbol: 6c6f
Elevation: 600 to 1,200 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Mancelona and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mancelona

Setting

Landform: Beach ridges, lake plains, moraines, kames, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope

Landform position (three-dimensional): Crest, interfluve, head slope, nose slope, side slope, base slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: gravelly sandy loam
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Newaygo

Percent of map unit: 5 percent
Landform: Outwash plains, lake terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, nose slope, side slope, base slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

MeA—Mancelona-East Lake loamy sands, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c6l
Elevation: 600 to 1,900 feet

Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Mancelona and similar soils: 55 percent
East lake and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mancelona

Setting

Landform: Moraines, kames, outwash plains, beach ridges, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F094AA006MI - Snowy Sandy Drift, F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Lake terraces, outwash plains, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F094AA006MI - Snowy Sandy Drift, F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Kalkaska

Percent of map unit: 5 percent
Landform: Moraines, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

MeE—Mancelona-East Lake loamy sands, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6c6r
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Mancelona and similar soils: 55 percent
East lake and similar soils: 40 percent

Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mancelona

Setting

Landform: Kames, beach ridges, lake plains, outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 6 inches: loamy sand
H2 - 6 to 13 inches: loamy sand
H3 - 13 to 20 inches: sandy clay loam
H4 - 20 to 60 inches: Error

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: F094AA006MI - Snowy Sandy Drift, F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Beach ridges, lake terraces, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: stratified gravelly sand to sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F094AA006MI - Snowy Sandy Drift, F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Kalkaska

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Mk—Adrian muck, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2rfgz
Elevation: 630 to 1,110 feet
Mean annual precipitation: 31 to 41 inches
Mean annual air temperature: 43 to 52 degrees F
Frost-free period: 125 to 205 days
Farmland classification: Not prime farmland

Map Unit Composition

Adrian and similar soils: 92 percent
Minor components: 8 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Adrian

Setting

Landform: Depressions on outwash plains, depressions on moraines on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Herbaceous organic material over sandy glaciofluvial deposits

Typical profile

Oa1 - 0 to 12 inches: muck
Oa2 - 12 to 34 inches: muck
Cg - 34 to 80 inches: sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline (0.3 to 1.9 mmhos/cm)
Sodium adsorption ratio, maximum: 0.2
Available water capacity: Very high (about 15.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F098XA006MI - Mucky Depressions, F096XB027MI - Mucky Depression
Hydric soil rating: Yes

Minor Components

Kingsville

Percent of map unit: 3 percent
Landform: Outwash plains, nearshore zones (relict)
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Edwards

Percent of map unit: 2 percent

Landform: Depressions on moraines on outwash plains, depressions on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Linear, concave
Across-slope shape: Linear
Hydric soil rating: Yes

Houghton

Percent of map unit: 2 percent
Landform: Depressions on outwash plains, depressions on moraines on outwash plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, dip
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: F098XA006MI - Mucky Depressions, F097XA030MI - Mucky Depression, F096XA014MI - Snowy Mucky Depression, F096XB027MI - Mucky Depression
Hydric soil rating: Yes

Gilford, gravelly subsoil

Percent of map unit: 1 percent
Landform: Glacial drainage channels, glacial drainage channels
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

RcA—Richter loams, 0 to 2 percent slopes, overwash

Map Unit Setting

National map unit symbol: 6c7k
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Richter and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Richter

Setting

Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear

Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 35 inches: very fine sandy loam
H3 - 35 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

RcB—Richter loams, 2 to 6 percent slopes, overwash

Map Unit Setting

National map unit symbol: 6c7l
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Richter and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Richter

Setting

Landform: Outwash plains, moraines, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 35 inches: very fine sandy loam
H3 - 35 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

RhA—Richter loams, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c7m
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Richter and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Richter

Setting

Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 35 inches: very fine sandy loam

H3 - 35 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

RpA—Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash

Map Unit Setting

National map unit symbol: 6c7p
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Richter and similar soils: 40 percent
Tonkey and similar soils: 30 percent
Pinconning and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Richter

Setting

Landform: Outwash plains, moraines, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 35 inches: very fine sandy loam

H3 - 35 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

Description of Tonkey

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 60 inches: stratified sand to loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Pinconning

Setting

Landform: Depressions on lake plains, depressions on moraines
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous clayey lacustrine deposits

Typical profile

H1 - 0 to 6 inches: sandy loam
H2 - 6 to 26 inches: loamy sand
H3 - 26 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 26 percent
Available water capacity: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

RrA—Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c7q
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Richter and similar soils: 40 percent
Tonkey and similar soils: 30 percent
Pinconning and similar soils: 30 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Richter

Setting

Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 35 inches: very fine sandy loam
H3 - 35 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Ecological site: F094AA003MI - Snowy Loamy Depression, F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

Description of Tonkey

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 60 inches: stratified sand to loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low

Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F094AA004MI - Snowy Wet Loamy Depression, F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Pinconning

Setting

Landform: Depressions on lake plains, depressions on moraines
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous clayey lacustrine deposits

Typical profile

H1 - 0 to 6 inches: sandy loam
H2 - 6 to 26 inches: loamy sand
H3 - 26 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 26 percent
Available water capacity: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F094AA004MI - Snowy Wet Loamy Depression, F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

RrC—Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6c7s
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Richter and similar soils: 40 percent
Pinconning and similar soils: 30 percent
Tonkey and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Richter

Setting

Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 35 inches: very fine sandy loam
H3 - 35 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 1 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression

Hydric soil rating: No

Description of Pinconning

Setting

Landform: Depressions on lake plains, depressions on moraines
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous clayey lacustrine deposits

Typical profile

H1 - 0 to 6 inches: sandy loam
H2 - 6 to 26 inches: loamy sand
H3 - 26 to 60 inches: silty clay

Properties and qualities

Slope: 1 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 26 percent
Available water capacity: Moderate (about 6.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Tonkey

Setting

Landform: Depressions on outwash plains, depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 60 inches: stratified sand to loam

Properties and qualities

Slope: 1 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)

Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Rs—Rifle peat

Map Unit Setting

National map unit symbol: 6c7t
Elevation: 600 to 1,500 feet
Mean annual precipitation: 22 to 35 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 60 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Rifle and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rifle

Setting

Landform: Depressions on moraines, depressions on outwash plains, depressions on lake plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: > 51 inches of organic material

Typical profile

Oi - 0 to 2 inches: peat
Oe - 2 to 60 inches: mucky peat

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 5.95 in/hr)
Depth to water table: About 0 inches

Frequency of flooding: None
Frequency of ponding: Frequent
Available water capacity: Very high (about 24.3 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: F094AA013MI - Snowy Mucky Depression, F096XA014MI - Snowy Mucky Depression
Hydric soil rating: Yes

Minor Components

Lupton
Percent of map unit: 5 percent
Landform: Depressions on lake plains, depressions on outwash plains, depressions on till plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Roscommon
Percent of map unit: 5 percent
Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Tawas
Percent of map unit: 5 percent
Landform: Depressions on lake plains, depressions on moraines, depressions on outwash plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Ru—Roscommon mucky loamy sand

Map Unit Setting
National map unit symbol: 6c7w
Elevation: 600 to 1,500 feet
Mean annual precipitation: 22 to 35 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 140 days
Farmland classification: Farmland of local importance

Map Unit Composition

Roscommon and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Roscommon

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 3 inches: mucky loamy sand
H2 - 3 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 4.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: F096XA011MI - Snowy Wet Sandy Depression
Hydric soil rating: Yes

Minor Components

Tawas

Percent of map unit: 5 percent
Landform: Depressions on moraines, depressions on outwash plains, depressions on lake plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

RwA—Rubicon sand, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c7y
Elevation: 600 to 1,800 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 80 to 140 days
Farmland classification: Not prime farmland

Map Unit Composition

Rubicon and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rubicon

Setting

Landform: Moraines, lake plains, outwash plains, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 5 inches: sand
H2 - 5 to 34 inches: sand
H3 - 34 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F094AA006MI - Snowy Sandy Drift, F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

RwB—Rubicon sand, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2qz6l
Elevation: 580 to 1,500 feet
Mean annual precipitation: 28 to 36 inches
Mean annual air temperature: 41 to 48 degrees F
Frost-free period: 90 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Rubicon and similar soils: 93 percent
Minor components: 7 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Rubicon

Setting

Landform: Flats, knolls, heads-of-outwash, drainageways, moraines
Landform position (two-dimensional): Backslope, summit, footslope, toeslope
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Linear, concave
Across-slope shape: Linear, convex
Parent material: Sandy glaciofluvial deposits

Typical profile

A - 0 to 1 inches: sand
E - 1 to 6 inches: sand
Bs - 6 to 18 inches: sand
C - 18 to 80 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (1.56 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 0.1 mmhos/cm)
Sodium adsorption ratio, maximum: 0.1
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F094AA006MI - Snowy Sandy Drift, F096XA007MI - Snowy Sandy Drift

Hydric soil rating: No

Minor Components

Croswell

Percent of map unit: 4 percent
Landform: Drainageways, moraines, till-floored lake plains, deltas
Landform position (two-dimensional): Footslope, summit, backslope
Landform position (three-dimensional): Base slope, interfluve
Down-slope shape: Concave, linear
Across-slope shape: Linear
Hydric soil rating: No

Au gres

Percent of map unit: 2 percent
Landform: Flats, drainageways
Landform position (two-dimensional): Backslope, footslope, toeslope
Landform position (three-dimensional): Base slope
Microfeatures of landform position: Swales
Down-slope shape: Linear, concave
Across-slope shape: Linear, concave
Hydric soil rating: No

Kinross

Percent of map unit: 1 percent
Landform: Flats, drainageways
Landform position (two-dimensional): Backslope, footslope, toeslope
Landform position (three-dimensional): Base slope
Microfeatures of landform position: Closed depressions
Down-slope shape: Linear, concave
Across-slope shape: Linear
Hydric soil rating: Yes

SrB—Sanilac-Richter loams, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c8f
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Sanilac and similar soils: 50 percent
Richter and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sanilac

Setting

Landform: Lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Calcareous silty lacustrine deposits and/or eolian deposits

Typical profile

H1 - 0 to 7 inches: loam
H2 - 7 to 42 inches: silt loam
H3 - 42 to 60 inches: stratified very fine sand to silt loam

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 12 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: High (about 11.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

Description of Richter

Setting

Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 35 inches: very fine sandy loam
H3 - 35 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

Minor Components

Alpena

Percent of map unit: 10 percent
Landform: Outwash plains, kames, lakeshores
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Ta—Tawas-Roscommon complex

Map Unit Setting

National map unit symbol: 6c8g
Elevation: 600 to 1,800 feet
Mean annual precipitation: 22 to 35 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 60 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Tawas and similar soils: 50 percent
Roscommon and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tawas

Setting

Landform: Depressions on moraines, depressions on outwash plains, depressions on lake plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 16 to 51 inches of organic material over sandy glaciofluvial deposits

Typical profile

Oa - 0 to 24 inches: muck
H2 - 24 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Available water capacity: Very high (about 12.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: F096XA014MI - Snowy Mucky Depression
Hydric soil rating: Yes

Description of Roscommon

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 3 inches: mucky sand
H2 - 3 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 4.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: F096XA011MI - Snowy Wet Sandy Depression
Hydric soil rating: Yes

Minor Components

Lupton

Percent of map unit: 5 percent
Landform: Depressions on lake plains, depressions on outwash plains, depressions on till plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Au gres

Percent of map unit: 5 percent
Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Croswell

Percent of map unit: 5 percent
Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Tm—Tonkey mucky sandy loam

Map Unit Setting

National map unit symbol: 6c8h
Elevation: 600 to 1,600 feet
Mean annual precipitation: 22 to 35 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tonkey and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tonkey

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: mucky sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 60 inches: stratified sand to loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Minor Components

Richter

Percent of map unit: 5 percent
Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Tawas

Percent of map unit: 5 percent
Landform: Depressions on lake plains, depressions on moraines, depressions on outwash plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Roscommon

Percent of map unit: 5 percent
Landform: Depressions on outwash plains, depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Tn—Tonkey sandy loam, overwash

Map Unit Setting

National map unit symbol: 6c8j
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 140 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tonkey and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tonkey

Setting

Landform: Depressions on outwash plains, depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 60 inches: stratified sand to loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

To—Tonkey sandy loam

Map Unit Setting

National map unit symbol: 6c8k
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tonkey and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tonkey

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 60 inches: stratified sand to loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Minor Components

Richter

Percent of map unit: 5 percent
Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Tp—Tonkey-Hettinger-Pickford loams, overwash

Map Unit Setting

National map unit symbol: 6c8l
Elevation: 600 to 1,600 feet
Mean annual precipitation: 26 to 34 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 70 to 140 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tonkey and similar soils: 45 percent
Hettinger and similar soils: 30 percent
Pickford and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tonkey

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 30 inches: sandy loam
H3 - 30 to 60 inches: stratified sand to loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent

Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F094AA004MI - Snowy Wet Loamy Depression, F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Hettinger

Setting

Landform: Depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 12 to 36 inches of fine-loamy material over stratified, calcareous silty and clayey glaciolacustrine deposits

Typical profile

H1 - 0 to 7 inches: loam
H2 - 7 to 12 inches: clay loam
H3 - 12 to 20 inches: clay loam
H4 - 20 to 60 inches: stratified clay loam to silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 35 percent
Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F094AA004MI - Snowy Wet Loamy Depression, F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Pickford

Setting

Landform: Depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 14 to 30 inches of loamy and clayey material over calcareous clayey lacustrine deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 20 inches: silty clay
H3 - 20 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: D
Ecological site: F094AA004MI - Snowy Wet Loamy Depression, F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Tr—Tonkey-Hettinger-Pickford loams

Map Unit Setting

National map unit symbol: 6c8m
Elevation: 600 to 1,600 feet
Mean annual precipitation: 26 to 34 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 70 to 140 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tonkey and similar soils: 45 percent
Hettinger and similar soils: 30 percent
Pickford and similar soils: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tonkey

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 30 inches: very fine sandy loam
H3 - 30 to 60 inches: sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 8.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Hettinger

Setting

Landform: Depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 12 to 36 inches of fine-loamy material over stratified, calcareous silty and clayey glaciolacustrine deposits

Typical profile

H1 - 0 to 7 inches: loam
H2 - 7 to 12 inches: clay loam
H3 - 12 to 20 inches: clay loam
H4 - 20 to 60 inches: stratified clay loam to silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 35 percent
Available water capacity: High (about 9.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Pickford

Setting

Landform: Depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 14 to 30 inches of loamy and clayey material over calcareous clayey lacustrine deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 20 inches: silty clay
H3 - 20 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

UnA—Ubly-Nester complex, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6c91
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Ubly and similar soils: 55 percent
Nester and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ubly

Setting

Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 30 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester

Setting

Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Mcbride

Percent of map unit: 5 percent
Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

UnB—Ubly-Nester complex, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6c92
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Ubly and similar soils: 55 percent
Nester and similar soils: 40 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ubly

Setting

Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 30 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F094AA002MI - Snowy Loamy Till, F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester

Setting

Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: F094AA002MI - Snowy Loamy Till, F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Mcbride

Percent of map unit: 5 percent
Landform: Moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

UnD2—Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c95
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Ubly, moderately eroded, and similar soils: 50 percent
Nester, moderately eroded, and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ubly, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope

Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 30 to 50 inches of loamy material over calcareous loamy till

Typical profile
H1 - 0 to 8 inches: sandy loam
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: clay loam

Properties and qualities
Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester, Moderately Eroded

Setting
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile
H1 - 0 to 8 inches: silt loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities
Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Montcalm

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

Mcbride

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

UnE—Ubly-Nester complex, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6c96
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Ubly and similar soils: 50 percent

Nester and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ubly

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 30 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: clay loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 14 inches: silty clay loam

H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Montcalm

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

Mcbride

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

UnE2—Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded

Map Unit Setting

National map unit symbol: 6c97
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 33 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Ubly, moderately eroded, and similar soils: 50 percent
Nester, moderately eroded, and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ubly, Moderately Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 30 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 24 inches: loamy sand
H3 - 24 to 60 inches: clay loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Nester, Moderately Eroded

Setting

Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 8 inches: silt loam
H2 - 8 to 14 inches: silty clay loam
H3 - 14 to 28 inches: clay loam
H4 - 28 to 60 inches: clay loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 9.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Montcalm

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear, convex

Across-slope shape: Convex, concave
Hydric soil rating: No

Mcbride

Percent of map unit: 5 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

W—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

WdD—Wind eroded land, strongly sloping

Map Unit Composition

Wind eroded land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Leelanau County, Michigan

ArA—Alcona-Richter sandy loams, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6dj3
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Alcona and similar soils: 55 percent
Richter and similar soils: 30 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alcona

Setting

Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified sandy and loamy glaciofluvial deposits and/or glaciolacustrine deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 12 inches: loamy fine sand
H3 - 12 to 18 inches: loamy sand
H4 - 18 to 24 inches: sandy loam
H5 - 24 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 30 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Richter

Setting

Landform: Moraines, lake plains, drainageways
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 27 inches: fine sandy loam
H3 - 27 to 60 inches: stratified loamy fine sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

Minor Components

Hettinger

Percent of map unit: 15 percent
Landform: Depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

ArB—Alcona-Richter sandy loams, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6dj4

Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Alcona and similar soils: 65 percent
Richter and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Alcona

Setting

Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified sandy and loamy glaciofluvial deposits and/or glaciolacustrine deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 12 inches: loamy fine sand
H3 - 12 to 18 inches: loamy sand
H4 - 18 to 24 inches: sandy loam
H5 - 24 to 60 inches: stratified loamy sand to sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 30 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Richter

Setting

Landform: Moraines, lake plains, drainageways
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 27 inches: fine sandy loam
H3 - 27 to 60 inches: stratified loamy fine sand to sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

Minor Components

Kalkaska

Percent of map unit: 5 percent
Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

AuA—Au Gres-Kalkaska sands, 0 to 4 percent slopes

Map Unit Setting

National map unit symbol: 6dj6
Elevation: 600 to 1,900 feet
Mean annual precipitation: 22 to 44 inches

Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Au gres and similar soils: 45 percent
Kalkaska and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Au Gres

Setting

Landform: Lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 12 inches: sand
H2 - 12 to 24 inches: sand
H3 - 24 to 60 inches: sand

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: A/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Description of Kalkaska

Setting

Landform: Lake plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: sand
H2 - 7 to 15 inches: sand
H3 - 15 to 32 inches: sand
H4 - 32 to 60 inches: sand

Properties and qualities

Slope: 0 to 4 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Markey

Percent of map unit: 10 percent
Landform: Depressions on lake plains, depressions on moraines, depressions on outwash plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Roscommon

Percent of map unit: 10 percent
Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

EdB—Eastport sand, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6djk
Elevation: 600 to 700 feet
Mean annual precipitation: 27 to 31 inches
Mean annual air temperature: 43 to 46 degrees F
Frost-free period: 130 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Eastport and similar soils: 93 percent
Minor components: 7 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Eastport

Setting

Landform: Beach ridges, dunes, lake terraces
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy eolian deposits

Typical profile

H1 - 0 to 3 inches: sand
H2 - 3 to 26 inches: sand
H3 - 26 to 60 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Alpena

Percent of map unit: 7 percent
Landform: Moraines, beach ridges, lake terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

EnB—Emmet-Leelanau complex, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6djn
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Emmet and similar soils: 60 percent
Leelanau and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Drumlins, moraines, till plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 26 inches: sandy loam
H3 - 26 to 32 inches: sandy clay loam
H4 - 32 to 60 inches: sandy loam

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Leelanau

Setting

Landform: Drumlins, till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 2 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 4 percent
Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Nester

Percent of map unit: 3 percent
Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Alcona

Percent of map unit: 3 percent
Landform: Lake plains, outwash plains, moraines

Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

EnC—Emmet-Leelanau complex, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6djp
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet and similar soils: 60 percent
Leelanau and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Moraines, till plains, drumlins
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, nose slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 26 inches: sandy loam
H3 - 26 to 32 inches: sandy clay loam
H4 - 32 to 60 inches: sandy loam

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Leelanau

Setting

Landform: Drumlins, till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Nester

Percent of map unit: 5 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope

Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

East lake

Percent of map unit: 5 percent
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

EnD—Emmet-Leelanau complex, 12 to 18 percent slopes

Map Unit Setting

National map unit symbol: 6djq
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet and similar soils: 50 percent
Leelanau and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, drumlins, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, nose slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 26 inches: sandy loam
H3 - 26 to 32 inches: sandy clay loam

H4 - 32 to 60 inches: sandy loam

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Leelanau

Setting

Landform: Drumlins, till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e

Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 5 percent
Landform: Moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Kalkaska

Percent of map unit: 5 percent
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Nester

Percent of map unit: 3 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Wallace

Percent of map unit: 3 percent
Landform: Moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Alcona

Percent of map unit: 2 percent
Landform: Moraines, lake plains, outwash plains
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope
Down-slope shape: Linear

Across-slope shape: Convex, linear
Hydric soil rating: No

Richter

Percent of map unit: 2 percent
Landform: Lake plains, drainageways, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

EnE—Emmet-Leelanau complex, 18 to 25 percent slopes

Map Unit Setting

National map unit symbol: 6djr
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Emmet and similar soils: 50 percent
Leelanau and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, drumlins, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, nose slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 26 inches: sandy loam
H3 - 26 to 32 inches: sandy clay loam
H4 - 32 to 60 inches: sandy loam

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Leelanau

Setting

Landform: Drumlins, till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Nester

Percent of map unit: 10 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

East lake

Percent of map unit: 10 percent
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

EnF—Emmet-Leelanau complex, 25 to 50 percent slopes

Map Unit Setting

National map unit symbol: 6djt
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Emmet and similar soils: 45 percent
Leelanau and similar soils: 30 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, drumlins, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, nose slope, crest

Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 26 inches: sandy loam
H3 - 26 to 32 inches: sandy clay loam
H4 - 32 to 60 inches: sandy loam

Properties and qualities

Slope: 25 to 50 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Leelanau

Setting

Landform: Moraines, drumlins, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 25 to 50 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

East lake

Percent of map unit: 13 percent
Landform: Moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Nester

Percent of map unit: 12 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

EoC—Emmet-Mancelona gravelly sandy loams, 4 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6djw
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 100 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Emmet and similar soils: 70 percent
Mancelona and similar soils: 25 percent

Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, drumlins, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, nose slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 26 inches: sandy loam
H3 - 26 to 32 inches: sandy clay loam
H4 - 32 to 60 inches: sandy loam

Properties and qualities

Slope: 4 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Mancelona

Setting

Landform: Valley trains, outwash plains, moraines, beach ridges, lake plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 25 inches: loamy sand

H3 - 25 to 30 inches: gravelly sandy loam
H4 - 30 to 60 inches: very gravelly coarse sand

Properties and qualities

Slope: 4 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Nester

Percent of map unit: 3 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Kiva

Percent of map unit: 2 percent
Landform: Lake plains, moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

EoE—Emmet-Mancelona gravelly sandy loams, 18 to 35 percent slopes

Map Unit Setting

National map unit symbol: 6djy

Elevation: 600 to 1,400 feet
Mean annual precipitation: 22 to 44 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 60 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Emmet and similar soils: 60 percent
Mancelona and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Emmet

Setting

Landform: Till plains, drumlins, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, nose slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Parent material: 24 to 50 inches of loamy material over calcareous loamy till

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 26 inches: sandy loam
H3 - 26 to 32 inches: sandy clay loam
H4 - 32 to 60 inches: sandy loam

Properties and qualities

Slope: 18 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Description of Mancelona

Setting

Landform: Beach ridges, lake plains, valley trains, outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope

Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 25 inches: loamy sand
H3 - 25 to 30 inches: gravelly sandy loam
H4 - 30 to 60 inches: very gravelly coarse sand

Properties and qualities

Slope: 18 to 35 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Alpena

Percent of map unit: 2 percent
Landform: Beach ridges, lake terraces, moraines
Landform position (two-dimensional): Backslope, footslope, toeslope
Landform position (three-dimensional): Nose slope, side slope, base slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Lupton

Percent of map unit: 2 percent
Landform: Depressions, depressions, depressions, moraines, lake terraces, till plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Kiva

Percent of map unit: 2 percent
Landform: Moraines, outwash plains, lake plains

Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Nester

Percent of map unit: 2 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Markey

Percent of map unit: 2 percent
Landform: Depressions on outwash plains, depressions on lake plains, depressions on moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Hm—Hettinger-Muck complex

Map Unit Setting

National map unit symbol: 6dk6
Elevation: 600 to 1,600 feet
Mean annual precipitation: 19 to 44 inches
Mean annual air temperature: 36 to 46 degrees F
Frost-free period: 60 to 172 days
Farmland classification: Not prime farmland

Map Unit Composition

Hettinger and similar soils: 45 percent
Muck: 30 percent
Minor components: 25 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hettinger

Setting

Landform: Depressions on lake plains
Landform position (three-dimensional): Talf

Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 12 to 36 inches of fine-loamy material over stratified, calcareous silty and clayey glaciolacustrine deposits

Typical profile

H1 - 0 to 8 inches: loam
H2 - 8 to 23 inches: silty clay loam
H3 - 23 to 60 inches: stratified clay loam to silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: High (about 10.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Muck

Setting

Landform: Depressions
Parent material: Organic material

Typical profile

Oa1 - 0 to 11 inches: muck
Oa2 - 11 to 23 inches: muck
2C - 23 to 60 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Drainage class: Very poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: About 0 inches
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 25 percent
Available water capacity: Very high (about 15.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Ecological site: F096XA014MI - Snowy Mucky Depression
Hydric soil rating: Yes

Minor Components

Kiva

Percent of map unit: 5 percent
Landform: Outwash plains, moraines, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Mancelona

Percent of map unit: 5 percent
Landform: Moraines, beach ridges, valley trains, outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Lupton

Percent of map unit: 5 percent
Landform: Moraines, till plains, depressions, depressions, depressions, lake terraces
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Markey

Percent of map unit: 3 percent
Landform: Depressions on outwash plains, depressions on lake plains, depressions on moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Tonkey

Percent of map unit: 3 percent
Landform: Outwash plains, depressions on depressions on lake plains, depressions on drainageways
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Edwards

Percent of map unit: 2 percent
Landform: Depressions on outwash plains, depressions on moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Roscommon

Percent of map unit: 2 percent
Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear

Across-slope shape: Linear
Hydric soil rating: Yes

KaB—Kaleva sand, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2w5mq
Elevation: 580 to 1,110 feet
Mean annual precipitation: 30 to 41 inches
Mean annual air temperature: 41 to 52 degrees F
Frost-free period: 110 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Kaleva and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kaleva

Setting

Landform: Moraines, lake plains, outwash plains
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, side slope, head slope, nose slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy outwash

Typical profile

A - 0 to 3 inches: sand
E - 3 to 9 inches: sand
Bhs - 9 to 12 inches: sand
Bs1 - 12 to 19 inches: sand
Bs2 - 19 to 30 inches: sand
BC - 30 to 35 inches: sand
C - 35 to 80 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 0.1 mmhos/cm)

Sodium adsorption ratio, maximum: 1.0
Available water capacity: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Pipestone

Percent of map unit: 5 percent
Landform: Outwash plains, lake plains, moraines
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Linear
Hydric soil rating: No

Nessen

Percent of map unit: 3 percent
Landform: Lake plains, moraines, outwash plains
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve, side slope, head slope, nose slope, tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Fern

Percent of map unit: 2 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Interfluve, head slope, side slope, nose slope
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

KaC—Kaleva sand, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 2w5mr
Elevation: 590 to 1,330 feet
Mean annual precipitation: 30 to 41 inches
Mean annual air temperature: 41 to 52 degrees F
Frost-free period: 110 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Kaleva and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kaleva

Setting

Landform: Lake plains, outwash plains, moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, head slope, nose slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Parent material: Sandy drift

Typical profile

A - 0 to 3 inches: sand
E - 3 to 9 inches: sand
Bhs - 9 to 12 inches: sand
Bs1 - 12 to 19 inches: sand
Bs2 - 19 to 30 inches: sand
BC - 30 to 35 inches: sand
C - 35 to 80 inches: sand

Properties and qualities

Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 0.1 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water capacity: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift, F094AA005MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Minor Components

Nessen

Percent of map unit: 5 percent
Landform: Lake plains, outwash plains, moraines
Landform position (two-dimensional): Shoulder, backslope
Landform position (three-dimensional): Side slope, head slope, nose slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Hydric soil rating: No

KeB—Kalkaska-East Lake loamy sands, 0 to 6 percent slopes, lake moderated

Map Unit Setting

National map unit symbol: 6dkg
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Kalkaska and similar soils: 55 percent
East lake and similar soils: 35 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Kalkaska

Setting

Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits

Typical profile

H1 - 0 to 7 inches: loamy sand
H2 - 7 to 15 inches: sand
H3 - 15 to 32 inches: sand
H4 - 32 to 60 inches: sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 26 inches: loamy sand
H3 - 26 to 60 inches: gravelly coarse sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Mancelona

Percent of map unit: 2 percent
Landform: Lake plains, valley trains, outwash plains, moraines, beach ridges
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Alcona

Percent of map unit: 2 percent
Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Richter

Percent of map unit: 2 percent
Landform: Lake plains, drainageways, moraines
Landform position (three-dimensional): Rise

Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Leelanau

Percent of map unit: 2 percent
Landform: Drumlins, till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Leelanau

Percent of map unit: 2 percent
Landform: Drumlins, till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

LIB—Leelanau-East Lake loamy sands, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6dkp
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Leelanau and similar soils: 60 percent
East lake and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Drumlins, till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam

H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Moraines, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 26 inches: loamy sand
H3 - 26 to 60 inches: gravelly coarse sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Alcona

Percent of map unit: 4 percent
Landform: Lake plains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Kalkaska

Percent of map unit: 3 percent
Landform: Outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Mancelona

Percent of map unit: 3 percent
Landform: Beach ridges, lake plains, valley trains, outwash plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

LIC—Leelanau-East Lake loamy sands, 6 to 12 percent slopes

Map Unit Setting

National map unit symbol: 6dkq
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Leelanau and similar soils: 65 percent
East lake and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Moraines, drumlins, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope

Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile
H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities
Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Linear, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile
H1 - 0 to 8 inches: loamy sand
H2 - 8 to 26 inches: loamy sand
H3 - 26 to 60 inches: gravelly coarse sand

Properties and qualities
Slope: 6 to 12 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low

Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Mancelona
Percent of map unit: 3 percent
Landform: Lake plains, valley trains, outwash plains, moraines, beach ridges
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Alcona
Percent of map unit: 2 percent
Landform: Moraines, lake plains, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Kalkaska
Percent of map unit: 2 percent
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Nester
Percent of map unit: 1 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest

Down-slope shape: Linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Richter
Percent of map unit: 1 percent
Landform: Drainageways, moraines, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Tonkey
Percent of map unit: 1 percent
Landform: Outwash plains, depressions on depressions on lake plains, depressions on drainageways
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

LID—Leelanau-East Lake loamy sands, 12 to 18 percent slopes, lake moderated

Map Unit Setting

National map unit symbol: 6dkr
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Leelanau and similar soils: 65 percent
East lake and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Till plains, moraines, drumlins
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 26 inches: loamy sand
H3 - 26 to 60 inches: gravelly coarse sand

Properties and qualities

Slope: 12 to 18 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Kalkaska

Percent of map unit: 3 percent
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Alcona

Percent of map unit: 3 percent
Landform: Lake plains, outwash plains, moraines
Landform position (two-dimensional): Shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Nester

Percent of map unit: 2 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Mancelona

Percent of map unit: 2 percent
Landform: Lake plains, valley trains, outwash plains, moraines, beach ridges
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

LIE—Leelanau-East Lake loamy sands, 18 to 25 percent slopes, lake moderated

Map Unit Setting

National map unit symbol: 6dks
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of unique importance

Map Unit Composition

Leelanau and similar soils: 50 percent
East lake and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Drumlins, till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 26 inches: loamy sand
H3 - 26 to 60 inches: gravelly coarse sand

Properties and qualities

Slope: 18 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Kalkaska

Percent of map unit: 4 percent
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex

Hydric soil rating: No

Mancelona

Percent of map unit: 4 percent
Landform: Lake plains, valley trains, outwash plains, moraines, beach ridges
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Nester

Percent of map unit: 4 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Alcona

Percent of map unit: 3 percent
Landform: Moraines, lake plains, outwash plains
Landform position (two-dimensional): Backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, nose slope, side slope, base slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

LIF—Leelanau-East Lake loamy sands, 25 to 45 percent slopes

Map Unit Setting

National map unit symbol: 6dkt
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 36 inches
Mean annual air temperature: 39 to 50 degrees F
Frost-free period: 70 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

Leelanau and similar soils: 50 percent
East lake and similar soils: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Leelanau

Setting

Landform: Drumlins, till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 52 inches of sandy and loamy material over calcareous sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 28 inches: loamy sand
H3 - 28 to 36 inches: sandy loam
H4 - 36 to 60 inches: loamy sand

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Low (about 5.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: A
Ecological site: F096XA006MI - Snowy Rich Sandy Drift
Hydric soil rating: No

Description of East Lake

Setting

Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 40 inches of sandy material over calcareous, sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 26 inches: loamy sand
H3 - 26 to 60 inches: gravelly coarse sand

Properties and qualities

Slope: 25 to 45 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Minor Components

Kalkaska

Percent of map unit: 3 percent
Landform: Outwash plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Mancelona

Percent of map unit: 3 percent
Landform: Moraines, beach ridges, lake plains, valley trains, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Nester

Percent of map unit: 3 percent
Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Alcona

Percent of map unit: 3 percent
Landform: Outwash plains, moraines, lake plains
Landform position (two-dimensional): Backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, nose slope, side slope, base slope
Down-slope shape: Linear
Across-slope shape: Convex, linear
Hydric soil rating: No

Wind eroded land

Percent of map unit: 3 percent
Hydric soil rating: Unranked

Lm—Lupton-Markey mucks

Map Unit Setting

National map unit symbol: 6dkv
Elevation: 600 to 1,500 feet
Mean annual precipitation: 19 to 44 inches
Mean annual air temperature: 36 to 46 degrees F
Frost-free period: 60 to 172 days
Farmland classification: Not prime farmland

Map Unit Composition

Lupton and similar soils: 60 percent
Markey and similar soils: 30 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lupton

Setting

Landform: Lake terraces, moraines, till plains, depressions, depressions, depressions
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Greater than 51 inches of organic material

Typical profile

Oa1 - 0 to 10 inches: muck
Oa2 - 10 to 60 inches: muck

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very low

Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Available water capacity: Very high (about 23.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: F096XA014MI - Snowy Mucky Depression
Hydric soil rating: Yes

Description of Markey

Setting

Landform: Depressions on outwash plains, depressions on lake plains, depressions on moraines
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 16 to 51 inches of organic material over sandy glaciofluvial deposits

Typical profile

Oa - 0 to 20 inches: muck
2C - 20 to 60 inches: sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 5 percent
Available water capacity: High (about 10.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA014MI - Snowy Mucky Depression
Hydric soil rating: Yes

Minor Components

Edwards

Percent of map unit: 5 percent
Landform: Depressions on moraines, depressions on outwash plains
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear

Hydric soil rating: Yes

Roscommon

Percent of map unit: 5 percent
Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

MrB—Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6dl3
Elevation: 600 to 1,600 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Farmland of local importance

Map Unit Composition

Mancelona and similar soils: 70 percent
Richter and similar soils: 25 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Mancelona

Setting

Landform: Outwash plains, lake plains, moraines, beach ridges, valley trains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 18 to 40 inches of sandy and/or gravelly material over calcareous sandy and gravelly glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: gravelly sandy loam
H2 - 8 to 25 inches: loamy sand
H3 - 25 to 30 inches: gravelly sandy loam
H4 - 30 to 60 inches: very gravelly coarse sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 25 percent
Available water capacity: Low (about 3.8 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Hydrologic Soil Group: A
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: No

Description of Richter

Setting
Landform: Valley trains, drainageways, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 25 to 40 inches of sandy and/or loamy material over stratified, calcareous sandy and silty glaciofluvial deposits

Typical profile
H1 - 0 to 8 inches: sandy loam
H2 - 8 to 27 inches: fine sandy loam
H3 - 27 to 60 inches: stratified loamy fine sand to sandy loam

Properties and qualities
Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 20 percent
Available water capacity: Moderate (about 7.4 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B/D
Ecological site: F096XA004MI - Snowy Loamy Depression
Hydric soil rating: No

Minor Components

Epoufette
Percent of map unit: 2 percent
Landform: Depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Tonkey
Percent of map unit: 2 percent

Landform: Depressions on drainageways, outwash plains, depressions on depressions on lake plains
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

Wallace

Percent of map unit: 1 percent
Landform: Lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Convex
Hydric soil rating: No

NtF3—Nester silty clay loam, 20 to 50 percent slopes, severely eroded

Map Unit Setting

National map unit symbol: 6dl9
Elevation: 600 to 1,400 feet
Mean annual precipitation: 27 to 32 inches
Mean annual air temperature: 41 to 46 degrees F
Frost-free period: 90 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Nester, severely eroded, and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Nester, Severely Eroded

Setting

Landform: Till plains, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Parent material: 20 to 36 inches of loamy and clayey material over calcareous loamy and clayey till

Typical profile

H1 - 0 to 6 inches: silty clay loam
H2 - 6 to 28 inches: silty clay loam
H3 - 28 to 60 inches: silty clay loam

Properties and qualities

Slope: 20 to 50 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 8.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F096XA003MI - Snowy Loamy Till
Hydric soil rating: No

Minor Components

Emmet

Percent of map unit: 4 percent
Landform: Till plains, drumlins, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, side slope, base slope, nose slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex, concave
Hydric soil rating: No

Leelanau

Percent of map unit: 3 percent
Landform: Moraines, drumlins, till plains
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Omena

Percent of map unit: 3 percent
Landform: Drumlins, moraines
Landform position (two-dimensional): Summit, shoulder, backslope, footslope, toeslope
Landform position (three-dimensional): Interfluve, head slope, nose slope, side slope, base slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Concave, convex
Hydric soil rating: No

Pt—Pits, gravel

Map Unit Composition

Pits, gravel: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

TmA—Tonkey-Munuscong-Iosco sandy loams, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 6dlh
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tonkey and similar soils: 40 percent
Iosco and similar soils: 25 percent
Munuscong and similar soils: 25 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tonkey

Setting

Landform: Outwash plains, depressions on depressions on lake plains, depressions on drainageways
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 20 inches: fine sandy loam
H3 - 20 to 60 inches: stratified sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent

Available water capacity: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Munuscong

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of loamy material over clayey lacustrine deposits

Typical profile

H1 - 0 to 10 inches: sandy loam
H2 - 10 to 24 inches: fine sandy loam
H3 - 24 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Iosco

Setting

Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy glaciofluvial deposits over loamy till or glacialacustrine deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 27 inches: sand
H3 - 27 to 34 inches: silty clay loam
H4 - 34 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Minor Components

Au gres

Percent of map unit: 4 percent
Landform: Lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Nester

Percent of map unit: 3 percent
Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Kalkaska

Percent of map unit: 3 percent
Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

TmB—Tonkey-Munuscong-Iosco sandy loams, 2 to 6 percent slopes

Map Unit Setting

National map unit symbol: 6dlj
Elevation: 600 to 1,900 feet
Mean annual precipitation: 27 to 34 inches
Mean annual air temperature: 39 to 46 degrees F
Frost-free period: 70 to 150 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Tonkey and similar soils: 35 percent
Munuscong and similar soils: 30 percent
Iosco and similar soils: 20 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tonkey

Setting

Landform: Depressions on depressions on lake plains, depressions on drainageways, outwash plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Stratified loamy and sandy glaciofluvial deposits

Typical profile

H1 - 0 to 8 inches: sandy loam
H2 - 8 to 20 inches: fine sandy loam
H3 - 20 to 60 inches: stratified sand to sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 10 percent
Available water capacity: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w

Hydrologic Soil Group: A/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Munuscong

Setting

Landform: Depressions on lake plains, depressions on outwash plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of loamy material over clayey lacustrine deposits

Typical profile

H1 - 0 to 10 inches: sandy loam
H2 - 10 to 24 inches: fine sandy loam
H3 - 24 to 60 inches: silty clay

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 0 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 8.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: C/D
Ecological site: F096XA005MI - Snowy Wet Loamy Depression
Hydric soil rating: Yes

Description of Iosco

Setting

Landform: Lake plains, outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: 20 to 40 inches of sandy glaciofluvial deposits over loamy till or glacialacustrine deposits

Typical profile

H1 - 0 to 8 inches: loamy sand
H2 - 8 to 27 inches: sand
H3 - 27 to 34 inches: silty clay loam
H4 - 34 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained

Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 6 to 18 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Available water capacity: Moderate (about 8.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Ecological site: F096XA008MI - Snowy Acidic Sandy Depression
Hydric soil rating: No

Minor Components

Kalkaska

Percent of map unit: 4 percent
Landform: Outwash plains, lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Nester

Percent of map unit: 4 percent
Landform: Till plains, moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Au gres

Percent of map unit: 4 percent
Landform: Lake plains
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Hettinger

Percent of map unit: 3 percent
Landform: Depressions on lake plains
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: Yes

WID—Wind eroded land, steep

Map Unit Setting

National map unit symbol: 6dln
Elevation: 600 to 1,000 feet
Mean annual precipitation: 28 to 36 inches
Mean annual air temperature: 39 to 50 degrees F
Frost-free period: 100 to 180 days
Farmland classification: Not prime farmland

Map Unit Composition

Wind eroded land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Wind Eroded Land

Typical profile

H1 - 0 to 60 inches: sand

Interpretive groups

Land capability classification (irrigated): None specified
Ecological site: F096XA007MI - Snowy Sandy Drift
Hydric soil rating: Unranked

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APPENDIX C: CITY OF TRAVERSE CITY CURRENT NPDES PERMIT

PERMIT NO. MI0027481

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the federal Clean Water Act (federal Water Pollution Control Act, 33 U.S.C., Section 1251 *et seq*., as amended); Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA); Part 41, Sewerage Systems, of the NREPA; and Michigan Executive Order 2019-06,

City of Traverse City
400 Boardman
PO Box 592
Traverse City, MI 49686

is authorized to discharge from the **Traverse City Regional Wastewater Treatment Plant** located at

606 Hannah Avenue
Traverse City, MI 49686

designated as **Traverse City WWTP**

to the receiving water named the Boardman River in accordance with effluent limitations, monitoring requirements, and other conditions set forth in this permit.

This permit is based on a complete application submitted on March 21, 2019.

This permit takes effect on November 1, 2020. The provisions of this permit are severable. After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term in accordance with applicable laws and rules. On its effective date, this permit shall supersede National Pollutant Discharge Elimination System (NPDES) Permit No. MI0027481 (expiring October 1, 2019).

This permit and the authorization to discharge shall expire at midnight on **October 1, 2024**. In order to receive authorization to discharge beyond the date of expiration, the permittee shall submit an application that contains such information, forms, and fees as are required by the Michigan Department of Environment, Great Lakes, and Energy (Department) by **April 4, 2024**.

Issued: September 28, 2020.

Original signed by Christine Alexander
Christine Alexander, Manager
Permits Section
Water Resources Division

PERMIT FEE REQUIREMENTS

In accordance with Section 324.3120 of the NREPA, the permittee shall make payment of an annual permit fee to the Department for each October 1 the permit is in effect regardless of occurrence of discharge. The permittee shall submit the fee in response to the Department's annual notice. Payment may be made electronically via the Department's MiWaters system. The MiWaters website is located at https://miwaters.deq.state.mi.us. Payment shall be submitted or postmarked by January 15 for notices mailed by December 1. Payment shall be submitted or postmarked no later than 45 days after receiving the notice for notices mailed after December 1.

Annual Permit Fee Classification: Municipal Major, less than 10 MGD (Individual Permit)

In accordance with Section 324.3132 of the NREPA, the permittee shall make payment of an annual biosolids land application fee to the Department if the permittee land applies biosolids. The permittee shall submit the fee in response to the Department's annual notice. Payment may be made electronically via the Department's MiWaters system. The MiWaters website is located at https://miwaters.deq.state.mi.us. Payment shall be submitted or postmarked no later than January 31 of each year for notices mailed by December 15. Payment shall be submitted or postmarked no later than 45 days after receiving the notice for notices mailed after December 15.

CONTACT INFORMATION

Unless specified otherwise, all contact with the Department required by this permit shall be made to the Cadillac District Office of the Water Resources Division. The Cadillac District Office is located at 120 West Chapin Street, Cadillac, MI 49601-2158, Telephone: 231-775-3960, Fax: 231-775-1511.

CONTESTED CASE INFORMATION

Any person who is aggrieved by this permit may file a sworn petition with the Michigan Administrative Hearing System within the Michigan Department of Licensing and Regulatory Affairs, c/o the Michigan Department of Environment, Great Lakes, and Energy, setting forth the conditions of the permit which are being challenged and specifying the grounds for the challenge. The Department of Licensing and Regulatory Affairs may reject any petition filed more than 60 days after issuance as being untimely.

PART I

Section A. Limitations and Monitoring Requirements

1. Final Effluent Limitations, Monitoring Point 001A

During the period beginning on the effective date of this permit and lasting until the expiration date of this permit, the permittee is authorized to discharge treated municipal wastewater from Monitoring Point 001A through Outfall 001. Outfall 001 discharges to the Boardman River at Latitude 44.75744, Longitude -85.62429. Such discharge shall be limited and monitored by the permittee as specified below.

	Maximum Limits for Quantity or Loading				Maximum Limits for Quality or Concentration					
Parameter	**Monthly**	**7-Day**	**Daily**	**Units**	**Monthly**	**7-Day**	**Daily**	**Units**	**Monitoring Frequency**	**Sample Type**
Flow	(report)	---	(report)	MGD	---		---	---	Daily	Report Total Daily Flow
Carbonaceous Biochemical Oxygen Demand (CBOD5)	1800	2800	(report)	lbs/day	25	40	(report)	mg/l	3xWeekly	24-Hr Composite
Total Suspended Solids (TSS)	2100	3200	(report)	lbs/day	30	45	(report)	mg/l	3xWeekly	24-Hr Composite
Ammonia Nitrogen (as N)										
May – September	780	---	(report)	lbs/day	11	---	(report)	mg/l	3xWeekly	24-Hr Composite
Total Phosphorus (as P)	35	---	(report)	lbs/day	0.5	---	(report)	mg/l	3x Weekly	24-Hr Composite
Fecal Coliform Bacteria	---	---	---	---	200	400	(report)	cts/100 ml	3xWeekly	Grab
Total Copper	5.0	---	(report)	lbs/day	70	---	(report)	ug/l	Monthly	24-Hr Composite
Total Mercury										
Corrected	(report)	---	(report)	lbs/day	(report)	---	(report)	ng/l	Quarterly	Calculation
Uncorrected	---	---	---	---	---	---	(report)	ng/l	Quarterly	Grab
Field Duplicate	---	---	---	---	---	---	(report)	ng/l	Quarterly	Grab
Field Blank	---	---	---	---	---	---	(report)	ng/l	Quarterly	Preparation
Laboratory Method Blank	---	---	---	---	---	---	(report)	ng/l	Quarterly	Preparation
					Minimum % Monthly		**Minimum % Daily**			
CBOD5 Minimum % Removal	---	---	---	---	85	---	(report)	%	Monthly	Calculation
TSS Minimum % Removal	---	---	---	---	85	---	(report)	%	Monthly	Calculation
					Minimum Daily		**Maximum Daily**			
pH	---		---	---	6.5	---	9.0	S.U.	3XWeekly	Grab
Dissolved Oxygen										
June – August	--	---	---	---	6.0	---	---	mg/l	3xWeekly	Grab
September – May	--	---	---	---	4.0	---	---	mg/l	3xWeekly	Grab

PART I

Section A. Limitations and Monitoring Requirements

The following design flow was used in determining the above limitations, but is not to be considered a limitation or actual capacity: 8.5 MGD

a. Narrative Standard
The receiving water shall contain no turbidity, color, oil films, floating solids, foams, settleable solids, or deposits as a result of this discharge in unnatural quantities which are or may become injurious to any designated use.

b. Sampling Locations
Samples for CBOD5, Total Suspended Solids, Ammonia Nitrogen, Total Phosphorus, Total Mercury, and Total Copper shall be taken prior to disinfection. Samples for Dissolved Oxygen, Fecal Coliform Bacteria, and pH shall be taken after disinfection. The Department may approve alternate sampling locations that are demonstrated by the permittee to be representative of the effluent.

c. Quarterly Monitoring
Quarterly samples shall be taken during the months of January, April, July, and October. If the facility does not discharge during these months, the permittee shall sample the next discharge occurring during the period in question. If the facility does not discharge during the period in question, a sample is not required for that period. For any month in which a sample is not taken, the permittee shall enter "*G" on the Discharge Monitoring Report (DMR). (For purposes of reporting on the Daily tab of the DMR, the permittee shall enter “*G” on the first day of the month only).

d. Ultraviolet Disinfection
It is understood that ultraviolet light will be used to achieve compliance with the fecal coliform limitations. If disinfection other than ultraviolet light will be used, the permittee shall notify the Department in accordance with Part II.C.12. of this permit.

e. Percent Removal Requirements
Monthly percent removal shall be calculated based on the monthly average CBOD5 and TSS concentrations and the monthly average influent concentrations for approximately the same period. Daily percent removal shall be calculated based on the daily effluent CBOD5 and TSS concentrations and the daily influent concentrations for the same day. Reporting of Daily percent removal is only required on days on which an influent sample is obtained.

f. Monitoring Frequency Reduction for Total Copper
After the submittal of 24 months of data, the permittee may request, in writing, Department approval for a reduction in monitoring frequency for Total Copper. This request shall contain an explanation as to why the reduced monitoring is appropriate. Upon receipt of written approval and consistent with such approval, the permittee may reduce the monitoring frequency indicated in Part I.A.1. of this permit. The monitoring frequency for Total Copper shall not be reduced to less than annually. The Department may revoke the approval for reduced monitoring at any time upon notification to the permittee.

g. Total Mercury Testing and Additional Reporting Requirements
The analytical protocol for total mercury shall be in accordance with EPA Method 1631, Revision E, "Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry," EPA-821-R-02-019, August 2002. The quantification level for total mercury shall be 0.5 ng/l, unless a higher level is appropriate because of sample matrix interference. Justification for higher quantification levels shall be submitted to the Department within 30 days of such determination.

The use of clean technique sampling procedures is required unless the permittee can demonstrate to the Department that an alternate sampling procedure is representative of the discharge. Guidance for clean technique sampling is contained in EPA Method 1669, “Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels (Sampling Guidance),” EPA-821-R96-001, July 1996. Information

PART I

Section A. Limitations and Monitoring Requirements

and data documenting the permittee's sampling and analytical protocols and data acceptability shall be submitted to the Department upon request.

In order to demonstrate compliance with EPA Method 1631E and EPA Method 1669, the permittee shall report, on the daily sheet, the analytical results of all field blanks and field duplicates collected in conjunction with each sampling event, as well as laboratory method blanks when used for blank correction. The permittee shall collect at least one (1) field blank and at least one (1) field duplicate per sampling event. If more than ten (10) samples are collected during a sampling event, the permittee shall collect at least one (1) additional field blank AND field duplicate for every ten (10) samples collected. Only field blanks or laboratory method blanks may be used to calculate a concentration lower than the actual sample analytical results (i.e., a blank correction). Only one (1) blank (field OR laboratory method) may be used for blank correction of a given sample result, and only if the blank meets the quality control acceptance criteria. If blank correction is not performed on a given sample analytical result, the permittee shall report under "Total Mercury – Corrected" the same value reported under "Total Mercury – Uncorrected." The field duplicate is for quality control purposes only; its analytical result shall not be averaged with the sample result.

The Department will review the mercury monitoring data using the reasonable potential process described in R 323.1211 of the Michigan Administrative Code to determine if there is a reasonable potential for the Water Quality Standard of 1.3 ng/l of total mercury to be exceeded in the effluent. If it is determined that the effluent has a reasonable potential to exceed 1.3 ng/l of total mercury, upon written notification by the Department, the permittee shall commence development and implementation of the Pollutant Minimization Program for Total Mercury contained in Part I.A.4. of this permit. If, at any time during the life of the permit, the final effluent concentration exceeds 5 ng/l, the permittee shall notify the Department at the time of its next regular monthly monitoring report and shall commence development and implementation of the Pollutant Minimization Program for Total Mercury contained in Part I.A.4. of this permit.

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Section A. Limitations and Monitoring Requirements

2. Quantification Levels and Analytical Methods for Selected Parameters

Maximum acceptable quantification levels (QLs) are specified for selected parameters in the table below. These QLs shall be considered the maximum acceptable unless a higher QL is appropriate because of sample matrix interference. Justification for higher QLs shall be submitted to the Department within 30 days of such determination. Where necessary to help ensure that the QLs specified can be achieved, analytical methods may also be specified in the table below. The sampling procedures, preservation and handling, and analytical protocol for all monitoring conducted in compliance with this permit, including monitoring conducted to meet the requirements of the application for permit reissuance, shall be in accordance with the methods specified in the table below, or in accordance with Part II.B.2. of this permit if no method is specified in the table below, unless an alternate method is approved by the Department. **Not all QLs are expressed in the same units in the table below**. The table is continued on the following page:

Parameter	QL	Units	Analytical Method
1,2-Diphenylhydrazine (as Azobenzene)	3.0	ug/l	
2,4,6-Trichlorophenol	5.0	ug/l	
2,4-Dinitrophenol	19	ug/l	
3,3’-Dichlorobenzidine	1.5	ug/l	EPA Method 605
4-Chloro-3-Methylphenol	7.0	ug/l	
4,4’-DDD	0.01	ug/l	EPA Method 608
4,4’-DDE	0.01	ug/l	EPA Method 608
4,4’-DDT	0.01	ug/l	EPA Method 608
Acrylonitrile	1.0	ug/l	
Aldrin	0.01	ug/l	EPA Method 608
Alpha-Endosulfan	0.01	ug/l	EPA Method 608
Alpha-Hexachlorocyclohexane	0.01	ug/l	EPA Method 608
Antimony, Total	1	ug/l	
Arsenic, Total	1	ug/l	
Barium, Total	5	ug/l	
Benzidine	0.1	ug/l	EPA Method 605
Beryllium, Total	1	ug/l	
Beta-Endosulfan	0.01	ug/l	EPA Method 608
Beta-Hexachlorocyclohexane	0.01	ug/l	EPA Method 608
Bis (2-Chloroethyl) Ether	1.0	ug/l	
Bis (2-Ethylhexyl) Phthalate	5.0	ug/l	
Boron, Total	20	ug/l	
Cadmium, Total	0.2	ug/l	
Chlordane	0.01	ug/l	EPA Method 608
Chloride	1.0	mg/l	
Chromium, Hexavalent	5	ug/l	
Chromium, Total	10	ug/l	
Copper, Total	1	ug/l	
Cyanide, Available	2	ug/l	EPA Method OIA 1677
Cyanide, Total	5	ug/l	
Delta-Hexachlorocyclohexane	0.01	ug/l	EPA Method 608

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Section A. Limitations and Monitoring Requirements

Parameter	QL	Units	Analytical Method
Dieldrin	0.01	ug/l	EPA Method 608
Di-N-Butyl Phthalate	9.0	ug/l	
Endosulfan Sulfate	0.01	ug/l	EPA Method 608
Endrin	0.01	ug/l	EPA Method 608
Endrin Aldehyde	0.01	ug/l	EPA Method 608
Fluoranthene	1.0	ug/l	
Heptachlor	0.01	ug/l	EPA Method 608
Heptachlor Epoxide	0.01	ug/l	EPA Method 608
Hexachlorobenzene	0.01	ug/l	EPA Method 612
Hexachlorobutadiene	0.01	ug/l	EPA Method 612
Hexachlorocyclopentadiene	0.01	ug/l	EPA Method 612
Hexachloroethane	5.0	ug/l	
Lead, Total	1	ug/l	
Lindane	0.01	ug/l	EPA Method 608
Lithium, Total	10	ug/l	
Mercury, Total	0.5	ng/l	EPA Method 1631E
Nickel, Total	5	ug/l	
PCB-1016	0.1	ug/l	EPA Method 608
PCB-1221	0.1	ug/l	EPA Method 608
PCB-1232	0.1	ug/l	EPA Method 608
PCB-1242	0.1	ug/l	EPA Method 608
PCB-1248	0.1	ug/l	EPA Method 608
PCB-1254	0.1	ug/l	EPA Method 608
PCB-1260	0.1	ug/l	EPA Method 608
Pentachlorophenol	1.8	ug/l	
Perfluorooctane sulfonate (PFOS)	2.0	ng/l	ASTM D7979 or an isotope dilution method (sometimes referred to as Method 537 modified)
Perfluorooctanoic acid (PFOA)	0.002	ug/l	ASTM D7979 or an isotope dilution method (sometimes referred to as Method 537 modified)
Phenanthrene	1.0	ug/l	
Selenium, Total	1.0	ug/l	
Silver, Total	0.5	ug/l	
Strontium, Total	1000	ug/l	
Sulfate	2.0	mg/l	
Sulfides, Dissolved	20	ug/l	
Thallium, Total	1	ug/l	
Toxaphene	0.1	ug/l	EPA Method 608
Vinyl Chloride	1.0	ug/l	
Zinc, Total	10	ug/l	

PART I

Section A. Limitations and Monitoring Requirements

3. Additional Monitoring Requirements

As a condition of this permit, the permittee shall monitor the discharge from monitoring point 001 for the constituents listed below. This monitoring is an application requirement of 40 CFR 122.21(j), effective December 2, 1999. Testing shall be conducted in August 2021, May 2022, March 2023, and October 2023. Grab samples shall be collected for available cyanide, total phenols, and the Perfluoroalkyl and Polyfluoroalkyl Substances and Volatile Organic Compounds identified below. For all other parameters, 24-hour composite samples shall be collected.

Test species for whole effluent toxicity monitoring shall include fathead minnow **and** *Ceriodaphnia dubia,* for a total of four (4) tests on each species. Testing and reporting procedures shall follow procedures contained in EPA-821-R-02-013, “Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms” (Fourth Edition). When the effluent ammonia nitrogen (as N) concentration is greater than 3 mg/l, the pH of the toxicity test shall be maintained at a pH of 8 Standard Units. Acute and chronic toxicity data shall be included in the reporting for the toxicity test results. Toxicity test data acceptability is contingent upon the validation of the test method by the testing laboratory. Such validation shall be submitted to the Department upon request. The permittee shall report to the Department any whole effluent toxicity test results greater than 1.0 TU_A or 1.0 TU_C within five (5) days of becoming aware of the result.

The results of such additional monitoring shall be submitted with the application for reissuance (see the cover page of this permit for the application due date). The permittee shall notify the Department within 14 days of completing the monitoring for each month specified above in accordance with Part II.C.5. Additional reporting requirements are specified in Part II.C.11. If, upon review of the analysis, it is determined that additional requirements are needed to protect the receiving waters in accordance with applicable water quality standards, the permit may then be modified by the Department in accordance with applicable laws and rules.

Whole Effluent Toxicity

acute toxicity	chronic toxicity

Hardness

calcium carbonate

Perfluoroalkyl and Polyfluoroalkyl Substances

Perfluorooctane Sulfonate (PFOS)	Perfluorooctanoic Acid (PFOA)

Metals (Total Recoverable), Cyanide and Total Phenols

antimony	arsenic	available cyanide	zinc
beryllium	cadmium	chromium	
lead	thallium	nickel	
selenium	silver	total phenolic compounds	

Volatile Organic Compounds

acrolein	acrylonitrile	benzene	bromoform
carbon tetrachloride	chlorobenzene	chlorodibromomethane	chloroethane
2-chloroethylvinyl ether	chloroform	dichlorobromomethane	1,1-dichloroethane
1,2-dichloroethane	trans-1,2-dichloroethylene	1,1-dichloroethylene	1,2-dichloropropane
1,3-dichloropropylene	ethylbenzene	methyl bromide	methyl chloride
methylene chloride	1,1,2,2-tetrachloroethane	tetrachloroethylene	toluene
1,1,1-trichloroethane	1,1,2-trichloroethane	trichloroethylene	vinyl chloride

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Section A. Limitations and Monitoring Requirements

Acid-Extractable Compounds

4-chloro-3-methylphenol	2-chlorophenol	2,4-dichlorophenol	2,4-dimethylphenol
4,6-dinitro-o-cresol	2,4-dinitrophenol	2-nitrophenol	4-nitrophenol
Pentachlorophenol	phenol	2,4,6-trichlorophenol	

Base/Neutral Compounds

acenaphthene	acenaphthylene	anthracene	benzidine
benzo(a)anthracene	benzo(a)pyrene	3,4-benzofluoranthene	benzo(ghi)perylene
benzo(k)fluoranthene	bis(2-chloroethoxy)methane	bis(2-chloroethyl)ether	bis(2-chloroisopropyl)ether
bis(2-ethylhexyl)phthalate	4-bromophenyl phenyl ether	butyl benzyl phthalate	2-chloronaphthalene
4-chlorophenyl phenyl ether	chrysene	di-n-butyl phthalate	di-n-octyl phthalate
dibenzo(a,h)anthracene	1,2-dichlorobenzene	1,3-dichlorobenzene	1,4-dichlorobenzene
3,3'-dichlorobenzidine	diethyl phthalate	dimethyl phthalate	2,4-dinitrotoluene
2,6-dinitrotoluene	1,2-diphenylhydrazine	fluoranthene	fluorene
Hexachlorobenzene	hexachlorobutadiene	hexachlorocyclo-pentadiene	hexachloroethane
indeno(1,2,3-cd)pyrene	isophorone	naphthalene	nitrobenzene
n-nitrosodi-n-propylamine	n-nitrosodimethylamine	n-nitrosodiphenylamine	phenanthrene
pyrene	1,2,4-trichlorobenzene		

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Section A. Limitations and Monitoring Requirements

4. Pollutant Minimization Program for Total Mercury

This condition is required, upon written notification by the Department or if the permittee notifies the Department that the final effluent concentration of total mercury has exceeded 5 ng/l, as specified in Part I.A.1. The goal of the Pollutant Minimization Program is to maintain the effluent concentration of total mercury at or below 1.3 ng/l. Within 180 days of written notification by the Department or after the permittee notifies the Department that the final effluent concentration of total mercury has exceeded 5 ng/l, the permittee shall submit to the Department an approvable Pollutant Minimization Program for mercury designed to proceed toward the goal.

The Pollutant Minimization Program shall include the following:

a. an annual review and semi-annual monitoring of potential sources of mercury entering the wastewater collection system;

b. a program for quarterly monitoring of influent and periodic monitoring of sludge for mercury; and

c. implementation of reasonable, cost-effective control measures when sources of mercury are discovered. Factors to be considered include significance of sources, economic considerations, and technical and treatability considerations.

On or before March 31 of each year following approval of the Pollutant Minimization Program, the permittee shall submit a status report for the previous calendar year to the Department that includes 1) the monitoring results for the previous year, 2) an updated list of potential mercury sources, and 3) a summary of all actions taken to reduce or eliminate identified sources of mercury.

Any information generated as a result of the Pollutant Minimization Program set forth in this permit may be used to support a request to modify the approved program or to demonstrate that the Pollutant Minimization Program requirement has been completed satisfactorily.

A request for modification of the approved program and supporting documentation shall be submitted in writing to the Department for review and approval. The Department may approve modifications to the approved program (approval of a program modification does not require a permit modification), including a reduction in the frequency of the requirements under items a. and b. above.

This permit may be modified in accordance with applicable laws and rules to include additional mercury conditions and/or limitations as necessary.

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Section A. Limitations and Monitoring Requirements

5. Untreated or Partially Treated Sewage Discharge Reporting and Testing Requirements

In accordance with Section 324.3112a of the NREPA, if untreated or partially treated sewage is directly or indirectly discharged from a sewer system onto land or into the waters of the state, the permittee shall immediately, but not more than 24 hours after the discharge begins, notify local health departments, a daily newspaper of general circulation in the county in which the permittee is located, and a daily newspaper of general circulation in the county or counties in which the municipalities whose waters may be affected by the discharge are located, that the discharge is occurring. The permittee shall also notify the Department via its MiWaters system on the form entitled "Report of Discharge (CSO\SSO\RTB)." The MiWaters website is located at https://miwaters.deq.state.mi.us. At the conclusion of the discharge, the permittee shall make all such notifications specified in, and in accordance with, Section 324.3112a of the NREPA, and shall notify the Department via its MiWaters system on the form entitled "Report of Discharge (CSO\SSO\RTB)."

The permittee shall also annually contact municipalities, including the superintendent of a public drinking water supply with potentially affected intakes, whose waters may be affected by the permittee's discharge of untreated or partially treated sewage, and if those municipalities wish to be notified in the same manner as specified above, the permittee shall provide such notification.

Additionally, in accordance with Section 324.3112a of the NREPA, each time a discharge of untreated or partially treated sewage occurs, the permittee shall test the affected waters for *Escherichia coli* to assess the risk to the public health as a result of the discharge and shall provide the test results to the affected local county health departments and to the Department. The results of this testing shall be submitted to the Department via MiWaters as part of the notification specified above, or, if the results are not yet available, submitted as soon as they become available. This testing is not required if it has been waived by the local health department, or if the discharge(s) did not affect surface waters. The testing shall be done at locations specified by each affected local county health department but shall not exceed 10 tests for each separate discharge event. The affected local county health department may waive this testing requirement if it determines that such testing is not needed to assess the risk to the public health as a result of the discharge event.

Permittees accepting sanitary or municipal sewage from other sewage collection systems are encouraged to notify the owners of those systems of the above reporting and testing requirements.

6. Facility Contact

The "Facility Contact" was specified in the application. The permittee may replace the facility contact at any time and shall notify the Department in writing <u>within 10 days</u> after replacement (including the name, address and telephone number of the new facility contact).

a. The facility contact shall be (or a duly authorized representative of this person):
   - for a corporation, a principal executive officer of at least the level of vice president; or a designated representative if the representative is responsible for the overall operation of the facility from which the discharge originates, as described in the permit application or other NPDES form,
   - for a partnership, a general partner,
   - for a sole proprietorship, the proprietor, or
   - for a municipal, state, or other public facility, either a principal executive officer, the mayor, village president, city or village manager or other duly authorized employee.

PART I

Section A. Limitations and Monitoring Requirements

b. A person is a duly authorized representative only if:
- the authorization is made in writing to the Department by a person described in paragraph a. of this section; and
- the authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the facility (a duly authorized representative may thus be either a named individual or any individual occupying a named position).

Nothing in this section releases the permittee from properly submitting reports and forms as required by law.

7. Monthly Operating Reports

Part 41 of Act 451 of 1994 as amended, specifically Section 324.4106 and associated R 299.2953, requires that the permittee file with the Department, on forms prescribed by the Department, operating reports showing the effectiveness of the treatment facility operation and the quantity and quality of liquid wastes discharged into waters of the state.

Within 30 days of the effective date of this permit, the permittee shall submit to the Department a revised treatment facility monitoring program to address monitoring requirement changes reflected in this permit, or submit justification explaining why monitoring requirement changes reflected in this permit do not necessitate revisions to the treatment facility monitoring program. The permittee shall implement the revised treatment facility monitoring program upon approval from the Department. Applicable forms and guidance are available on the Department's web site at https://www.michigan.gov/egle/0,9429,7-135-3313_71618_44117---,00.html. The permittee may use alternate forms if they are consistent with the approved treatment facility monitoring program. Unless the Department provides written notification to the permittee that monthly submittal of operating reports is required, operating reports that result from implementation of the approved treatment facility monitoring program shall be maintained on site for a minimum of three (3) years and shall be made available to the Department for review upon request.

PART I

Section A. Limitations and Monitoring Requirements

8. Asset Management

The permittee shall at all times properly operate and maintain all facilities (i.e., the sewer system and treatment works as defined in Part 41 of the NREPA), and control systems installed or used by the permittee to operate the sewer system and treatment works and achieve and maintain compliance with the conditions of this permit (also see Part II.D.3 of this permit). The requirements of an Asset Management Program function to achieve the goals of effective performance, adequate funding, and adequate operator staffing and training. Asset management is a planning process for ensuring that optimum value is gained for each asset and that financial resources are available to rehabilitate and replace those assets when necessary. Asset management is centered on a framework of five (5) core elements: the current state of the assets; the required sustainable level of service; the assets critical to sustained performance; the minimum life-cycle costs; and the best long-term funding strategy.

a. Asset Management Program Requirements
The permittee shall continue to implement the Asset Management Plan approved on February 8, 2019, and approved modifications thereto. The Asset Management Plan contains a schedule for the development and implementation of an Asset Management Program that meets the requirements outlined below in 1) – 4):

1) *Maintenance Staff.* The permittee shall provide an adequate staff to carry out the operation, maintenance, repair, and testing functions required to ensure compliance with the terms and conditions of this permit. The level of staffing needed shall be determined by taking into account the work involved in operating the sewer system and treatment works, planning for and conducting maintenance, and complying with this permit.

2) *Collection System Map.* The permittee shall complete a map of the sewer collection system it owns and operates. The map shall be of sufficient detail and at a scale to allow easy interpretation. The collection system information shown on the map shall be based on current conditions and shall be kept up-to-date and available for review by the Department. **Note: Items below referencing combined sewer systems are not applicable to separate sewer systems.** Such map(s) shall include but not be limited to the following:

a) all sanitary sewer lines and related manholes;

b) all combined sewer lines, related manholes, catch basins and CSO regulators;

c) all known or suspected connections between the sanitary sewer or combined sewer and storm drain systems;

d) all outfalls, including the treatment plant outfall(s), combined sewer treatment facility outfalls, untreated CSOs, and any known SSOs;

e) all pump stations and force mains;

f) the wastewater treatment facility(ies), including all treatment processes;

g) all surface waters (labeled);

h) other major appurtenances such as inverted siphons and air release valves;

i) a numbering system which uniquely identifies manholes, catch basins, overflow points, regulators and outfalls;

PART I

Section A. Limitations and Monitoring Requirements

j) the scale and a north arrow;

k) the pipe diameter, date of installation, type of material, distance between manholes, and the direction of flow; and

l) the manhole interior material, rim elevation (optional), and invert elevations.

3) *Inventory and assessment of fixed assets.* The permittee shall complete an inventory and assessment of operations-related fixed assets including portions of the collection system owned and operated by the permittee. Fixed assets are assets that are normally stationary (e.g., pumps, blowers, buildings, manholes, and sewer lines). The inventory and assessment shall be based on current conditions and shall be kept up-to-date and available for review by the Department.

a) The fixed asset inventory shall include the following:

(1) a brief description of the fixed asset, its design capacity (e.g., pump: 120 gallons per minute), its level of redundancy, and its tag number if applicable;

(2) the location of the fixed asset;

(3) the year the fixed asset was installed;

(4) the present condition of the fixed asset (e.g., excellent, good, fair, poor); and

(5) the current fixed asset (replacement) cost in dollars for year specified in accordance with approved schedules;

b) The fixed asset assessment shall include a "Business Risk Evaluation" that combines the probability of failure of the fixed asset and the criticality of the fixed asset, as follows:

(1) Rate the probability of failure of the fixed asset on a scale of 1-5 (low to high) using criteria such as maintenance history, failure history, and remaining percentage of useful life (or years remaining);

(2) Rate the criticality of the fixed asset on a scale of 1-5 (low to high) based on the consequence of failure versus the desired level of service for the facility; and

(3) Compute the Business Risk Factor of the fixed asset by multiplying the failure rating from (1) by the criticality rating from (2).

4) *Operation, Maintenance & Replacement (OM&R) Budget and Rate Sufficiency for the Sewer System and Treatment Works.* The permittee shall complete an assessment of its user rates and replacement fund, including the following:

a) beginning and end dates of fiscal year;

b) name of the department, committee, board, or other organization that sets rates for the operation of the sewer system and treatment works;

c) amount in the permittee's replacement fund in dollars for year specified in accordance with approved schedules;

d) replacement fund strategy of all assets with a useful life of 20 years or less;

PART I

Section A. Limitations and Monitoring Requirements

e) expenditures for maintenance, corrective action and capital improvement taken during the fiscal year;

f) OM&R budget for the fiscal year; and

g) rate calculation demonstrating sufficient revenues to cover OM&R expenses. If the rate calculation shows there are insufficient revenues to cover OM&R expenses, the permittee shall document, within three (3) fiscal years after submittal of the Asset Management Plan, that there is at least one rate adjustment that reduces the revenue gap by at least 10 percent. The permittee may prepare and submit an alternate plan, subject to Department approval, for addressing the revenue gap. The ultimate goal of the Asset Management Program is to ensure sufficient revenues to cover OM&R expenses.

b. Annual Reporting
The permittee shall develop a written report that summarizes asset management activities completed during the previous year and planned for the upcoming year. The written report shall be submitted to the Department on or before July 30th of each year. The written report shall include:

1) a description of the staffing levels maintained during the year;

2) a description of inspections and maintenance activities conducted and corrective actions taken during the previous year;

3) expenditures for collection system maintenance activities, treatment works maintenance activities, corrective actions, and capital improvement during the previous year;

4) a summary of assets/areas identified for inspection/action (including capital improvement) in the upcoming year based on the five (5) core elements and the Business Risk Factors computed in accordance with condition a.3)b)(3) above;

5) a maintenance budget and capital improvement budget for the upcoming year that take into account implementation of an effective Asset Management Program that meets the five (5) core elements;

6) an updated asset inventory based on the original submission; and

7) an updated OM&R budget with an updated rate schedule that includes the amount of insufficient revenues, if any.

PART I

Section A. Limitations and Monitoring Requirements

9. Discharge Monitoring Report – Quality Assurance Study Program

The permittee shall participate in the Discharge Monitoring Report – Quality Assurance (DMR-QA) Study Program. The purpose of the DMR-QA Study Program is to annually evaluate the proficiency of all in-house and/or contract laboratory(ies) that perform, on behalf of the facility authorized to discharge under this permit, the analytical testing required under this permit. In accordance with Section 308 of the Clean Water Act (33 U.S.C. § 1318); and R 323.2138 and R 323.2154 of Part 21, Wastewater Discharge Permits, promulgated under Part 31 of the NREPA, participation in the DMR-QA Study Program is required for all major facilities, and for minor facilities selected for participation by the Department.

Annually and in accordance with DMR-QA Study Program requirements and submittal due dates, the permittee shall submit to the Michigan DMR-QA Study Program state coordinator all documentation required by the DMR-QA Study. DMR-QA Study Program participation is required only for the analytes required under this permit and only when those analytes are also identified in the DMR-QA Study.

If the permitted facility's status as a major facility should change, participation in the DMR-QA Study Program may be reevaluated. Questions concerning participation in the DMR-QA Study Program should be directed to the Michigan DMR-QA Study Program state coordinator.

All forms and instructions required for participation in the DMR-QA Study Program, including submittal due dates and state coordinator contact information, can be found at http://www.epa.gov/compliance/discharge-monitoring-report-quality-assurance-study-program.

10. Continuous Monitoring

If continuous monitoring equipment is used and becomes temporarily inoperable, the permittee shall manually obtain a minimum of three (3) equally spaced grab samples/readings within each 24-hour period for the affected parameter(s). On such days, in the comment field on the Daily tab of the DMR, the permittee shall indicate "continuous monitoring system inoperable," the date on which the system is expected to become operable again, and the number of samples/readings obtained during each 24-hour period.

Section B. Storm Water Pollution Prevention

Section B. Storm Water Pollution Prevention is not required for this permit.

PART I

Section C. Industrial Waste Pretreatment Program

1. Federal Industrial Pretreatment Program

a. The permittee shall implement the Federal Industrial Pretreatment Program (FIPP) approved on July 23, 1985, and any subsequent modifications approved up to the issuance of this permit. Approval of substantial program modifications after the issuance of this permit shall be incorporated into this permit by minor modification in accordance with 40 CFR 122.63.

b. The permittee shall comply with R 323.2301 through R 323.2317 of the Michigan Administrative Code (Part 23 Rules), the General Pretreatment Regulations for Existing and New Sources of Pollution (40 CFR Part 403), and the approved FIPP.

c. The permittee shall have the legal authority and necessary interjurisdictional agreements that provide the basis for the implementation and enforcement of the approved FIPP throughout the service area. The legal authority and necessary interjurisdictional agreements shall include, at a minimum, the authority to carry out the activities specified in R 323.2306(a).

d. The permittee shall develop procedures which describe, in sufficient detail, program commitments which enable implementation of the approved FIPP, 40 CFR Part 403, and the Part 23 Rules in accordance with R 323.2306(c).

e. The permittee shall establish an interjurisdictional agreement (or comparable document) with all tributary governmental jurisdictions. Each interjurisdictional agreement shall contain, at a minimum, the following:

1) identification of the agency responsible for the implementation and enforcement of the approved FIPP within the tributary governmental jurisdiction's boundaries; and

2) the provision of the legal authority which provides the basis for the implementation and enforcement of the approved FIPP within the tributary governmental jurisdiction's boundaries.

f. The permittee shall prohibit discharges that:

1) cause, in whole or in part, the permittee's failure to comply with any condition of this permit or the NREPA;

2) restrict, in whole or in part, the permittee's management of biosolids;

3) cause, in whole or in part, operational problems at the treatment facility or in its collection system;

4) violate any of the general or specific prohibitions identified in R 323.2303(1) and (2);

5) violate categorical standards identified in R 323.2311; and

6) violate local limits established in accordance with R 323.2303(4).

g. The permittee shall maintain a list of its nondomestic users that meet the criteria of a significant industrial user as identified in R 323.2302(cc).

h. The permittee shall develop an enforcement response plan which describes, in sufficient detail, program commitments which will enable the enforcement of the approved FIPP, 40 CFR Part 403, and the Part 23 Rules in accordance with R 323.2306(g).

PART I

Section C. Industrial Waste Pretreatment Program

i. The Department may require modifications to the approved FIPP which are necessary to ensure compliance with 40 CFR Part 403 and the Part 23 Rules in accordance with R 323.2309.

j. The permittee shall not implement changes or modifications to the approved FIPP without notification to the Department. Any substantial modification shall be subject to Department public noticing and approval in accordance with R 323.2309.

k. The permittee shall maintain an adequate revenue structure and staffing level for effective implementation of the approved FIPP.

l. The permittee shall develop and maintain, for a minimum of three (3) years, all records and information necessary to determine nondomestic user compliance with 40 CFR Part 403, Part 23 Rules and the approved FIPP. This period of retention shall be extended during the course of any unresolved enforcement action or litigation regarding a nondomestic user or when requested by the Department or the United States Environmental Protection Agency. All of the aforementioned records and information shall be made available upon request for inspection and copying by the Department and the United States Environmental Protection Agency.

m. The permittee shall evaluate the approved FIPP for compliance with the 40 CFR Part 403, Part 23 Rules and the prohibitions stated in item f. above. Based upon this evaluation, the permittee shall propose to the Department all necessary changes or modifications to the approved FIPP no later than the next Industrial Pretreatment Program Annual Report due date (see item p. below).

n. The permittee shall develop and enforce local limits to implement the prohibitions listed in item f above. Local limits shall be based upon data representative of actual conditions demonstrated in a maximum allowable headworks loading analysis. An evaluation of whether the existing local limits need to be revised shall be submitted to the Department by September 1, 2021. The submittal shall provide a technical evaluation of the basis upon which this determination was made which includes information regarding the maximum allowable headworks loading, collection system protection criteria, and worker health and safety, based upon data collected since the last local limits review.

The following pollutants shall be evaluated:

1) Arsenic, Cadmium, Chromium, Copper, Cyanide, Lead, Mercury, Nickel, Silver, and Zinc;

2) Pollutants that are subject to limits or monitoring in this permit;

3) Pollutants that have an existing local limit; and,

4) Other pollutants of concern which would reasonably be expected to be discharged or transported by truck or rail or otherwise introduced into the POTW.

PART I

Section C. Industrial Waste Pretreatment Program

o. The permittee is required under this permit and R 323.2303(4) of the Michigan Administrative Code to review and update their local limits when:

1) new pollutants are introduced;

2) new pollutants that were previously unevaluated are identified;

3) new water quality or biosolids standards are established or additional information becomes available about the nature of pollutants, such as removal rates and accumulation in biosolids; or

4) substantial increases of pollutants are proposed as required in the notification of new or increased uses in accordance with the provisions of 40 CFR 122.42.

p. On or before April 1 of each year, the permittee shall submit to the Department, as required by R 323.2310(8), an Industrial Pretreatment Program Annual Report on the status of program implementation and enforcement activities. The reporting period shall begin on January 1 and end on December 31. At a minimum, the Industrial Pretreatment Program Annual Report shall include:

1) the Pretreatment Program Reports data identified in Appendix A to 40 CFR Part 127 – NPDES Electronic Reporting;

2) a summary of changes to the approved FIPP that have not been previously reported to the Department;

3) a summary of results of all the sampling and analyses performed of the wastewater treatment plant's influent, effluent, and biosolids conducted in accordance with approved methods during the reporting period. The summary shall include the monthly average, daily maximum, quantification level, and number of samples analyzed for each pollutant. At a minimum, the results of analyses for all locally limited parameters for at least one monitoring event that tests influent, effluent and biosolids during the reporting period shall be submitted with each report, unless otherwise required by the Department. Sample collection shall be at intervals sufficient to provide pollutant removal rates, unless the pollutant is not measurable; and

4) any other relevant information requested by the Department.

PART I

Section D. Residuals Management Program

1. Residuals Management Program for Land Application of Biosolids

The permittee is authorized to land-apply bulk biosolids or prepare bulk biosolids for land application in accordance with the permittee's approved Residuals Management Program (RMP) approved on June 18, 2001, and approved modifications thereto, and the requirements established in R 323.2401 through R 323.2418 of the Michigan Administrative Code (Part 24 Rules). The approved RMP, and any approved modifications thereto, are enforceable requirements of this permit. Incineration, landfilling and other residual disposal activities shall be conducted in accordance with Part II.D.7. of this permit. The Part 24 Rules can be obtained via the internet (http://www.michigan.gov/egle/ and near the top of the screen click on Water, then towards the bottom right of the screen click on Permits, Wastewater, Biosolids, then click on Biosolids Laws and Rules Information which is under the Laws & Rules banner in the center of the screen).

a. Annual Report
On or before October 30 of each year, the permittee shall submit an annual report to the Department for the previous fiscal year of October 1 through September 30. The report shall be submitted electronically via the Department's MiWaters system at https://miwaters.deq.state.mi.us. At a minimum, the report shall contain:

1) a certification that current residuals management practices are in accordance with the approved RMP, or a proposal for modification to the approved RMP; and

2) a completed Annual Report Form for Reporting Biosolids, available at https://miwaters.deq.state.mi.us.

b. Modifications to the Approved RMP
Prior to implementation of modifications to the RMP, the permittee shall submit proposed modifications to the Department for approval. The approved modification shall become effective upon the date of approval. Upon written notification, the Department may impose additional requirements and/or limitations to the approved RMP as necessary to protect public health and the environment from any adverse effect of a pollutant in the biosolids.

c. Record Keeping
Records required by the Part 24 Rules shall be kept for a minimum of five (5) years. However, the records documenting cumulative loading for sites subject to cumulative pollutant loading rates shall be kept as long as the site receives biosolids.

d. Contact Information
RMP-related submittals shall be made to the Department.

PART II

Part II may include terms and /or conditions not applicable to discharges covered under this permit.

Section A. Definitions

Acute toxic unit (TU_A) means $100/LC_{50}$ where the LC_{50} is determined from a whole effluent toxicity (WET) test which produces a result that is statistically or graphically estimated to be lethal to 50% of the test organisms.

Annual monitoring frequency refers to a calendar year beginning on January 1 and ending on December 31. When required by this permit, an analytical result, reading, value or observation shall be reported for that period if a discharge occurs during that period.

Authorized public agency means a state, local, or county agency that is designated pursuant to the provisions of Section 9110 of Part 91, Soil and Sedimentation Control, of the NREPA, to implement soil erosion and sedimentation control requirements with regard to construction activities undertaken by that agency.

Best management practices (BMPs) means structural devices or nonstructural practices that are designed to prevent pollutants from entering into storm water, to direct the flow of storm water, or to treat polluted storm water.

Bioaccumulative chemical of concern (BCC) means a chemical which, upon entering the surface waters, by itself or as its toxic transformation product, accumulates in aquatic organisms by a human health bioaccumulation factor of more than 1000 after considering metabolism and other physiochemical properties that might enhance or inhibit bioaccumulation. The human health bioaccumulation factor shall be derived according to R 323.1057(5). Chemicals with half-lives of less than 8 weeks in the water column, sediment, and biota are not BCCs. The minimum bioaccumulation concentration factor (BAF) information needed to define an organic chemical as a BCC is either a field-measured BAF or a BAF derived using the biota-sediment accumulation factor (BSAF) methodology. The minimum BAF information needed to define an inorganic chemical as a BCC, including an organometal, is either a field-measured BAF or a laboratory-measured bioconcentration factor (BCF). The BCCs to which these rules apply are identified in Table 5 of R 323.1057 of the Water Quality Standards.

Biosolids are the solid, semisolid, or liquid residues generated during the treatment of sanitary sewage or domestic sewage in a treatment works. This includes, but is not limited to, scum or solids removed in primary, secondary, or advanced wastewater treatment processes and a derivative of the removed scum or solids.

Bulk biosolids means biosolids that are not sold or given away in a bag or other container for application to a lawn or home garden.

Certificate of Coverage (COC) is a document, issued by the Department, which authorizes a discharge under a general permit.

Chronic toxic unit (TU_C) means 100/MATC or $100/IC_{25}$, where the maximum acceptable toxicant concentration (MATC) and IC_{25} are expressed as a percent effluent in the test medium.

Class B biosolids refers to material that has met the Class B pathogen reduction requirements or equivalent treatment by a Process to Significantly Reduce Pathogens (PSRP) in accordance with the Part 24 Rules, Land Application of Biosolids, promulgated under Part 31 of the NREPA. Processes include aerobic digestion, composting, anaerobic digestion, lime stabilization and air drying.

Combined sewer system is a sewer system in which storm water runoff is combined with sanitary wastes.

Continuous monitoring refers to sampling/readings that occur at regular and consistent intervals throughout a 24-hour period and at a frequency sufficient to capture data that are representative of the discharge. The maximum acceptable interval between samples/readings shall be one (1) hour.

PART II

Section A. Definitions

Daily concentration
FOR PARAMETERS OTHER THAN pH, DISSOLVED OXYGEN, TEMPERATURE, AND CONDUCTIVITY – Daily concentration is the sum of the concentrations of the individual samples of a parameter taken within a calendar day divided by the number of samples taken within that calendar day. The daily concentration will be used to determine compliance with any maximum and minimum daily concentration limitations. For guidance and examples showing how to perform calculations using results below quantification levels, see the document entitled "Reporting Results Below Quantification," available at https://www.michigan.gov/documents/deq/wrd-npdes-results-quantification_620791_7.pdf.

FOR pH, DISSOLVED OXYGEN, TEMPERATURE, AND CONDUCTIVITY – The daily concentration used to determine compliance with maximum daily pH, temperature, and conductivity limitations is the highest pH, temperature, and conductivity readings obtained within a calendar day. The daily concentration used to determine compliance with minimum daily pH and dissolved oxygen limitations is the lowest pH and dissolved oxygen readings obtained within a calendar day.

Daily loading is the total discharge by weight of a parameter discharged during any calendar day. This value is calculated by multiplying the daily concentration by the total daily flow and by the appropriate conversion factor. The daily loading will be used to determine compliance with any maximum daily loading limitations. When required by the permit, report the maximum calculated daily loading for the month in the "MAXIMUM" column under "QUANTITY OR LOADING" on the DMRs.

Daily monitoring frequency refers to a 24-hour day. When required by this permit, an analytical result, reading, value or observation shall be reported for that period if a discharge occurs during that period.

Department means the Michigan Department of Environment, Great Lakes, and Energy.

Detection level means the lowest concentration or amount of the target analyte that can be determined to be different from zero by a single measurement at a stated level of probability.

Discharge means the addition of any waste, waste effluent, wastewater, pollutant, or any combination thereof to any surface water of the state.

EC_{50} means a statistically or graphically estimated concentration that is expected to cause 1 or more specified effects in 50% of a group of organisms under specified conditions.

Fecal coliform bacteria monthly
FOR WWSLs THAT COLLECT AND STORE WASTEWATER AND ARE AUTHORIZED TO DISCHARGE ONLY IN THE SPRING AND/OR FALL ON AN INTERMITTENT BASIS – Fecal coliform bacteria monthly is the geometric mean of all daily concentrations determined during a discharge event. Days on which no daily concentration is determined shall not be used to determine the calculated monthly value. The calculated monthly value will be used to determine compliance with the maximum monthly fecal coliform bacteria limitations. When required by the permit, report the calculated monthly value in the "AVERAGE" column under "QUALITY OR CONCENTRATION" on the DMR. If the period in which the discharge event occurred was partially in each of two months, the calculated monthly value shall be reported on the DMR of the month in which the last day of discharge occurred.

FOR ALL OTHER DISCHARGES – Fecal coliform bacteria monthly is the geometric mean of all daily concentrations determined during a reporting month. Days on which no daily concentration is determined shall not be used to determine the calculated monthly value. The calculated monthly value will be used to determine compliance with the maximum monthly fecal coliform bacteria limitations. When required by the permit, report the calculated monthly value in the "AVERAGE" column under "QUALITY OR CONCENTRATION" on the DMR.

PART II

Section A. Definitions

Fecal coliform bacteria 7-day
FOR WWSLs THAT COLLECT AND STORE WASTEWATER AND ARE AUTHORIZED TO DISCHARGE ONLY IN THE SPRING AND/OR FALL ON AN INTERMITTENT BASIS – Fecal coliform bacteria 7-day is the geometric mean of the daily concentrations determined during any 7 consecutive days of discharge during a discharge event. If the number of daily concentrations determined during the discharge event is less than 7 days, the number of actual daily concentrations determined shall be used for the calculation. Days on which no daily concentration is determined shall not be used to determine the value. The calculated 7-day value will be used to determine compliance with the maximum 7-day fecal coliform bacteria limitations. When required by the permit, report the maximum calculated 7-day geometric mean value for the month in the "MAXIMUM" column under "QUALITY OR CONCENTRATION" on the DMRs. If the 7-day period was partially in each of two months, the value shall be reported on the DMR of the month in which the last day of discharge occurred.

FOR ALL OTHER DISCHARGES – Fecal coliform bacteria 7-day is the geometric mean of the daily concentrations determined during any 7 consecutive days in a reporting month. If the number of daily concentrations determined is less than 7, the actual number of daily concentrations determined shall be used for the calculation. Days on which no daily concentration is determined shall not be used to determine the value. The calculated 7-day value will be used to determine compliance with the maximum 7-day fecal coliform bacteria limitations. When required by the permit, report the maximum calculated 7-day geometric mean for the month in the "MAXIMUM" column under "QUALITY OR CONCENTRATION" on the DMRs. The first calculation shall be made on day 7 of the reporting month, and the last calculation shall be made on the last day of the reporting month.

Flow-proportioned sample is a composite sample with the sample volume proportional to the effluent flow.

General permit means an NPDES permit issued authorizing a category of similar discharges.

Geometric mean is the average of the logarithmic values of a base 10 data set, converted back to a base 10 number.

Grab sample is a single sample taken at neither a set time nor flow.

IC_{25} means the toxicant concentration that would cause a 25% reduction in a nonquantal biological measurement for the test population.

Illicit connection means a physical connection to a municipal separate storm sewer system that primarily conveys non-storm water discharges other than uncontaminated groundwater into the storm sewer; or a physical connection not authorized or permitted by the local authority, where a local authority requires authorization or a permit for physical connections.

Illicit discharge means any discharge to, or seepage into, a municipal separate storm sewer system that is not composed entirely of storm water or uncontaminated groundwater. Illicit discharges include non-storm water discharges through pipes or other physical connections; dumping of motor vehicle fluids, household hazardous wastes, domestic animal wastes, or litter; collection and intentional dumping of grass clippings or leaf litter; or unauthorized discharges of sewage, industrial waste, restaurant wastes, or any other non-storm water waste directly into a separate storm sewer.

Individual permit means a site-specific NPDES permit.

Inlet means a catch basin, roof drain, conduit, drain tile, retention pond riser pipe, sump pump, or other point where storm water or wastewater enters into a closed conveyance system prior to discharge off site or into waters of the state.

PART II

Section A. Definitions

Interference is a discharge which, alone or in conjunction with a discharge or discharges from other sources, both: 1) inhibits or disrupts a POTW, its treatment processes or operations, or its sludge processes, use or disposal; and 2) therefore, is a cause of a violation of any requirement of the POTW's NPDES permit (including an increase in the magnitude or duration of a violation) or, of the prevention of sewage sludge use or disposal in compliance with the following statutory provisions and regulations or permits issued thereunder (or more stringent state or local regulations): Section 405 of the Clean Water Act, the Solid Waste Disposal Act (SWDA) (including Title II, more commonly referred to as the Resource Conservation and Recovery Act (RCRA), and including state regulations contained in any state sludge management plan prepared pursuant to Subtitle D of the SWDA), the Clean Air Act, the Toxic Substances Control Act, and the Marine Protection, Research and Sanctuaries Act. [This definition does not apply to sample matrix interference].

Land application means spraying or spreading biosolids or a biosolids derivative onto the land surface, injecting below the land surface, or incorporating into the soil so that the biosolids or biosolids derivative can either condition the soil or fertilize crops or vegetation grown in the soil.

LC_{50} means a statistically or graphically estimated concentration that is expected to be lethal to 50% of a group of organisms under specified conditions.

Maximum acceptable toxicant concentration (MATC) means the concentration obtained by calculating the geometric mean of the lower and upper chronic limits from a chronic test. A lower chronic limit is the highest tested concentration that did not cause the occurrence of a specific adverse effect. An upper chronic limit is the lowest tested concentration which did cause the occurrence of a specific adverse effect and above which all tested concentrations caused such an occurrence.

Maximum extent practicable means implementation of best management practices by a public body to comply with an approved storm water management program as required by a national permit for a municipal separate storm sewer system, in a manner that is environmentally beneficial, technically feasible, and within the public body's legal authority.

MBTU/hr means million British Thermal Units per hour.

MGD means million gallons per day.

Monthly concentration is the sum of the daily concentrations determined during a reporting period divided by the number of daily concentrations determined. The calculated monthly concentration will be used to determine compliance with any maximum monthly concentration limitations. Days with no discharge shall not be used to determine the value. When required by the permit, report the calculated monthly concentration in the "AVERAGE" column under "QUALITY OR CONCENTRATION" on the DMR.

For minimum percent removal requirements, the monthly influent concentration and the monthly effluent concentration shall be determined. The calculated monthly percent removal, which is equal to 100 times the quantity [1 minus the quantity (monthly effluent concentration divided by the monthly influent concentration)], shall be reported in the "MINIMUM" column under "QUALITY OR CONCENTRATION" on the DMRs.

Monthly loading is the sum of the daily loadings of a parameter divided by the number of daily loadings determined during a reporting period. The calculated monthly loading will be used to determine compliance with any maximum monthly loading limitations. Days with no discharge shall not be used to determine the value. When required by the permit, report the calculated monthly loading in the "AVERAGE" column under "QUANTITY OR LOADING" on the DMR.

Monthly monitoring frequency refers to a calendar month. When required by this permit, an analytical result, reading, value or observation shall be reported for that period if a discharge occurs during that period.

PART II

Section A. Definitions

Municipal separate storm sewer means a conveyance or system of conveyances designed or used for collecting or conveying storm water which is not a combined sewer and which is not part of a POTW as defined in the Code of Federal Regulations at 40 CFR 122.2.
Municipal separate storm sewer system (MS4) means all separate storm sewers that are owned or operated by the United States, a state, city, village, township, county, district, association, or other public body created by or pursuant to state law, having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under state law, such as a sewer district, flood control district, or drainage district, or similar entity, or a designated or approved management agency under Section 208 of the Clean Water Act that discharges to the waters of the state. This term includes systems similar to separate storm sewer systems in municipalities, such as systems at military bases, large hospital or prison complexes, and highways and other thoroughfares. The term does not include separate storm sewers in very discrete areas, such as individual buildings.

National Pretreatment Standards are the regulations promulgated by or to be promulgated by the Federal Environmental Protection Agency pursuant to Section 307(b) and (c) of the Clean Water Act. The standards establish nationwide limits for specific industrial categories for discharge to a POTW.

No observed adverse effect level (NOAEL) means the highest tested dose or concentration of a substance which results in no observed adverse effect in exposed test organisms where higher doses or concentrations result in an adverse effect.

Noncontact cooling water is water used for cooling which does not come into direct contact with any raw material, intermediate product, by-product, waste product or finished product.

Nondomestic user is any discharger to a POTW that discharges wastes other than or in addition to water-carried wastes from toilet, kitchen, laundry, bathing or other facilities used for household purposes.

Nonstructural controls are practices or procedures implemented by employees at a facility to manage storm water or to prevent contamination of storm water.

NPDES means National Pollutant Discharge Elimination System.

Outfall is the location at which a point source discharge first enters a surface water of the state.

Part 91 agency means an agency that is designated by a county board of commissioners pursuant to the provisions of Section 9105 of Part 91 of the NREPA; an agency that is designated by a city, village, or township in accordance with the provisions of Section 9106 of Part 91 of the NREPA; or the Department for soil erosion and sedimentation control activities under Part 615, Supervisor of Wells; Part 631, Reclamation of Mining Lands; or Part 632, Nonferrous Metallic Mineral Mining, of the NREPA, pursuant to the provisions of Section 9115 of Part 91 of the NREPA.

Part 91 permit means a soil erosion and sedimentation control permit issued by a Part 91 agency pursuant to the provisions of Part 91 of the NREPA.

Partially treated sewage is any sewage, sewage and storm water, or sewage and wastewater, from domestic or industrial sources that is treated to a level less than that required by the permittee's NPDES permit, or that is not treated to national secondary treatment standards for wastewater, including discharges to surface waters from retention treatment facilities.

Point of discharge is the location of a point source discharge where storm water is discharged directly into a separate storm sewer system.

PART II

Section A. Definitions

Point source discharge means a discharge from any discernible, confined, discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, or rolling stock. Changing the surface of land or establishing grading patterns on land will result in a point source discharge where the runoff from the site is ultimately discharged to waters of the state.

Polluting material means any material, in solid or liquid form, identified as a polluting material under the Part 5 Rules, Spillage of Oil and Polluting Materials, promulgated under Part 31 of the NREPA (R 324.2001 through R 324.2009 of the Michigan Administrative Code).

POTW is a publicly owned treatment work.

Predevelopment is the last land use prior to the planned new development or redevelopment.

Pretreatment is reducing the amount of pollutants, eliminating pollutants, or altering the nature of pollutant properties to a less harmful state prior to discharge into a public sewer. The reduction or alteration can be by physical, chemical, or biological processes, process changes, or by other means. Dilution is not considered pretreatment unless expressly authorized by an applicable National Pretreatment Standard for a particular industrial category.

Public (as used in the MS4 individual permit) means all persons who potentially could affect the authorized storm water discharges, including, but not limited to, residents, visitors to the area, public employees, businesses, industries, and construction contractors and developers.

Public body means the United States; the state of Michigan; a city, village, township, county, school district, public college or university, or single-purpose governmental agency; or any other body which is created by federal or state statute or law.

Qualified Personnel means an individual who meets qualifications acceptable to the Department and who is authorized by an Industrial Storm Water Certified Operator to collect the storm water sample.

Qualifying storm event means a storm event causing greater than 0.1 inch of rainfall and occurring at least 72 hours after the previous measurable storm event that also caused greater than 0.1 inch of rainfall. Upon request, the Department may approve an alternate definition meeting the condition of a qualifying storm event.

Quantification level means the measurement of the concentration of a contaminant obtained by using a specified laboratory procedure calculated at a specified concentration above the detection level. It is considered the lowest concentration at which a particular contaminant can be quantitatively measured using a specified laboratory procedure for monitoring of the contaminant.

Quarterly monitoring frequency refers to a three month period, defined as January through March, April through June, July through September, and October through December. When required by this permit, an analytical result, reading, value or observation shall be reported for that period if a discharge occurs during that period.

Regional Administrator is the Region 5 Administrator, U.S. EPA, located at R-19J, 77 W. Jackson Blvd., Chicago, Illinois 60604.

Regulated area means the permittee's urbanized area, where urbanized area is defined as a place and its adjacent densely-populated territory that together have a minimum population of 50,000 people as defined by the United States Bureau of the Census and as determined by the latest available decennial census.

PART II

Section A. Definitions

Secondary containment structure means a unit, other than the primary container, in which significant materials are packaged or held, which is required by state or federal law to prevent the escape of significant materials by gravity into sewers, drains, or otherwise directly or indirectly into any sewer system or to the surface waters or groundwaters of the state.

Separate storm sewer system means a system of drainage, including, but not limited to, roads, catch basins, curbs, gutters, parking lots, ditches, conduits, pumping devices, or man-made channels, which is not a combined sewer where storm water mixes with sanitary wastes, and is not part of a POTW.

Significant industrial user is a nondomestic user that: 1) is subject to Categorical Pretreatment Standards under 40 CFR 403.6 and 40 CFR Chapter I, Subchapter N; or 2) discharges an average of 25,000 gallons per day or more of process wastewater to a POTW (excluding sanitary, noncontact cooling and boiler blowdown wastewater); contributes a process waste stream which makes up five (5) percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant; or is designated as such by the permittee as defined in 40 CFR 403.12(a) on the basis that the industrial user has a reasonable potential for adversely affecting the POTW's treatment plant operation or violating any pretreatment standard or requirement (in accordance with 40 CFR 403.8(f)(6)).

Significant materials means any material which could degrade or impair water quality, including but not limited to: raw materials; fuels; solvents, detergents, and plastic pellets; finished materials such as metallic products; hazardous substances designated under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (see 40 CFR 372.65); any chemical the facility is required to report pursuant to Section 313 of Emergency Planning and Community Right-to-Know Act (EPCRA); polluting materials as identified under the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code); Hazardous Wastes as defined in Part 111, Hazardous Waste Management, of the NREPA; fertilizers; pesticides; and waste products such as ashes, slag, and sludge that have the potential to be released with storm water discharges.

Significant spills and significant leaks means any release of a polluting material reportable under the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code).

Special-use area means storm water discharges for which the Department has determined that additional monitoring is needed from: secondary containment structures required by state or federal law; lands on Michigan’s List of Sites of Environmental Contamination pursuant to Part 201, Environmental Remediation, of the NREPA; and/or areas with other activities that may contribute pollutants to the storm water.

Stoichiometric means the quantity of a reagent calculated to be necessary and sufficient for a given chemical reaction.

Storm water means storm water runoff, snow melt runoff, surface runoff and drainage, and non-storm water included under the conditions of this permit.

Storm water discharge point is the location where the point source discharge of storm water is directed to surface waters of the state or to a separate storm sewer. It includes the location of all point source discharges where storm water exits the facility, including *outfalls* which discharge directly to surface waters of the state, and *points of discharge* which discharge directly into separate storm sewer systems.

Structural controls are physical features or structures used at a facility to manage or treat storm water.

SWPPP means the Storm Water Pollution Prevention Plan prepared in accordance with this permit.

PART II

Section A. Definitions

Tier I value means a value for aquatic life, human health or wildlife calculated under R 323.1057 of the Water Quality Standards using a tier I toxicity database.

Tier II value means a value for aquatic life, human health or wildlife calculated under R 323.1057 of the Water Quality Standards using a tier II toxicity database.

Total maximum daily loads (TMDLs) are required by the Clean Water Act for waterbodies that do not meet water quality standards. TMDLs represent the maximum daily load of a pollutant that a waterbody can assimilate and meet water quality standards, and an allocation of that load among point sources, nonpoint sources, and a margin of safety.

Toxicity reduction evaluation (TRE) means a site-specific study conducted in a stepwise process designed to identify the causative agents of effluent toxicity, isolate the sources of toxicity, evaluate the effectiveness of toxicity control options, and then confirm the reduction in effluent toxicity.

Water Quality Standards means the Part 4 Water Quality Standards promulgated pursuant to Part 31 of the NREPA, being R 323.1041 through R 323.1117 of the Michigan Administrative Code.

Weekly monitoring frequency refers to a calendar week which begins on Sunday and ends on Saturday. When required by this permit, an analytical result, reading, value or observation shall be reported for that period if a discharge occurs during that period.

WWSL is a wastewater stabilization lagoon.

WWSL discharge event is a discrete occurrence during which effluent is discharged to the surface water up to 10 days of a consecutive 14 day period.

3-portion composite sample is a sample consisting of three equal-volume grab samples collected at equal intervals over an 8-hour period.

7-day concentration
FOR WWSLs THAT COLLECT AND STORE WASTEWATER AND ARE AUTHORIZED TO DISCHARGE ONLY IN THE SPRING AND/OR FALL ON AN INTERMITTENT BASIS – The 7-day concentration is the sum of the daily concentrations determined during any 7 consecutive days of discharge during a WWSL discharge event divided by the number of daily concentrations determined. If the number of daily concentrations determined during the WWSL discharge event is less than 7 days, the number of actual daily concentrations determined shall be used for the calculation. The calculated 7-day concentration will be used to determine compliance with any maximum 7-day concentration limitations. When required by the permit, report the maximum calculated 7-day concentration for the WWSL discharge event in the “MAXIMUM” column under “QUALITY OR CONCENTRATION” on the DMR. If the WWSL discharge event was partially in each of two months, the value shall be reported on the DMR of the month in which the last day of discharge occurred.

FOR ALL OTHER DISCHARGES – The 7-day concentration is the sum of the daily concentrations determined during any 7 consecutive days in a reporting month divided by the number of daily concentrations determined. If the number of daily concentrations determined is less than 7, the actual number of daily concentrations determined shall be used for the calculation. The calculated 7-day concentration will be used to determine compliance with any maximum 7-day concentration limitations in the reporting month. When required by the permit, report the maximum calculated 7-day concentration for the month in the “MAXIMUM” column under “QUALITY OR CONCENTRATION” on the DMR. The first 7-day calculation shall be made on day 7 of the reporting month, and the last calculation shall be made on the last day of the reporting month.

PART II

Section A. Definitions

7-day loading
FOR WWSLs THAT COLLECT AND STORE WASTEWATER AND ARE AUTHORIZED TO DISCHARGE ONLY IN THE SPRING AND/OR FALL ON AN INTERMITTENT BASIS – The 7-day loading is the sum of the daily loadings determined during any 7 consecutive days of discharge during a WWSL discharge event divided by the number of daily loadings determined. If the number of daily loadings determined during the WWSL discharge event is less than 7 days, the number of actual daily loadings determined shall be used for the calculation. The calculated 7-day loading will be used to determine compliance with any maximum 7-day loading limitations. When required by the permit, report the maximum calculated 7-day loading for the WWSL discharge event in the "MAXIMUM" column under "QUANTITY OR LOADING" on the DMR. If the WWSL discharge event was partially in each of two months, the value shall be reported on the DMR of the month in which the last day of discharge occurred.

FOR ALL OTHER DISCHARGES – The 7-day loading is the sum of the daily loadings determined during any 7 consecutive days in a reporting month divided by the number of daily loadings determined. If the number of daily loadings determined is less than 7, the actual number of daily loadings determined shall be used for the calculation. The calculated 7-day loading will be used to determine compliance with any maximum 7-day loading limitations in the reporting month. When required by the permit, report the maximum calculated 7-day loading for the month in the "MAXIMUM" column under "QUANTITY OR LOADING" on the DMR. The first 7-day calculation shall be made on day 7 of the reporting month, and the last calculation shall be made on the last day of the reporting month.

24-hour composite sample is a flow-proportioned composite sample consisting of hourly or more frequent portions that are taken over a 24-hour period. A time-proportioned composite sample may be used upon approval of the Department if the permittee demonstrates it is representative of the discharge.

PART II

Section B. Monitoring Procedures

1. Representative Samples

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Test Procedures

Test procedures for the analysis of pollutants shall conform to regulations promulgated pursuant to Section 304(h) of the Clean Water Act (40 CFR Part 136 – Guidelines Establishing Test Procedures for the Analysis of Pollutants), unless specified otherwise in this permit. **Test procedures used shall be sufficiently sensitive to determine compliance with applicable effluent limitations**. Requests to use test procedures not promulgated under 40 CFR Part 136 for pollutant monitoring required by this permit shall be made in accordance with the Alternate Test Procedures regulations specified in 40 CFR 136.4. These requests shall be submitted to the Manager of the Permits Section, Water Resources Division, Michigan Department of Environment, Great Lakes, and Energy, P.O. Box 30458, Lansing, Michigan, 48909-7958. The permittee may use such procedures upon approval.

The permittee shall periodically calibrate and perform maintenance procedures on all analytical instrumentation at intervals to ensure accuracy of measurements. The calibration and maintenance shall be performed as part of the permittee's laboratory Quality Assurance/Quality Control program.

3. Instrumentation

The permittee shall periodically calibrate and perform maintenance procedures on all monitoring instrumentation at intervals to ensure accuracy of measurements.

4. Recording Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information: 1) the exact place, date, and time of measurement or sampling; 2) the person(s) who performed the measurement or sample collection; 3) the dates the analyses were performed; 4) the person(s) who performed the analyses; 5) the analytical techniques or methods used; 6) the date of and person responsible for equipment calibration; and 7) the results of all required analyses.

5. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Regional Administrator or the Department.

PART II

Section C. Reporting Requirements

1. Start-Up Notification

If the permittee will not discharge during the first 60 days following the effective date of this permit, the permittee shall notify the Department within 14 days following the effective date of this permit, and then 60 days prior to the commencement of the discharge.

2. Submittal Requirements for Self-Monitoring Data

Part 31 of the NREPA (specifically Section 324.3110(7)); and R 323.2155(2) of Part 21, Wastewater Discharge Permits, promulgated under Part 31 of the NREPA, allow the Department to specify the forms to be utilized for reporting the required self-monitoring data. Unless instructed on the effluent limitations page to conduct “Retained Self-Monitoring,” the permittee shall submit self-monitoring data via the Department’s MiWaters system.

The permittee shall utilize the information provided on the MiWaters website, located at https://miwaters.deq.state.mi.us, to access and submit the electronic forms. Both monthly summary and daily data shall be submitted to the Department no later than the 20th day of the month following each month of the authorized discharge period(s). The permittee may be allowed to submit the electronic forms after this date if the Department has granted an extension to the submittal date.

3. Retained Self-Monitoring Requirements

If instructed on the effluent limits page (or otherwise authorized by the Department in accordance with the provisions of this permit) to conduct retained self-monitoring, the permittee shall maintain a year-to-date log of retained self-monitoring results and, upon request, provide such log for inspection to the staff of the Department. Retained self-monitoring results are public information and shall be promptly provided to the public upon request.

The permittee shall certify, in writing, to the Department, on or before January 10th (April 1st for animal feeding operation facilities) of each year, that: 1) all retained self-monitoring requirements have been complied with and a year-to-date log has been maintained; and 2) the application on which this permit is based still accurately describes the discharge. With this annual certification, the permittee shall submit a summary of the previous year’s monitoring data. The summary shall include maximum values for samples to be reported as daily maximums and/or monthly maximums and minimum values for any daily minimum samples.

Retained self-monitoring may be denied to a permittee by notification in writing from the Department. In such cases, the permittee shall submit self-monitoring data in accordance with Part II.C.2., above. Such a denial may be rescinded by the Department upon written notification to the permittee. Reissuance or modification of this permit or reissuance or modification of an individual permittee’s authorization to discharge shall not affect previous approval or denial for retained self-monitoring unless the Department provides notification in writing to the permittee.

4. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report. Such increased frequency shall also be indicated.

PART II

Section C. Reporting Requirements

Monitoring required pursuant to Part 41 of the NREPA or Rule 35 of the Mobile Home Park Commission Act, 1987 PA 96, as amended, for assurance of proper facility operation, shall be submitted as required by the Department.

5. Compliance Dates Notification

Within 14 days of every compliance date specified in this permit, the permittee shall submit a *written* notification to the Department indicating whether or not the particular requirement was accomplished. If the requirement was not accomplished, the notification shall include an explanation of the failure to accomplish the requirement, actions taken or planned by the permittee to correct the situation, and an estimate of when the requirement will be accomplished. If a written report is required to be submitted by a specified date and the permittee accomplishes this, a separate written notification is not required.

6. Noncompliance Notification

Compliance with all applicable requirements set forth in the Clean Water Act, Parts 31 and 41 of the NREPA, and related regulations and rules is required. All instances of noncompliance shall be reported as follows:

a. 24-Hour Reporting
Any noncompliance which may endanger health or the environment (including maximum and/or minimum daily concentration discharge limitation exceedances) shall be reported, verbally, within 24 hours from the time the permittee becomes aware of the noncompliance. A written submission shall also be provided within five (5) days.

b. Other Reporting
The permittee shall report, in writing, all other instances of noncompliance not described in a. above at the time monitoring reports are submitted; or, in the case of retained self-monitoring, within five (5) days from the time the permittee becomes aware of the noncompliance.

Written reporting shall include: 1) a description of the discharge and cause of noncompliance; and 2) the period of noncompliance, including exact dates and times, or, if not yet corrected, the anticipated time the noncompliance is expected to continue, and the steps taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

7. Spill Notification

The permittee shall immediately report any release of any polluting material which occurs to the surface waters or groundwaters of the state, unless the permittee has determined that the release is not in excess of the threshold reporting quantities specified in the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code), by calling the Department at the number indicated on the second page of this permit (or, if this is a general permit, on the COC); or, if the notice is provided after regular working hours, call the Department's 24-hour Pollution Emergency Alerting System telephone number, 1-800-292-4706 (calls from **out-of-state** call 1-517-373-7660).

Within ten (10) days of the release, the permittee shall submit to the Department a full written explanation as to the cause of the release, the discovery of the release, response (clean-up and/or recovery) measures taken, and preventive measures taken or a schedule for completion of measures to be taken to prevent reoccurrence of similar releases.

PART II

Section C. Reporting Requirements

8. Upset Noncompliance Notification

If a process "upset" (defined as an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the permittee) has occurred, the permittee who wishes to establish the affirmative defense of upset shall notify the Department by telephone within 24 hours of becoming aware of such conditions; and within five (5) days, provide in writing, the following information:

a. that an upset occurred and that the permittee can identify the specific cause(s) of the upset;

b. that the permitted wastewater treatment facility was, at the time, being properly operated and maintained (note that an upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation); and

c. that the permittee has specified and taken action on all responsible steps to minimize or correct any adverse impact in the environment resulting from noncompliance with this permit.

No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

In any enforcement proceedings, the permittee, seeking to establish the occurrence of an upset, has the burden of proof.

9. Bypass Prohibition and Notification

a. Bypass Prohibition
Bypass is prohibited, and the Department may take an enforcement action, unless:

1) bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

2) there were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass; and

3) the permittee submitted notices as required under 9.b. or 9.c. below.

b. Notice of Anticipated Bypass
If the permittee knows in advance of the need for a bypass, it shall submit prior notice to the Department, if possible at least ten (10) days before the date of the bypass, and provide information about the anticipated bypass as required by the Department. The Department may approve an anticipated bypass, after considering its adverse effects, if it will meet the three (3) conditions listed in 9.a. above.

c. Notice of Unanticipated Bypass
The permittee shall submit notice to the Department of an unanticipated bypass by calling the Department at the number indicated on the second page of this permit (if the notice is provided after regular working hours, call: 1-800-292-4706) as soon as possible, but no later than 24 hours from the time the permittee becomes aware of the circumstances.

PART II

Section C. Reporting Requirements

d. Written Report of Bypass
A written submission shall be provided within five (5) working days of commencing any bypass to the Department, and at additional times as directed by the Department. The written submission shall contain a description of the bypass and its cause; the period of bypass, including exact dates and times, and if the bypass has not been corrected, the anticipated time it is expected to continue; steps taken or planned to reduce, eliminate, and prevent reoccurrence of the bypass; and other information as required by the Department.

e. Bypass Not Exceeding Limitations
The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to ensure efficient operation. These bypasses are not subject to the provisions of 9.a., 9.b., 9.c., and 9.d., above. This provision does not relieve the permittee of any notification responsibilities under Part II.C.11. of this permit.

f. Definitions

1) Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

2) Severe property damage means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

10. Bioaccumulative Chemicals of Concern (BCC)

Consistent with the requirements of R 323.1098 and R 323.1215 of the Michigan Administrative Code, the permittee is prohibited from undertaking any action that would result in a lowering of water quality from an increased loading of a BCC unless an increased use request and antidegradation demonstration have been submitted and approved by the Department.

11. Notification of Changes in Discharge

The permittee shall notify the Department, in writing, as soon as possible but no later than 10 days of knowing, or having reason to believe, that any activity or change has occurred or will occur which would result in the discharge of: 1) detectable levels of chemicals on the current Michigan Critical Materials Register, priority pollutants or hazardous substances set forth in 40 CFR 122.21, Appendix D, or the Pollutants of Initial Focus in the Great Lakes Water Quality Initiative specified in 40 CFR 132.6, Table 6, which were not acknowledged in the application or listed in the application at less than detectable levels; 2) detectable levels of any other chemical not listed in the application or listed at less than detection, for which the application specifically requested information; or 3) any chemical at levels greater than five times the average level reported in the complete application (see the first page of this permit, for the date(s) the complete application was submitted). Any other monitoring results obtained as a requirement of this permit shall be reported in accordance with the compliance schedules.

PART II

Section C. Reporting Requirements

12. Changes in Facility Operations

Any anticipated action or activity, including but not limited to facility expansion, production increases, or process modification, which will result in new or increased loadings of pollutants to the receiving waters must be reported to the Department by a) submission of an increased use request (application) and all information required under R 323.1098 (Antidegradation) of the Water Quality Standards or b) by notice if the following conditions are met: 1) the action or activity will not result in a change in the types of wastewater discharged or result in a greater quantity of wastewater than currently authorized by this permit; 2) the action or activity will not result in violations of the effluent limitations specified in this permit; 3) the action or activity is not prohibited by the requirements of Part II.C.10.; and 4) the action or activity will not require notification pursuant to Part II.C.11. Following such notice, the permit or, if applicable, the facility's COC may be modified according to applicable laws and rules to specify and limit any pollutant not previously limited.

13. Transfer of Ownership or Control

In the event of any change in control or ownership of facilities from which the authorized discharge emanates, the permittee shall submit to the Department 30 days prior to the actual transfer of ownership or control a written agreement between the current permittee and the new permittee containing: 1) the legal name and address of the new owner; 2) a specific date for the effective transfer of permit responsibility, coverage and liability; and 3) a certification of the continuity of or any changes in operations, wastewater discharge, or wastewater treatment.

If the new permittee is proposing changes in operations, wastewater discharge, or wastewater treatment, the Department may propose modification of this permit in accordance with applicable laws and rules.

14. Operations and Maintenance Manual

For wastewater treatment facilities that serve the public (and are thus subject to Part 41 of the NREPA), Section 4104 of Part 41 and associated Rule 2957 of the Michigan Administrative Code allow the Department to require an Operations and Maintenance (O&M) Manual from the facility. An up-to-date copy of the O&M Manual shall be kept at the facility and shall be provided to the Department upon request. The Department may review the O&M Manual in whole or in part at its discretion and require modifications to it if portions are determined to be inadequate.

At a minimum, the O&M Manual shall include the following information: permit standards; descriptions and operation information for all equipment; staffing information; laboratory requirements; record keeping requirements; a maintenance plan for equipment; an emergency operating plan; safety program information; and copies of all pertinent forms, as-built plans, and manufacturer's manuals.

Certification of the existence and accuracy of the O&M Manual shall be submitted to the Department at least sixty days prior to start-up of a new wastewater treatment facility. Recertification shall be submitted sixty days prior to start-up of any substantial improvements or modifications made to an existing wastewater treatment facility.

PART II

Section C. Reporting Requirements

15. Signatory Requirements

All applications, reports, or information submitted to the Department in accordance with the conditions of this permit and that require a signature shall be signed and certified as described in the Clean Water Act and the NREPA.

The Clean Water Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance, shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

The NREPA (Section 3115(2)) provides that a person who at the time of the violation knew or should have known that he or she discharged a substance contrary to this part, or contrary to a permit, COC, or order issued or rule promulgated under this part, or who intentionally makes a false statement, representation, or certification in an application for or form pertaining to a permit or COC or in a notice or report required by the terms and conditions of an issued permit or COC, or who intentionally renders inaccurate a monitoring device or record required to be maintained by the Department, is guilty of a felony and shall be fined not less than $2,500.00 or more than $25,000.00 for each violation. The court may impose an additional fine of not more than $25,000.00 for each day during which the unlawful discharge occurred. If the conviction is for a violation committed after a first conviction of the person under this subsection, the court shall impose a fine of not less than $25,000.00 per day and not more than $50,000.00 per day of violation. Upon conviction, in addition to a fine, the court in its discretion may sentence the defendant to imprisonment for not more than 2 years or impose probation upon a person for a violation of this part. With the exception of the issuance of criminal complaints, issuance of warrants, and the holding of an arraignment, the circuit court for the county in which the violation occurred has exclusive jurisdiction. However, the person shall not be subject to the penalties of this subsection if the discharge of the effluent is in conformance with and obedient to a rule, order, permit, or COC of the Department. In addition to a fine, the attorney general may file a civil suit in a court of competent jurisdiction to recover the full value of the injuries done to the natural resources of the state and the costs of surveillance and enforcement by the state resulting from the violation.

16. Electronic Reporting

Upon notice by the Department that electronic reporting tools are available for specific reports or notifications, the permittee shall submit electronically all such reports or notifications as required by this permit, on forms provided by the Department.

PART II

Section D. Management Responsibilities

1. Duty to Comply

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit, more frequently than, or at a level in excess of, that authorized, shall constitute a violation of the permit.

It is the duty of the permittee to comply with all the terms and conditions of this permit. Any noncompliance with the Effluent Limitations, Special Conditions, or terms of this permit constitutes a violation of the NREPA and/or the Clean Water Act and constitutes grounds for enforcement action; for permit or Certificate of Coverage (COC) termination, revocation and reissuance, or modification; or denial of an application for permit or COC renewal.

It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

2. Operator Certification

The permittee shall have the waste treatment facilities under direct supervision of an operator certified at the appropriate level for the facility certification by the Department, as required by Sections 3110 and 4104 of the NREPA. Permittees authorized to discharge storm water shall have the storm water treatment and/or control measures under direct supervision of a storm water operator certified by the Department, as required by Section 3110 of the NREPA.

3. Facilities Operation

The permittee shall, at all times, properly operate and maintain all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance includes adequate laboratory controls and appropriate quality assurance procedures.

4. Power Failures

In order to maintain compliance with the effluent limitations of this permit and prevent unauthorized discharges, the permittee shall either:

a. provide an alternative power source sufficient to operate facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit; or

b. upon the reduction, loss, or failure of one or more of the primary sources of power to facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit, the permittee shall halt, reduce or otherwise control production and/or all discharge in order to maintain compliance with the effluent limitations and conditions of this permit.

5. Adverse Impact

The permittee shall take all reasonable steps to minimize or prevent any adverse impact to the surface waters or groundwaters of the state resulting from noncompliance with any effluent limitation specified in this permit including, but not limited to, such accelerated or additional monitoring as necessary to determine the nature and impact of the discharge in noncompliance.

Section D. Management Responsibilities

6. Containment Facilities

The permittee shall provide facilities for containment of any accidental losses of polluting materials in accordance with the requirements of the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code). For a POTW, these facilities shall be approved under Part 41 of the NREPA.

7. Waste Treatment Residues

Residuals (i.e. solids, sludges, biosolids, filter backwash, scrubber water, ash, grit, or other pollutants or wastes) removed from or resulting from treatment or control of wastewaters, including those that are generated during treatment or left over after treatment or control has ceased, shall be disposed of in an environmentally compatible manner and according to applicable laws and rules. These laws may include, but are not limited to, the NREPA, Part 31 for protection of water resources, Part 55 for air pollution control, Part 111 for hazardous waste management, Part 115 for solid waste management, Part 121 for liquid industrial wastes, Part 301 for protection of inland lakes and streams, and Part 303 for wetlands protection. Such disposal shall not result in any unlawful pollution of the air, surface waters or groundwaters of the state.

8. Right of Entry

The permittee shall allow the Department, any agent appointed by the Department, or the Regional Administrator, upon the presentation of credentials and, for animal feeding operation facilities, following appropriate biosecurity protocols:

a. to enter upon the permittee’s premises where an effluent source is located or any place in which records are required to be kept under the terms and conditions of this permit; and

b. at reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect process facilities, treatment works, monitoring methods and equipment regulated or required under this permit; and to sample any discharge of pollutants.

9. Availability of Reports

Except for data determined to be confidential under Section 308 of the Clean Water Act and Rule 2128 (R 323.2128 of the Michigan Administrative Code), all reports prepared in accordance with the terms of this permit, shall be available for public inspection at the offices of the Department and the Regional Administrator. As required by the Clean Water Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Clean Water Act and Sections 3112, 3115, 4106 and 4110 of the NREPA.

10. Duty to Provide Information

The permittee shall furnish to the Department, <u>within a reasonable time</u>, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or the facility’s COC, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or information.

PART II

Section D. Management Responsibilities

PART II

Section E. Activities Not Authorized by This Permit

1. Discharge to the Groundwaters
This permit does not authorize any discharge to the groundwaters. Such discharge may be authorized by a groundwater discharge permit issued pursuant to the NREPA.

2. POTW Construction
This permit does not authorize or approve the construction or modification of any physical structures or facilities at a POTW. Approval for the construction or modification of any physical structures or facilities at a POTW shall be by permit issued under Part 41 of the NREPA.

3. Civil and Criminal Liability
Except as provided in permit conditions on "Bypass" (Part II.C.9. pursuant to 40 CFR 122.41(m)), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance, whether or not such noncompliance is due to factors beyond the permittee's control, such as accidents, equipment breakdowns, or labor disputes.

4. Oil and Hazardous Substance Liability
Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee may be subject under Section 311 of the Clean Water Act except as are exempted by federal regulations.

5. State Laws
Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable state law or regulation under authority preserved by Section 510 of the Clean Water Act.

6. Property Rights
The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize violation of any federal, state or local laws or regulations, nor does it obviate the necessity of obtaining such permits, including any other Department of Environment, Great Lakes, and Energy permits, or approvals from other units of government as may be required by law.

APPENDIX D: UV DISINFECTION EVALUATION (DATED SEPTEMBER 2017)

REPORT

Traverse City Regional Wastewater Treatment Plant Ultraviolet Disinfection Evaluation

Prepared for

Traverse City, Michigan

September 2017

ch2m

Executive Summary

Surge events in September 2016 damaged electronics in the ultraviolet (UV) modules. In response to this damage, CH2M HILL (CH2M) created and executed an action plan to minimize the likelihood of future UV channel surges and subsequent flooding of the modules and conducted an evaluation to determine the existing hydraulic capacity of the UV system, identify hydraulic bottlenecks, and identify improvements that could be made to prevent future damage to the UV system. The evaluation included both hydraulic improvements and UV equipment improvements. The Michigan Department of Environmental Quality would like the long-term resolution to maintain treatment to the 25-year Boardman Lake Level and prevent damage to the UV equipment at the 100-year Boardman Lake level. The original 1995 UV equipment was not designed for these criteria.

Improvements Already Made

Instrumentation and controls, spare UV modules, and operational procedures were implemented to minimize the potential for flow surges and to minimize interruption of UV disinfection should surges or peak wet-weather flows occur. These improvements are summarized in Section 1.2, Background.

Near-Term Recommended Improvements

Modifications to the existing UV system will protect the existing UV equipment from damage and defer the significant cost associated with replacing UV equipment until the existing UV equipment reaches the end of its useful life. The recommended improvements are as follows (Total estimated cost, excluding engineering, is $118,280) :

- Raising the UV electrical equipment out of the channel and sealing components is recommended until the existing UV equipment has reached the end of its useful life. Non-watertight electrical equipment should be positioned such that the bottom is at least 12 inches above the UV channel top of concrete (TOC) (positioned at or above EL 115.0 feet). If possible, the UV electrical equipment and sealing of components should be designed to be protected from damage at the 25-year and 100-year flood elevations (refer to the Figure 2 hydraulic profile). The City has received quotes from an aftermarket UV equipment supplier and electrical contractors to accomplish this. The City would modify 6 modules consisting of 4 installed modules (2 per channel) and 2 uninstalled spares.
  The quoted cost for the longer quartz sleeves is $12,480, based on 6 modules with 40 quartz sleeves per module at a quoted cost of $52 per quartz sleeve. The quoted cost for an electrician to raise electrical components out of the channel was $34,458, based on 6 modules at $5,743 per module. With handrail, the estimated cost is $57,000.
- Relocate weir plates to Permeate Discharge Structure. The estimated cost is $13,600.
- Raise the Permeate Discharge Structure TOC. The estimated cost is $6,700.
- Raise the existing electrical conduits in the UV channel nominally 1 foot above the top of channel. The estimated cost is $12,500.
- Venting to address the air binding issue in the pipe from the UV channel is discretionary. This could be implemented and field testing repeated to determine if the hydraulic grade line in the UV effluent channel downstream of the Automatic Level Control Gate has been reduced and if so by how much (the most expected is 0.32 foot). A reduction in hydraulic grade line (HGL) here would allow a reduction in the future design HGL in the UV channel associated with new UV equipment. This, in turn, would result in a commensurate increase in freeboard in the UV channel and in upstream structures. The estimated cost is $16,000.

Improvements Recommended When the Existing UV Equipment Reaches the End of Its Useful Life

When the existing UV equipment reaches the end of its useful life, new UV equipment, a raised UV channel HGL, a raised UV channel invert, and a modulating weir gate are recommended. The new UV equipment should be designed not to be damaged at 100-year flood levels and provide full disinfection at 25-year flood levels (refer to the Figure 2 hydraulic profile).

The existing UV technology employed at the Traverse City Regional Wastewater Treatment Plant (WWTP) is low-pressure, low-output. WWTPs typically replace these systems with low-pressure, high-output systems when they have reached the ends of their useful lives. The high-output systems require significantly fewer lamps than the low-output systems. They also offer modulation of lamp output in addition to the ability to turn banks or modules on and off. This can provide energy savings due to flow and water quality variability typical of WWTPs. And most relevant to the flooding events that occurred at the Traverse City Regional WWTP, the electronics in this next generation of UV equipment are better protected from flooding.

When the existing UV equipment is to be replaced, the alternative of horizontally oriented lamps has the best benefit-to-cost ratio and is therefore recommended. The estimated capital cost (includes engineering) is $1,298,400 to $1,550,400 in current dollars based on the Calgon and Trojan proposals, or $1,526,000 to $1,822,000 in 10 years if inflation rates remained as low as in recent years.

Retrofitting existing channels with vertically oriented lamps was ranked second. This alternative offered modest savings but less protection from damage at high water levels, and the cost savings versus the lowest budgetary estimate of the horizontally oriented lamps was small. The in-vessel alternatives provide a robust solution to address flooding and would eliminate the need for additional hydraulic improvements provided the permeate pumps are not impacted by the head loss through the in-vessel equipment. However, due to the high cost of constructing a new building, this technology has the lowest benefit-to-cost ratios, is ranked third in the evaluation, and is therefore not recommended. UV equipment offerings continue to change. Therefore, a similar review and evaluation of alternatives is recommended when the UV equipment is to be replaced in the future.

The 25-year flood elevation may be reduced below the Federal Emergency Management Agency elevation noted herein as a result of the planned Union Street Dam replacement. Therefore, the 25-year flood elevation should be determined after the dam replacement at the time of UV replacement and the new UV channel HGL set accordingly.

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Acronyms and Abbreviations

ALCG	Automatic Level Control Gate
CFU	colony forming units
CH2M	CH2M HILL
CPES	**C**H2M's **P**arametric Cost **E**stimating **S**ystem
EL	elevation
FEMA	Federal Emergency Management Agency
HGL	hydraulic grade line
IDI	Infilco Degremont, Inc.
MDEQ	Michigan Department of Environmental Quality
mgd	million gallons per day
NAVD 88	North American Vertical Datum of 1988
NGVD	National Geodetic Vertical Datum of 1929
NPV	net present value
SCADA	supervisory control and data acquisition
TBD	to be determined
TOC	top of concrete
UV	ultraviolet
WWTP	wastewater treatment plant

SECTION 1

Introduction

1.1 Purpose

In September 2016, two “surge” events within the Traverse City Regional wastewater treatment plant (WWTP) generated short-term peak flow conditions through the ultraviolet (UV) disinfection system. Both resulted in damage to the electronics in the UV modules. Neither of these events were wet-weather related. In response to this damage, CH2M HILL (CH2M) created and executed an action plan to minimize the likelihood of future UV channel surges and conducted an evaluation to determine the existing hydraulic capacity of the UV system, identify hydraulic bottlenecks, and identify improvements that could be made to prevent future damage to the UV system. The evaluation included both hydraulic improvements and UV equipment improvements.

This work is not intended to serve as a predesign for any of the alternatives presented but instead to aid selection of the preferred alternatives. Once alternatives are selected, additional engineering will be required to confirm and/or revise the assumed design criteria presented herein.

1.2 Background

The existing UV disinfection system (refer to Figure 1) is a low-pressure, low-output Aquaray 40 model by Infilco Degremont, Inc. (IDI), now a subsidiary of Suez Environmental (Suez). Suez UV equipment is marketed under the brand name Ozonia. The UV modules contain multiple lamps in a vertical arrangement. The system was designed in 1995 and included two channels with six modules per channel and space for an additional module in each. Design peak flow for the UV system was 11 to 12.2 million gallons per day (mgd) with secondary clarifier effluent. In 1998, two additional modules were added to the available spaces, resulting in up to 14 in-service UV modules.

Figure 1. Photos of Existing UV System

UV Module in Channel

UV Channels

Current UV Module

In 2004 (2002 design), the WWTP was upgraded to a membrane bioreactor facility sized to treat a peak flow up to 17 mgd. The UV system was not included in this upgrade, because the system had no identified issues at that time. As a result of the upgrade, fewer UV modules were deemed necessary because of the high-quality membrane effluent. Removing modules due to the higher-quality effluent reduced head loss through the system and increased hydraulic throughput, thus 8 of the 14 UV modules were removed from the channel. Hydraulic calculations during design indicated that this would provide 17 mgd of capacity.

In September 2016, two “surge” events within the WWTP generated short-term peak flow conditions through the UV system. Both of these peak flow “surge” events resulted in damage to the electronics in the UV modules. Neither of these events were wet-weather related. The water rose above the bottom of the module enclosures, which is elevation (EL) 111.7 feet plant datum (plant 0.00 = 482.13 National Geodetic Vertical Datum of 1929 [NGVD] = 481.71 North American Vertical Datum of 1988 [NAVD 88], assuming a 0.42-foot differential between NGVD and NAVD 88 at the WWTP). The sleeve penetrations into the bottom of this enclosure, the power and control wiring penetrations that are located at approximately EL 112 feet, and the hinged cover at approximately EL 112.7 feet are not designed for submergence.

In response to the above-described events, CH2M staff created and executed an action plan to minimize the likelihood of future UV channel surges and subsequent flooding of the modules. The following are the improvements and modification to date that resulted from this action plan:

- Onsite staff addressed the damage to the 4 in-service modules, and prepared two modules to be used as quick replacements in the event that the in-service modules are flooded.
- CH2M added alarms that will trigger if either channel of UV modules loses power.
- A concrete slab was added directly in front of the UV channel to allow use of a forklift when replacing modules. This will reduce response time.
- CH2M engineers verified UV channel flow capacity as described herein.
- Onsite staff adjusted the peak flow set point for each membrane train to better compliment the capacity of the UV system and created a procedure to manually override these set points to meet the influent flow demand during a high-flow event, when or if it becomes necessary, in a manner that would reduce the possibility of flooding the UV modules.
- CH2M added supervisory control and data acquisition (SCADA) alarming triggered when any one membrane train enters peak flow mode.
- CH2M added alarming and programing to the SCADA that would allow the RAS channel level transducers to trigger an alarm if they go out of range, and the control loop to default to the other level transducer in the channel.

SECTION 2

Hydraulic Evaluation

2.1 Hydraulic Model Development

CH2M's WinHydro was used to evaluate the hydraulics of this system. WinHydro is a steady-state analysis and design tool for hydraulics in WWTPs. In order to evaluate UV capacity, the WWTP hydraulics were evaluated from the receiving stream (Boardman River) to the Permeate Discharge Structure, which is just upstream of the UV system (refer to Appendix A). The Permeate Discharge Structure was constructed subsequent to the Appendix A drawing; therefore, its location has been indicated. Disinfected effluent is discharged at the confluence of Boardman Lake and the Boardman River, both of which are regulated by the Union Street Dam located less than 1 mile downstream of the outfall. There is no difference in hydraulic grade line (HGL), the hydraulic terminology for water level, between the lake and the discharge point into the river.

As-built drawings, in combination with information gathered at the site, were used to build the model. In addition, the following information related to the UV equipment was gathered from direct coordination with Suez:

1. UV bank head loss data. Although less significant than the head loss over the automatic level control gate and subsequent downstream head loss, some head loss occurs as flow passes through the UV modules. This data was not included in the IDI operation and maintenance manual. Therefore, CH2M contacted Suez and acquired head loss values with 6 modules at 3 system flow rates (10, 14, and 17 mgd). From this data, a head loss curve was developed that estimated head loss through a single module at a given system flow rate. This curve, included in Appendix B, was used in the evaluation.
2. Automatic Level Control Gate (ALCG) maximum downstream water elevation. The counter-weighted style gate installed at the Traverse City WWTP is a common method of regulating upstream water levels within UV systems (refer to Appendix C). Performance of these gates is impacted by downstream conditions. If a specified downstream level is exceeded, the gate's ability to maintain upstream levels is comprised. According to the installation drawings, the maximum allowable downstream level was EL 109.58 feet. According to recent Suez correspondence, the maximum allowable downstream level for the ALCG is EL 109.25 feet. Therefore, there is about a 4-inch discrepancy and thus uncertainty as to when downstream level impacts upstream UV channel level.

After collecting the above data, the base model was constructed. A coordination call with operation personnel was conducted to verify that model elements accurately reflected actual field conditions. Items such as flow path, structures, process streams, gate positions, etc., were confirmed.

2.2 Hydraulic Model Calibration

Accurate water level elevations from field measurements were necessary for the calibration because the difference between the manufacturer's intended maximum water level at high flow and the water level that causes damage to the electronics is a matter of inches. The water elevations from field measurements were based on depth to water measurements and the corresponding elevations of the structures from which the depths to water were taken. The elevations of the structures were initially taken from design drawings. Some of the structures date back to 1970, from which the following two issues were identified:

1. The top of concrete from one manhole on the effluent pipe could not be found on the drawings.
2. A concrete cap had been placed on the effluent structure adjacent to the river, which was not reflected on the drawings, thereby raising the top of concrete (TOC).

Although these two issues were addressed by using a laser level from another structure and by measuring the height of the concrete cap placed on the effluent structure, there was a slight concern regarding the accuracy of TOC elevations used to measure water level for the model calibration. Therefore, an engineering survey was ordered for all the structures used in the calibration. With the exception of the most upstream structure, the survey measurements agreed to within 3/8 inch or less of what had previously been used in the model. The initial model calibration and results were updated when the survey results became available, even though the effect was very small. Appendix E includes the survey data.

Operation personnel conducted a series of flow tests in which specified flow rates were maintained, and freeboard was measured at critical locations in the system. This data, which is provided in Appendix D, was used to calibrate the model. Operation personnel conducted a total of 9 flow tests on 3 separate occasions ranging from approximately 10 to 16 mgd. The first three tests on the first day of testing captured freeboard data from within the UV system only and did not include freeboard from downstream structures. As a result of this data gap, an additional series of flow tests was conducted to develop a more comprehensive freeboard profile, including downstream structures. Upon review of this second data set, operation personnel had some concerns regarding whether flow was held steady during the testing, and therefore conducted a third series of flow tests.

The calibration effort involved replicating the flow scenarios in WinHydro, and comparing model output to reported field conditions. Manning's Roughness coefficients for pipes and minor loss coefficients associated with various hydraulic elements (e.g., entrance and exit losses) were adjusted to achieve an acceptable error in predicted versus reported freeboard. Calibration was conducted with the 12.78-mgd scenario from the first data set and was subsequently updated with the 15.55-mgd scenario from the second data set and the 15-mgd scenario from the third data set. It was apparent from the measurements analyzed in WinHydro that the third data set was more consistent across the flow scenarios conducted. Therefore, when model output between the various calibration runs conflicted, the third data set was used to reach a resolution. This resulted in greater model accuracy over a larger flow range. Ultimately, a freeboard error of less than 3 percent was achieved (less than 1 inch). It is noteworthy that matching the field-observed head losses in the system required using minor loss K-values that are lower than typical values. Appendix D includes a summary of K-values used.

2.2.1 Simulation of the Automatic Level Control Gate

Review of the field data collected as part of the calibration effort revealed that actual downstream HGLs were in excess of maximum allowable levels specified by the ALCG manufacturer at higher flows. Therefore, the HGL downstream of the ALCG is impacting the HGL in the UV channels. When the downstream HGL is below the manufacturer's maximum recommended HGL, then typically ALCGs are simulated by manually setting the HGL in the UV channel at the level the ALCG is designed to maintain at a given flow rate. However, because the downstream HGL was exceeded, an alternative way of modeling the ALCG was developed. Field data collected as part of the calibration effort was used to develop a head loss curve for the ALCG, which estimated upstream HGLs as a function of system flow. This curve, shown in Appendix F, was used in the capacity analysis.

A second approach was also considered. In the second approach, the fixed concrete weir that the ALCG sits on and the and ALCG itself were modeled as separate elements in WinHydro. The model was used to estimate the UV channel HGL with the fixed concrete weir wall but without the ALCG, and these values were subtracted from the field-measured water levels in the UV channel to estimate the head loss attributable to the ALCG. This approach resulted in a more variable estimate of head loss. The estimated head loss caused by the ALCG above that attributable to the fixed concrete weir wall was between 0.55 and 0.8 foot at higher flows. A static head loss of 0.65 foot for the ALCG at 17 mgd was estimated using engineering judgment for this second approach, although there is 0.1 to 0.15 foot (1.2 to 1.8 inches) of uncertainty with this approach.

2.3 Existing Hydraulic Capacity

Due to the fact that there is not a hydraulic break at high flow between the UV system and the receiving water, Boardman River level has a direct impact on UV hydraulic capacity, which decreases with increasing river level. Hydraulic capacity also decreases with a third module installed in each channel due to the added head loss. Engineering drawings from past plant designs identified the river elevation in the hydraulic profile as “106.5 + or – ” in 1970, “106.5 (varies)” in 1995, and “107.7 (5-16-02)” in 2002. The hydraulic profile from the 1995 engineering drawing set corresponds to the UV installation. During the high flow tests in October and November 2016, the river level at the outfall was coincidently at 107.7, matching the 2002 hydraulic profile from the membrane plant design. However, on the day of the November survey, river level at the outfall had risen 0.3 foot to 108.00. As of the next reading on December 2, river level had fallen slightly to 107.86. CH2M searched for additional data, but the nearest United States Geological Survey river gaging station is located several miles upstream, and operating data from the Union Street Dam was not readily available. The initial evaluation was conducted at Boardman River elevations of 106.5 and 107.7, corresponding to the 1970, 1995, and 2002 drawing sets, as well as at the 108.0 measured in the survey.

Upon review of this initial evaluation, the Michigan Department of Environmental Quality (MDEQ) commented that the UV system should be operational up to the 25-year flood event and protected from damage at a 100-year flood event. MDEQ noted that there was a Federal Emergency Management Agency (FEMA) flood study of Boardman Lake identifying 10-, 50-, 100-, and 500-year flood elevations. Based on review of the FEMA elevations, this requires significant change from the original 1995 UV design, which was not designed for the 25-year lake level. The FEMA 100-year lake level provided by MDEQ is 592.1 NGVD 1929, which corresponds to 591.68 NAVD 88 and plant datum 109.97. The FEMA elevations at the 10-, 50-, 100-, and 500-year events were used to interpolate a 25-year flood elevation of 591.41 NGVD (590.99 NAVD 88) corresponding to plant datum 109.28. The interpolation of this elevation can be found in Appendix G.

Traverse City is in the process of studying the replacement of the Union Street Dam. Therefore, discussions were held about the impacts of the dam replacement on the 25-year flood level and whether the dam design could potentially reduce 25-year lake level. A Great Lakes Fishery Commission engineer involved with the dam replacement study noted that the current design is based on maintaining the existing condition, without use of the experimental channel being considered. But he noted that, with an experimental channel in service, it may be possible to control the 25-year flood level to 0.5 foot less immediately upstream of the dam. Without a head loss model of the river from Boardman Lake to the dam, it is not known whether a 0.5-foot drop upstream of the dam will result in a 0.5-foot drop in Boardman Lake, which has a water elevation a few tenths of a foot higher than at the dam. Those involved with the dam replacement design were doubtful they could accommodate lower lake flood elevations than that and still maintain enough differential at the dam to prevent sea lamprey passage. Therefore, there is the possibility that the new dam will allow control of the 25-year lake level to 0.5-foot less than the current 25-year lake level. Until the new dam is constructed, uncertainty regarding this will remain.

The hydraulic capacity evaluation was updated to reflect the current 25-year lake level. Table 1 summarizes the existing capacity as defined by the UV manufacturer’s maximum HGL of 111.417 in the UV channel at the aforementioned river elevations, with two and three UV modules installed in each channel.

Table 1. Estimated Hydraulic Capacity at Varying River Levels

Plant Datum River Level (EL)	UV Capacity, Two modules (mgd)	UV Capacity, Three modules (mgd)
106.5	15.8	15.3
107.7	14.4	13.8
108.0	13.6	13.3
109.28 (25-year flood level)[a]	10.3	9.8
109.97 (100-year flood level)	7.42	7.01

[a] The 25-year flood elevation was based on interpolation of FEMA flood-study data.

The following is a summary of key observations from the capacity analysis:

1. Field testing and the calibrated WinHydro model demonstrate that the HGL in the UV effluent channel is higher than what was estimated in the 2002 hydraulic profile at the depicted condition. The higher effluent channel HGL results in a higher HGL in the UV channel and thus less peak hydraulic capacity.

2. Freeboard and thus capacity in the UV channel decreases as river elevations increase.

3. There is approximately 3 feet of head loss generated between the Boardman River and the UV effluent channel. The three most significant head losses limiting UV capacity in decreasing order are: (1) the 30-inch effluent pipe installed in the 1970s, (2) the combination of the concrete weir wall and the ALCG, and (3) higher than expected head loss between the UV effluent channel and the UV bypass structure. Figure 2 illustrates the head loss through each element of the model (bars in chart), as well as a simplified hydraulic profile (line in chart) for the system at the design peak flow rate of 17 mgd and river elevations of EL 107.7, EL 109.28 (25-year flood), and EL 109.97 feet (100-year flood). Table 2 shows the resulting freeboard in existing structures at the design peak flow rate of 17 mgd. Flooding of structures is observed in each scenario presented. It is worth noting that the ground surface adjacent to the UV structure is approximately EL 112.9 feet, which is approximately 2.9 feet higher than the 100-year river elevation. Therefore, any process water that overtops the concrete channels/walls will drain away from the UV system rather than ponding. The following provides additional information regarding the three most significant head losses limiting UV capacity:

   a. 30-inch Effluent Pipe: Of the 3 feet of head loss generated between the Boardman River and the UV effluent channel, approximately 1.47 feet, corresponding to 49 percent of the total, is generated by the two 30-inch-diameter sections of the final effluent pipe.

   b. The weir wall with ALCG mounted on it results in an estimated 0.85 foot of head loss at 17 mgd (see Appendix F).

   c. UV Effluent Channel to UV Bypass Structure: WinHydro predicted head loss between the UV effluent channel and the UV bypass structure to be 0.45 foot at 17 mgd. Based on field measurements, an additional 0.32 foot occurs at 17 mgd. Based on observations and experience, it is suspected that air binding is the culprit of the excess head loss. Air binding means that the flow of water is impeded as a result of air trapped in the crown of the pipe. It is suspected that the air is trapped in this particular pipe when water level increases rapidly. The higher-than-expected head loss was modeled by a sluice gate and is labeled as “sluice gate” in Figure 2. This sluice gate exists but is fully open and thus is not thought to be contributing to head loss. Therefore, the sluice gate was used as a surrogate to calibrate the model to field measured data. The sluice gate in the UV effluent bypass structure was modeled at approximately 30 percent closed to generate the field-observed head loss.

Figure 2. Hydraulic Profile and Head Loss Profile at 17 mgd

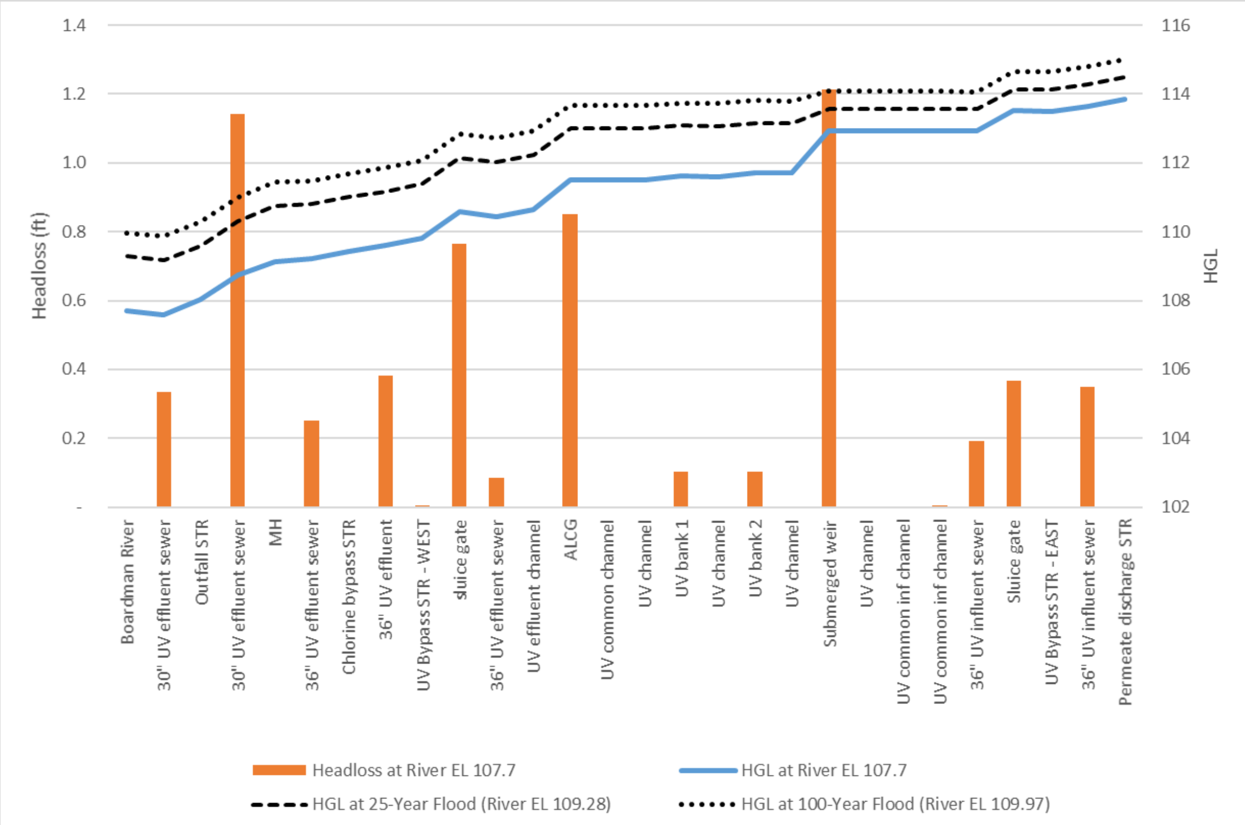


Table 2. Estimated Feet of Freeboard in Existing Structures at 17 mgd, Existing Conditions

Structure	River EL 107.7 feet	25-Year Flood (River EL 109.28 feet)	100-Year Flood (River EL 109.97 feet)
Outfall Structure	0.4	None, submerged[a]	None, submerged[a]
Unmarked Manhole	3.0	1.4	0.7
Chlorine Bypass Structure	5.1	3.5	2.8
UV Bypass Structure—WEST	4.1	2.5	1.8
UV Effluent Channel	3.3	1.7	1.1
UV Channel	2.3	0.8	0.2
UV Channel (upstream of weir plate)	1.1, electrical conduits submerged	0.4, electrical conduits submerged	None, flooded[b]
UV Influent Channel	1.0	0.4	None, flooded[b]
UV Bypass Structure—EAST	0.3	None, flooded[b]	None, flooded[b]
Permeate Discharge Structure	None, flooded[b]	None, flooded[b]	None, flooded[b]

Notes:
[a] Submergence of the Outfall Structure at the river bank is not a problem.
[b] Water anticipated to flow out of structure with weir plates left in place.

4. Modeling identified that weir plates installed in the upstream slide gate slots of the UV system to maintain prime of the membrane backpulse pumps contribute to inadequate free board in the Permeate Discharge Structure even at the typical river level. The weirs also contribute to high water level and less-than-desired freeboard in the UV influent channel at higher flows.

5. At higher flows, the HGL downstream of the ALCG is higher than manufacturer's design criteria. This can compromise the gate's ability to maintain allowable water levels in the UV channels. Based on model output, downstream HGL begins to have measurable effects at and above 12.8 mgd. Based on collected field data, this results in variable head loss through the ALCG that impacts HGLs in the UV channel.

2.4 Alternatives to Control the HGL and Equipment Modifications to Protect the UV Equipment at High HGLs

This section identifies alternatives to increase the hydraulic capacity of the UV system to 17 mgd during typical river levels and a 25-year flood event (river EL 109.28 feet) and identifies equipment modifications to protect the UV system and upstream structures at the HGLs associated with these conditions. For clarity, this section is divided into two parts as follows:

1. Downstream improvements to protect the UV equipment. This part identifies alternatives for modifications to hydraulic elements from the UV channels downstream to the outfall at the Boardman River.

2. Upstream improvements to protect structures upstream of the UV equipment. This part identifies alternatives for modifications to hydraulic elements upstream of the UV channels to the Permeate Discharge Structure. As downstream hydraulic conditions control, the degree of required upstream improvements is influenced by the selected downstream improvement(s).

The recommended path forward is presented in the next section.

2.4.1 Downstream Improvements to Protect the UV Equipment

The following downstream improvement alternatives were identified:

1. Replace the two 30-inch steel pipe sections (approximately 340 linear feet) with a larger-diameter pipe. As noted, the two 30-inch effluent pipes account for approximately 1.47 feet of head loss. Upsizing the two 30-inch sections of effluent pipe to 36-inch diameter will drop the water level in the UV effluent channel by approximately 0.9 foot and reduce the HGL in the UV channels to approximately EL 112.45 feet. Further upsizing to 42-inch diameter will reduce the HGL in the UV channels about an additional 0.2 foot to approximately EL 112.21 feet. However, the maximum allowable HGL in the UV channel per the UV manufacturer is EL 111.42 feet. Therefore, upsizing the sewer segments alone will not drop the water level in the UV channels to below the UV manufacturer's maximum allowable criteria. While analysis showed that the combination of upsizing the sewer segments and installing a new weir gate for level control (Alternative 4) could resolve hydraulic issues, upsizing the sewer is estimated to have a capital cost of $312,000. While this in conjunction with a new weir gate will be less than replacement of UV equipment, the existing UV equipment was installed in 1995 and is approaching the end of its useful life. Also, replacement of the weir gate is best done at the time of UV equipment replacement. Given these considerations, replacement of the 30-inch steel sections of effluent pipe was not considered further.

2. Remediate the head loss between the UV effluent channel and the West UV Bypass Structure. Air binding (trapped air that impedes flow) is suspected as the culprit based on the higher-than-expected observed head loss in this relatively short section of pipe for which inspection indicated that there are no physical obstructions and observed air release into the UV bypass structure during high flow. Adding air-relief vents would be expected to relieve the air that impedes flow. However, due to this pipe running below parking spaces and a plant road, air vents could only be installed at either end. Although this would be expected to at least partially resolve air binding it is unknown whether this would fully resolve air binding. Based on modeling, fully addressing the issue would drop levels in the UV effluent channel by approximately 0.32 foot or 3.8 inches. Air vents will not result in 17 mgd of capacity but are expected to slightly increase capacity. Venting may also reduce the oscillating water surface in the West UV Bypass Structure and UV effluent channel making future depth to water measurements for future hydraulic model calibration easier. Installing vents at either end will be relatively low cost.

3. New opening with modulating gate in the existing weir wall. This alternative consists of cutting a rectangular opening in the concrete weir wall, installing a modulating gate over the opening, and installing a level element upstream of the most upstream UV module. The gate would be controlled to open when the water level is approaching the UV manufacturer's maximum water level and modulate to control water level between the UV manufacturer's minimum and maximum level. As flow and level subside, the gate would close, and level would be solely controlled by the ALCG again.

   – For the existing UV equipment: Hydraulic analysis revealed that this may be a viable option at the river levels used in previous design drawing hydraulic profiles dating back to 1970. However, this alternative is not recommended for further consideration for the following reasons:

     ▪ At the 25-year flood level, the HGL immediately downstream of the weir wall already exceeds the maximum allowable HGL in the UV channel, even if implemented in combination with resolving air-binding issues.

     ▪ The size opening that would be required relative to the dimensions of the existing weir wall introduces structural concerns that would require detailed analysis to verify viability.

     ▪ Weir gates as described in the next alternative are commonly used by UV equipment manufacturers to control UV channel level. Therefore, a weir gate, if it could be used for the existing UV equipment and future UV equipment, would be preferred.

   – For new UV equipment: The same points as for the existing UV equipment apply.

4. Replace the ALCG with a modulating weir gate. A modulating weir gate is a common alternative to the counter-weighted style ALCG. This differs from the aforementioned addition of a rectangular orifice with a gate that opens up. Instead, a weir gate acts as an adjustable weir allowing water to flow over the weir, and it would travel down to maintain upstream water level as flow increases.

   – For the existing UV equipment: As with the previous orifice gate alternative, hydraulic analysis revealed that this is a viable option at the river levels used in previous design drawing hydraulic profiles dating back to 1970. However, at the 25-year flood level, the HGL immediately downstream of where the weir gate would be installed already exceeds the maximum allowable HGL in the UV channel even if the air-binding issue was resolved. However, a weir gate could be used if the operating UV channel HGL was also raised to accommodate hydraulics associated with the 25-year flood. In order to maintain a 2-inch freefall over the weir gate during peak flow analysis indicates that the top of the weir gate would operate at EL 109.2 feet. The UV channel invert would also need to be raised to approximately EL 107.2 feet. Raising the UV channel invert and level control device as specified would raise operating levels within the UV channel by approximately 1.1 feet. However, raising the channel invert and installing a weir gate to replace the weir wall and ALCG are significant structural modifications that may not be compatible with the modifications required when the UV equipment is ultimately replaced at the end of its useful life.

  - For new UV equipment: A new UV system would have the same hydraulic challenges as existing during the 25-year flood level unless the operating UV channel HGL is raised as described in the previous bullet. Modifications to the UV channel invert and weir gate elevations would vary according to the various UV manufacturer requirements, as well as required/preferred freeboard and freefall criteria. Based on a typical freeboard of 12 inches and minimum weir freefall of 2 inches, it is anticipated that the new operating HGL would be between 1.1 and 1.6 feet higher than current operating levels.

5. Installation of a new counter-weighted-style ALCG was also considered. Golden Harvest manufactures ALCGs that can maintain levels down to 1.2-inch differentials. However, a gate of this type would require expanding the downstream width of the structure by 3 to 4 feet to accommodate the gate's footprint. Furthermore, additional hydraulic improvements such as upsizing the effluent sewer would be required to reduce downstream water levels to the gate's operating range. Therefore, this alternative was ruled out.
6. Raise and protect UV electronics without changing the HGL in the UV channel.
   - For the existing UV equipment: The existing UV module electronics would be raised to above the existing grating, and the quartz sleeves would be replaced with longer quartz sleeves to extend above flood level or sealed at the cable entry. Although the UV manufacturer, Suez, was unwilling to support this, the City has received quotes from aftermarket UV equipment suppliers and an electrical contractor to accomplish this. The existing lamps would remain at their current locations, but the longer quartz sleeves and relocated electronics would enable the modules to continue operation when HGLs rise above the manufacturer's current maximum allowable level without sustaining damage to the equipment. When HGLs rise above the tops of lamps, the portion of flow that is above the UV lamps will not receive UV disinfection. While the top portion of flow would not receive UV disinfection, this would be an infrequent event, and the membrane processes upstream of the UV facility have demonstrated reliable bacterial removal to well below discharge permit criteria upstream of UV disinfection. This alternative would require MDEQ acceptance until the existing UV equipment reaches the end of its useful life, and a new UV system is installed.
   - For New UV Equipment: This alternative is not applicable to new UV equipment, which would be installed at a higher elevation for operation at a higher HGL to address MDEQ's comments.

Table 3 summarizes the alternatives analysis of downstream improvements to protect the UV equipment, considering both the existing and new UV system.

Table 3. Alternatives Analysis of Downstream Improvements to Protect the UV Equipment

Alternative	Description	Existing UV System	New UV System
1	Upsize effluent sewer segments	Feasible in combination with Alternative 4, but given the estimated $312, 000 cost and the eventual need to replace the UV equipment anyway, this alternative is not recommended.	Feasible in combination with Alternative 4, but given the estimated $312, 000 cost and the eventual need to replace the UV equipment anyway, this alternative is not recommended.
2	Vent to relieve air binding	Does not resolve issues, but can drop HGLs by as much as 0.32 foot. Low cost.	Does not resolve issues, but can drop HGLs by as much as 0. 32 foot. Low cost.
3	Orifice-style modification to existing weir wall	Feasible for "typical" river levels, but not 25-year flood level. Not recommended for reasons noted above.	Feasible for "typical" river levels, but not 25-year flood level. Not recommended for reasons noted above.
4	Replace ALCG with modulating weir gate and raise the UV Channel HGL	Feasible for "typical" river levels without raising channel floor level, but at 25-year flood level, this alternative would require raising UV channel HGL, raising the UV equipment, raising the UV channel floor, and raising the electronics ~1.1 feet. Not recommended because significant structural modifications would be required that may not be compatible with future UV equipment replacement.	Feasible for "typical" river levels without raising channel floor level, but at 25-year flood level this alternative would require raising UV channel HGL, raising the UV equipment, raising the UV channel floor, and raising the electronics ~1.1-1.6 feet depending on UV equipment. This alternative is recommended in the future when the existing UV equipment reaches the end of its useful life.
5	Install new counter-weighted style ALCG	Does not resolve issues without effluent sewer modifications. Would require the effluent structure to be significantly modified to accommodate width. Not recommended	Does not resolve issues without effluent sewer modifications. Would require the effluent structure to be significantly modified to accommodate width. Not recommended
6	Raise electrical equipment out of channel and seal components	Expected to allow UV equipment to operate up to 25-year flood level, but would result in the top portion of the flow in the channel not being disinfected during infrequent high-flow events. However, fecal coliform limits are expected to be met due to membranes, and flow at and below the UV lamps would continue to receive full UV disinfection. Recommended as interim resolution until existing UV equipment reaches the end of its useful life.	Not Applicable. New UV equipment would be designed to operate at a higher HGL in conjunction with raising the invert of the UV channel (i.e., Alternative 4).

2.4.2 Upstream Improvements to Protect Structures Upstream of the UV Equipment

Hydraulic issues exist upstream of the UV modules that will remain after implementing one or more of the alternatives above or even become more problematic if the UV channel HGL were raised.

Recommended Alternative 6 for the near term would require upstream improvements to expand hydraulic capacity to 17 mgd during 25-year flood conditions. The following two options were identified.

1. Relocate the weir plates installed in the upstream slide-gate slots of the UV channels and raise the Permeate Discharge Structure TOC.
   - The weir plates in the upstream end of the UV channels maintain prime on the membrane bioreactor backpulse pumps, but result in low freeboard in the UV influent channel, East UV Bypass Structure, and in the Permeate Discharge Structure. Relocating the weirs to where the permeate pipe discharges into the Permeate Discharge Structure would increase freeboard in all three of these structures. Relocating the weir would require temporarily interrupting effluent flow and affixing a weir to the interior wall of the Permeate Discharge Structure at the bottom of the permeate pipe.
   - The Permeate Discharge Structure TOC would also need to be raised. It is recommended that this be raised to accommodate the UV channel HGL being raised 1.1 to 1.6 feet with new UV equipment designed for the 25-year lake level. This corresponds to EL 114.58 to 115.08 feet. Doing so will provide 12 inches of freeboard to the bottom of the top slab during peak flow.
   - The freeboard in the UV East Bypass Structure is anticipated to be approximately 7 inches to the bottom of the top slab and approximately 15 inches to the top of concrete. While a new structure would be designed with a 12-inch free board to the bottom of the top slab, 7 inches at the 25-year lake level condition should be sufficient. For this reason, raising the TOC at that structure is not recommended at this time if the weir plates are moved to the Permeate Discharge Structure.
   - Although the existing electrical conduits are above the estimated maximum HGL with the weir plates relocated upstream, raising the electrical conduits as described in the next option will further ensure the protection of these conduits.
2. Leave the weir plates in place, raise and seal electrical conduits in the upstream end of the UV channel, and raise the UV East Bypass Structure and Permeate Discharge Structure TOCs.
   - At 17 mgd, water levels in the UV influent channel exceed the bottom elevation (EL 112.67 feet) of the conduit runs by approximately 3.5 inches. This exposes the conduit and associated power/control infrastructure to process water. Raising this conduit above (1 foot above is recommended) the top of concrete is recommended if the weirs are not relocated upstream.
   - The East UV Bypass Structure would need to be raised approximately 11.2 inches to EL 115.42 feet TOC. This provides 12 inches of freeboard to the bottom of the top slab during peak flow conditions.
   - The Permeate Discharge Structure would need to be raised approximately 18 inches to EL 115.77 feet TOC. This provides 12 inches of freeboard to the bottom of the top slab during peak flow conditions.
   - The freeboard in the UV influent channel is anticipated to be approximately 9.5 inches. While a new structure would be designed with a 12-inch free board, 9.5 inches at the 25-year lake level

condition should be sufficient. For this reason, raising the TOC at the UV influent channel is not recommended.

Upstream improvements were identified for Alternative 4, which is recommended when the existing UV equipment reaches the end of its useful life. As mentioned, this alternative involves raising the operating HGL in the UV channels and, as a result, upstream structures. Upstream improvements (which are based on a 2-inch freefall over the UV level control device) are as follows:

- Remove the weir plates installed in the upstream slide-gate slots of the UV channels and, if relocated to the Permeate Discharge Structure, remove them from there. The higher HGL in the UV channel will maintain prime on the membrane bioreactor backpulse pumps and eliminate the need for these.
- Install a new weir gate, and raise the UV channel invert to accommodate UV system design criteria. The weir gate will need to extend as low as approximately EL 109.2 feet and act as a submerged weir to maintain 2 inches of freefall at peak flow. All values should be confirmed based on 25-year lake level after the Union Street Dam replacement.
- Raise the East UV Bypass Structure per above if not already raised.
- Raise the Permeate Discharge Structure per above if not already raised.
- Raise the existing conduit below the UV channel's TOC per above if not already raised.

Table 4 summarizes key findings from the analysis of upstream improvements.

Table 4. Summary of Upstream Improvements to Protect Structures Upstream of the UV Equipment

Downstream Alternative	Upstream Option	Description	Key Observations
Alt 6	Option 1	Relocate weir plates to Permeate Discharge Structure and raise structure. Consider raising existing electrical conduits in UV channel.	12 inches of freeboard achieved in upstream structures during peak flow with exception of East UV Bypass Structure (estimated 7 inches).
	Option 2	Do not relocate weir plates. Instead, raise existing electrical conduits in UV channel, raise East UV Bypass Structure, and raise the Permeate Discharge Structure TOC.	12 inches of freeboard achieved in upstream structures during peak flow with exception of UV influent channel.
Alt 4	Only 1 option	Remove weir plates, raise East UV Bypass Structure TOC if freeboard is deemed insufficient, raise Permeate Discharge Structure TOC.	Operating HGL in UV channel would be approximately 1.1 to 1.6 feet higher than existing conditions (analysis assumed 1.1 feet); 12 inches of freeboard achieved in all upstream structures during peak flow; estimated 2 inches of freefall over new UV effluent weir gate.

2.5 Recommendations

Based on the above analysis, Alternative 6 Option 1 is recommended in the near term, and Alternative 4 is recommended when the existing UV equipment reaches the end of its useful life. These alternatives are summarized below along with construction cost estimates (engineering costs are not included):

- Raising the UV electrical equipment out of the channel and sealing components is recommended until the existing UV equipment has reached the end of its useful life. Non-watertight electrical equipment should be positioned such that the bottom is at least 12 inches above the UV channel TOC (positioned at or above EL 115.0 feet). If possible the UV electrical equipment and sealing of components should be designed to be protected from damage at the 25-year and 100-year flood elevations (refer to the Figure 2 hydraulic profile). The City has received quotes from an aftermarket UV equipment supplier and electrical contractors to accomplish this. The City would modify 6 modules consisting of 4 installed modules (2 per channel) and 2 uninstalled spares. The quoted cost for the longer quartz sleeves is $12,480, based on 6 modules with 40 quartz sleeves per module at a quoted cost of $52 per quartz sleeve. The quoted cost for an electrician to raise electrical components out of the channel was $34,458 based on 6 modules at $5,743 per module. With handrail, the estimated cost is $57,000.
- Relocate weir plates to Permeate Discharge Structure. The estimated cost is $13,600.
- Raise the Permeate Discharge Structure TOC. The estimated cost is $6,700.
- Raise the existing electrical conduits in the UV channel nominally 1 foot above the top of channel. The estimated cost is $12,500.
- Alternative 2 (venting to address the air binding issue) is discretionary. It could be implemented and field testing repeated to determine if the hydraulic grade line in the UV effluent channel downstream of the ALCG has been reduced and if so by how much (the most expected is 0.32 foot). A reduction in HGL here would allow a reduction in the future design HGL in the UV channel associated with new UV equipment. This, in turn, would result in a commensurate increase in freeboard in the UV channel and in upstream structures. The estimated cost is $16,000.
- When the existing UV equipment reaches the end of its useful life, Alternative 4 involving new UV equipment, a raised UV channel HGL, a raised UV channel invert, and a modulating weir gate is recommended. The new UV equipment should be designed to not be damaged at 100-year flood levels and provide full disinfection at 25-year flood levels (refer to the Figure 2 hydraulic profile). The 25-year flood elevation may be reduced below the FEMA elevation noted herein as a result of the planned Union Street Dam replacement. Therefore, the 25-year flood elevation should be determined, and the new UV channel HGL set accordingly. The cost estimate for this is presented in the following section.

Ultraviolet Equipment Replacement Evaluation

3.1 Introduction

Raising electrical equipment out of channel and sealing components until the existing UV equipment reaches the end of its useful life will protect the existing UV equipment from damage and defer the significant cost associated with replacing UV equipment. However, new UV equipment alternatives were included for comparison and planning for the future.

The physical dimensions of the existing UV channels affect what alternatives will be cost effective. The dimensions of the existing system are outlined in Table 5.

Table 5. Geometry Associated with Existing UV System

Parameter	Dimension/Elevation
Channel length (influent stop gate to effluent stop gate)	32 feet
Channel width	24.5 inches
Channel depth	93 inches
Normal water depth in the UV channels (downstream of lamp banks)	57.5 to 62 inches
Water elevation flood criteria	114 feet (this is equal to the top of wall of the existing UV channels)

3.2 Ultraviolet Equipment Alternatives

Based on the values presented in Table 5, CH2M identified two alternative UV technologies for evaluation. One alternative involves upgrading the existing open-channel UV system, and the other involves installing a completely new in-vessel UV system that would be located in a new building. Only manufacturers of UV disinfection systems that are typically used for municipal wastewater applications on a scale similar to that required for the Traverse City Regional WWTP were considered for this evaluation.

There are two subalternatives for open-channel UV systems, vertically and horizontally oriented lamps. Only one open-channel UV system manufacturer meeting the criterion was identified for vertically oriented lamps—Suez Ozonia, the same manufacturer as the existing system formally manufactured under the name IDI. An advantage of Suez Ozonia's system is that the channel depth and width would not need to be modified. There are several manufacturers of horizontally oriented lamps potentially meeting the criterion. Three leading manufacturers of horizontally oriented lamps meeting the criterion were contacted to solicit proposals. Additional manufacturers were not contacted because only a couple of budgetary proposals were needed to evaluate the relative cost for this alternative for comparison to the vertical-oriented lamps and in vessel alternative. Horizontally oriented lamps require the existing channel depth be reduced, and the channel walls narrowed to accommodate the horizontally oriented lamp equipment.

Only two manufacturers meeting the criterion were identified for low-pressure high output in vessel UV systems. Additional manufacturers offer medium pressure in vessel systems, but these were ruled out due to a disadvantage described in Table 6 (i.e., algae growth).

1. Retain open-channel approach replacing the existing system with:
   - Suez Aquaray 40 HO: Vertically oriented lamps with ballasts located above the channel.
   - Trojan 3000Plus: Horizontally oriented lamps with ballasts located in watertight enclosure above lamps racks.
   - Xylem Wedeco TAK-55: Horizontally oriented lamps with ballasts located above the channel. Still offered but being phased out. Their new product line is an inclined lamp system.
   - Calgon C3500D: Horizontally oriented lamps with ballasts located above the channel.
2. In-Vessel approach: Replace existing system with an in-vessel system:
   - Trojan UVFIT
   - Xylem Wedeco LBX 1500e

3.3 Additional Ultraviolet Equipment Alternatives Considered and Eliminated from Further Consideration

Based on the constraints of the existing facility and/or specific requirements of the manufacturer's system, the following UV systems were determined to be infeasible and/or cost prohibitive for the reasons noted in Table 6.

Table 6. Systems That Were Ruled Out from Consideration for This Evaluation

UV System Manufacturer/System	Reason(s) for not considering further
Suez Aquaray 3X LPHO open-channel system	Would require significant modifications to existing channels or construction of new UV channels.
Suez HiCAP enhanced LPHO open-channel system	Would require significant modifications to existing channels or construction of new UV channels.
Trojan Signa enhanced LPHO open-channel system	Would require significant modifications to existing channels or construction of new UV channels.
Wedeco Duron enhanced LPHO open-channel system	Would require significant modifications to existing channels or construction of new UV channels.
Calgon Sentinel medium pressure in-vessel system	Medium-pressure lamps emit visible spectrum, which grows algae in the reactor in wastewater applications.
Aquionics InLine W 16000+ medium pressure in-vessel system	Medium-pressure lamps emit visible spectrum, which grows algae in the reactor in wastewater applications

LPHO = Low Pressure High Output

Other alternatives considered and ruled out are described as in the following subsections.

3.3.1 Original Equipment Manufacturer Extending the Quartz Sleeves of the Existing System

An inquiry was made with Suez as to whether Suez could replace the quartz sleeves of the existing IDI system with longer sleeves so that there would be a section of the sleeve above the peak channel water level that would be above the top of lamp (i.e., the top section of the sleeve would just include the wires that power the lamp). This would raise the module enclosures above the high-water level. Suez stated that they cannot offer this. As discussed herein, if this alternative were to be pursued further, it would require a custom approach without the involvement of Suez.

3.3.2 Original Equipment Manufacturer Moving the Ballast and Other Electronics to a Custom Enclosure Above the Existing Enclosure

In this alternative, the existing enclosure would continue to support the quartz sleeves and lamps, but the ballasts and electronics would be moved to a new enclosure above the existing enclosure. The bottom of the new enclosure would be installed above the peak expected hydraulic grade line. This alternative would require a water-tight seal at the top of the quartz sleeve, which would remain at the current elevation. This alternative would also likely result in either the replacement of the grating over the channels with handrail around the channels or a curb and an elevated grated platform. An inquiry was made with Suez to discuss the feasibility of this alternative. Suez stated that from its perspective, it would have to essentially develop a new product that would have to be designed and tested. This would entail developing a new ballast and lamp design and new wires and connectors. Suez would have to work with its ballast supplier and other suppliers to do this. Suez was not sure what it would be able to reuse, including the ballasts. Suez could not provide a cost estimate, but said that it would be comparable to the costs for developing its other new products, and that the cost would be more than it would cost for Traverse City to purchase an entirely new system. Therefore, Suez does not recommend this approach. If this alternative were to be pursued further, it would require a custom approach without the involvement of Suez.

While these two alternatives were ruled out with the Original Equipment Manufacturer (Suez), WWTP personnel have received quotes from an aftermarket UV equipment parts supplier and an electrical contractor to accomplish replacing the sleeves with longer sleeves or sealing the sleeves and raising electronics without the involvement of Suez as described for Alternative 6.

3.3.3 Stair Step Channel Floor and UV Equipment

In this alternative, the floor level and UV equipment level are highest for the upstream modules or banks to account for the increased head resulting from the downstream modules or banks. By this approach, submergence of the lamps can be maintained relatively the same between modules or banks across the length of the channel even though the water level is progressively higher upstream of each module or bank. A stair-step approach to the channel floor and UV equipment elevation is relatively common. The potential benefits of a stair-step approach would be greater with the original 1995 UV design when there were a large number of modules in series. With the reduction in the required number of UV modules resulting from the high-quality membrane effluent, there would be very little benefit to a stair-step approach because the difference in water level between modules is small in comparison to the other factors affecting the water level.

3.3.4 Remove Existing Modules During High Water Events

Lifting the existing IDI modules out of the channels during high water level was also considered. It was concluded that this approach would not be practical because high water levels can occur in a matter of minutes, which would not provide operations personnel enough time to remove the modules.

Also, there would be no disinfection of the effluent with the modules removed from the channels. Therefore, this option was not considered further.

3.4 Design Criteria Assumptions

The design criteria assumed for this evaluation are presented in Table 7. These values were provided to the equipment manufacturers, so that they could provide budgetary proposals to be used in this evaluation.

Table 7. UV System Design Criteria

Item	Open Channel Retrofit	New In-Vessel System
Number of UV Channels/Reactors	2 duty	2 duty + 1 spare
Current Annual Average Flow[a]	4.7 mgd	
Average Design Flow	8.5 mgd	
Peak Hour Flow	17 mgd	
National Pollutant Discharge Elimination System Final Effluent Limitations for Pathogens:		
Monthly Average Fecal Coliform	< 200 CFU/100 mL[b]	
7-Day Fecal Coliform	< 400 CFU/100 mL[b]	
Design UV Dose at Average Design Flow	30 mJ/cm^2 National Water Research Institute Reduction Equivalent Dose based on T1 or MS2 Phage indicator organism, whichever is less stringent	
Design UV Dose at Peak Hour Flow	15 mJ/cm^2 National Water Research Institute Reduction Equivalent Dose based on T1 or MS2 Phage indicator organism, whichever is less stringent[c]	
UV Transmittance	65%	
Total Suspended Solids	< 5 milligrams per liter	

[a] This flow is used for annual operating cost estimates.
[b] These limits are typically met after MBR treatment before UV disinfection; however, UV disinfection is still required by MDEQ.
[C] The UV manufacturers were requested to provide quotes that would meet these minimum design UV dosages; in some cases, the UV vendors provided more conservative sizing as a result of physical/hydraulic constraints associated with retrofitting their equipment into the existing Traverse City Regional WWTP and/or the lack of modularity of its product offerings. See next section of this technical memorandum for resulting design dosages. Required design dose would need to be verified with MDEQ if new UV equipment is designed.

CFU = colony forming units

mL = milliliter

mJ/cm^2 = millijoules per square centimeter

3.5 Summary of UV Manufacturer Budgetary Quotes

Budgetary quotes were solicited from the selected manufacturers. Key system components, as well as the budgetary equipment costs, are provided in Tables 8 through 10. The complete budgetary quotes are provided in Appendix H through L. Table 8 summarizes the key items associated with the vertical system from Suez. No structural modifications to the existing channels would be necessary for this option.

Table 8. Information Summary for Vertically Oriented Lamps (Suez Aquaray 40 HO)

Item	**Quantity**
Design Dose at 17 mgd, mJ/cm^2	15
Channels	2
Modules/Channel	2
Modules Installed in Channels/Total Modules Provided	4/6
Lamps per Row/Rows per Module	8/5
Lamps/Module	40
Lamps Installed in Channels/Total Lamps Provided	160/240[a]
Watts/Lamp	165
Connected Load, kilowatt	27.5
Head Loss Across Banks (17 mgd/22.4 mgd), inches	4.96/8.62
Schedule (submittals/equipment delivery to site after approved submittals), weeks	6 weeks/16 to 18 weeks
Budgetary Quote	$340,000

[a] Four modules are installed in the channels (160 lamps). Two uninstalled spares would be provided to install if flooding damage occurred to electronics in channel. A total of 240 lamps are provided, including the two spare modules.

mJ/cm^2 = millijoules per square centimeter

Table 9 summarizes the key items associated with the systems that would be retrofitted into the existing UV channels with horizontally oriented lamps provided by Trojan Technologies, Wedeco (a Xylem Company), and Calgon Carbon Corporation. For the Trojan system, the width of the existing channels would have to be reduced from 24.5 to 20 inches. For the Calgon system, the width of the existing channels would have to be reduced from 24.5 to 18 inches. Similar channel modifications are assumed to be required for the Wedeco lamps, although Wedeco did not provide a proposal for its horizontally oriented lamp UV system because although it is still available, Wedeco is phasing it out. The new product line is an inclined lamp open-channel UV system with the market name Duron. The Duron equipment would require the channels be widened by approximately 5 inches on each side for a channel width of 29.53 inches. For all of the new horizontally oriented lamp systems or the Wedeco Duron inclined lamp system, concrete fill would need to be poured on the channel floor to reduce the depth of the channel. The depth of concrete fill required varies by manufacturer, and the structural acceptability of the manufacturers requiring more fill would need to be evaluated during preliminary design.

Table 9. Information Summary for Horizontally Oriented Lamps

Item	Trojan 3000Plus	Wedeco TAK-55[c]	Calgon C3500D
Design Dose at 17 mgd, mJ/cm^2	30[a]	Not provided	31.4[a]
Channels	2	2	2
Banks/channel	2	2[b]	2
Lamps per module/rack	8	Not provided	7
Racks or modules/bank	5	Not provided	3
Lamps/bank	40	Not provided	21
Total lamps	160	Not provided	84
Channel length required	25 feet, 4 inches	25.9 feet[b]	28.4 feet
Channel width	20 inches	17.1 inches[b]	18 inches
Water depth (nominal)	32 inches	25.6 inches[b]	42
Channel depth	62 inches	41.4 inches[b]	66
Watts/lamp, nominal	250	285[b]	500
Power demand per lamp (including ballast), watts	250	Not provided	565
Connected Load, kilowatts	40	Not provided	50
Input power required	480V, 3ph, 4 wire plus ground, 60Hz	480V, 3ph, 4 wire plus ground, 60Hz[b]	480/277V, 3ph, 4 wire plus ground, 60Hz or 480/230V, 3ph, 4 wire plus ground, 60Hz
Head loss across banks (17 mgd/22.4 mgd), inches	3/5	Not provided	4.7/TBD
Schedule (submittals/equipment delivery to site after approved submittals), weeks	4 to 6 weeks/8 to 10 weeks[b]	TBD/24 to 28 weeks[b]	TBD/14 to 18 weeks
Budgetary quote	$425,000	Not provided	$352,000

[a] Fewer number of modules per bank cannot be provided because too much head loss is generated in a narrower channel.
[b] Based on other recent proposals provided by the manufacturer or based on CH2M's general knowledge of the system.
[c] Wedeco still offers but is phasing out the TAC-55. Their new product offering is a Duron inclined bulb system, which would require widening of the channel width. The budgetary equipment cost for this alternative was $349,000.

mJ/cm^2 = millijoules per square centimeter

TBD = to be determined

Table 10 summarizes the key items associated with the in-vessel systems provided by Trojan Technologies and Wedeco.

Table 10. Information Summary for In Vessel Systems

Item	Trojan UV Fit	Wedeco LBX 1500e
Design dose at 17 mgd, mJ/cm^2	24[a]	15
Reactors	3 (2 duty, 1 standby)	3 (2 duty, 1 standby)
Lamps per reactor	72	60
Total lamps	216	180
Watts/lamp		300
Connected load, kilowatts		55.2
Input power required	480/277V, 3 phase, 4 wire, 60Hz	480V, 3 phase, 4 wire, 60Hz
Head loss across banks (17 mgd/22.4 mgd), inches	~27/~40	53.9/TBD
Schedule (submittals/equipment delivery to site after approved submittals), weeks	TBD/14 to 16	8/18
Budgetary quote	$750,000	$366,000

[a] Trojan must use a smaller reactor to reduce the design dose any lower; the next size smaller is a 32-lamp reactor, which only provides a dose of 13 mJ/cm^2, and also results in excessive head loss.

mJ/cm^2 = millijoules per square centimeter

3.6 Effectiveness of Alternatives to Mitigate Elevated Water Levels in UV Channels

The two alternatives and associated manufacturer's equipment were assessed with respect to the ability to remain in service if the water level in the existing UV channels were to rise to the top of the channel at EL 114 feet. A relative, qualitative score of 1 through 10 is assigned to each. A score of 10 represents fully mitigating equipment damage and the ability to continue operating with no impacts/equipment damage. A score of one represents no improvement relative to existing system.

3.6.1 Alternatives that Retain Open Channels

3.6.1.1 Suez Aquaray 40 HO

Ballasts are remote in separate enclosures at grade but the motors that drive the wiper system are still in the module panels (refer to Figure 3). In the event of elevated water levels, the system would automatically turn off to protect the lamps. The flooded modules would be removed and replaced with the spare units provided. This activity is anticipated to take up to 90 minutes depending on the circumstance. The flooded modules would be dried out over a period of several days, and then the units could be reinstalled in the channels.

Figure 3. Suez Aquaray 40 HO

Damage to the lamps is not anticipated under this scenario; however, the motors that drive the automatic sleeve wiper plates in each module may have to be replaced depending on the extent and duration of the submergence.

This option locates the ballasts in panels remote from the channels, protecting them if the channels were to flood. However, this option does not provide module enclosures that can withstand submergence; therefore, interruption of service is still anticipated if flooding occurs. This option is assigned a flood mitigation score of 6.

3.6.1.2 Trojan UV3000Plus

The Trojan 3000Plus system consists of horizontally oriented lamps with ballasts located in watertight enclosures in the channel above the lamps racks (refer to Figure 4). The UV3000Plus system has module enclosures with NEMA 6P ratings that house the ballasts. This rating means the units can withstand 6 feet of submergence for 24 hours, and likely longer at lower water levels. This system is expected to be protective of the equipment, but there is a small uncertainty regarding moisture leakage into the annular space of the quartz sleeves due to lack of operating data at flood levels. The automatic sleeve wiper system is driven hydraulically by a hydraulic power pack, which is located at-grade remote from the channel. This option is assigned a flood mitigation score of 9.

Figure 4. Trojan UV3000Plus

3.6.1.3 Wedeco TAK-55

The Wedeco TAK-55 system consists of horizontally oriented lamps with ballasts located in at-grade enclosures that are remote to the channels (refer to Figure 5). The automatic sleeve wiper system is driven pneumatically by an air compressor which is located at-grade remote from the channel. This system is expected to be protective of the equipment, but there is a small uncertainty regarding moisture leakage into the annular space of the quartz sleeves due to lack of operating data at flood levels. This equipment may provide a slightly higher level of protection than Trojan because all electronics are above the channel. This option is assigned a flood mitigation score of 9.5.

Figure 5. Wedeco TAK-55

3.6.1.4 Calgon C3500D

The Calgon C3500D system consists of horizontally oriented lamps with ballasts located in at-grade enclosures that are remote to the channels (refer to Figure 6). The automatic sleeve wiper system for each lamp rack is driven by electric motor, which would be located below EL 114 feet but is housed in a NEMA 6P enclosure that is rated for submergence. This system is expected to be protective of the equipment, but there is a small uncertainty regarding moisture leakage into the annular space of the quartz sleeves or the automatic sleeve wiper system due to lack of operating data at flood levels. This option is assigned a flood mitigation score of 9.5.

Figure 6. Calgon C3500DD

3.6.2 Alternatives that Use In-Vessel Systems Outside of the Existing UV Channels

The two in vessel manufacturers under consideration would be located at grade and would be housed in a new building. They would be fed by the permeate pumps. The permeate pumps discharge to a common overhead pipe that is connected to a vertical pipe that runs from the overhead pipe through the floor where it transitions to a buried horizontal gravity flow pipe. Verification that the permeate pumps are not impacted by the head loss through the in-vessel UV equipment would be required for this alternative.

3.6.2.1 Trojan UVFIT

All of the UV equipment associated with this Trojan in-vessel system (refer to Figure 7) would be located above EL 114 feet, and this option is assigned a flood mitigation score of 10.

Figure 7. Trojan UVFIT

3.6.2.2 Wedeco LBX 1500e

All of the UV equipment associated with this Wedeco in vessel system (refer to Figure 8) would be located above EL 114 feet, and this option is assigned a flood mitigation score of 10.

Figure 8. Wedeco LBX 1500e

3.7 Ultraviolet Equipment Replacement Cost Estimates and Flood Mitigation Effectiveness

Construction and Capital (construction plus engineering) costs were estimated for each UV disinfection system using **C**H2M's **P**arametric Cost **E**stimating **S**ystem (CPES) software. Annual electricity costs were estimated using the current annual average flow of 4.7 mgd.

The cost for hydraulic improvements recommended for the open-channel UV alternative to prevent flooding were not included in the cost estimate. Inclusion of these costs would decrease the benefit-to-cost ratios for the in-channel alternative. Although the hydraulic improvements identified for the open-channel UV alternative would not be necessary for the in-vessel UV alternative, the costs for these hydraulic improvements are small relative to the costs for the in-vessel UV alternative. Therefore, inclusion of the costs would not change the relative rankings. If the in-vessel UV alternative were to be pursued further, it would be necessary to verify that the permeate pumps would not be impacted by the head loss through the in-vessel equipment because this could decrease the benefit-to-cost ratio of the in-vessel alternative.

The remaining operating and maintenance costs such as lamp replacement and labor were not estimated; the recurring annual costs associated with operating maintaining these systems are not anticipated to be significantly different between the alternatives under consideration.

Using the upfront project costs and the annual power cost estimates, 20-year net present value (NPV) estimates were developed for each option. Table 11 lists the factors assumed for developing the cost estimates.

Table 11. Factors and Allowances Used for Cost Estimates

Item	Value	Basis
Construction contingency	20%	Typical value
Engineering, legal and administrative costs	20%	Typical value
Power costs	$0.0761 per kilowatt-hour	Average industrial electricity rate in Traverse City
Discount rate	3.5%	Typical value

The 20-year NPV and the flood mitigation scores are presented in Table 12. Additional details are included in Appendix M.

Table 12. Summary of Project Cost Estimates and Flood Mitigation Effectiveness

Option Category	System	Equipment Cost[a]	Estimated Capital Cost[a]	20-Year NPV Costs[a]	Flood Mitigation Effectiveness[b]	Benefit to Cost Ratio[c]	Ranking
Retrofit Existing Channels with Vertically Oriented Lamps	Suez Aquaray 40 HO	$340,000	$1,206,000	$1,291,000	6	4.6	2
Retrofit Existing Channels with Horizontally Oriented Lamps	Trojan UV3000Plus	$425,000	$1,550,400	$1,612,000	9	5.6	1
	Wedeco TAK-55	Not Provided	Not Available	Not Available	9.5	Not Available	
	Calgon C3500D	$352,000	$1,298,400	$1,355,000	9.5	7.0	
In Vessel Systems	Trojan UVFIT	$750,000	$3,685,200	$3,755,000	10	2.7	3
	Wedeco LBX 1500e	$366,000	$2,653,200	$2,767,000	10	3.6	

[a] Cost are estimated at the end of 2017.
[b] Scored 1 through 10, with 10 representing fully mitigated and 1 representing no improvement relative to existing system.
[c] Benefit score multiplied by 1,000,000 then divided by the estimated project costs.

The values in Table 12, which are in current dollars, would need to be adjusted for inflation if budgeting for new UV equipment in the future. Although inflation rates may change, based on the last 5 years, the historical RSMeans construction cost index has increased at an annual average rate of 1.626 percent. This equates to a multiplier of 1.084 and 1.175 for 5 and 10 years, respectively. For example, the estimated capital cost for the Calgon 3500D and Trojan UV3000Plus in 10 years would be $1,526,000 and $1,822,000, respectively, if inflation rates remained as low as in recent years.

Conclusions

4.1 Improvements Already Made

Instrumentation and controls, spare UV modules, and operational procedures were implemented to minimize the potential for flow surges and to minimize interruption of UV disinfection should surges or peak wet-weather flows occur. These improvements are summarized in Section 1.2, Background.

4.2 Near-Term Recommended Improvements

Modifications to the existing UV system will protect the existing UV equipment from damage and defer the significant cost associated with replacing UV equipment until the existing UV equipment reaches the end of its useful life. The recommended improvements are as follows (Total estimated cost, excluding engineering, is $118,280) :

- Raising the UV electrical equipment out of the channel and sealing components is recommended until the existing UV equipment has reached the end of its useful life. Non-watertight electrical equipment should be positioned such that the bottom is at least 12 inches above the UV channel TOC (positioned at or above EL 115.0 feet). If possible, the UV electrical equipment and sealing of components should be designed to be protected from damage at the 25-year and 100-year flood elevations (refer to the Figure 2 hydraulic profile). The City has received quotes from an aftermarket UV equipment supplier and electrical contractors to accomplish this. The City would modify 6 modules consisting of 4 installed modules (2 per channel) and 2 uninstalled spares. The quoted cost for the longer quartz sleeves is $12,480, based on 6 modules with 40 quartz sleeves per module at a quoted cost of $52 per quartz sleeve. The quoted cost for an electrician to raise electrical components out of the channel was $34,458, based on 6 modules at $5,743 per module. With handrail, the estimated cost is $57,000.
- Relocate weir plates to Permeate Discharge Structure. The estimated cost is $13,600.
- Raise the Permeate Discharge Structure TOC. The estimated cost is $6,700.
- Raise the existing electrical conduits in the UV channel nominally 1 foot above the top of channel. The estimated cost is $12,500.

Venting to address the air binding issue in the pipe from the UV channel is discretionary. This could be implemented and field testing repeated to determine if the hydraulic grade line in the UV effluent channel downstream of the ALCG has been reduced and if so by how much (the most expected is 0.32 foot). A reduction in HGL here would allow a reduction in the future design HGL in the UV channel associated with new UV equipment. This, in turn, would result in a commensurate increase in freeboard in the UV channel and in upstream structures. The estimated cost is $16,000.

4.3 Improvements Recommended When the Existing UV Equipment Reaches the End of Its Useful Life

When the existing UV equipment reaches the end of its useful life, new UV equipment, a raised UV channel HGL, a raised UV channel invert, and a modulating weir gate are recommended. The new UV equipment should be designed not to be damaged at 100-year flood levels and provide full disinfection at 25-year flood levels (refer to the Figure 2 hydraulic profile).

The existing UV technology employed at the Traverse City Regional WWTP is low-pressure, low-output. WWTPs typically replace these systems with low-pressure, high-output systems when they have reached the ends of their useful lives. The high-output systems require significantly fewer lamps than the low-output systems. They also offer modulation of lamp output in addition to the ability to turn banks or modules on and off. This can provide energy savings due to flow and water quality variability typical of WWTPs. And most relevant to the flooding events that occurred at the Traverse City Regional WWTP, the electronics in this next generation of UV equipment are better protected from flooding.

When the existing UV equipment is to be replaced, the alternative of horizontally oriented lamps has the best benefit-to-cost ratio and is therefore recommended. The estimated capital cost (includes engineering) is $1,298,400 to $1,550,400 in current dollars based on the Calgon and Trojan proposals, or $1,526,000 to $1,822,000 in 10 years if inflation rates remained as low as in recent years.

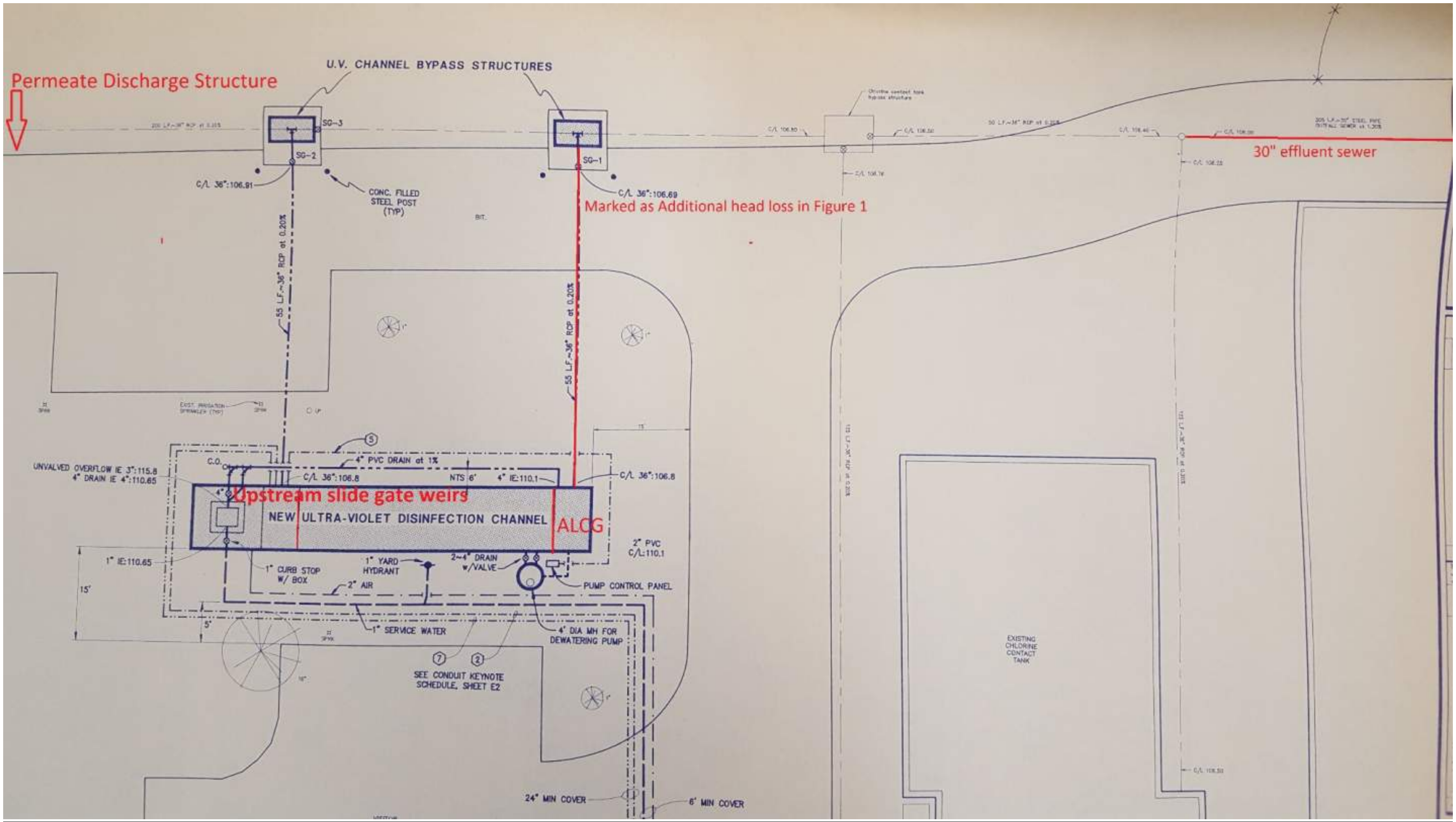
Retrofitting existing channels with vertically oriented lamps was ranked second. This alternative offered modest savings but less protection from damage at high water levels and the cost savings versus the lowest budgetary estimate of the horizontally oriented lamps was small. The in-vessel alternatives provide a robust solution to address flooding and would eliminate the need for additional hydraulic improvements provided the permeate pumps are not impacted by the head loss through the in-vessel equipment. However, due to the high cost of constructing a new building, this technology has the lowest benefit-to-cost ratios, is ranked third in the evaluation, and is therefore not recommended. UV equipment offerings continue to change. Therefore, a similar review and evaluation of alternatives is recommended when the UV equipment is to be replaced in the future.

The 25-year flood elevation at the WWTP discharge may be reduced below the FEMA elevation noted herein as a result of the planned Union Street Dam replacement. Therefore, the 25-year flood elevation should be determined after the dam replacement at the time of UV replacement and the new UV channel HGL set accordingly.

Appendixes

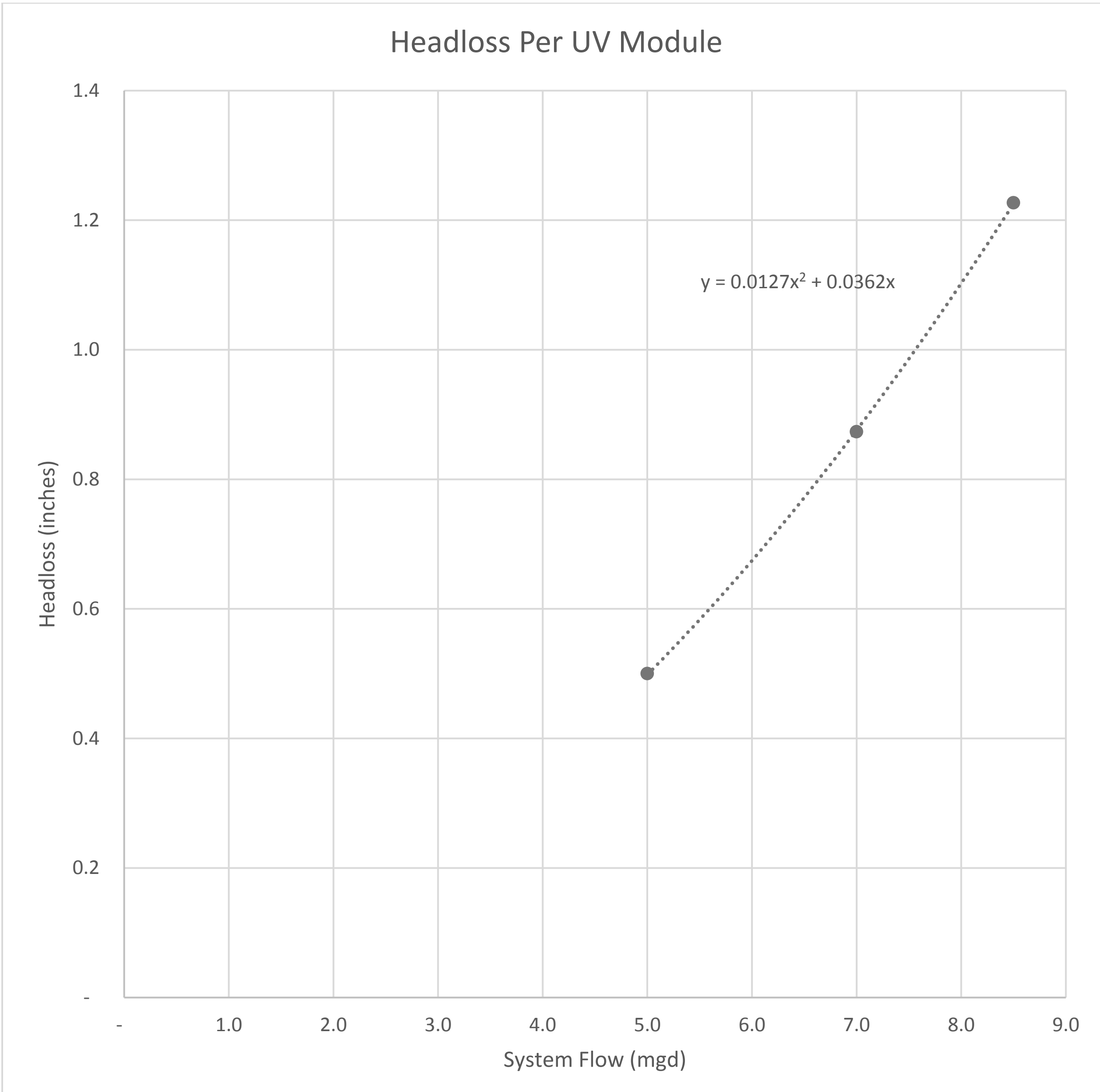
APPENDIX A

UV System and Related Structures



APPENDIX B

UV Module Head Loss Curve



APPENDIX C

Automatic Level Control Gate (ALCG)

APPENDIX D

Field Data and K-Values

First and Second Data Sets

	TOC to Water (feet)					
Flow rate (mgd)	**10.9**	**11.72**	**12.78**	**13.63**	**15.55**	**16.35**
A= East of upstream weir (inserted stoplog weir)						
B= East of first module (upstream)	2.67	2.66	2.60	2.56	2.18	2.48
C= In between modules	2.75	2.66	2.65	2.56	2.20	2.28
D= Upstream (east) of adjustable weir	2.89	2.70	2.75	2.69	2.33	2.35
E= Downstream (west) of adjustable weir	5.00	4.73	4.50	3.98	3.50	3.61
F= UV effluent structure aka West UV Bypass Structure	-	5.86	-	5.40	4.98	-
G= Cl2 bypass structure	-	6.05	-	5.83	5.56	-
H= Cl2 manhole west of bypass structure	-	4.83	-	3.53	3.32	-

Third Data Set

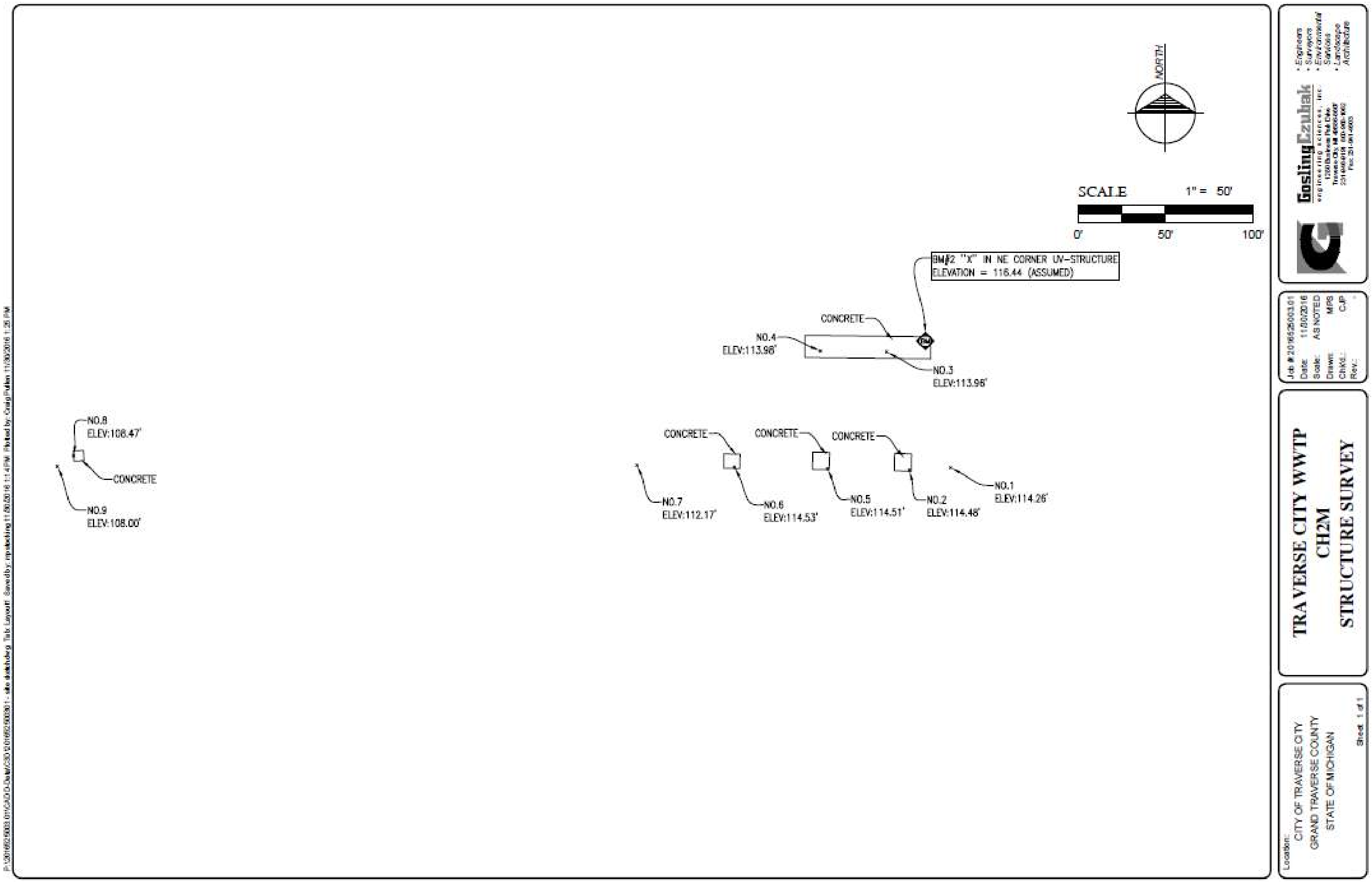
	TOC to Water (feet)			
Flow rate	**11.3 mgd**	**13 mgd**	**15 mgd**	**TOC Elevation**
A= East of upstream weir (inserted stop log weir)	1.47	1.36	1.26	113.98
B= East of first module (upstream)	2.65	2.61	2.54	113.98
C= In between modules	2.69	2.68	2.53	113.98
D= Upstream (east) of adjustable weir	2.75	2.72	2.7	113.98
E= Downstream (west) of adjustable weir	4.86 / 4.95	4.47 / 4.50	3.83 / 4.10	113.98
E at Start of Test	4.86	4.47	3.83	113.98
E at End of Test	4.95	4.50	4.10	113.98
F= UV effluent structure	6.12/ 5.85	5.88 / 5.42	5.20 / 5.19	114.51
F at Start of Test	6.12	5.88	5.2	114.51
F at End of Test	5.85	5.42	5.19	114.51
G= Cl2 bypass structure	6.12	5.88	5.48	114.53
H= Cl2 manhole west of bypass structure	3.93	3.6	3.36	112.17
Outfall TOC to River	0.77	0.77	0.77	108.47
One-time measurement at low flows of top of channel to bottom of UV enclosure where quartz tubes enter (inches)	27.25			113.98
Observations: We took the "A" measurement east of the upstream weir, since the "A" measurement was essentially the same at measurement "B". We took two measurements of "E" and "F" once at beginning of each flow test and once at the end of each flow test. UV effluent structure did not stop burping air for the 2nd measurement. This was our most consistent flow test. Flow in channel rose up to the UV control cabinet fans and tripped the breaker on modules 1 and 4.				

Minor Loss K-values

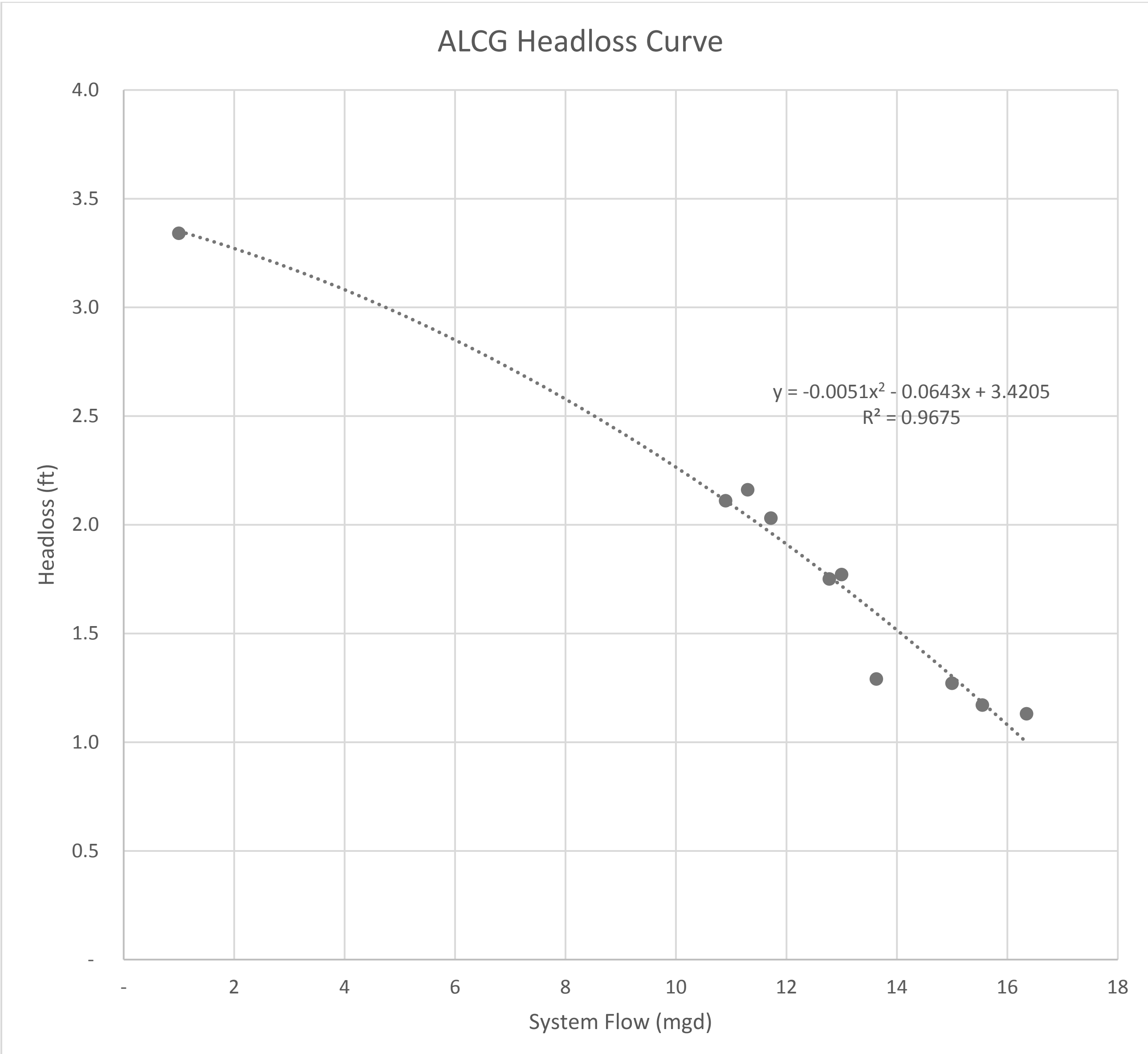
		Minor Loss K Values	
Upstream Node	**Model Element**	**Preliminary Calibration**	**Follow-Up Calibration**
5	Boardman River	0	0
10	Final effluent sewer	1.8	0.55
15	Outfall STR	0	0
20	Final effluent sewer	1.8	0.55
25	MH	0	0
30	36" UV effluent	1.8	0.8
35	Chlorine bypass STR	0	0
40	36" UV effluent	1.75	2.8
45	UV Bypass STR - WEST	0	0.35
50	Sluice gate	0	0.6
55	UV effluent	1.7	0
60	UV effluent channel	0	0
65	ALCG	0	0
70	UV common channel	0	0
75	UV bank 1	0	0
80	UV channel	0	0
85	UV bank 2	0	0
90	UV channel	0	0
95	Submerged weir	0	0
100	UV channel	0	0
105	UV common inf channel	0	0
110	UV common inf channel	0.75	0.35
115	UV influent	0.5	0.5
120	Sluice gate	0	0
125	UV Bypass STR - EAST	0.75	0.35
130	Permeate discharge sewer	1.5	1.5
135	Permeate discharge STR	0	0

APPENDIX E

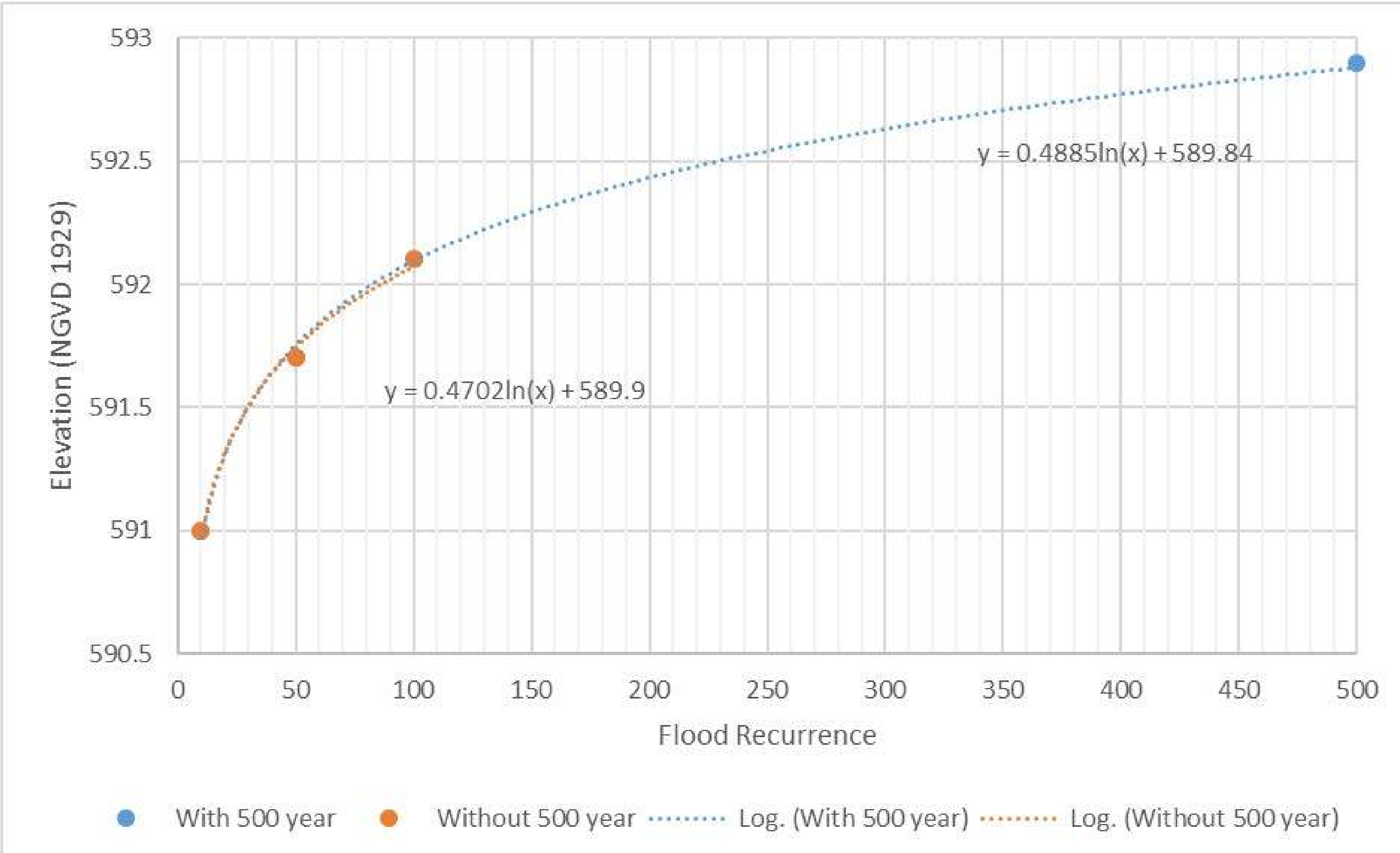
Survey Data



ALCG Head Loss Curve



25-Year Flood Level Interpolation



APPENDIX H

Budgetary Quote for Suez Aquaray 40 HO

Aquaray® 40 “HO” Vertical Lamp Ultraviolet Disinfection Equipment

Preliminary Budget Proposal

For

Traverse City WWTP

Traverse City, MI

November 23, 2016

SUEZ Treatment Solutions Inc.
600 Willow Tree Road
Leonia, NJ 07605, USA
Tel: +1 201 676 2525

November 23, 2016

Matt G. Noesen, P.E.
CH2M HILL Engineers, Inc

Re: Aquaray® 40 HO Vertical Lamp Ultraviolet Disinfection Equipment
Traverse City WWTP

SUEZ Treatment Solutions Inc is pleased to submit our budget proposal for the replacement Aquaray® 40 HO Vertical Lamp ultraviolet disinfection system for the above referenced project.

The Aquaray 40 "HO" system is latest generation and improvement of the previous Aquaray® VLS design which has been in use since 1986 and is currently installed at the Traverse City WWTP. The Aquaray® 40 "HO" is based on the arrangement of the original Aquaray® 40 VLS "Type-B" design, fits in the existing channels without any modifications and includes the following additional features:

- Reduced Number of Lamps and Ballasts (approximately 50% less for same permit)
- Longer Lamp Life (13,000 Hours vs. 10,000 Hours)
- In-Channel Automatic Wiping System
- Fully automated operation. Only requires a 4-20 mA flow signal
- Allen Bradley CompactLogix PLC with 10" Color Panelview 1000 Plus Interface
- Additional Alarms and Monitoring Features
- ***Fits in existing channels without need for civil modifications***

If you have any questions or require any additional information, please don't hesitate to contact our Representative below or the writer.

Sincerely,
For SUEZ Treatment Solutions Inc.

Pedro DaCruz
Director - Sales

AQUARAY® 40 HO (High Output) SYSTEM DESCRIPTION

The Aquaray 40 “HO” system is latest generation and improvement of the previous Aquaray® VLS design which has been in use around the world since 1986. The Aquaray® 40 “HO” VLS System is based on the arrangement of the original Aquaray® 40 VLS “Type-B” design. The vertical lamp orientation and configuration has been proven, through general use and extensive pilot studies, to be a very effective form of disinfection. The system also has many features that make it easy and safe to operate and maintain.

The low pressure, low intensity lamps of the original Aquaray® 40 VLS have been replaced with new low pressure, high output lamps - requiring fewer lamps to treat the same capacity. Fewer lamps guarantee considerable savings on capital, operation, and maintenance costs.

UV DOSAGE ENHANCEMENT:

The ultraviolet dosage is the product of the ultraviolet intensity multiplied by the time (in seconds) that the water is in contact with that UV intensity. Based on completed bioassays, the Aquaray® HO VLS system can treat more than twice the flow compared to the standard low pressure low intensity lamps in an Aquaray® 40 configuration with the same UV dosage (uWatts-secs/cm^2) requirement. Flow deflection baffles have been added to enhance the disinfection performance capability of the Aquaray® HO VLS system.

HIGH OUTPUT LAMP ARRANGEMENT:

The ultraviolet lamps are mounted vertically so that all electrical connections are made out of the water and within the protection of a NEMA 4X stainless steel enclosure. Unlike other designs, all the lamps are easily accessed through the lid of this enclosure. Therefore, routine service such as lamp changes can be made without having to remove the lamp modules from the channel.

The lamps are also mounted in a uniform staggered array, three inch on center across the channel and five inch on center along the channel. This ensures a semi-tortuous path so that every particle of water will come into intimate contact with the most intense point of lamp output.

MODULE ARRANGEMENT:

The number and layout of the modules within the channel is determined based on the required UV dosage and a UV path for the water that eliminates any possibility of hydraulic short-circuiting.

See "DESIGN BRIEF" for details of module arrangement for this project.

CONTROL AND MONITORING:

Electronic lamp control is utilized to minimize power consumption. Electronic lamp control assemblies are conveniently mounted in the Aquaray® High Output Module's NEMA-4X enclosure. This locates the assemblies close to the high output lamps, which minimizes the effect of outside interference such as radio waves, lightning, and voltage spikes.

With our Aquaray® High Output Module each individual lamp is monitored through the use of an on-board computer called a Data Controller Assembly (DCA). The DCA gathers and stores information relative to individual lamp hours and cycles. A non-volatile memory is included so that a possible relocation of the module will not result in a loss or misdirection of valuable lamp data.

The benefits of recording the individual lamp history may not be immediately apparent. UV lamps are guaranteed to provide a minimum operating life measured in terms of active operating hours, usually up to 13,000 hours. If a lamp fails electrically before the guarantee, our end-of-lamp life conditional warranty provides for a replacement at a cost pro-rated to the actual use achieved with the original lamp. For example, if a lamp fails at mid-life the replacement will be provided at half price.

A Power Distribution and Data Center (PDDC) included which houses the load center enclosure and GFCI Breakers for each high output module. The PDDC also includes the Allen CompactLogix PLC and Panelview 1000 Plus Operator Interface. Each Aquaray ® High Output module in the UV disinfection channel receives power from the load center locally mounted at the PDDC via a single power cable with waterproof plug-in connectors.

Each Aquaray® High Output module is fully independent and capable of automatic, fail safe operation in case of a control fault. This "default on" design ensures continuous disinfection even under emergency conditions.

FLOW PACING:

Flow Pacing is a system whereby lamp rows are switched on and off in relation to plant flow variations. The Aquaray® 40 HO System provides for very fine adjustments of the number of High Output lamps in service. Adjustments are made in direct proportion to the flow, with switching increments as low as 3%. To take full advantage of this feature we take a control signal, usually from the plant flow meter, and switch the lamps on or off as the flow changes.

The advantage of being able to switch the lamps by row is two fold:

- Energy Conservation
- Lamp Conservation

In our system each lamp requires 165 Watts. You realize immediate savings by activating only the minimum number of lamps required.

SYSTEM CLEANING:

Any UV system gradually accumulates a coating on the quartz sleeves housing the lamps. This routine fouling must be removed periodically. The Aquaray® 40 HO VLS System offers a fully automatic, in-channel cleaning system which reduces maintenance. The automatic wiping system is to be operated once daily and the wipers are to be replaced once every two years. This system is included in our proposal.

SERVICE:

Every piece of equipment within a wastewater plant requires service. The Aquaray® 40 HO VLS System has been developed to permit easy troubleshooting and quick replacement of components. The majority of maintenance activities can be carried out while the equipment is still located within the channel. The recommended spares included in this proposal will ensure that the system can be maintained efficiently and brought back to full operation in the shortest possible time.

DESIGN BRIEF

PLANT INFORMATION AND DESIGN BASIS;

Plant Name .... Traverse City WWTP
Plant Location .... Traverse City, MI

Instantaneous Hydraulic Flow .... 22.4 MGD (non disinfection)
Peak Design Flow .... 17 MGD
Average Design Flow .... 8.5 MGD

UVT………... 65% minimum
TSS………... Less than 15 mg/l (assumed)

Required Effluent, MPN/100ml:
Fecal Coliform .... < 200 MPN (30 day average)
Fecal Coliform .... < 400 MPN (7 day average)

Minimum Delivered MS-2 UV Dose .... 15 mJ/cm^2

SUMMARY:

Based on the information in the design table below, the system proposed will provide a minimum UV dosage of 15,000 uWatts-secs/cm^2 at the peak flow with all banks in service. The dosage calculation takes into account several factors including the end of lamp life, the quartz sleeve transmittance factor, and the peak capacity.

Based on a peak design flow of 17 MGD, we are proposing retrofitting the existing UV channels each with two (2) Aquaray 40 HO UV modules mounted one (1) across by two (2) banks in series. The total number of Aquaray® 40 HO UV modules is four (4)

Each Aquaray® 40 HO module includes 40 Low Pressure High Output Lamps, arranged in five rows of eight lamps each.

PROPOSED AQUARAY® 40 HO VERTICAL LAMP SYSTEM DESIGN:

Peak Flow, MGD	17 MGD
% UV Transmission	65%
Bioassay UV Dosage at Peak Flow	15 mJ/cm2
Number of Channels	2
Number of Modules Across (Modules per Bank)	1
Number of Modules in Series (Number of Banks)	2
Channel Width, in.	***existing***
Channel Length, ft.	***existing***
Channel Depth, in.	***existing***
Aquaray® Modules/Channel	2
Total Number of Modules	4
Number of Lamps/Module	40
Total Number of Lamps	160
Headloss across all the UV modules, in.	4.96 inches @ 17 MGD 8.62 inches @ 22.4 MGD
Power Consumption per Lamp, W	Up to 172 watts
Power Consumption	27.52 kW @ 8 MGD 27.52 kW @ 17 MGD (assuming we run all ON to ensure we meet average permit)
Total Installed Power	27.52 kW

SPARE PART REPLACEMENT COST:

UV Lamps	$30
Sleeves	$30
Ballasts	$250

SCOPE OF SUPPLY AND BUDGET PRICE

We propose to furnish the following equipment for the Aquaray® 40 HO Vertical Lamp ultraviolet disinfection system described in the previous sections

- Aquaray® 40 HO Vertical UV modules with Automatic Cleaning Wipers, 316L stainless steel components
- Mounting Rail/Eye Shields, 304 stainless steel
- Power Distribution & Data Center(s) (PDDC) ***Including Remote Ballasts*** and Allen Bradley CompactLogix PLC with Panelview 1000 Plus Operator Interface
- Wireways
- Stepdown Transformers
- Interconnecting Cables between the Modules and the Data Control Center and between the Modules and Power Distribution Center(s)
- Lamp Row by Row Flow Pacing
- In-Channel Cleaning System (automatic cleaning wipers)
- New Level Control gates
- Lifting Spreader Bar
- Anchor Bolts
- Recommended Spare Parts
- ***Two (2) spare UV modules***

The following will also be included:

- Freight to the jobsite
- Start-up service: eight (8) days in three (3) trips
- Four (4) O&M manuals

Note that the following items are to be provided by others (unless indicated otherwise above):

- 1/2 ton Jib Crane and Hoist (existing)
- Any Channel Grating
- Any Slides Gates
- Any Remote Computer System
- Any Installation
- Any Embedded Conduits
- Any Sampling and Effluent Performance Testing

BUDGET PRICE: ***Our current budget estimating price is Three Hundred and Forty Thousand Dollars ($340,000)***. This price will be valid for one (1) year; payment terms will be as below and commercial terms and conditions are given on the following page. The price is in accordance with the Scope of Supply and terms of this proposal and any changes may require the price to be adjusted.

Payment Terms:

10% Net Cash, Payable in thirty (30) days from date of submittal of initial drawings for approval;
80% Net Cash, Payable in progress payments thirty (30) days from dates of respective shipments of the Products;
10% Net Cash, Payable in thirty (30) days from Product installation and acceptance or Ninety (90) days after date of final Product delivery, whichever occurs first.

SCHEDULE: Approval drawings and data can be submitted approximately 6 weeks after agreement to all terms, as evidenced by SUEZ's receipt of this proposal, fully executed; or, in the event that Purchaser issues a Purchase Order, OZONIA's receipt of fully executed letter agreement. SUEZ estimates that shipment of the Products can be made in approximately 16-18 weeks after SUEZ has received from Purchaser final approval of all submittal drawings and data.

Typical Aquaray® 40 "HO" Vertical Lamp Ultraviolet Disinfection System Installations

Plant Location: Selkirk, MB

Peak Flow: 12 MGD

Number of Channels: 2

Number of Modules: 3 per channel (6 total)

Typical Aquaray® 40 "HO" Vertical Lamp Ultraviolet Disinfection System Installations

Plant Location:	Chalfont – New Britain, PA
Peak Flow:	20 MGD
Number of Channels:	2
Number of Modules:	4 per channel (8 total)

Typical Aquaray® 40 "HO" Vertical Lamp Ultraviolet Disinfection System Installations

Plant Location:	Peekskill, NY
Peak Flow:	24 MGD
Number of Channels:	2
Number of Modules:	6 per channel (12 total)

Typical Aquaray® 40 "HO" Vertical Lamp Ultraviolet Disinfection System Installations

Plant Location: Greensburg, PA

Peak Flow: 20 MGD

Number of Channels: 2

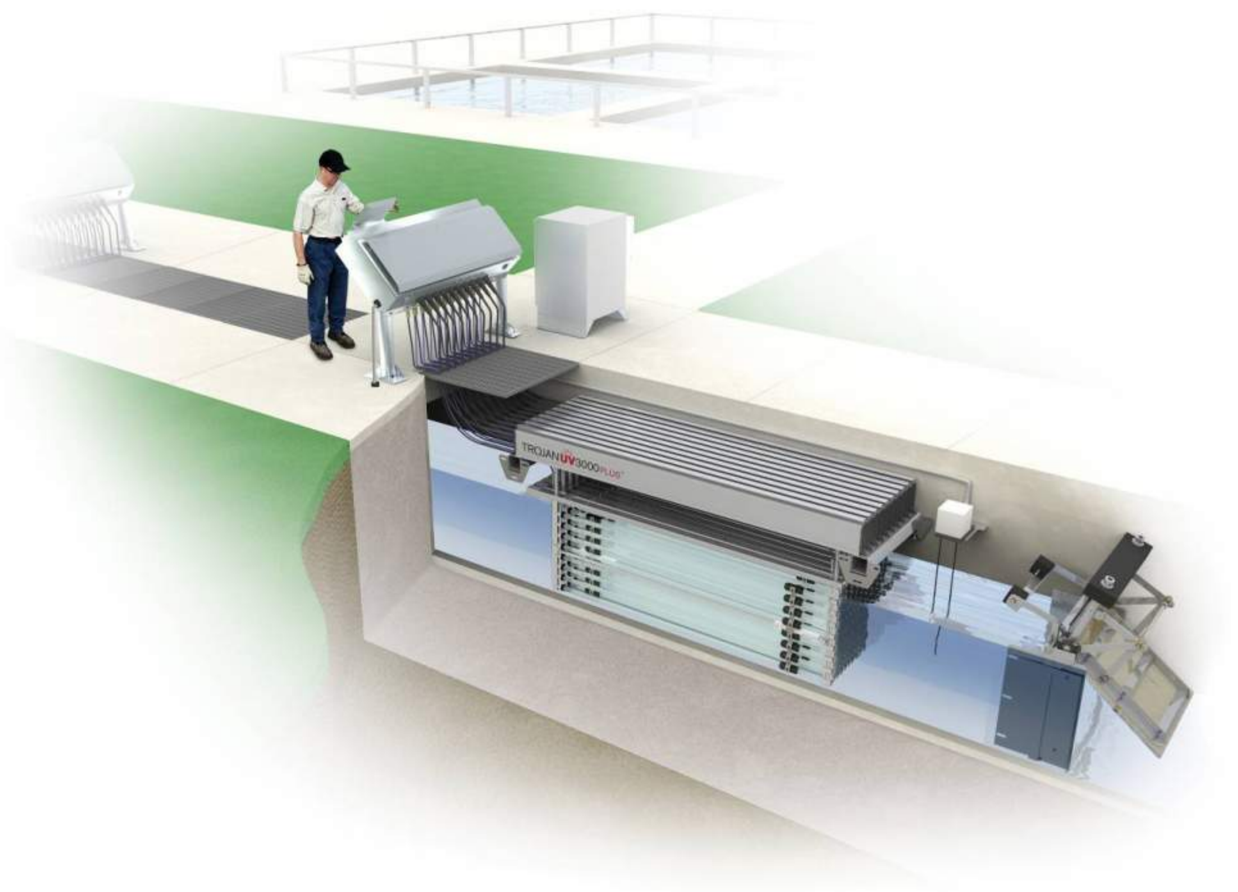
Number of Modules: 4 per channel (8 total)

APPENDIX I

Budgetary Quote for Trojan UV3000Plus

TROJANUV3000PLUS™

PROPOSAL FOR TRAVERSE CITY, MI
QUOTE: 211374
11/23/2016



The TrojanUV3000Plus™ is operating in **over 1300** municipal wastewater plants around the world. Disinfecting **over 17 billion** gallons a day, the TrojanUV3000Plus™ has become the reference standard in the industry.

November 23, 2016

In response to your request, we are pleased to provide the following TrojanUV3000Plus™ proposal for the Traverse City project.

The TrojanUV3000Plus™ has been shown in over 1300 installations to provide dependable performance, simplified maintenance, and superior electrical efficiency. As explained in this proposal, the system incorporates innovative features to reduce O&M costs, including variable output electronic ballasts to provide dimming capability and Trojan's revolutionary ActiClean-WW™ system – the industry's only online chemical and mechanical quartz sleeve cleaning system. All Trojan installations are supported by a global network of certified Service Representatives providing local service and support.

Please do not hesitate to call us if you have any questions regarding this proposal. Thank you for the opportunity to quote the TrojanUV3000Plus™ and we look forward to working with you on this project.

With best regards,

Jordan Fournier
3020 Gore Road
London, Ontario N5V 4T7
Canada
(519) 457 – 3400 ext. 2193
jfournier@trojanuv.com

DESIGN CRITERIA

Traverse City

Peak Design Flow:	**17 MGD**
Peak Hydraulic Flow:	**22.4 MGD**
UV Transmittance:	**65 %** (minimum)
Total Suspended Solids:	**5 mg/l (30 Day Average,** grab sample)
Disinfection Limit:	**200 Fecal Coliform per 100 ml,** based on a 30 day average of grab samples
Design Dose:	**30 mJ/cm^2,** bioassay validated
Validation Factors:	**0.98 end of lamp life factor** **0.95 fouling factor**

DESIGN SUMMARY

QUOTE: 211374

Based on the above design criteria, the TrojanUV3000Plus™ proposed consists of:

CHANNEL (Please reference Trojan layout drawings for details.)	
Number of Channels:	**2**
Approximate Channel Length Required:	**25 ft 4 in**
Channel Width Based on Number of UV Modules:	**20 in**
Channel Depth Recommended for UV Module Access:	**62 in**
UV MODULES	
Total Number of Banks:	**4**
Number of Modules per Bank:	**5**
Number of Lamps per Module:	**8**
Total Number of UV Lamps:	**160**
Maximum Power Draw:	**40 kW**
UV PANELS	
Power Distribution Center Quantity:	**4**
System Control Center Quantity:	**1**
MISCELLANEOUS EQUIPMENT	
Level Controller Quantity:	**2**
Type of Level Controller:	**Weighted Gate**
Automatic Chemical / Mechanical Cleaning:	**Trojan ActiClean-WW™**
UV Module Lifting Device:	**Davit Crane**
On-line UVT Monitor:	**Not Included**

Standard Spare Parts / Safety Equipment:	**Included**
Other Equipment:	
ELECTRICAL REQUIREMENTS	

1. Each Power Distribution Center requires an electrical supply of one (1) 480V, 3 Ph, 4 Wire + Gnd, 10.2 kVA.
2. The Hydraulic System Center requires an electrical supply of one (1), 480V, 3 Ph, 3 Wire + Gnd, 2 kVA.
3. The System Control Center requires an electrical supply of one (1) 120V 1 Ph, 2 Wire + Gnd, 15 Amps.
4. Electrical disconnects required per local code are not included in this proposal.

COMMERCIAL INFORMATION

Total Capital Cost: $425,000 (USD)
Deduct to Remove Wiping: $80,000 (USD)

This price excludes any taxes that may be applicable and is valid for 90 days from the date of this letter.

EQUIPMENT WARRANTEES

1. Trojan Technologies warrants all components of the system (excluding UV lamps) against faulty workmanship and materials for a period of 12 months from date of start-up or 18 months after shipment, whichever comes first.
2. UV lamps purchased are warranted for 12,000 hours of operation or 3 years from shipment, whichever comes first. The warranty is pro-rated after 9,000 hours of operation. This means that if a lamp fails prior to 9,000 hours of use, a new lamp is provided at no charge.
3. Electronic ballasts are warranted for 5 years, pro-rated after 1 year.

APPENDIX J

Budgetary Quote for Calgon C3500D

EXECUTIVE SUMMARY

Proposal # QW-1611-47
Revision: 0

Traverse City, MI WWTP - C3500D UV Disinfection System

Calgon Carbon proposes to supply our C3500TM D Ultraviolet Disinfection System to treat effluent at the above site. This system will include 84 UV lamps to treat the peak flow of 17 MGD. The system will be configured into 2 channels, 2 banks per channel, 3 racks per bank each with 7 lamps.

The main advantages of the C3500TMD system are as follows:

- The C3500TMD uses the highest power low pressure horizontal lamps available. The UV lamp emits 204 W of UV light at 254 nm. This means our system will have fewer lamps, resulting in less maintenance.
- The C^3500^{TM}D system includes automatic, in-place cleaning as a key feature. This reduces the need for operators to remove lamp racks and manually clean them, significantly reducing maintenance. The Calgon Carbon automatic cleaner is mechanical only – no chemicals are required.
- The patented mixing devices dramatically improve the hydraulic and germicidal efficiency of the UV reactor providing unparalleled performance.

Calgon Carbon is a world leader in granular activated carbon solutions. We are also one of the world's foremost providers of ultraviolet light (UV) disinfection and oxidation technologies for water. From the initial introduction of our UV advanced oxidation systems to the continued development of drinking water and wastewater disinfection technologies, we've been delivering proven UV water treatment solutions for more than 25 years. Combined we have over 500 installations in operation or under construction.

This proposal includes system sizing and a bill of materials. If you need any further information, please feel free to contact Christie Theys at 724.218.7262.

PROJECT SPECIFICATIONS

Proposal # QW-1611-47
Revision: 0

Traverse City, MI WWTP - C3500D UV Disinfection System

1.	Design Conditions	
	Peak Flow	17.0 MGD
	Average Flow	8.5 MGD
	Minimum UV Transmittance	65 %
	Total Suspended Solids	30 mg/L
2.	$C^3$500D Specifications	
	Lamp UV Radiation at 254 nm	204
	Lamp Life	16,000 Hours
	Lamp Life Factor	0.90
	Quartz Fouling Factor	0.95
	MS2 RED	31.4 mJ/cm2 validated
3.	System Configuration	
	Number of Channels	2
	Number of Banks/Channel	2
	Number of Racks/Bank	3
	Number of Lamps/Rack	7
	Total Number of Lamps	84
	Number of UV Sensors	4
	Number of Power Distribution Centers	4
	Number of System Control Centers	1
	Number of Weirs	2
4.	Hydraulic Considerations	
	Peak Velocity in Channel	30.06 inches/s
	Headloss per UV Bank	2.35 inches
	Headloss across Level Control Device	22 inches
	Total Headloss across UV System	26.7 inches
	Retention Time	3.51 seconds
5.	Electrical Requirements	
	Input Voltage	480/277 VAC, 3 Phase, 4 Wire, 60 Hz
	Peak Loading per PDC	16.15 Amps
	Power Consumption per PDC	12.51 kW
	Total System Power Consumption	50.02 kW
6.	Approximate Channel Dimensions	
	Length	341 inches
	Width	18 inches
	Width at Level Control Weir	24.5 inches
	Depth	66 inches
	Depth at Level Control Weir	64 inches
	Effluent Depth in Channel	42 inches, nominal

BILL OF MATERIALS

Proposal # QW-1611-47
Revision: 0

Traverse City, MI WWTP - C3500D UV Disinfection System

Item No.	Qty.	Model Number C3500D2203071LP	
1.	2	Channel Equipment	
		Qty. 1	Motorized Level Control Gate
		Qty. 8	Bank Support Brackets
		Qty. 4	Lamp Rack Support Brackets
		Qty. 1	Point Ultrasonic Level Sensor with Mounting Bracket
		Qty. 2	UV Sensors with Mounting Bracket and Scrapers
2.	12	Lamp Rack Assemblies	
		Qty. 7	Low Pressure High Intensity Amalgam Lamps
		Qty. 7	Quartz Sleeves
		Qty. 2	Cable Assemblies
		Qty. 1	Cleaning System Motor
		Qty. Lot	Cleaning System Mechanism and Accessories
		Qty. 7	Scrapers
3.	4	Power Distribution Centers	
		Qty. 21	Electronic Ballasts
		Qty. 1	Main Breaker
		Qty. 3	Earth Leakage Circuit Breakers
		Qty. Lot	Control & Monitoring Equipment with Operator Station
4.	1	System Control Center	
		Qty. 1	Main Breaker
		Qty. Lot	Allen Bradley CompactLogix L32E PLC Equipment and Accessories
		Qty. 1	Allen Bradley PanelView 600 Plus Operator Interface
5.	Lot	Spare Parts and Accessories	
		Qty. 1	UV Face Shield
		Qty. 1	Service Trolley
		Qty. 1	Rack Lifting Sling
6.	Lot	Equipment Documentation	
7.	Lot	Start-up and Commissioning Services	
8.		One (1) Year Warranty Period	

Terms and Conditions

Payment Terms:	CCC Standard Terms
FOB:	Jobsite
Delivery:	14 to 18 weeks after receipt of approved shop drawings

CCC Standard Terms & Conditions Will Apply

Budgetary Price (USD): $352,000

APPENDIX K

Budgetary Quote for Trojan UVFIT

TROJANUVFIT™

PROPOSAL FOR TRAVERSE CITY, MI
QUOTE: MW-211344
Nov 23 2016

With **over 100** installed reactors, the TrojanUVFit™ has demonstrated its validated, cost-effective disinfection solutions in municipal wastewater plants around the world.

November 23, 2016

Reference: Traverse City, MI
Quote Number: MW-211344

In response to your request, we are pleased to provide the following TrojanUVFit™ proposal for the **Traverse City** project. The TrojanUVFit™ is our latest UV solution introduced for wastewater reuse and high level disinfection applications. Ideal for piped systems, the TrojanUVFit™ system delivers effective chemical-free disinfection in a pressurized reactor. This configuration is well-suited for media or membrane filtered effluent where effluent is already under pressure.

The UV system uses low-pressure high intensity amalgam lamps to provide an energy-efficient solution. The compact reactor design minimizes footprint and headloss while ensuring that maintenance activities such as lamp replacement are be performed quickly and safely. The TrojanUVFit™ reactor has undergone stringent bioassay validation in accordance with industry protocols published by the (US) National Water Research Institute – enabling Trojan to fully guarantee disinfection performance.

Lastly, and perhaps most importantly, each of Trojan's municipal installations are supported by a global network of certified Service Representatives to provide rapid local service and support.

Please call us if you have any questions regarding this proposal or the TrojanUVFit™ solution. Thank you for the opportunity to quote this technology and we look forward to working with you on this project.

With best regards,

Jordan Fournier
Regional Manager
Trojan Technologies
(519) 457 – 3400 ext. 2193
jfournier@trojanuv.com

TROJANUVFIT™

DESIGN CRITERIA

Peak Design Flow:	**17 MGD**
Peak Hydraulic Flow:	**22.4 MGD**
UV Transmittance:	**65%** (minimum)
Total Suspended Solids:	**5 mg/l** (Maximum grab sample)
Disinfection Limit:	**200 Fecal Coliform per 100 ml,** based on a 30 day average of grab samples
Design UV Dose:	**24 mJ/cm^2**, bioassay validated
Validation Requirements:	Bioassay Validation – NWRI UV Guidelines 0.98 Lamp aging factor

DESIGN SUMMARY

UV REACTOR	
Reactor Model	**TrojanUVFit™ - 72AL75**
Number of SS316L Reactors	**3** (including 1 redundant reactor)
Number of Lamps per Reactor Chamber	**72**
Total Headloss at Peak Design Flow	**26 in - H2O**
Total Headloss at Hydraulic Flow	**38 in - H2O**
Sleeve Wiping	**Automatic Mechanical**
CONTROL AND POWER PANELS	
Power Distribution Center (PDC) Quantity	**3 (1 per reactor)**
PDC Enclosure Rating	**Mild Painted Steel (Type 12)**
System Control Center (SCC) Quantity	**1**
SCC Enclosure Rating	**Mild Painted Steel (Type 12)**
EQUIPMENT LAYOUT & DIMENSIONS	
Reactor Flange Size	**20 in. ANSI 150 lb**
Approximate Reactor Length (+ clearance)	**89 in. + 66 in. clearance at reactor endcap**
PDC Dimensions (WxHxD)	**48 in. x 86 in. x 24 in.**
Cable Length Between PDC and Reactor	**15 ft. – other options available**
SCC Dimensions (WxHxD)	**40 in. x 78 in. x 18 in.**
ELECTRICAL REQUIREMENTS	
Each Power Distribution Center	**One (1) 480Y/277 V, 3-phase, 4-wire + ground, 50/60Hz 18 kVA**
System Control Center	**One (1) 120 V, 1-phase, 2-wire + ground, 60Hz 1.2 kVA**

COMMERCIAL INFORMATION

Total Capital Cost: $750,000 (USD)
Deduct to Remove Wiping: $37,000 (USD)
Notes: This price excludes any taxes that may be applicable and is valid for 90 days from the date of this letter. Electrical disconnects required per local code are not included in this proposal. Standard Spare parts and safety equipment are included.

EQUIPMENT WARRANTEES

1. Trojan Technologies warrants all components of the system (excluding UV lamps) against faulty workmanship and materials for a period of 12 months from date of start-up or 18 months after shipment, which ever comes first.

2. UV lamps purchased are warranted for 12,000 hours of operation or 3 years from shipment, whichever comes first. The warranty is pro-rated after 9,000 hours of operation. This means that if a lamp fails prior to 9,000 hours of use, a new lamp is provided at no charge.

3. Electronic ballasts are warranted for 5 years, pro-rated after 1 year.

APPENDIX L

Budgetary Quote for Wedeco LBX 1500e

Budget Proposal

Traverse City, MI

prepared for:

CH2M Hill
Matt Noesen

November 18, 2016

Xylem Water Solutions USA, Inc.
14125 South Bridge Circle
Charlotte, NC
28273

November 18, 2016

CH2M Hill
Matt Noesen

Project Name: Traverse City, MI
Project Number:
Revision Number:

Dear Matt Noesen,

We are pleased to submit the following proposal for the Traverse City, MI UV opportunity based on the information provided within your inquiry.

The LBX series is a closed vessel system specifically designed for water and wastewater applications. We have highlighted below the major benefits of the LBX vessels that can improve the performance of the system and increase the lifespan of the equipment:

- Our system includes our latest low-pressure, high-intensity Ecoray lamps which have a guaranteed life of 14,000 hours and are a more efficient lamp with a lower power consumption requirement. In addition, from a maintenance standpoint, the Ecoray lamps are more robust and easy to remove and replace.
- Latest sensor technology – germicidal UV sensor of reference sensor quality (ÖNORM approved) providing the highest accuracy in UV system monitoring and control.
- Automatic wiping system that prevents fouling of the quartz sleeve with easy replacement of wipers.
- The WEDECO Remote Service Support, a combination of the PLC interface and a telephone modem, allows us to monitor and if necessary to adjust the LBX control unit from remote in the same way as directly on site. Therefore Remote Service Support improves the service quality of the LBX unit due to faster and even more cost effective technical support (e.g. maintenance, software updates or service diagnosis) through WEDECO service technicians.
- WEDECO's established and proven TotalCare Program provides our customers with proactive services all designed to minimize the cost of ownership to operate and maintain a UV system. TotalCare services can provide our customers with system health checks, efficiency audits, training and preventative maintenance contracts.

Please feel free to contact us if you have any questions. We look forward to working with you on this exciting project.

Sincerely,

Phil Pino
Senior Sales Engineer
(704) 441-6623

Bill Mattfeld
Senior Applications Engineer

Table of Content

1 Xylem Overview

Xylem is a leading global water technology provider, enabling customers to transport, treat, test and efficiently use water in public utility, residential and commercial building services, industrial and agricultural settings. The company does business in more than 150 countries through a number of market-leading product brands, and its people bring broad applications expertise with a strong focus on finding local solutions to the world's most challenging water and wastewater problems.

Xylem's treatment business offers a portfolio of products and systems designed to effectively meet the demands and challenges of treating water and wastewater. From smarter aeration to advanced filtration to chemical-free disinfection, Xylem leverages its well-known Treatment brands, Flygt, Leopold, Sanitaire, and Wedeco, to offer hundreds of solutions backed by a comprehensive, integrated portfolio of services designed to ensure we can meet our customers' needs in a number of different industries including municipal water and wastewater, aquaculture, biogas and agriculture, food and beverages, pharmaceuticals, and mining.

Our scientists and engineers utilize their deep applications expertise and continually listen and learn from our customers' situations to create solutions that not only use less energy and reduce life-cycle costs, but also promote the smarter use of water.

Wedeco has accepted the challenge of the 21st century. With the Wedeco brand for UV Disinfection, ozone oxidation & AOP solutions, we own the advanced technologies for chemical-free and environmentally friendly treatment of drinking water, wastewater and process water as well as further industrial treatment processes. We constantly invest a large portion of our energy in the development of high-tech components, systems and equipment, as well as in the study of new areas of application for UV, ozone & AOP. In doing so, we have always given special attention to the increase in energy efficiency of our Products equipped with our unique UV lamps and ozone electrodes.

The special characteristics of the Wedeco Ecoray UV lamp are its special doping and the unique long-life coating. Because of these features, a constantly high UV light yield is achieved with a substantially extended lamp service life at the same time. In addition, by using this technology it is not necessary to apply liquid mercury inside the lamp. Wedeco UV lamps cannot be surpassed in economic efficiency.

In relation to expenditure of energy, the High-Intensity/Low-Pressure Technology provides a light yield three times higher than comparable UV lamps of widely used Medium Pressure Technology. A higher light yield also means a lower heat generation at the same time.

Thanks to this, Wedeco UV lamps become less susceptible to varying water temperatures. Even the formation of deposits on the quartz sleeves as well as lamp aging is considerably lower than with alternative UV lamp technologies in Herford and Essen.

WEDECO Ecoray UV lamp

Xylem's Wedeco ozone systems combine maximum flexibility and reliable operating characteristics for small to large ozone capacities. The ozone generator system and control unit can be combined and supplemented with option sets that allow for various application requirements.

Effizon evo 2G ozone electrodes are the core of our technology and achieve an unmatched level of reliability and energy efficiency. The electrodes are manufactured completely from inert materials, without the need for fuses or coatings, making them highly resistant to corrosion. This means that the Wedeco ozone generators are practically maintenance free with no need for regular cleaning or replacement of the electrodes.

We rely on consistently high-quality standards in all divisions of the company. Moreover, product quality and manufacturing operations are constantly monitored and optimized in continuous improvement processes. Established quality controls give Xylem and you the security of knowing that Wedeco UV, Ozone & AOP systems will always operate reliably.

WEDECO Effizon® evo 2G
Ozone electrode

For more information please visit us at
http://www.xylem.com/treatment/

2 General Process Description

2.1 DESIGN

• Design Flow Rates	
- Peak Design Flow	17 MGD
- Average Design Flow	8.5 MGD
• Total Suspended Solids (Maximum)	< 5 mg/l
• Allowable Effluent Temperature Range	41-86°F
• UV Transmittance at 253.7 nm	65%, minimum
• Maximum Influent Fecal Coliforms Count	200,000 Fecal Coliforms/100 mL
• Effluent Disinfection Standard	
- Fecal Coliforms (30 day geometric mean)	200 Fecal Coliforms/100 mL
- Fecal Coliforms (7 day geometric mean)	400 Fecal Coliforms/100 mL
• UV Dose	
- Minimum Design UV Dose (based on IUVA/UVDGM (T1) bioassay)	15 mJ/cm²

2.2 PROCESS DESCRIPTION

The proposed design is based upon effluent from a properly functioning MBR system.

3 Technical Description

CONFIGURATION:	LBX 1500e	
DESCRIPTION	**UNITS**	**VALUE**
Number of 316L SS vessels Number of lamps per vessel Number of intensity sensors per vessel Total number of lamps		3 (2 duty, 1 standby) 60 1 180
REACTOR DIMENSIONS:	Inches	See attached drawing
HEADLOSS PER VESSEL (at peak flow):	Inches	53.9
POWER CONSUMPTION: Peak Flow (lamp and ballast only) Average Flow (lamp and ballast only) Total Connected System Power	kW	 40.11 20.05 55.2

4 Price & Scope of Supply

4.1 WEDECO SCOPE OF SUPPLY

- Cylindrical 316L stainless steel reactor with integrated baffle plates
- 60 low pressure, high intensity WEDECO Ecoray® UV lamps per vessel
- One (1) Type 12, Fan-cooled, Painted Steel electrical enclosure per vessel
- Calibrated UV intensity monitoring system (UV sensor ÖNORM certified)
- Electronic UV lamp supervision system
- WEDECO EcoTouch Controller with Touchscreen HMI (one per vessel)
- Dose pacing incl. variable lamp power
- Automatic wiping system (Electric)
- 39 ft (12 m) lamp cables
- Manufacturer's field service on site [1 trip(s) / 4 days]
- Electrical supply: 480 V, 3 phase, 60 Hz, 4 wire + ground

4.2 BUDGET PRICE

LBX Standard Equipment	
Total	***$366,000***

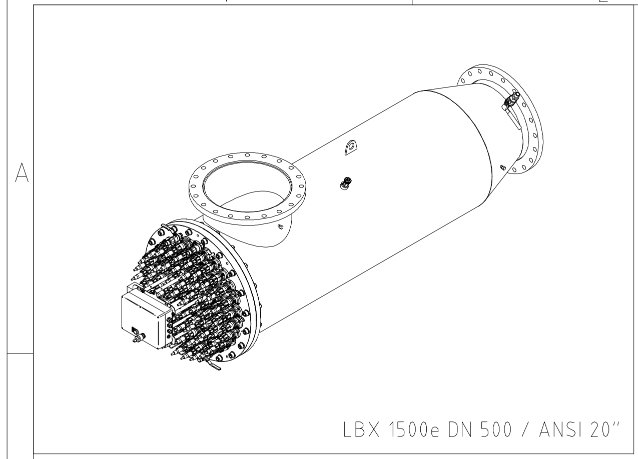
Optional Adders	
Type 4X, Air-conditioned, 304 Stainless Steel Electrical Enclosure	Please contact us for additional information
Allen Bradley PLC and HMI (one per vessel)	Please contact us for additional information
Spare parts: 10% Lamps, 10% wipers, 3% ballasts	Please contact us for additional information

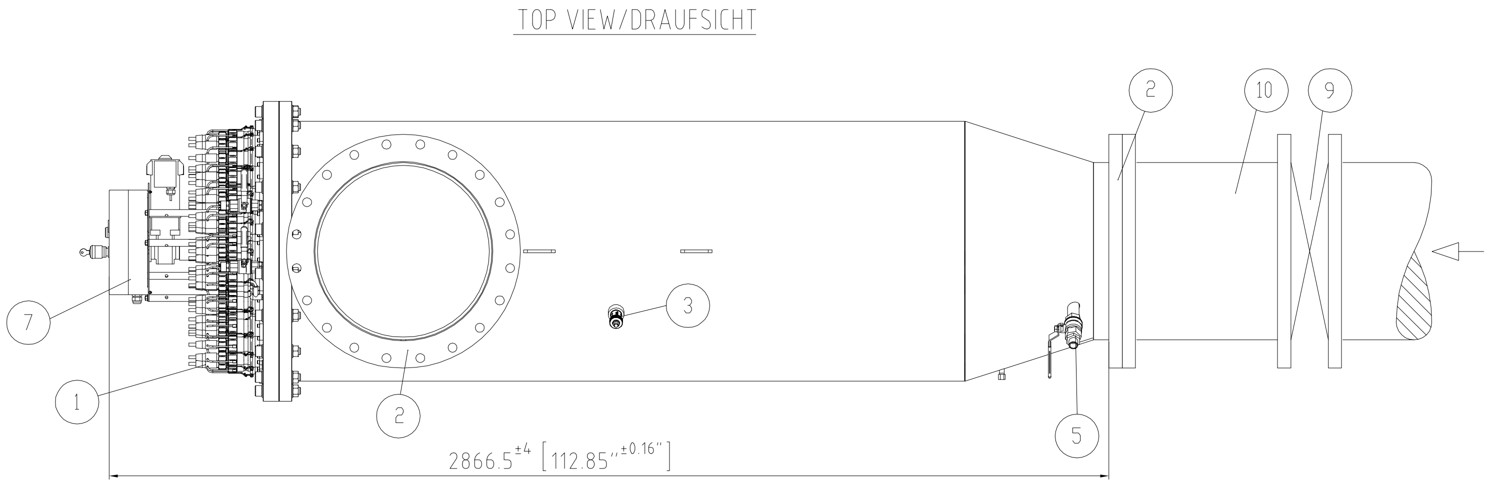
5 Commercial Terms & Conditions

Commercial Details	
Submittal time:	8 weeks after approved purchase order
Delivery time:	18 weeks after approved submittals
Terms of Delivery:	All prices are FCA factory with full freight allowed to the job site**.**
Terms of Payment:	This proposal is based upon WEDECO's General Terms of Business. Price is based upon the following payment terms (net 30 days): • 10% net 30 days upon initial submittal of mechanical/electrical drawings for approval • 80% net 30 days from the date of the respective shipments of the product • 5% installation of the Xylem equipment, NTE 150 days after shipment • 5% start-up / training on the Xylem equipment, NTE 180 days after shipment
Warranties:	Lamp Warranty: Guaranteed 14,000 hours of operation, prorated after 9,000 hours. System Warranty: 18 months from date of delivery or 12 months from date of substantial completion of UV equipment whichever comes first.

6 Attachments

6.1 BROCHURES / DRAWINGS / OTHERS





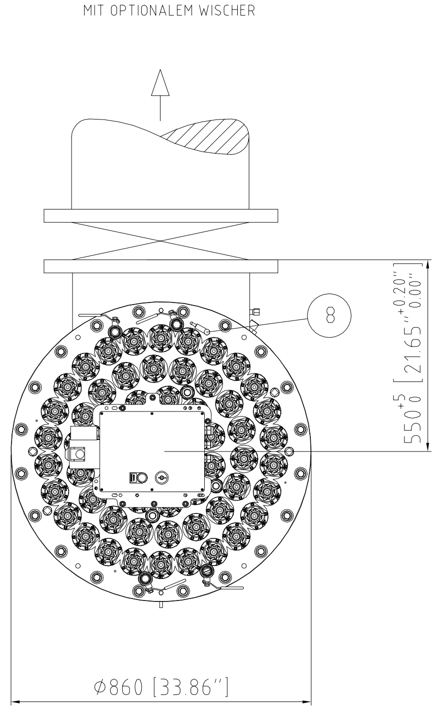
NOTES:

1. The dimensions given on this drawing are required to ensure correct installation operation and performance of the WEDECO UV equipment. All Modifications from this drawing must be approved by WEDECO.
2. Before installation of the UV Equipment all piping must be flushed to prevent objects like sand or stones from damaging components inside the UV vessel.
3. All flow isolation equipment is supplied by others.
4. All field wiring and conduits required to connect power and controls to the electrical enclosure and optional wiping unit shall be sized, supplied, and installed by others. All governing Local/state and national electrical codes/regulations apply (for example but not limited to state, local, CE, NEC, cUL)
5. All equipment shall be located in accordance with all state local, and national electrical codes and per dimensions shown on this drawing.
6. Protect your eyes and skin against UV light. Extended exposure causes sun burn and eye irritation.

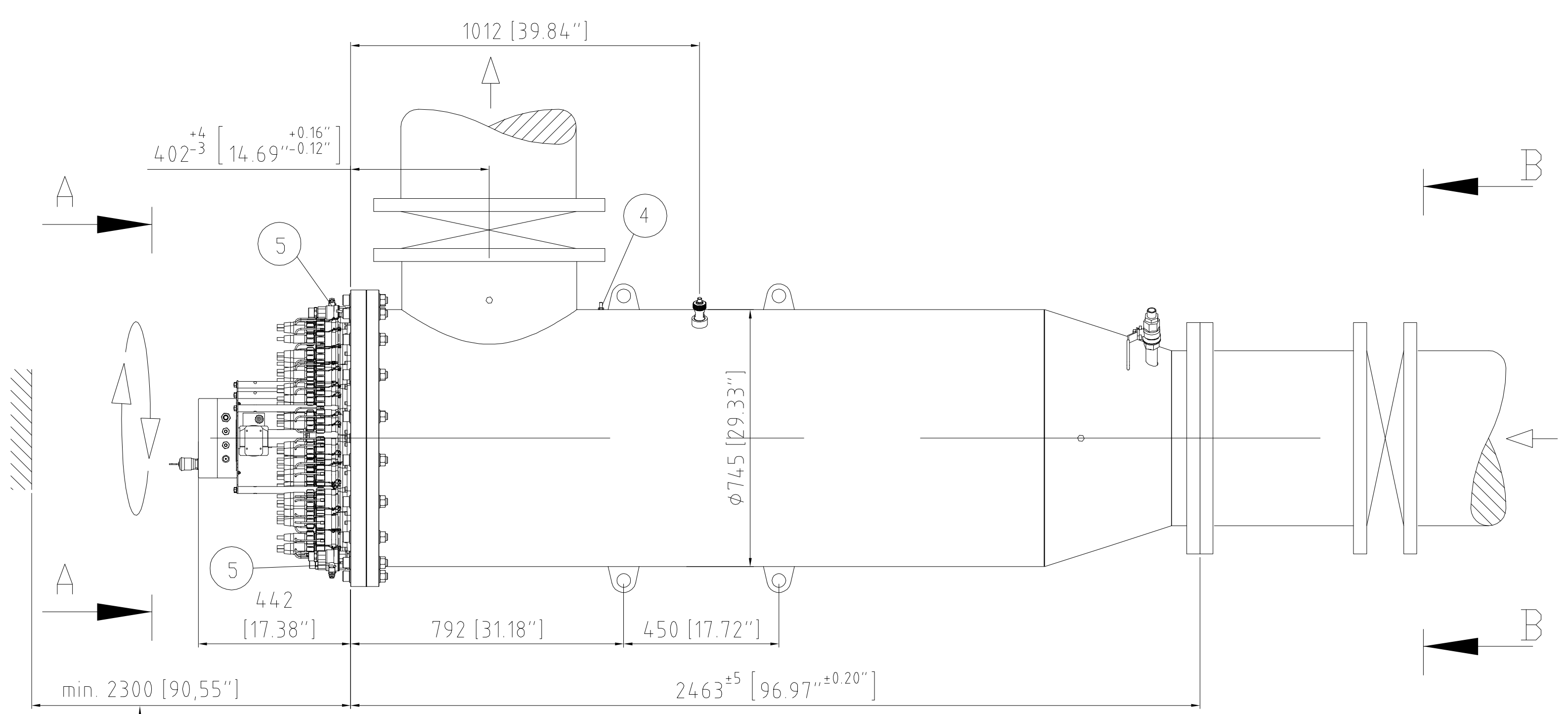
ANMERKUNGEN:

1. Alle Maßangaben dieser Zeichnung sind erforderlich, um eine korrekte Installation, Betrieb und Funktion sicher zu stellen. Alle Änderungen müssen von Wedeco genehmigt werden.
2. Vor der Installation der UV-Anlage müssen alle Rohrleitungen gespült werden, damit Sand, Steine o.ä. keine Komponenten im UV-Reaktor beschädigen können.
3. Alle Absperreinrichtungen sind nicht im Lieferumfang von Wedeco.
4. Alle Verkabelungen, Kabelkanäle und elektrische Anschlüsse des Schaltkastens, sind durch Dritte zu liefern und zu installieren. Alle lokal zutreffenden Gesetze, Normen und Regularien, (z.B. EN, IEC, NEC, cUL, etc.) sind zu berücksichtigen.
5. Die Anlage ist entsprechend den jeweils lokal gültigen Normen, Gesetze und Regularien und gemäß der angegebenen Dimensionen zu installieren.
6. UV-Licht kann Augen und Haut schädigen. Schützen Sie Augen und Haut.

VIEW/ ANSICHT A-A
WITH OPTIONAL WIPER/
MIT OPTIONALEM WISCHER

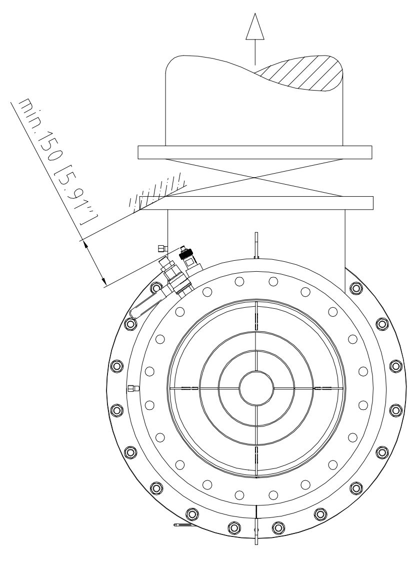


FRONT VIEW/ VORDERANSICHT



min. 2700 (106,30")
if wiper option was selected
wenn Wischer Option ausgewählt wurde

VIEW/ ANSICHT B-B



MOUNTING/EINBAU: PREFERABLY HORIZONTAL/ BEVORZUGT HOTIZONTAL

LBX 1500e DN 500 / ANSI 20"

Item	Description / Beschreibung	Notes	Material
1	Lamp Connector/cable to electrical Cabinet / Lampenanschluß/ Kabel zum Schaltschrank	60 per Unit/ 60 je Einheit	
2	Inlet / outlet flanges / Eingangs- und Ausgangsflansch	DN500/PN10 EN 1092-1/02 or 20" ANSI B16.5 150 lbs.)	ASTM316 (1.4571)
3	UV Sensor	1 per Unit/1je Einheit, cable provided for connection to Cabinet Kabel fur Anschluß an Schaltschrank bereitstellen	
4	Ground Connector / Erdungsanschluß		ASTM316 (1.4571)
5	Cleaning and drain/vent valve / Reinigungs-und Spülventil	3 per unit/ 3 je Einheit, R 1" Din 2999 (1" NPT with ANSI units)	ASTM316 (1.4571)
7	Wiping system (Optional)/Wischersystem (optional)	1 per Unit/ 1 je Einheit requires power and controls connection to Cabinet Anschluß an Schaltschrank erforderlich	
8	High temperature switch / Temperaturschalter	1 per Unit, cable provided for connection to Cabinet Kabel fur Anschluß an Schaltschrank bereitstellen	
9	Isolation Valve/ Absperrarmatur	By Others/ durch Dritte	ASTM316 (1.4571) recommended
10	Streight Pipe length equal to 0.5 X pipe diameter/ Rohrlänge gleich 0,5 x Rohrdurchmesser	only required for butterfly type valves (by others) nur bei Absperrklappe erforderlich (durch dritte)	

Xylem Water Solutions Herford GmbH
Boschstr. 4 - 14, 32051 Herford, Germany
Tel. +49 5221 930-0, Fax +49 5221 930-222
info@xyleminc.com
www.xyleminc.com

WEDECO a xylem brand

Project: LBX 1500e

Scale: 1:15

Title: GENERAL ARRANGEMENT DRAWING
UV REACTOR

	Date	Name
Drawn	20.11.2015	rluja
Chkd.		

Material :
Weight:
Article-ID:
Drawing-Nr.: U-97680-0
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of

Rev.	Description	Date	Name
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A2

APPENDIX M

CPES Cost Estimates

CH2M's Parametric Cost Estimating System (CPES)				
Manufacturer and Model	**Equipment Quote**	**CPES Construction Estimate**	**Engineering Design and Services During Construction**	**Total Capital Cost Estimate**
Suez Ozonia AquaRay 40	$340,000	$1,005,000	$201,000	$1,206,000
Trojan UV3000PLUS	$425,000	$1,292,000	$258,400	$1,550,400
Calgon	$352,000	$1,082,000	$216,400	$1,298,400
Trojan Fit	$750,000	$3,071,000	$614,200	$3,685,200
Wedeco LBX 1500e	$366,000	$2,211,000	$442,200	$2,653,200

APPENDIX E: HEADWORKS AND PRIMARY TREATMENT OPTIONS REPORT (DATED DECEMBER 2020)

HEADWORKS AND PRIMARY TREATMENT OPTIONS STUDY

FOR THE CITY OF TRAVERSE CITY REGIONAL WASTEWATER TREATMENT PLANT

Draft: December 2019
Revised: May 2020
Final: January 2021
HRC Job No. 20190115

CITY of TRAVERSE CITY MICHIGAN

PREPARED BY:

HRC
HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

1925 Breton Road SE, Suite 100
Grand Rapids, Michigan 49506

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SECTION 1.0 — INTRODUCTION

1.1 SCOPE

This report provides an evaluation of the headworks and primary treatment at the Traverse City Regional Wastewater Treatment Plant (TCRWWTP). The Primary Influent Distribution Piping is in severely distressed condition and requires corrective action as it is reportedly on the verge of failure and has already exhibited leaks that have been arrested but almost caused disastrous flooding of the lower level of the TCRWWTP. This Options Study considers several alternatives for improvements of the Headworks as well as the primary treatment system including interim repairs, a totally different primary treatment option, and proceeding with an expedited complete replacement of the header pipe at the conclusion of the study.

1.2 BACKGROUND

Currently, raw sewage enters the TCRWWTP through four force mains which flow into the influent channel of the Preliminary Treatment Building. The influent channel directs the wastewater through a Rotary (Lakeside Rotamat) Semi-Fine Screen (3/8-inch +/- openings). The screened wastewater then flows by gravity through two 24-inch pipes to the two separate grit removal systems (East and West). The influent wastewater flow is measured through two 24-inch Parshall Flumes located upstream of both grit tanks each with a range of 0–10 MGD. The design capacity of the WWTP is 8.5 MGD with a peak flow capacity of 17 MGD.

If the flow is in excess of the rotary screen's capacity, it can overflow a slide gate and proceed through a bypass channel that is equipped with a manually cleaned coarse bar screen with 1-inch openings. Since it is a manually cleaned screen it can become blinded rather quickly and result in problematic overflows of both of the channels or bypassing around the rotary screen since the rotary screen has points of overflow that are below the top of the channel walls. It has been indicated that equipping the overflow channel with a fine screen mechanism would be desirable.

Grit removal is achieved using two 18' x18' square Detritor Style grit chambers (East and West Grit Tanks). The effluent from the West Grit Tank then flows through three cast iron sluice gates to the Primary Settling Tanks: one 24-inch diameter sluice gate/pipe and one 18-inch diameter sluice gate/pipe to the North Primary Settling Tanks (Numbered 1 thru 4 in this report for clarity – See below) and one 24-inch diameter sluice gate/pipe to the South Primary Settling Tanks (5 thru 8). The effluent from the East Grit Tank flows through one 24-inch diameter sluice gate/pipe to the South Primary Settling Tanks and through one 24-inch diameter sluice gate/pipe to the North Primary Settling Tanks. The existing gates from each grit tank are nearly inoperable and the TCRWWTP is unable to isolate flows downstream of each grit chamber.

The eight rectangular Primary Settling Tanks (each 66.5 feet long) are used to remove suspended solids and organics via gravity settling. In this report, the tanks are labeled Numbers 1 through 8 from North to South for clarity. Tanks 3, 4, 5 & 6 are the original Primary Settling Tanks and located closest to the center plant walkway (original plant axis) are each 14 feet wide and was originally constructed in the 1930s. The newer tanks, 1, 2, 7 & 8 are each 16-ft wide and were constructed in the 1950s. The primary setting tank effluent discharges via overflow weirs and then flows to the Secondary Influent Screw pumps which then lifts the flow to the secondary biological process. The primary settling tanks are entirely covered with fiberglass covers supported by fiberglass beams that are anchored to the concrete walls with mild steel hardware that has indications of severe corrosion.

The sludge that settles to the bottom of the primary settling tanks is collected using chain and flight sludge removal mechanisms. Reportedly there is some grit carryover from the grit tanks that ends up in the primary sludge and has accumulated in the digesters.

Most of the influent pipe between the grit tanks and both sets of Primary Settling Tanks is spiral welded steel pipe. This pipe also has several points of connection that were completed using bolted flexible connections (BFC's or "Dresser Couplings"), some are exposed but most were buried. The buried BFC's were likely coated with an asphaltic material prior to burying. A significant section of this piping adjacent to the south primary settling tanks has since ended up under the Sludge Thickening Building and is thus not easily accessible for any maintenance or repairs.

The section of these 24-inch pipes from the buried section outside of the south and north ends of the pipe gallery to the 18-inch pipe inside is a high point and not vented. At these locations, air tends to accumulate in this piping at the headspace. In wastewater, this air gap allows hydrogen sulfide to off-gas and collect in the pipe headspace. Bacteria in the biofilm of the pipe oxidize hydrogen sulfide to form corrosive acids (typically sulfuric acid) which causes crown corrosion at the top of the metal pipe. Visual inspection of this steel pipe exterior at the south end of the gallery indicates severe corrosion and exposed holes. Also, the noticeable sound of the pipe "gulping" was present at the south end of the pipe gallery indicating that the trapped bubble at the larger diameter section of buried pipe outside was periodically being released into the pipe within the building. In addition, at the pipe gallery sump pump discharge pipe connection, a severe leak developed previously. This leak almost resulted in a catastrophic failure of the entire pipe system but was averted by the TCRWWTP maintenance personnel. At the north end of the pipe gallery any accumulated air in the pipe can also relieve itself through the 24-inch pipe section that connects to the West Grit tank provided that the sluice gate at the west grit tank is totally open. However, there could still be small sections of air pockets since pipes are never perfectly level and bubbles in level pipes move very slowly so acids could still accumulate at the top of the pipe.

It is likely that most of the primary influent piping is totally submerged given that the pipe centerline is typically at centerline elevation 112.0 (from the East Grit) or 113.0 (from the West Grit) at the point where it leaves the grit tanks and then rises up to centerline elevation 113.0 for tanks 1, 2, 7 & 8. The older tanks (3,4,5 & 6) are all at a lower centerline elevation, 111.50. Given that the water surface elevation in the primary settling tanks is usually always at or above the weir elevation of 116.0, the pipes should be submerged except at the location in the south pipe gallery entrance where the pipe transitions from 24 to 18-inch diameter where the top air (or offgas generated within the pipe) gets trapped. As mentioned above, the air at the north end is not totally trapped since it can relieve itself to the north grit tank which is relatively close to this location. Installing vents at the north and south ends of the pipe gallery would help serve to eliminate any potential gas bubble buildup.

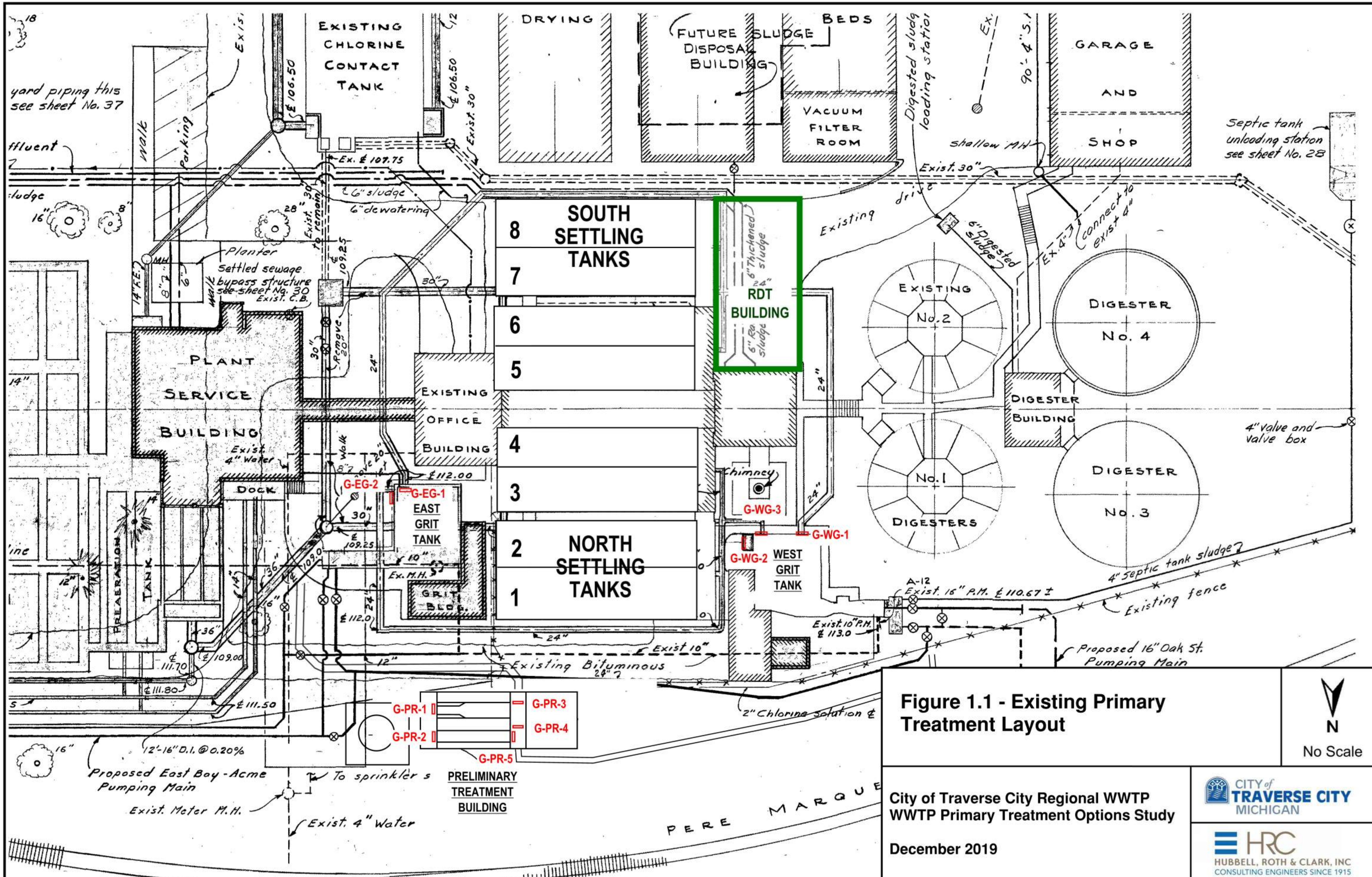

Figure 1.1 - Existing Primary Treatment Layout

City of Traverse City Regional WWTP
WWTP Primary Treatment Options Study

December 2019

CITY of TRAVERSE CITY MICHIGAN

HRC HUBBELL, ROTH & CLARK, INC CONSULTING ENGINEERS SINCE 1915

SECTION 2.0 — HEADWORKS AND PRELIMINARY TREATMENT

2.1 BACKGROUND

The Headworks or Preliminary Treatment provides preliminary treatment of the wastewater before other treatment processes, mainly screening and grit removal. The screening system at the TCRWWTP currently consists of two screening channels that each provide screening of the wastewater before subsequent treatment. The removed screenings are compacted and deposited into a dumpster for landfill disposal.

The primary screen channel has a ROTAMAT (proprietary tipped rotary cylindrical screen) installed inside of a 6-feet 3-inch wide channel that is provided with approximately 3/8" openings. When flow exceeds the capacity of the ROTAMAT, it overflows into a bypass channel. This channel is equipped with a manually raked bar screen with 1-inch wide openings. Since the screen in the bypass channel is manually cleaned, it very easily becomes blinded, and then its capacity is exceeded. Plant staff have indicated that it would be desirable to also install a mechanically cleaned screen in the bypass channel so that when high flows are experienced, all of the wastewater flow can be screened.

The primary ROTAMAT screen has a limited capacity since it is tipped and therefore the entire space of the channel is not utilized for screen media and therefore it would be also desirable to replace this screen with something with a greater capacity although this need may not be as urgent. The options for replacement of this screen include a fixed bar rack mechanically clean bar screen or a band screen where the screen media travels through the waste and the flow passes through both sides of the traveling band screen after turning a right angle. The 6-feet 3-inch wide section of this channel would easily accommodate either a traveling band screen or a fixed bar rake mechanically cleaned screen.

The bypass channel is narrower at 3.5 feet wide and probably would not easily accommodate a band screen but could accommodate a fixed bar rack mechanically raked screen.

If a new mechanically cleaned screen were to be installed at the headworks building, a washer-compactor would also need to be installed downstream of the unit and would provide for the washing and compacting of the screenings as well as conveying them to the same dumpster as the current ROTAMAT screen.

In addition, it has been noted by plant staff that the flow rate to each of the grit processes (east and west) is often exceeded during times of high flow. It would be desirable to regulate the flow to either of the east and west grit removal processes so that the grit removal efficiency is not impaired from the higher flows. This can be accomplished through the installation of a mechanical motorized gate operator on the slide gate downstream of the screen processes. By installing a motorized actuator on either or both of the slide gates downstream of the screens and upstream of each of the grit removal processes, the flow rate can be regulated to a set maximum flow rate as measured at the Parshall flume upstream of either grit tank or to control the flow rate to a set maximum or to split the flow rate to a preset, desired percentage of the total. This would involve the installation of gate operators on both of the gates at the downstream end of the channel after screening and upstream of each grit removal tank.

2.2 PRELIMINARY SCREENING ALTERNATIVES

2.2.1 Alternative S1 - Mechanically Raked Bar Screen in Bypass Channel, Band Screen in Primary Channel

This alternative would include the installation of a mechanically raked bar screen on a fixed bar rack in the current bypass channel and the installation of motorized gate actuators to regulate the flow to the grit removal processes downstream similar to Alternative S1 and the installation of a mechanical traveling band screen in the current primary channel.

The Opinion of Probable Project Cost for this alternative is $1,739,000. There would likely be minimal changes in Operation Cost since the additional periodic operation of the bypass channel screen would likely be offset by fewer problems resulting from bypassing of excess flows with lower levels of screenings as well as the cost of labor of tending to the manual screen bypass. This alternative would address the need for mechanical screening of all flows. The overall screen capacity during high plant flows would also be increased since the band screen has a higher capacity than the Rotamat.

2.2.2 Alternative S2 - Mechanically Raked Bar Screen in both Bypass Channel and Primary Channels

This alternative would include the installation of a 3/8" mechanically raked bar screen on a fixed bar rack in the current bypass channel similar to Alternative S1. In addition, the existing Rotamat screen would be replaced with a fixed bar rack mechanically cleaned screen.

The Opinion of Probable Project Cost for this alternative is $1,662,000. There would likely be minimal changes in Operation Cost since the additional periodic operation of the bypass channel screen would likely be offset by fewer problems resulting from bypassing of excess flows with lower levels of screenings as well as the cost of labor of tending to the manual screen bypass. This alternative would address the need for mechanical screening of all flows. The overall screen capacity during high plant flows would also be increased since the mechanically cleaned bar screen has a higher capacity than the Rotamat.

2.3 GRIT REMOVAL ALTERNATIVES

The existing Detritor Grit Removal Tanks are both very old (approaching 90 and 70 years old respectively). As such, their component parts have been rebuilt extensively and several of the isolation gates are in need of replacement. This process relies on very simple flow-thru hydraulic settling technology and does not provide reliable grit removal at higher flow rates. New, more efficient grit removal processes such as stacked trays are more effective at reducing the flow energy and balancing the settling velocities so that grit removal is more efficient. This hydraulic grit removal system uses vortex flow and stacked trays to settle grit over a large surface area and provides higher grit removal efficiencies compared to other systems such as aerated grit, forced vortex, or the Detritor style technology. This increased grit removal improves the downstream processes as well as the sludge digestion and storage issues associated with excessive grit such as wear on equipment and increased tank cleaning frequency. At this stage of considering a major upgrade of the front of the treatment plant it is prudent to consider a more efficient grit removal process such as the head cell tank arrangement which is essentially a stacked tray configuration that reduces the settling distance so that grit removal efficiency is enhanced. Considering this, there are essentially two options for grit removal for consideration at the TCRWWTP:

2.3.1 Alternative G1 - Rehabilitate the Existing Grit Removal Treatment Process (Detritors)

This option assumes the two existing Detritor grit removal tanks continued to be used. The existing tanks would be rehabilitated, and new covers would be installed. The mechanisms and grit classifiers would be replaced to match the existing. Additional building repairs are also included in this estimate. The two existing flumes are also old and should be replaced or modified to ensure their accuracy. The Project Cost for Alternative G1 is $900,000.

A concern has been expressed over the lack of adequate flow control to the Grit removal since there is currently no means to limit the flow to one grit tank versus the other. This could be rectified by installing a motor actuator on the channel gates downstream of the primary screen channel. If the actuator were set to limit the flow to one of the grit systems, the other channel could be used for the excess flow. Specific programming would be required to control the actuator to perform one of the following functions:

- Limit the flow to either of the grit tanks based on the measured flow at the influent primary flumes
- Split the flow based on a desired percentage flow split (i.e. 50-50, 60-40, etc.).

Since the plant normally operates the flow to the plant with all the flow going to one or the other grit tank, having this control might improve grit removal since lower flows could be directed to both tanks easier.

The Project Cost for this item is included in the alternatives. The additional annual operation and maintenance costs would be minimal in comparison to the benefits obtained from improved grit removal. This item would address the need for regulation of flows to the grit removal process downstream.

2.3.2 Alternative G2 - Replace the Existing Grit Removal Using Stacked Tray System

This alternative assumes the grit system would be replaced with two stacked tray grit removal units (Hydro HeadCell). For this evaluation, two 9' diameter stacked tray systems would be installed in grit removal tanks. A grit classifier/washer would be installed in a new building adjacent to the tanks for final grit disposal to achieve greater than 95% grit removal with less and 5% volatile solids. The building would be equipped with foul air odor control and connected to the existing odor control system. Flow splitting to each grit tank would be achieved using a splitter box and flow metering using a Parshall flumes.

The Project Cost for Alternative G2 is $4,820,000.

SECTION 3.0 — PRIMARY TREATMENT

3.1 BACKGROUND

Primary treatment in wastewater treatment is most commonly completed through conventional sedimentation using rectangular or circular settling tanks. This treatment typically achieves a removal of total solids (30 to 50%) and BOD (25 to 30%) prior to biological treatment. However, this total solids and BOD separation can also be completed using primary solids separation equipment with rotating belt fine mesh sieves. The existing primary settling tanks have exhibited a variety of problems resulting from the corrosion of the primary influent piping between the grit tanks and the primary settling tanks. These pipes were constructed using spiral-welded steel pipe which was prevalent in the 1970s and early 1980s. Generally, steel pipe is appropriate for wastewater conveyance if it is kept submerged in all areas. Since the existing primary influent piping has several size changes plus changes in elevation there are areas where air pockets accumulate and are not be easily relieved. One of these is at the south end of the south pipe gallery where the pipe size changed from 24-inch to 18-inch. It was observed during the plant walk through that there was a noticeable (audible) gulping of air at this location. A similar condition exists at the north end of the North Primary pipe gallery but, at this location, the 24-inch piping continues around to the west and the air pocket can be relieved into the West Grit tank provided that the 24-inch sluice gate from this tank is open entirely. Figure 3-1 shows the approximate extent of primary influent piping replacements and proposed replacement procedure.

The existing settling tanks are also covered with insulated fiberglass panels. Since the covers had minor leaks, the insulation has become water-logged thus making the covers extremely heavy and with freeze-thaw action working on them, they are likely all ruined and in need of replacement. In addition, the covers are supported by fiberglass beams connected to the walls using painted steel supports which are now all corroding. The covers and connecting hardware are all likely in need of replacement except that perhaps the support beams may possibly be salvaged except that there is reportedly spider cracking present on some of these beams, which may require that they too be replaced.

Recognizing that the settling tank equipment may also need replacement, one alternative that may exist would be to replace the settling tank equipment including scum troughs, influent piping covers, connecting hardware and optionally cover support beams and perform the recommended concrete rehabilitation of the portions of the concrete tank that are showing distress.

If the existing tanks are utilized in their current configuration, the existing primary influent conveyance lines will need to be replaced since they have indicated signs of distress due to internal corrosion and have already had significant leakage at the area where the primary gallery sump pump discharges into the line. A hydraulic analysis was prepared for the existing piping arrangement which includes several parallel paths of 18 and 24-inch piping. These parallel paths are likely problematic in that, when the flow divides, there may be grit settling in the lesser used path which does not easily get re-suspended. A check of the hydraulic level during our site visit indicated that there may be evidence of grit settling in the line between the East Grit Tanks and the primary settling tanks since the hydraulic losses seemed slightly higher than what would exist in a clean pipe condition. When the primary influent lines are to be replaced, it is recommended that these parallel paths be eliminated to the greatest extent possible. The proposed layout of primary influent piping completely eliminates the parallel paths so that there would only be two paths each from the East and West Grit Tanks – One to the North and One to the South set of Primary

Tanks from each grit tank. This elimination of redundant, hydraulically unequal paths would help to minimize the potential for grit settling in the lines. Note that the proposed line size would need to be one to two sizes larger where the parallel lines are eliminated so that the effect on hydraulic capacity would be negligible. The primary influent lines can be replaced concurrently with the installation of new isolation gates at the Grit Tank effluent. The specific procedure to allow for this replacement is discussed in detail in the following sections of this report.

An alternative to conventional primary settling would be to install mechanical primary solids separation equipment for primary treatment to replace the primary settling tanks and to reduce the dependence on long lengths of underground primary influent piping and also reduce the need for extensive equipment replacement of the plastic chain and flight settling tank equipment. Mechanical treatment alternatives to primary settling were evaluated as part of earlier drafts of this report. These alternatives were fairly capital cost intensive and would likely be operationally more demanding. Accordingly, it was agreed between the City and its Operations Consultant, Jacobs, not to pursue mechanical treatment alternatives any further.

3.1.1 Primary Tank Structural Analysis

HRC completed a structural inspection as part of an effort to provide a more conclusive and definitive course of action relative to options for the rehabilitation of the existing Primary Tanks or replacement with of new tanks. The inspection was completed using visual and non-destructive inspection methods of the tanks in October 2020. In addition, concrete compressive strength testing and petrographic analysis of core samples were taken, the locations of which were determined based on the structural inspection observations. The inspection report and reports on the concrete evaluation including the compressive strength testing and petrographic analysis are included in Appendix C.

Based on the observations, the structural conditions of the concrete in Tanks 1S and 3N are sound. Deterioration of the beams spanning the tanks supporting the covers was observed. Deterioration was also observed of the concrete along the top slab and walls near the grit tanks. Minor to moderate structural repairs are recommended to extend the service life of the tanks. These recommended repairs include:

- Protective coating and surface repairs to the primary tanks and pipe gallery walls to address cracking and spalling
- Reconstructions of the scum troughs
- Repairs to the walls and beams

Together with the results and conclusions of the compressive strength tests and petrographic analyses of the cores taken as part of the study scope, HRC recommends that the Primary Tanks are good candidates for reuse provided the service and exposure types are not changed significantly from current conditions.

3.2 PRIMARY SETTLING ALTERNATIVES

Several alternatives were evaluated to address the immediate issues with Primary Treatment at the TCRWWTP. Considering all of the above factors, two primary settling alternatives are presented for consideration as described below.

3.2.1 Alternative P1 - Upgrade Existing Primary Settling Tanks and Influent Piping

This alternative includes the complete replacement of the four dual chain and flight primary settling tanks including drive mechanisms, chains, flights scrapers and scum trough actuators, replacement of critical primary influent distribution piping -- mainly in the primary pipe gallery and just beyond the wall to facilitate removal of all parallel pipe paths and the installation of all twelve 12-inch influent valves, three redundant 24-inch knife gate valves (all except the path from West Grit to North Primary since it is so short), cleaning of 24-inch piping between the East Grit Tank and the South Primary Settling Tanks and the installation of slide gates at the location of four of the inoperable sluice gates downstream of both grit tanks (the fifth one – 18-inch from West Grit Tank would be removed and this pipe abandoned). Odor control treatment of the foul air from the revised tanks would still be required similar to existing practices.

The Opinion of Probable Project Cost for this alternative is $3,550,000 and could be combined with either Headworks Alternative S1 or S2 and Grit Removal Alternatives G1 or G2. It is worth noting that the replacement of the primary treatment settling tank mechanisms could possibly be deferred if their replacement is not urgent as the replacement of the influent piping and gates is much more urgent.

3.2.2 Alternative P2 – New Circular Primary Settling Tanks

This alternative includes two new circular settling tanks that would be installed to provide similar capacity as the existing rectangular units. Operations staff at the facility have indicated that circular settling tank mechanisms are easier to maintain, and this is consistent with industry practices. With only two tanks there would be only two mechanisms versus the current four collector mechanisms and significantly fewer moving parts since there would be no chains and flights. Settling rates using two 70 feet diameter units would be approximately the same as the as the existing 8 rectangular tanks as the settling area is 7,702 SF and the proposed settling area would be 7,693 SF. For this alternative, the circular tanks would be installed at approximately the same hydraulic grade line and within the footprint of the existing rectangular tanks. The settled water from the circular primary tanks would then flow to the existing fine band screens and Primary Effluent screw pumps to be lifted up to the secondary treatment process. Each of the circular primary treatment tanks could be paired with one of either the east or west grit tanks (either the existing or new ones) with flow control occurring upstream of these tanks in accordance with paragraph 2.5 above. Doing so would equally distribute the hydraulic capacity between the two primary settling tanks. Covering the circular tanks for odor containment would be more challenging but still feasible. Odor control treatment of the foul air would also still be required similar to existing practices.

The Opinion of Probable Project Cost for this alternative is $6,340,000 and could be combined with Headworks Alternative S1 or S2 and Grit Removal Alternative G1 or G2.

3.3 PRIMARY EFFLUENT PUMPING ALTERNATIVES

Currently the TCRWWTP utilizes screw pumps to lift the Primary Effluent up to the level required for secondary biological treatment. Alternatives that would change the level of the front of the TCRWWTP were investigated as part of this study with the intent of eliminating the need for pumping of the primary effluent but the Capital Cost of these alternatives were very expensive and the impacts of raising the front end of the plant would have far reaching impacts on several upstream pumping stations that pump to this plant. Accordingly, continued primary effluent pumping has been determined to be a more cost-effective long-term alternative. There are basically two alternatives for continued primary effluent pumping, using new screw centrifugal immersible/submersible pumps or rehabilitating or replacing the existing screw pumps.

3.3.1 Alternative PE1 – Primary Effluent Pumping Using Submersible Pumps

Primary Effluent currently flows through one of two existing fine mesh opening band screens and then into one of four screw pumps for pumping to the secondary treatment process. These screw pump bays could be reconfigured to accept a submersible pump that can operate at the low levels. Alternative PE1 would include a Hidrostal™ screw centrifugal pump with pre-rotation basin installed in each bay along with a discharge pipe that would extend up to the level of the existing discharge channel. This type of pump can routinely operate at very low suction levels similar to the existing screw pumps and would fit fairly nicely into the existing screw pump bays with a slight alteration of the floor in each bay.

The Opinion of Probable Project Cost for this alternative is $1,717,000. The approximate layout of this alternative is shown in Figure 3-2.

3.3.2 Alternative PE2 – Primary Effluent Pumping Using Existing Screw Pumps

Alternative PE2 includes replacement of the existing screw pumps in kind. In addition, replacement of some of the concrete on the discharge channels with sulfide resistant concrete is recommended due to the extensive corrosion which has been experienced in this area due to the sulfide release and eventual hydrochloric acid deposition on the wall, which has seriously degraded the existing concrete.

The Opinion of Probable Project Cost for this alternative is $2,711,000.

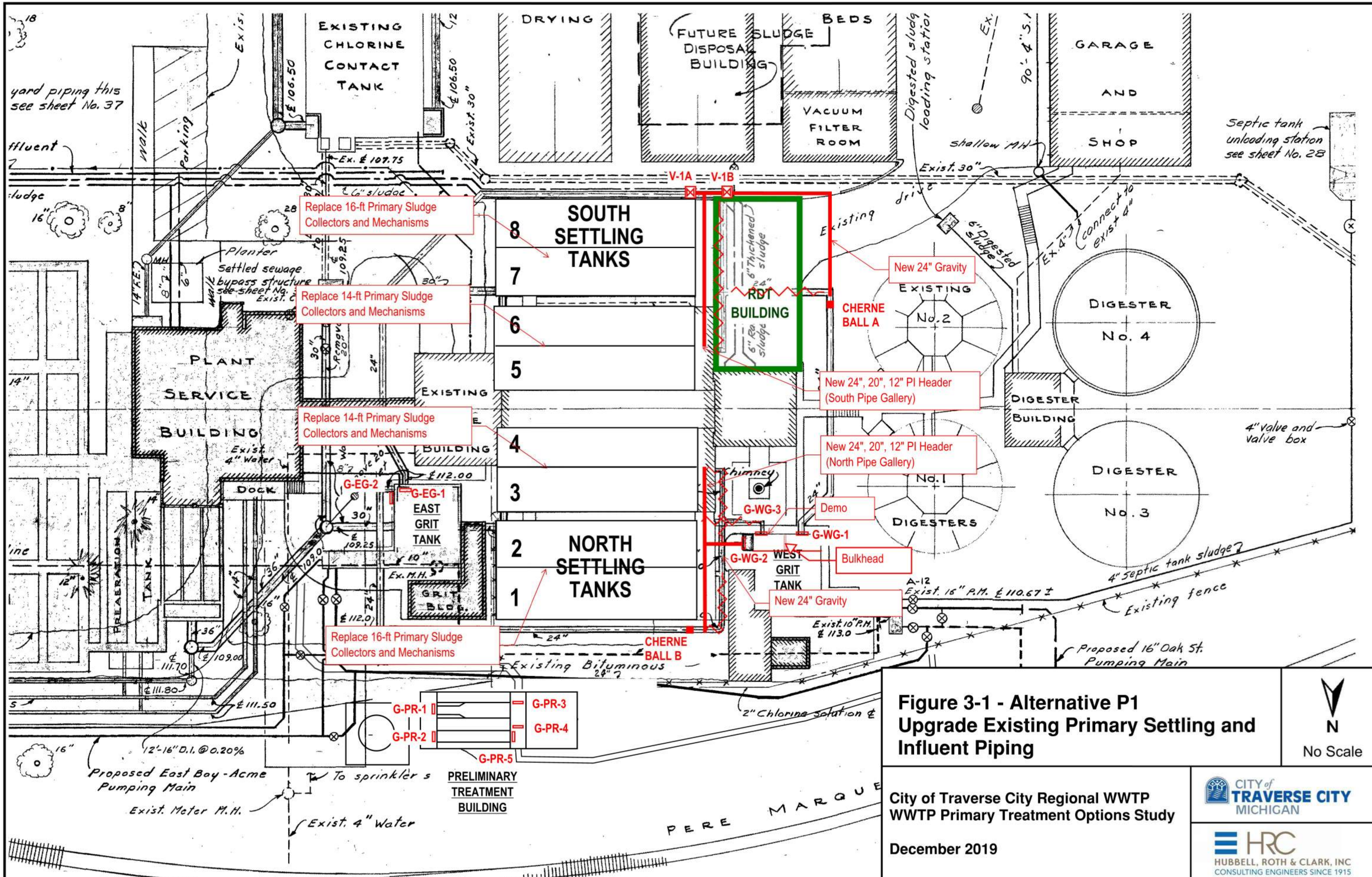

Figure 3-1 - Alternative P1 Upgrade Existing Primary Settling and Influent Piping

City of Traverse City Regional WWTP
WWTP Primary Treatment Options Study

December 2019

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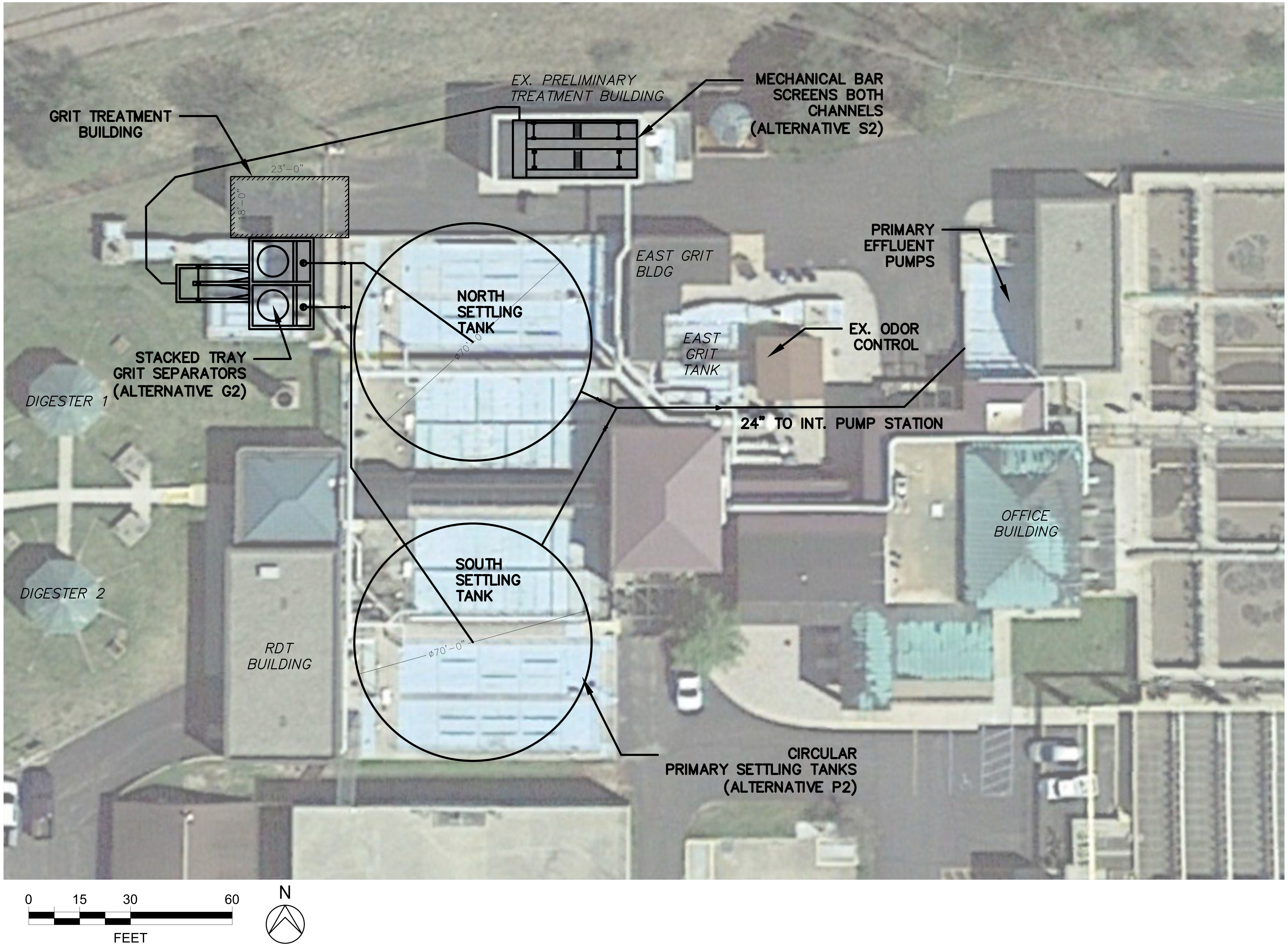

CITY of TRAVERSE CITY MICHIGAN

HRC
HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

1925 BRETON SUITE 100
GRAND RAPIDS, MICH. 49506

CITY OF TRAVERSE CITY
REGIONAL WWTP

HEADWORKS AND PRIMARY OPTIONS STUDY

ALTERNATIVE S2/M2/P2
CIRCULAR PRIMARY TANKS
NEW SCREENS/GRIT REMOVAL

HRC JOB NO.	FIGURE NO.
20190115	3.2
SEPT 2020	

SECTION 4.0 — ALTERNATIVE EVALUATION

To get a reasonable comparison of alternatives for Preliminary and Primary Treatment, the improvement alternatives suggested for both Preliminary and Primary Treatment were compared between each equivalent alternative so that a complete Capital and Operating Cost impact could be determined and compared.

The Opinion of Probable Project Cost for the lowest PW alternatives is shown in Table 4-1 below along with a proportional amount of Annual Operation & Maintenance (O&M) cost for each. This comparison included various differential components such as an allowance for the HV costs based on the relative volumes of the additional building volumes that would need to be ventilated and heated on an annual basis, the cost of dealing with grit carryover from the existing grit removal process as opposed to improved grit removal from a more efficient process, the relative cost of screenings removal versus improved screenings equipment, as well as the relative cost of operation of rectangular settling equipment versus circular clarifier equipment. A Present Worth factor was applied to the relative Annual O&M cost (3.5% at 20 years) in each case to determine a 20-year Present Worth of the O&M costs to develop an Equivalent Present Worth Cost for each of the alternatives being considered. This provides a baseline economic comparison upon which each of these alternative combinations was compared. The table below summarizes the results of this economic comparison.

Table 4-1 – Present Worth Comparison of Alternatives

DESCRIPTION	PROJECT AMOUNT	ANNUAL O&M [4]	20 YEAR PW OF O&M [1.]	TOTAL PW
Preliminary Screening				
Alternative S1 - Mech. Fine Bar Screen in Bypass Ch, Band Screen in Exist Ch.	$1,739,000	$202,368	$2,876,137	$4,429,137
Alternative S2 - Mech. Fine Bar Screen in Both Channels	$1,662,000	$202,368	$2,876,137	**$4,360,137**
Grit Removal				
Alternative G1 - Ex. Grit Removal [3]	$900,000	$270,471	$6,094,039	$6,994,039
Alternative G2 - New Grit Removal	$4,820,000	$42,909	$609,838	**$5,429,838**
Primary Settling				
Alternative P1 - Primary Settling and Influent Piping/Valves Replacements[2]	$3,550,000	$63,932	$3,408,631	$6,958,631
Alternative P2 - Two new 70' diam circular Primary Settling Tanks	$6,340,000	$12,416	$176,463	**$6,516,463**
Primary Effluent Pump				
Alternative PE1 - New Submersible Primary Effluent Pumps	$1,717,000	$49,724	$706,698	**$2,423,698**
Alternative PE2 - Rehab Exist Primary Effluent Screw Pumps	$2,711,000	$180,843	$2,570,207	$5,281,207

1. Assumes 3.5% Interest Rate over 20 years.
2. Alternative P1 annual O&M includes the future tank replacements as a percentage of the future cost.
3. Alternative G1 annual O&M includes future tank replacements – West Grit Tank in 20 years and East Grit Tank in 40 years*
4. A portion of the total O&M Cost most relevant to each alternative and utilized for comparison of the alternatives.

The most cost-effective alternative for preliminary screening is Alternative S2, for two new mechanical fine bar screens. Improved flow splitting before the grit removal is also recommended to equally distribute the flow to each grit removal unit.

The rehabilitation of the existing grit tanks would also require their eventual complete replacement. New, more efficient, stacked tray grit removal would provide significantly less wear on downstream equipment. Accordingly, the life cycle cost (20-year present worth) of Alternative G1 is $6,994,039 versus $5,429,838 for Alternative G2. Therefore, Alternative G2 would provide a more cost-effective solution for the long-term grit removal at the TCRWWTP.

Re-using the existing primary settling tanks represents the lowest capital cost and based on the structural analysis, the existing primary sludge tanks are in sound condition if concrete repairs are completed. However, given their age, the tanks would likely need to be replaced in the next 40 to 60 years. Alternative P2, replacement of the existing primary settling tanks with circular tanks, provides a lower 20-year present worth mainly due to the lower estimated O&M costs and the anticipated replacement cost of the existing tanks (one pair in 40 years and one pair in 60 years). The O&M and potential safety risks of continuing to work in the crowded primary piping gallery (both very difficult to quantify) also contribute to recommending replacement of the primary tanks at this time.

Preliminary Effluent Pumping Alternative PE1 using new submersible pumps in the existing screw pump bays represents the most cost-effective alternative versus continued reliance on the screw pumps.

SECTION 5.0 — RECOMMENDATIONS

Addressing the Primary Influent Distribution Piping remains one of the more urgent focus needs of the facility. The estimated cost of this replacement is $1M if completed independently in advance of the recommended project alternatives. If this replacement is completed prior to the implementation of new circular primary tanks it would only be functional temporarily or at least until new tanks are available for use and thus would not be a wise investment if new tanks are pursued.

Improvements to the Headworks and Primary Treatment are necessary to improve the reliability of treatment and address the system deficiencies. The total estimated project cost of these recommended alternatives is $14,177,000 and is summarized in Table 5-1.

Table 5-1 – Summary of Recommended Headworks and Primary Treatment Projects

Project Component	Estimated Cost [1]
Alternative S2 - Mech. Fine Bar Screen in Both Channels	$1,662,000
Alternative G2 - New Grit Removal	$4,820,000
Alternative P2 - Two new 70' diam Circular Primary Settling Tanks	$6,340,000
Alternative PE1 - New Submersible Primary Effluent Pumps	$1,717,000
Total	**$14,539,000**

Notes:

1. Rounded Values, includes 20% contingency and 20% engineering and administrative.

The specific formulation of project improvements warrants additional discussion with the City leaders and Operations Staff before the development of a specific capital improvement project. These projects would address the Preliminary and Primary Treatment needs of the facility as well as other needs such as building improvements, odor control, corridor piping, yard piping, and other site work. Additionally, we recommend completing site visits to similar installations for the proposed equipment and processes so that City and plant operations staff can gain a full concurrence in the specific equipment selection.

Appendix A — Cost Opinion Breakdowns

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PROJECT:	Traverse City Regional WWTP Primary Treatment Options Study	DATE:	10/8/2020
LOCATION:	Traverse City, Michigan	PROJECT NO.	20190115
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	DJB
WORK:	Project Cost Summary	CHECKED BY:	DJB
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	PROJECT AMOUNT	ANNUAL O&M **	20 YEAR PW OF O&M ***	TOTAL PW AMOUNT
1	**Headworks Alternatives**				
2	Alternative S1 - Mech. Fine Bar Screen in Bypass Ch, Band Screen in Exist Ch.	$1,739,000	$202,368	$2,876,137	$4,615,137
3	Alternative S2 - Mech. Fine Bar Screen in Both Channels	**$1,662,000**	$202,368	$2,876,137	**$4,538,137**
4	**Lowest Cost Headworks Alternative - Alternative S2**	**$1,662,000**			
5					
6	**Grit Removal Alternatives**				
7	Alt. G1 - Ex. Grit Removal (incl tank replacements - West, 20 yrs and East, 40 yrs)*	$900,000	$270,471	$6,094,039	$6,994,039
8	Alternative G2 - New Grit Removal	**$4,820,000**	$42,909	$609,838	**$5,429,838**
9	**Lowest Cost Grit Removal Alternative - Alternative G2**	**$4,820,000**			
10					
11	**Primary Treatment Alternatives**				
12	Alternative P1 - Primary Settling and Influent Piping/Valves Replacements*	$3,550,000	$63,932	$3,408,631	$6,958,631
13	Alternative P2 - Two new 70' diam circular Primary Settling Tanks	**$6,340,000**	$12,416	$176,463	**$6,516,463**
14	**Lowest Cost Primary Treatment Alternative - Alternative P2**	**$6,340,000**			
15					
16					
17	**Primary Effluent Pump Alternatives**				
18	Alternative PE1 - New Submersible Primary Effluent Pumps	**$1,717,000**	$49,724	$706,698	**$2,423,698**
19	Alternative PE2 - Rehab Exist Primary Effluent Screw Pumps	$2,711,000	$180,843	$2,570,207	$5,281,207
20	**Lowest Cost PE Pump Alt. - Alternative PE1**	**$1,717,000**			**$2,423,698**
21					
22	**Total Projected Project Cost**	**$14,539,000**			
23					
24					
25					
26					
27					
28					
29	* Note that the 20 Year Present Worth of O&M of P1 includes tank replacements (One pair in 40 and another pair in 60 yrs)				
30	** This is a portion of the O&M Cost most relevant to each Alternative and utilized for comparison of the aLternatives				
31	*** Using 3.5% Interest Rate over 20 years				
32					
33					
34					

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**9/18/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DIU**
WORK:	**Alternative S1 - Mech. Fine Bar Screen in Bypass Ch, Band Screen in Exist Ch.**	CHECKED BY:	**DJB**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	42-inch wide Mechanically Raked Fine Bar screen and wash/compact	1	EA	$427,500	$427,500
2	Demo Exist Manual Screen	1	LS	$12,000	$12,000
3	Conveyance Duct to Dumpster	10	LF	$800	$8,000
4	Grating modifications	24	SF	$125	$3,000
5	Handrail Additions	12	LF	$120	$1,440
6	Concrete Rehab Allowance	20	SF	$100	$2,000
7	72-inch wide Channel - Band screen and washer/compactor	1	EA	$513,000	$513,000
8	Demo Exist Rotamat Screen	1	LS	$20,000	$20,000
9	Conveyance Duct to Dumpster	8	LF	$800	$6,400
10	Slide Gate Actuators for Grit Flow Control	2	EA	$18,500	$37,000
11	Controls Modifications and Programming	1	LS	$20,000	$20,000
#REF!					
#REF!	Misc Metal	1	%	$11,000	$11,000
#REF!	Misc Mechanical	1	%	$11,000	$11,000
#REF!	Misc Painting	1	%	$11,000	$11,000
#REF!	Electrical Allowance	15	%	$158,000	$158,000
	Construction Subtotal				**$1,242,000**
	Engineering, Legal, Administrative and Contingencies	40	%		$497,000
	TOTAL PROJECT COST				**$1,739,000**

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**9/18/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DIU**
WORK:	**Alternative S2 - Mech. Fine Bar Screen in Both Channels**	CHECKED BY:	**DJB**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	42-inch wide Mechanically Raked Fine Bar screen and wash/compact	1	EA	$427,500	$427,500
2	Demo Exist Manual Screen	1	LS	$12,000	$12,000
3	Conveyance Duct to Dumpster	10	LF	$800	$8,000
4	grating modifications	24	SF	$125	$3,000
5	handrail additions	12	LF	$120	$1,440
6	Concrete Rehab Allowance	20	SF	$100	$2,000
7	72-inch wide Channel - Mech Fine Bar screen and washer/compactor	1	EA	$465,500	$465,500
8	Demo Exist Rotamat Screen	1	LS	$20,000	$20,000
9	Conveyance Duct to Dumpster	8	LF	$800	$6,400
10	Slide Gate Actuators for Grit Flow Control	2	EA	$18,500	$37,000
11	Controls Modifications and Programming	1	LS	$20,000	$20,000
12					
13	Misc Metal	1	%	$11,000	$11,000
14	Misc Mechanical	1	%	$11,000	$11,000
15	Misc Painting	1	%	$11,000	$11,000
16	Electrical Allowance	15	%	$151,000	$151,000
	Construction Subtotal				**$1,187,000**
	Engineering, Legal, Administrative and Contingencies	40	%		$475,000
	TOTAL PROJECT COST				**$1,662,000**

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**10/8/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DJB**
WORK:	**Alternative G1 Rehab Exist Grit Removal Tanks**	CHECKED BY:	**DJB**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Replace 24-inch Slide Gates	4	EA	$19,500	$78,000
2	Clean 24-inch pipe from West Grit Tank to South Primary Tanks	1	LS	$6,700	$6,700
3	New Grit Detritor Mechs	2	EA	$80,000	$160,000
4	New Classifiers	2	EA	$100,000	$200,000
5	Misc Building Repairs	1	LS	$30,000	$30,000
6	New Tank Covers	800	SF	$80	$64,000
7					
8	Misc Metal	1.0	%	$6,000	$6,000
9	Misc Mechanical (Pl HVAC)	0.5	%	$3,000	$3,000
10	Painting	1.5	%	$9,000	$9,000
11	Electrical	15	%	$81,000	$81,000
	Construction Subtotal				**$638,000**
	Engineering, Legal, Administrative and Contingencies	40	%		$256,000
	TOTAL PROJECT COST				**$900,000**

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**9/18/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DJB**
WORK:	**Alternative G2 - New Grit Removal**	CHECKED BY:	**DJB**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Demo Old West Detritor	1	LS	$35,000	$35,000
2	Concrete Floors and Footings on Grade	126	CY	$800	$101,096
3	Concrete Walls	243	CY	$1,000	$242,667
4	Concrete Oper Floor & Struts	99	LS	$1,200	$118,933
5	Superstructure	2,172	SF	$250	$543,000
6	Grit Weirs/Baffles	24	LF	$100	$2,400
7	Isolation Slide Gates	7	EA	$32,000	$224,000
8	Tank Covers	1,008	SF	$80	$80,640
9	Soil or Flowable Fill Below and Around Channels	506	CY	$75	$37,949
10	FRP Foul Air Ductwork (just in this building)	102	LF	$200	$20,400
11	FRP Foul Air Registers and Grilles	1	LS	$20,000	$20,000
12	Site Improvements (Minor)	1	LS	$50,000	$50,000
13	Excavation and Backfill	400	CY	$200	$80,000
14					
15	Influent 24 Valves	6	EA	$12,000	$72,000
16	24" RS Extension/Revisions	200	LF	$250	$50,000
17	Influent Meters (s)	2	EA	$36,000	$72,000
18	Influent Sampler and piping	1	EA	$20,000	$20,000
19	Grit Tank Equipment Package	1	LS	$967,500	$967,500
20					
21	Handrails	46	LF	$150	$6,900
22	Stairs	25	VLF	$1,500	$36,750
23					
24	Misc Metal	2	%	$56,000	$56,000
25	Misc Mechanical (Pl HVAC)	5	%	$140,000	$140,000
26	Painting	1.5	%	$42,000	$42,000
27	Electrical	15	%	$418,000	$418,000
	Construction Subtotal				**$3,438,000**
	Engineering, Legal, Administrative and Contingencies	40	%		$1,376,000
	TOTAL PROJECT COST				**$4,820,000**

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**9/18/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DIU**
WORK:	**Alternative P1 - Primary Settling and Influent Piping/Valve Replacements**	CHECKED BY:	**DJB**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Replace 24-inch Slide Gates	4	EA	$19,500	$78,000
2	Chain and Flight in 14-ft Settling Tanks (3,4 and 5,6)	2	EA	$145,500	$291,000
3	Chain and Flight in 16-ft Settling Tanks (1,2 and 7,8)	2	EA	$151,500	$303,000
4	Primary Influent Header Replacement (See breakdown, other sheet)	1	LS	$587,000	$587,000
5	12-inch Knife Gate Valves	4	EA	$21,400	$85,600
6	10-inch Knife Gate Valves	8	EA	$16,000	$128,000
7	Clean 24-inch pipe from West Grit Tank to South Primary Tanks	1	LS	$6,700	$6,700
8	Cover Replacements	6,886	SF	$80	$550,880
9	Beam Support Connector Replacements	108	EA	$1,500	$162,000
10	Clarifier concrete repairs	2,880	SF	$25	$72,000
11					
12					
13					
14	Misc Metal	2	%	$46,000	$46,000
15	Misc Mechanical	5	%	$114,000	$114,000
16	Misc Painting	3	%	$68,000	$68,000
17	Electrical	15	%	$340,000	$340,000
	Construction Subtotal				**$2,833,000**
	Engineering, Legal, Administrative and Contingencies	25	%		$709,000
	TOTAL PROJECT COST				**$3,550,000**

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**9/18/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DIU**
WORK:	**Primary Influent Header Piping Replacements**	CHECKED BY:	**DJB**
	Completed with P1	CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	15 foot long Flg-Flg 24-inch SS Header with two (2) 12" Flg Nozzles	4	EA	$25,100	$100,400
2	20 foot long Flg-PE 20-inch x 12-inch SS Header with 18" vertical offset 20x24	2	EA	$26,700	$53,400
3	18-inch steel bulkheads (exposed)	5	EA	$3,300	$16,500
4	Core concrete walls in gallery for 24 inch pipe	3	EA	$5,800	$17,400
5	Buried 24-inch DIP or SS piping (from West Grit to SPS)	90	LF	$800	$72,000
6	Buried SS piping (from West Grit to North PS)	8	LF	$1,700	$13,600
7	Buried 24-inch 90 bends	2	EA	$10,000	$20,000
8	Buried 24-inch tees	1	EA	$20,000	$20,000
9	Buried 24-inch knife gates with manhole structure	2	EA	$60,100	$120,200
10	24-inch knife gate in gallery (North end)	1	EA	$37,600	$37,600
11	24-inch BFCs for buried connections	4	EA	$10,000	$40,000
12	24-inch steel bulkheads (buried)	2	EA	$5,000	$10,000
13	18-inch steel bulkheads (buried)	1	EA	$4,200	$4,200
14	4-inch vent piping thru ceiling	2	EA	$6,700	$13,400
15	4-inch sump pump discharge connection with valve	1	EA	$10,900	$10,900
16	Clean 24-inch pipe from S Primary to East Grit Tank and NP to W Grit	1	LS	$10,000	$10,000
17	24-inch SS F x PE connectors at North and South Ends of Gallery	2	EA	$13,400	$26,800
	Construction Subtotal				**$587,000**
	TOTAL CONSTRUCTION COST				**$587,000**

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**9/18/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DIU**
WORK:	**Primary Influent Header Piping Replacements**	CHECKED BY:	**DJB**
	Completed Independent of Other Projects	CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	15 foot long Flg-Flg 24-inch SS Header with two (2) 12" Flg Nozzles	4	EA	$25,100	$100,400
2	20 foot long Flg-PE 20-inch x 12-inch SS Header with 18" vertical offset 20x24	2	EA	$26,700	$53,400
3	18-inch steel bulkheads (exposed)	5	EA	$3,300	$16,500
4	Core concrete walls in gallery for 24 inch pipe	3	EA	$5,800	$17,400
5	Buried 24-inch DIP or SS piping (from West Grit to SPS)	90	LF	$800	$72,000
6	Buried SS piping (from West Grit to North PS)	8	LF	$1,700	$13,600
7	Buried 24-inch 90 bends	2	EA	$10,000	$20,000
8	Buried 24-inch tees	1	EA	$20,000	$20,000
9	Buried 24-inch knife gates with manhole structure	2	EA	$60,100	$120,200
10	24-inch knife gate in gallery (North end)	1	EA	$37,600	$37,600
11	24-inch BFCs for buried connections	4	EA	$10,000	$40,000
12	24-inch steel bulkheads (buried)	2	EA	$5,000	$10,000
13	18-inch steel bulkheads (buried)	1	EA	$4,200	$4,200
14	4-inch vent piping thru ceiling	2	EA	$6,700	$13,400
15	4-inch sump pump discharge connection with valve	1	EA	$10,900	$10,900
16	Clean 24-inch pipe from S Primary to East Grit Tank and NP to W Grit	1	LS	$10,000	$10,000
17	24-inch SS F x PE connectors at North and South Ends of Gallery	2	EA	$13,400	$26,800
18	Replace 24-inch Slide Gates	4	EA	$19,500	$78,000
19	12-inch Knife Gate Valves	4	EA	21400	$85,600
20	10-inch Knife Gate Valves	8	EA	16000	$128,000
21	Clean 24-inch pipe from West Grit Tank to South Primary Tanks	1	LS	6700	$6,700
	Construction Subtotal				**$885,000**
	Contingency	10	%	$885,000	$88,500
	TOTAL CONSTRUCTION COST				**$974,000**

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PROJECT: **Traverse City Regional WWTP Primary Treatment Options Study**
DATE: **9/18/2020**

LOCATION: **Traverse City, Michigan**
PROJECT NO. **20190115**

BASIS FOR ESTIMATE: [X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL
ESTIMATOR: **DJB**

WORK: **Alternative P2 - Two new 70' diam circular Primary Settling Tanks**
CHECKED BY: **DJB**

CURRENT ENR:

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Floor Fill	2133	CY	$100	$213,333
2	Concrete Floor	372	CY	$800	$297,719
3	Concrete Walls	228	CY	$1,000	$227,941
4	Concrete Weirs Struts	98	LS	$1,200	$117,227
5	12-inch Knife Gate Valves	4	EA	$21,400	$85,600
6	Weirs/Baffles	440	LF	$100	$43,960
7	Concrete Wall Demo (Partial)	344	CY	$400	$137,600
8	Covers	7,693	SF	$80	$615,440
9	Collection Mechanisms	2	EA	$288,000	$576,000
10	30-inch Influent / Effluent Piping	400	LF	$350	$140,000
11	Handrails	879	LF	$150	$131,880
12	Stairs	40	VLF	$1,500	$60,000
13	Relocating PE Screens and Channels	1	LS	$1,000,000	$1,000,000
14	Misc Metal	2	%	$73,000	$73,000
15	Misc Mechanical	5	%	$183,000	$183,000
16	Misc Painting	2	%	$73,000	$73,000
17	Electrical	15	%	$548,000	$548,000
	Construction Subtotal				**$4,524,000**
	Engineering, Legal, Administrative and Contingencies	40	%		$1,810,000
	TOTAL PROJECT COST				**$6,340,000**

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PROJECT:	**Traverse City Regional WWTP Primary Treatment Options Study**	DATE:	**9/18/2020**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20190115**
BASIS FOR ESTIMATE:	[X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL	ESTIMATOR:	**DIU**
WORK:	**Alternative PE1 - New Submersible Primary Effluent Pumps**	CHECKED BY:	**DJB**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Submersible Pump Package with Prerostal Basin	3	EA	$222,400	$667,200
2	Concrete Core for Basin Install	3	EA	$4,000	$12,000
3	Concrete Grout around Basin and Base Elbow Install	33	CY	$2,000	$66,667
4	Discharge Piping 24-inch	48	LF	$300	$14,400
5	Pump VFDs	3	EA	$60,000	$180,000
6	Control Panel and Programming	1	LS	$70,000	$70,000
7					
8	Misc Metal	3	%	$31,000	$31,000
9	Misc Mechanical	2	%	$21,000	$21,000
10	Misc Painting	1	%	$11,000	$11,000
11	Misc. Electrical	15	%	$152,000	$152,000
12	**Construction Subtotal**				**$1,226,000**
13					
14	Engineering, Legal, Administrative and Contingencies	40	%		$491,000
	TOTAL PROJECT COST				**$1,717,000**

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Telephone: (616) 454-4286

PROJECT: **Traverse City Regional WWTP Primary Treatment Options Study**

DATE: **9/18/2020**

LOCATION: **Traverse City, Michigan**

PROJECT NO. **20190115**

BASIS FOR ESTIMATE: [X] CONCEPTUAL [ ] PRELIMINARY [ ] FINAL

ESTIMATOR: **DIU**

WORK: **Alternative PE2 - Rehab Exist Primary Effluent Screw Pumps**

CHECKED BY: **DJB**

CURRENT ENR:

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	New Screw Pumps	2	EA	$750,000	$1,500,000
2	Demo and regrout Channels	2	EA	$50,000	$100,000
3					
4					
5	Misc Metal	3	%	$48,000	$48,000
6	Misc Mechanical	2	%	$32,000	$32,000
7	Misc Painting	1	%	$16,000	$16,000
8	Misc. Electrical	15	%	$240,000	$240,000
9	**Construction Subtotal**				**$1,936,000**
10					
11	Engineering, Legal, Administrative and Contingencies	40	%		$775,000
	TOTAL PROJECT COST				**$2,711,000**

Appendix B — Vendor Backup Materials

Full-Range Flexibility and Maximum Capture with Thru-Bar™ Cleaning; Adapts Automatically to Wide Variations in Debris

FlexRake® FPFS

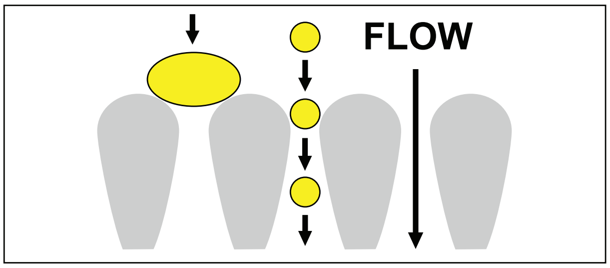
Thru-Bar™ Cleaning Fine Screen

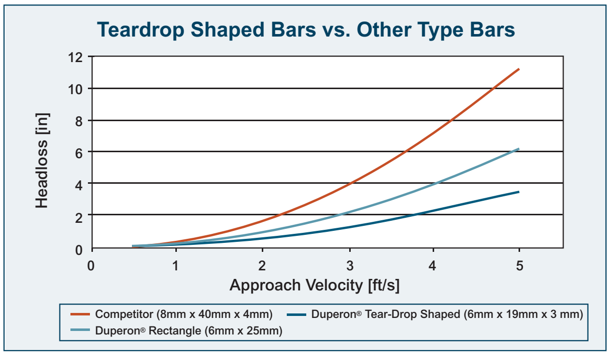
Simple front-cleaning, front-return Duperon® FlexRake® technology. Utilizes stainless steel teardrop shaped bars with 1/4 inch, 3/8 inch or 1/2 inch openings.

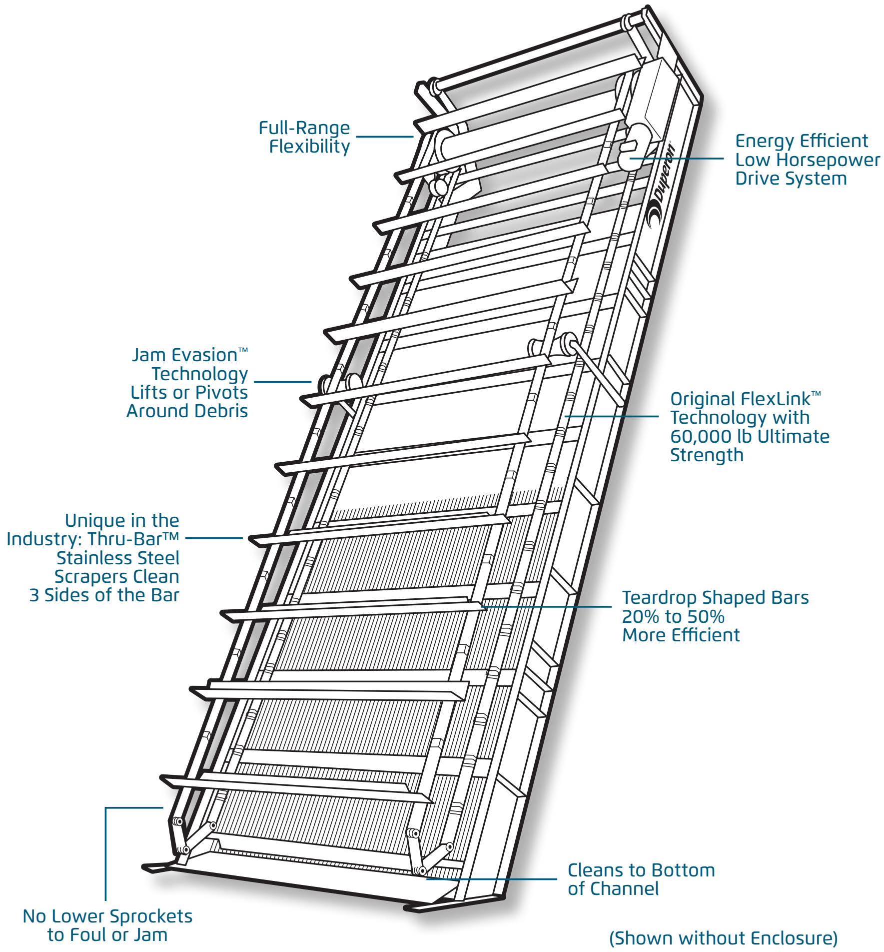
- No Lower Sprockets, Bearings or Tracks to Foul or Jam
- Adapts to Debris Variations; Full-Range Flexibility
- High Capture Thru-Bar™ Stainless Steel Scrapers
- Low Horsepower, Energy Efficient Drive System
- Teardrop Shaped Bars Most Efficient in the Market
- Five-Year Warranty for Wastewater Applications

The Duperon® FlexRake® FPFS

TEARDROP SHAPED BARS ARE THE MOST EFFICIENT BARS IN THE INDUSTRY







(Shown without Enclosure)

TYPICAL APPLICATIONS
Wastewater, combined sewer overflows and prison applications. Also used in pulp/paper mills, raw water intakes and other applications where debris is highly variable or difficult to capture.

UNIT WIDTH
- 2 feet to 12 feet
- Single Strand FlexRake® configuration available for channel widths of 18 inches to 24 inches

UNIT LENGTH
10 feet to 100 feet

ANGLE OF INSTALLATION
Vertical to 45 degrees

STANDARD MATERIALS OF CONSTRUCTION
- Standard: 304 Stainless Steel
- Available in: 316 Stainless Steel

BAR OPENING
1/4 inch, 3/8 inch and 1/2 inch

STANDARD SCRAPER SPACING
Every 2nd link (21 inches)

SCRAPER CONFIGURATION
- 3:1 UHMW-PE staging scraper/stainless steel Thru-Bar™ teeth ratio

TYPICAL MOTOR
1/2 HP, 1 PH/3 PH explosion-proof inverter-duty motor

STANDARD OPERATING SPEED
- 0.5 RPM
- Can be increased to 2.2 RPM in high flow conditions
- 1 discharge/minute on low; 4 discharges/minute on high
- Scrapers move 28 inches/minute

SHIPPING DATA
Ships fully assembled or can be provided in modular form.

STANDARD CONTROLS OPTIONS
Base packages range from simple start/stop to sophisticated automation. Motor overload protection provided. Contact Duperon® for further details and assistance in selecting the perfect package for your site.

OPERATION OPTIONS
- Continuous/Manual
- Automatic with timer, float, SCADA, differential/high level sensing options with I/O as needed

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3340/7/18/1M

MILLENNIAL PLATFORM

LOWEST COST OF OWNERSHIP

WASHING COMPACTING

WASHER COMPACTOR

Positive Displacement, Dual-Auger System

Self-Regulating Compaction Provides a Reliable, No-Hassle Way to Reduce Landfill Costs

Robustly simple, high-efficiency, non-batching process machine that cleans and compacts screenings up to 4 inches. Standard discharge lengths up to 20 feet.

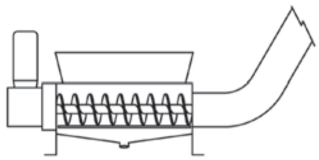
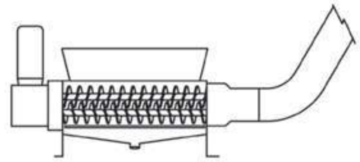
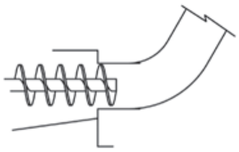
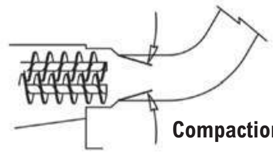
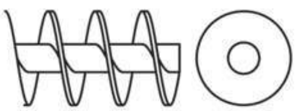
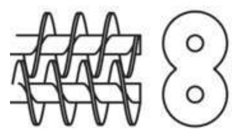
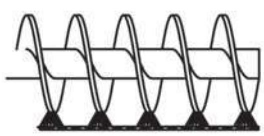
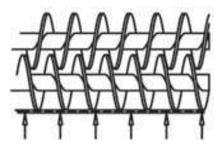
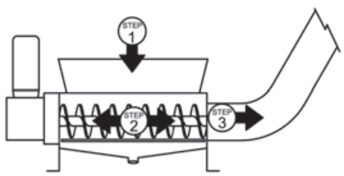
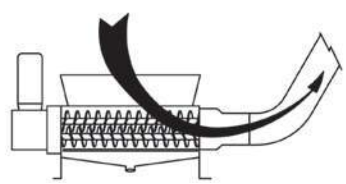
- Consistent Compaction Regardless of Debris Size or Volume (Using Proprietary Compaction Zone*)
- Positive Displacement: What Goes In, Comes Out
- Up To 84% Volume Reduction, Up To 60% Dry Solids
- Processes Non-Standard Wastewater Debris (Rocks, Clothing, Concrete, Metal) up to 4 inches
- Self-Centering Dual Augers Prevent Debris Wrapping
- Housing Geometry Controls Potential for “Slip Flow” When Handling Grease, Septage and Similar Debris
- Non-Clogging Flood Wash Port: Ideal For Non-Potable Water

*Patent Pending

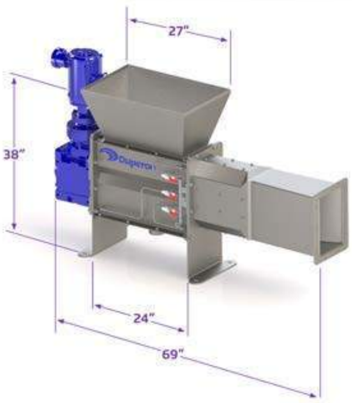
Duperon® ADAPTIVE TECHNOLOGY™

PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

THE DUPERON® WASHER COMPACTOR VS. OTHER MANUFACTURERS

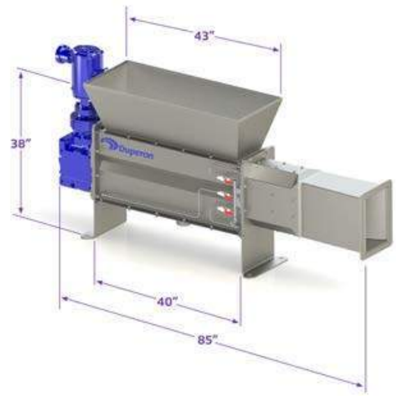
OTHER WASHER COMPACTORS	DUPERON® WASHER COMPACTOR
	
Fixed Reduction Compaction	**Controlled Reduction**
	
Dependent on friction, debris volume and type	Depends on mechanical device that controls compaction regardless of size & volume
RESULT: inconsistent dry solids	**RESULT:** consistent dry solids
Single Screw	**Dual Auger**
	
Debris falls & if it can move along the flight, it is dragged forward	Positive displacement (like meat grinder) counter rotation
Prone to sticking & then rotating w/auger (not driving forward) OR wrapping & overflowing hopper, churning, slipflow	Flights prevent wrapping and slipflow (The flight of one auger continuously interrupts the debris wrapping on the other auger)
	Two small augers = less HP, more energy efficient, stretches and stresses debris without chopping or grinding
RESULT: overflowing or wrapped debris not driven forward	**RESULT:** what goes in must go out
BRUSHES	**STRAINER – No Brushes**
	
High maintenance & inconsistent performance	Self-cleaning strainer as a result of maintained auger contact
Expensive, potentially labor intensive, requires replacement of parts	Non-clogging, durable & non-wearing
BATCHING	**CONTINUOUS FLOW NON-BATCHING**
	
Debris is stored in hopper during batch cycle	Continuous screen operation
Can have odor issues	Immediate processing of debris for low odor
	Low HP = Low energy requirement
AGITATION	**SATURATE – WRING**
Large motor/gearbox & batch times	Consistent high-pressure throughout system
Complexity of controls	Wash ports – flood vs. high maintenance fine spray nozzles
Maintenance, energy, storage & possible overflow	Wash ports located prior to compaction so debris is not forced into nozzle openings
	No Splashing

DUPERON® WASHER COMPACTOR CONFIGURATIONS AND APPLICATIONS



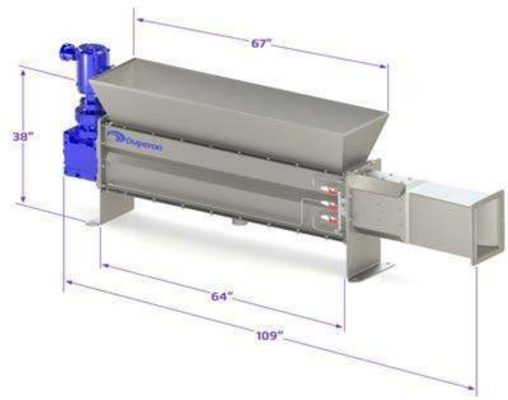
WC BODY 1

- ¾ HP Motor typical
- For bar screens up to 2' wide
- Ideal for FlexRake® Low Flow units
- Generally for flows less than 15MGD



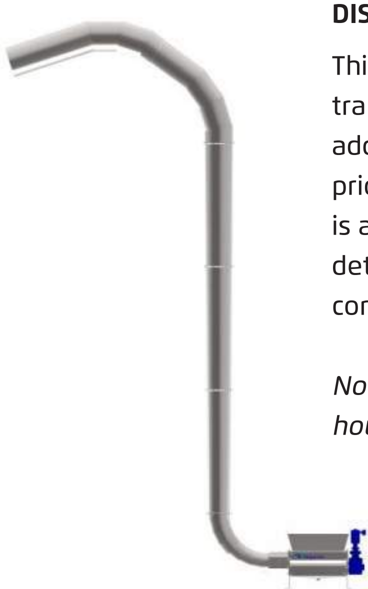
WC BODY 2

- ¾, 3, 5 HP motors
- For bar screens 2' to 6' wide
- Flows up to 60 MGD
- 3 and 5 HP conveyor-fed and Industrial applications



WC BODY 3

- ¾, 3, 5 HP motors
- For bar screens 5' to 10' wide
- Flows up to 100 MGD
- 3 and 5 HP conveyor-fed and Industrial applications



DISCHARGE EXTENSION OPTION

This option is available for the Duperon® Washer Compactor and can transport debris up to 40 feet in any direction, eliminating the need for additional motorized conveyance systems. With debris being compressed prior to the discharge chute, extended transport distance and elevation is achieved with little or no resistance and is unaffected by extended detention times. It contains no moving parts to fail and can operate continually if required.

Note: Screenings compaction is achieved without the use of a compaction housing in this configuration.

WATER

- Utilizes filtered effluent or municipal water
- Washer consumes 3-10 gallons per minute
- Requires 40 PSI-60 PSI
- Drain connection 3" NPT
- Supply connection 1/2" NPT

UTILITY

- 120/240 volt, single phase
- 240/480 volt, three phase (0.6 kW/2.3 kW/3.8kW)

DRIVE

3/4 HP, 3 HP, 5 HP inverter duty motors available

MATERIALS OF CONSTRUCTION

- 304 SSTL or 316 SSTL
- SSTL spur gears (17 - 4 PH)
- Self-lubricating main auger bearings

TYPICAL PERFORMANCE

- 30% - 60% dry solids
- 60% - 70% weight reduction
- Significantly decreases odor and fecal content

CAPACITY

Available from: 30 ft³/hour to 150 ft³/hour

MAINTENANCE

Five years: Recommended gearbox service

DUPERON® WASHER COMPACTOR ACCESSORIES

BAGGER: The Bagger System attaches to the discharge chute for applications where bag dispensing and odor control are required. Included is a 100 meter length of continuous feed bags.

SPECIFICATIONS:
LATCH AND HOLDER: 304 SS or 316 SSTL
BAG: 1.3 mil Polyethylene
BAG SIZE: 22" Diameter x 295 ft. length

DROP SLEEVE: This flexible Drop Sleeve is an economical way to direct and contain downward debris discharge. Also used where waste container hauling may cause damage to metal discharge chutes.

SPECIFICATIONS:
LATCH AND HOLDER: 304 SS/316 SSTL
SLEEVE: Heavy Duty Urethane Canvas

ACCESS CHUTE: In applications that involve periodic inspection of discharging solids, the Access Chute with inspection panel is available in modular segments, installed as needed in the discharge chute system.

SPECIFICATIONS:
CHUTE: 14 ga. 304/316 SSTL
FLANGES: 1/4"
DRAW TYPE LATCHES:Hinged and Latched or Latched Both Sides

CASTER ASSEMBLY: Optional casters allow for flexible placement of the Washer Compactor and simple movement of the unit.

SPECIFICATIONS:
CASTERS: Urethane Wheels, 304/316 SSTL
FRAME: 2x2x1/4 Tubular, 304/316
LOCKING CASTERS
EXPLOSION PROOF ELEC. DISCONNECT

HEAT BLANKET: The Compaction Zone and discharge chute can be thermally protected from cold temperatures with the addition of the Heat Blanket with integral heat trace.

SPECIFICATIONS:
EXPLOSION PROOF HEAT TRACE SYSTEM
(All connections NEMA 7/9)
10 W/FT = 600 w max., 120V
HARD CONTACT THERMOSTAT (NEMA 7/9)
INSULATED BLANKET: All Weather Teflon

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

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Duperon ADAPTIVE TECHNOLOGY™
Let's Build a System that Works for You™

Date: September 26, 2019
Project: Traverse City, MI
Number: P10342

HYDRAULIC CALCULATIONS

Notes: 8.5 MGD Peak Flow, 3.5' wide channel, 0.375" bar openings, 3' upstream water level, 25% blinding

INPUT: Channel Physics

Flow in MGD	8.50	MGD
Upstream water level *	3.00	ft
Channel width	3.50	ft
Channel depth	5.00	ft
Degree of blinding	25%	

INPUT: Screen Physics

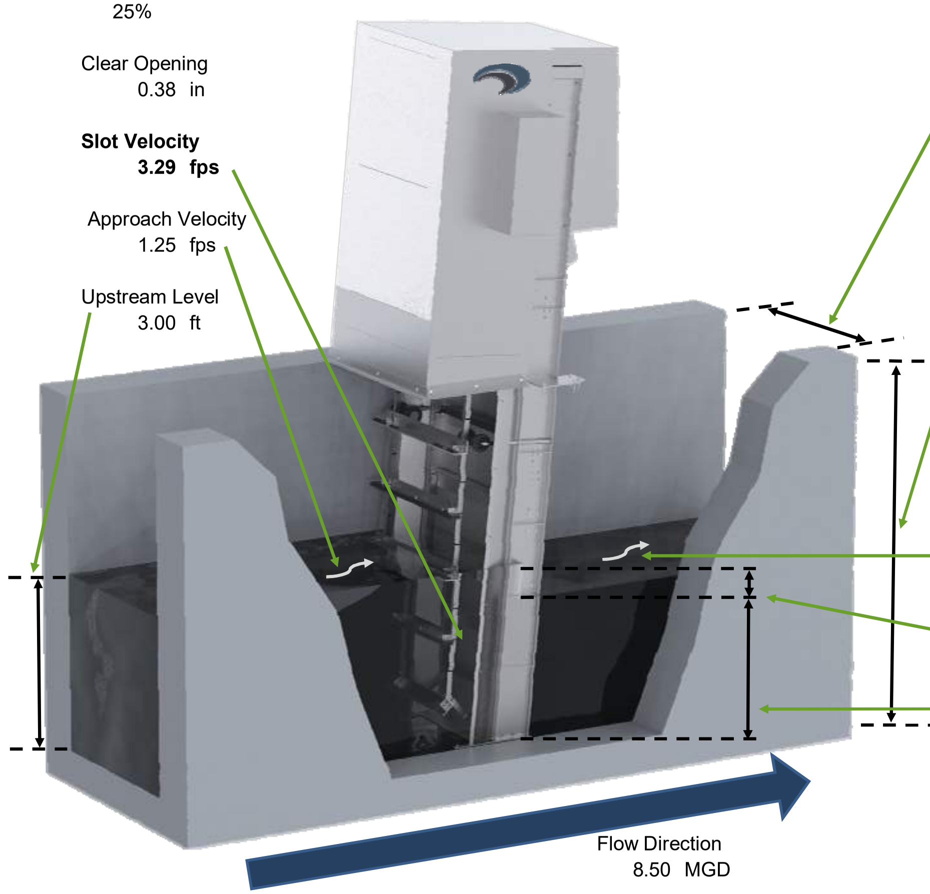
Clear Opening	0.38	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft

Calculations

Side fab & closeout area	1.74	sft
Flow area between side fab & closeouts	8.76	sft
Number of bars	55.00	ea
Flow area taken up by bars	3.44	sft
Total Channel flow without screen	10.50	sft
Flow area after screen area and blinding taken out	3.99	sft
Approach Velocity	1.25	fps
Slot Velocity	3.29	fps
Downstream Velocity	1.34	fps
Downstream Depth	2.79	ft
Head Loss	2.47	in

Bernoulli Calculations

Velocity thru bar screen	3.29	fps
Velocity upstream of bar screen	1.25	fps
Gravitational acceleration (constant)	32.20	ft/s^2
Frictional coefficient (constant)	1.43	c
Headloss	0.21	ft
Headloss	2.47	inches



These calculations are an estimation based upon the information available. Flow channel hydraulics are highly dependent on water levels and the degree of blinding. The calculations above are a snapshot of only one condition. To fully analyze the hydraulics please contact your local Duperon representative.
Duperon recommends a minimum of 1.00 ft water depth when the unit is in operation to keep the SSTL FlexLinks lubricated and ensure an optimal amount of screening area.
Duperon recommends using Water Environment Federation (WEF) & "10 States" standards as design guidelines:
Approach velocity should be greater than 1.25 ft/s to prevent settling. Slot velocities should be less than 4 ft/s to prevent forcing material thru openings.

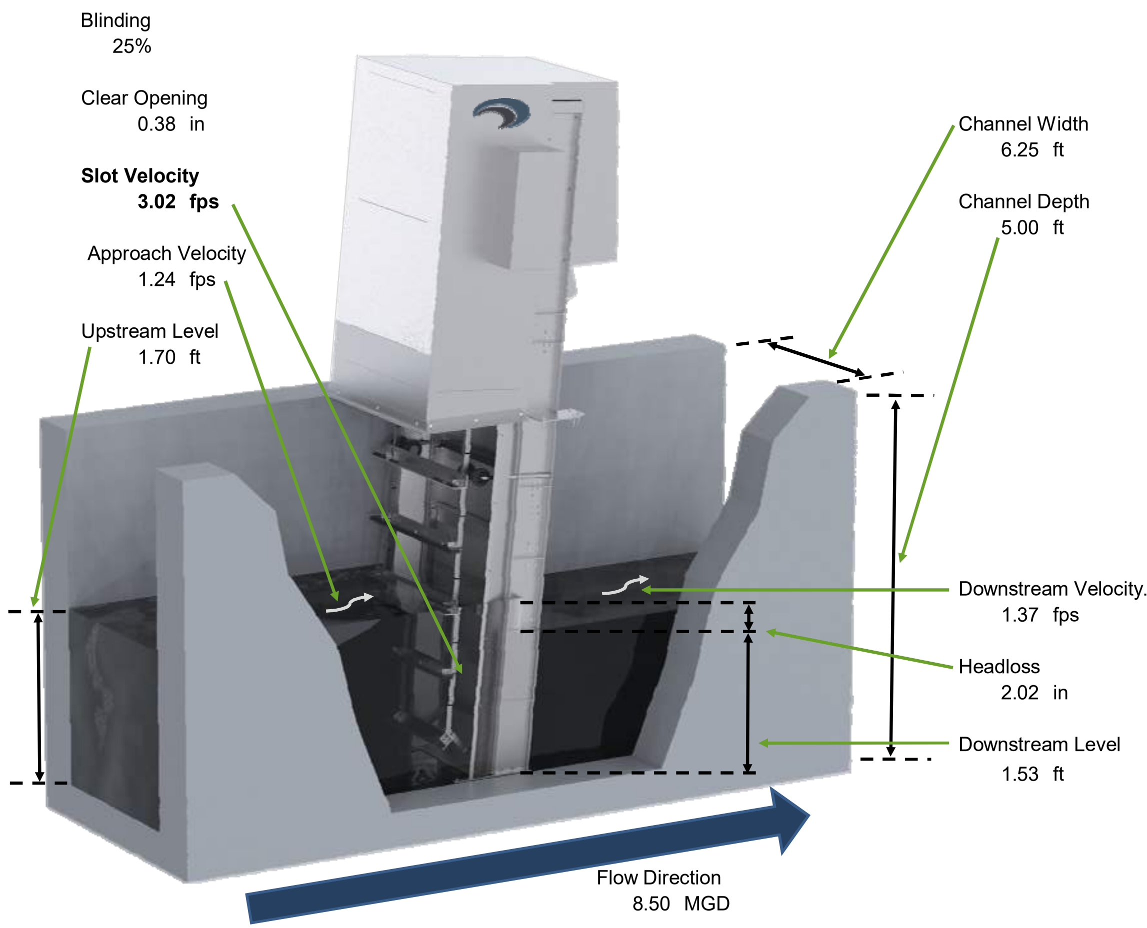
Date: September 26, 2019
Project: Traverse City, MI
Number: P10342

Duperon ADAPTIVE TECHNOLOGY™
Let's Build a System that Works for You™

HYDRAULIC CALCULATIONS

Notes: 8.5 MGD Peak Flow, 6.25' wide channel, 0.375" bar openings, 1.7' upstream water level, 25% blinding

INPUT: Channel Physics		
Flow in MGD	8.50	MGD
Upstream water level *	1.70	ft
Channel width	6.25	ft
Channel depth	5.00	ft
Degree of blinding	25%	
INPUT: Screen Physics		
Clear Opening	0.38	in
Bar thickness	0.25	in
Thickness of side fab and closeout (2)	0.58	ft
Calculations		
Side fab & closeout area	0.99	sft
Flow area between side fab & closeouts	9.64	sft
Number of bars	108.00	ea
Flow area taken up by bars	3.83	sft
Total Channel flow without screen	10.63	sft
Flow area after screen area and blinding taken out	4.36	sft
Approach Velocity	1.24	fps
Slot Velocity	3.02	fps
Downstream Velocity	1.37	fps
Downstream Depth	1.53	ft
Head Loss	2.02	in
Bernoulli Calculations		
Velocity thru bar screen	3.02	fps
Velocity upstream of bar screen	1.24	fps
Gravitational acceleration (constant)	32.20	ft/s^2
Frictional coefficient (constant)	1.43	c
Headloss	0.17	ft
Headloss	2.02	inches



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Date: September 26, 2019

Project: Traverse City WWTP, MI (3.5 ft wide channel) **Proposal Number:** 10342

BUDGET EQUIPMENT SCOPE

To: Traverse City, MI

Rep: Jay Vermilye
Dubois Cooper Associates
(248) 935-4456
jvermilye@duboiscooper.com

From: Your Duperon® Team
David Herald
Lead Sales Project Manager
(989) 754-8800
dherald@duperon.com

Steve Aiken
Regional Sales Manager
(989) 754-8800
saiken@duperon.com

Duperon® ADAPTIVE TECHNOLOGY™

PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: September 26, 2019

Project: Traverse City WWTP, MI (3.5 ft wide channel) **Proposal Number:** 10342

BUDGET EQUIPMENT SCOPE

Thank you for considering Duperon® system solutions for your project. We appreciate the opportunity to provide you with a Budget Equipment Scope. Please do not hesitate to contact your Duperon® Team with any questions as we work with you through the design process and ensure a successful project.

Equipment Scope

SCREENS:

QTY	UNIT	Notes	DESCRIPTION		
1	**EA**		**Duperon® FlexRake® - Front Clean Front-Return**		
			Model:	FPFS - Full Penetration, Fine Screen	
		Notes: Based on 3.5' wide x 5' tall channel.	Enclosure (& Material):	Fully Enclosed (304)	
			Nom Width x Length:	3.5 x 13	Feet
			Clear Opening Size:	0.375 in	
			Angle of Installation:	30	Deg. from Vertical
			Material Construction:	304	SSTL

Screenings Processing

QTY	UNIT	Notes	DESCRIPTION		
1	**EA**			**Duperon® Washer Compactor**	
			Model:	WC3.A2.5	
		Notes:	Appx Footprint:	2 ft wide x 9 ft long	
			Motor HP:	0.75 HP	
			Chute Allowance:	10 ft long w/ 1 bend (customizable)	
			Material Construction:	304	SSTL

CONTROLS

QTY	UNIT	Notes			
1	**EA**			**Main Control Panel:**	**1 - FPFS / 1 - WC**
				Power:	480V/3ph/60hz
		Notes: 1 Main Panel		Panel Rating:	NEMA 4X
				PLC/Relay Based:	Relay
				Screen Instrumentation:	(2) Transducers w/ HydroRanger
			2	Local Pushbutton Station(s):	Three Button (E-Stop/Run/Jog Rev)

TECH/FREIGHT

QTY	UNIT	DESCRIPTION		
1	**LOT**	**On-Site Technical Assistance**		
		Number of Trips:	1	Trip(s)
		Days On-Site per Trip:	2	8-hour man-day(s)
1	**LOT**	**Freight**		
		FOB Factory, Full Freight Allowed		

Clarifications:

- This is not a fully designed project; pricing may be affected by scope change/project development
- Operational, structural, wind, or seismic calculations are not included
- Scope is based on models and assumptions widely utilized in the industry
- Scope does not convey an offer to sell; installation and taxes are not included
- **For reference only:** Standard Delivery Schedule: Submittals 4-6 week from PO - Delivery 8-12 weeks from approval

BUDGET PRICING: **$220,000.00**

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: September 26, 2019

Project: Traverse City WWTP, MI (3.5 ft wide channel) **Proposal Number:** 10342

OPTIONAL EQUIPMENT AND ACCESSORIES

Thank you for considering Duperon® system solutions for your project. We appreciate the opportunity to provide you with a Budget Equipment Scope. Please do not hesitate to contact your Duperon® Team with any questions as we work with you through the design process and ensure a successful project.

Optional Accessories

Bar Screen Deadplate Heat Pad
24" x 24" heat pad (power by others)
Thermostat

ADD PRICE (EA): $3,000

Bar Screen Deadplate Heat Pad
12" x 12" heat pad (power by others)
Thermostat

ADD PRICE (EA): $1,800

Washer Compactor Elephant Drop Sleeve
Solid canvas flexible tube
10 ft overall length
Attaches directly to discharge chute

ADD PRICE (EA): $1,575

Washer Compactor Heat Trace & Blanket Kit
Required in applications where freezing temperature are possible
Teflon heat blanket (weather-proof) construction
Thermostat (NEXA 4X) with remote probe for temperature reading
Components are CLASS I DIVISION I rated

ADD PRICE (EA): $5,000

Washer Compactor Bagging System
Longofill cassette holder - SSTL & ABS plastic
Longopac PE continuous bagger cassette, 295 ft (90 m)

ADD PRICE (EA): $3,400

Date: September 26, 2019

Project: Traverse City WWTP, MI (6.25 ft wide channel) **Proposal Number:** 10342 R1

BUDGET EQUIPMENT SCOPE

To: Traverse City, MI

From: **Your Duperon® Team**
David Herald
Lead Sales Project Manager
(989) 754-8800
dherald@duperon.com

Rep: Jay Vermilye
Dubois Cooper Associates
(248) 935-4456
jvermilye@duboiscooper.com

Steve Aiken
Regional Sales Manager
(989) 754-8800
saiken@duperon.com

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: September 26, 2019

Project: Traverse City WWTP, MI (6.25 ft wide channel) **Proposal Number:** 10342 R1

BUDGET EQUIPMENT SCOPE

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Equipment Scope

SCREENS:

QTY	UNIT		DESCRIPTION		
1	EA		**Duperon® FlexRake® - Front Clean Front-Return**		
			Model:	FPFS - Full Penetration, Fine Screen	
Notes: Based on 6.25' wide x 5' tall channel.			Enclosure (& Material):	Fully Enclosed (304)	
			Nom Width x Length:	6.25 x 13	Feet
			Clear Opening Size:	0.375 in	
			Angle of Installation:	30	Deg. from Vertical
			Material Construction:	304	SSTL

Screenings Processing

QTY	UNIT		DESCRIPTION		
1	EA			**Duperon® Washer Compactor**	
			Model:	WC3.A3.5	
Notes:			Appx Footprint:	2 ft wide x 10 ft long	
			Motor HP:	0.75 HP	
			Chute Allowance:	10 ft long w/ 1 bend (customizable)	
			Material Construction:	304	SSTL

CONTROLS

QTY	UNIT			
1	EA		**Main Control Panel:**	**1 - FPFS / 1 - WC**
			Power:	480V/3ph/60hz
Notes: 1 Main Panel			Panel Rating:	NEMA 4X
			PLC/Relay Based:	Relay
			Screen Instrumentation:	(2) Transducers w/ HydroRanger
		2	Local Pushbutton Station(s):	Three Button (E-Stop/Run/Jog Rev)

TECH/FREIGHT

QTY	UNIT	DESCRIPTION		
1	LOT	**On-Site Technical Assistance**		
		Number of Trips:	1	Trip(s)
		Days On-Site per Trip:	2	8-hour man-day(s)
1	LOT	**Freight**		
		FOB Factory, Full Freight Allowed		

Clarifications:

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- Operational, structural, wind, or seismic calculations are not included
- Scope is based on models and assumptions widely utilized in the industry
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- **For reference only:** Standard Delivery Schedule: Submittals 4-6 week from PO - Delivery 8-12 weeks from approval

BUDGET PRICING:	**$240,000.00**

Duperon® ADAPTIVE TECHNOLOGY™
PRELIMINARY | LIQUIDS/SOLIDS SEPARATION SYSTEMS

Date: September 26, 2019

Project: Traverse City WWTP, MI (6.25 ft wide channel) **Proposal Number:** 10342 R1

OPTIONAL EQUIPMENT AND ACCESSORIES

Thank you for considering Duperon® system solutions for your project. We appreciate the opportunity to provide you with a Budget Equipment Scope. Please do not hesitate to contact your Duperon® Team with any questions as we work with you through the design process and ensure a successful project.

Optional Accessories

Bar Screen Deadplate Heat Pad
24" x 24" heat pad (power by others)
Thermostat

ADD PRICE (EA): $3,000

Bar Screen Deadplate Heat Pad
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Required in applications where freezing temperature are possible
Teflon heat blanket (weather-proof) construction
Thermostat (NEXA 4X) with remote probe for temperature reading
Components are CLASS I DIVISION I rated

ADD PRICE (EA): $5,000

Washer Compactor Bagging System
Longofill cassette holder - SSTL & ABS plastic
Longopac PE continuous bagger cassette, 295 ft (90 m)

ADD PRICE (EA): $3,400

Budget Proposal

Project:
Traverse City WWTP

Equipment:
FSM Multirake Bar Screen Model HUR1500 x 75/6
FSM Screenings Wash Press Model SPW 300-1300

Represented By:
Peterson and Matz, Inc.
Michael Wright
Phone: 248-476-3204
Email: michael.wright@petersonandmatz.com

Regional Sales Manager:
Enviro-Care
Chris Kincaid
Phone: 224-302-0309
Email: ckincaid@enviro-care.com

Project No.: WEC219343
October 7, 2019

Enviro-Care
A WAMGROUP® Company
1570 St. Paul Avenue - Gurnee IL 60031
P: 815.636.8306
F: 847.672.7968
www.enviro-care.com

ITEM: "A" – One (1) FSM Multirake Bar Screen
Model HUR1500 x 75/6

BASIS OF DESIGN (EACH)

Application:	Municipal Wastewater
Peak Flow:	18.0 MGD
Screen Bar Opening:	1/4 inch (6 mm)
Angle of Screen:	75 degrees from horizontal
Channel Width:	6.0 feet
Channel Depth:	5.0 feet
Downstream Water Level:	26.8 inches @ Peak Flow**
Headloss:	6.1 inches @ Peak Flow with 0% blinding
	10.5 inches @ Peak Flow with 20% blinding
Discharge Height:	4.0 feet (above top of channel)

***Downstream water level is crucial to properly size a screen and to calculate the headloss through the screen. The downstream water level used for the screen sizing and headloss calculations assumes that a 24 inch Parshall Flume will be located downstream of the screen. If this is incorrect, please advise Enviro-Care of what will be controlling the downstream water level and the headloss calculations will be revised.*

MULTIRAKE BAR SCREEN (EACH)

- Frame constructed from type 304 stainless steel.
- Barfield with continuous tapered bars from type 304 stainless steel.
- Guide rails constructed from type 304 stainless steel.
- Rake assemblies entirely constructed from type 304 stainless steel.
- Dead plate constructed from type 304 stainless steel.
- Stainless steel screen drive roller chain from 304 stainless steel with PA6 rollers, bushings, and pins from 304 stainless steel.
- Stainless steel roller chain and screen rake elements driven by two (2) drive shaft mounted 304 stainless steel sprockets.
- Drive shaft from solid 304 stainless steel.

- Lower rotating guide sprockets from type 304 stainless steel with ceramic collar bonded to the stub shaft with fiber reinforced PTFE self-lubricating bushing.
- Lower stub shafts from solid 304 stainless steel.
- Discharge chute constructed from type 304 stainless steel.
- Replaceable polyethylene wiper mounted to pivoting 304 stainless steel support arm.
- Screen electric drive motor, 2.0 HP TEFC, 1760 rpm suitable for 230/460/3/60 supplied with gear reducer mounted directly onto screen drive shaft.
- Neoprene side seals with type 304 stainless steel backing plates prevent bypass of material around the screen unit.
- Screen covers above the top of channel from type 304 stainless steel.
- Shop surface preparation, stainless steel full dip passivation and painting as required.

HARDWARE (EACH)

- Assembly fasteners from type 304 stainless steel.
- Anchor rods from type 304 stainless steel.

CONTROL PANEL AND INSTRUMENTATION (EACH)

- One (1) NEMA 4X type 304 stainless steel wall mount main control panel suitable for 480/3/60 electrical supply. Control panel shall contain the following control devices for operation of the bar screen.
    1. Main disconnect with through door interlock handle.
    2. Control transformer 480/120.
    3. Branch circuit protection.
    4. Screen motor starter (IEC), reversing with overload.
    5. Load monitor for screen motor overtorque/overload protection
    6. Emergency stop pushbutton.
    7. HOA switch for each motor.
    8. Hour meter for each motor.
    9. Run indicating lights.
    10. Alarm lights indicating overcurrent and starter overload.
    11. Alarm reset pushbutton.
    12. Programmable control relay for screen control logic functions.
    13. Run and alarm auxiliary contacts.
    14. UL Label.

- One (1) NEMA 4X local Emergency Stop pushbutton control station complete.
- One (1) Ultrasonic Level Controller: A 120V differential level controller shall be provided in a windowed NEMA 4X polycarbonate enclosure suitable for wall mounting, to receive and interpret a 4-20mA scaled signal from a upstream and downstream transducers. The controller shall have 5 internal relays and provide an LCD display.
- Two (2) Ultrasonic level transducers shall be provided with type 304 stainless steel mounting brackets and expansion anchors. Each sensor shall have an ETFE housing with an integral sensor to provide compensation for acoustic variations due to temperature. Each sensor shall have a range of 1-33 ft and be supplied with a 33 ft integral cable. Sensor shall be suitable for installation in a Class I, Division 1, Group D area.

SPARE PARTS (TOTAL)

- None.

FIELD SERVICE (TOTAL)

- Site service of one (1) trip for a total of two (2) days for installation inspection, startup and operator training.

CLARIFICATIONS/COMMENTS

- None.

OPTIONAL ITEMS

- None.

NOTE: ANY ITEM NOT LISTED ABOVE TO BE FURNISHED BY OTHERS.

EXCLUSIONS

Taxes, electrical wiring, conduit or electrical equipment, piping, valves, or fittings, shimming material, lubricating oil or grease, shop or field painting, field welding, erection, hoist or lifting apparatus, detail shop fabrication drawings, performance testing, unloading, storage, concrete work, civil design, grating, platforms, stairs, hand railing, dumpster (except as specifically noted).

This proposal section has been reviewed for accuracy and is approved for issue:
By: Beth Emmelot Date: October 7, 2019

ITEM: "B" - One (1) FSM Screenings Wash Press Model SPW 300-1300

BASIS OF DESIGN (EACH)

Application:	Municipal Headworks
Screenings Capacity:	177 ft3/hr
Inlet Opening:	1300 mm (51.2 inches)
Screw Diameter:	300 mm (11.81 inches)
Discharged Material Dry Solids:	>40%
Volume Reduction:	60 – 85%
Weight Reduction:	60 – 85%
Fecal Reduction:	90% (<20 mg/g BOD5)
Wash Water:	16 gpm @ 20-40 psi

SCREENINGS COMPACTOR (EACH)

- Screenings washer and compactor from type 304 stainless steel.
- Discharge chute an inlet hopper and spray header – 304 stainless steel.
- Screw auger with torque tube and nylon brushes fitted to screw flights to clean drainage trough perforations – shaft from high tensile steel with flights from Hardox 400.
- Axial thrust bearing with stainless steel body.
- Wear bars from Hardox® 400 alloy steel.
- 6 mm perforated curved drainage section from type 304 stainless steel.
- Drainage collection pan with 4 inch diameter outlet connection and 1 inch NPT flush water connection from type 304 stainless steel.
- Wash water piping from type 304 stainless steel.
- Inlet and outlet flanges from type 304 stainless steel.
- Discharge piping with 45 degree elbows from type 304 stainless steel.
- Washer/compactor electric drive motor 5.0 HP TEFC 1760 rpm suitable for 460/3/60 supply with gear reducer mounted directly onto auger drive shaft.
- Support legs, stand and frame from type 304 stainless steel.
- Anchor bolts from type 304 stainless steel.
- Fasteners from type 304 stainless steel.
- Shop surface preparation, stainless steel full dip passivation and painting as required.

CONTROL PANEL AND INSTRUMENTATION (EACH)

- The following control devices will be added to the screen control panel for operation of the screenings wash press.
    1. Branch circuit protection.
    2. Compactor motor starter (IEC) with overloads.
    3. Load monitor for compactor motor overtorque/overload protection.
    4. HOA switch for motor.
    5. Open-Close-Auto switch for washer compactor wash water solenoid valve.
    6. Hour meter for each motor.
    7. Run indicating lights.
    8. Alarm lights indicating overcurrent and starter overload.
    9. Run and alarm auxiliary contacts.

- One (1) NEMA 4X brass body wash water solenoid valve.

SPARE PARTS (TOTAL)

- None.

FIELD SERVICE (TOTAL)

- Provided with screen start-up services.

CLARIFICATIONS/COMMENTS

- None.

OPTIONAL ITEMS

- None.

NOTE: ANY ITEM NOT LISTED ABOVE TO BE FURNISHED BY OTHERS.

EXCLUSIONS

Taxes, electrical wiring, conduit or electrical equipment, piping, valves, or fittings, shimming material, lubricating oil or grease, shop or field painting, field welding, erection, hoist or lifting apparatus, detail shop fabrication drawings, performance testing, unloading, storage, concrete work, civil design, grating, platforms, stairs, hand railing, dumpster (except as specifically noted).

This proposal section has been reviewed for accuracy and is approved for issue:
By: Beth Emmelot Date: October 7, 2019

BUDGET

Item	Equipment	Budget Price
A	One (1) FSM Multirake Bar Screen Model HUR1500 x 75/6	$ 176,000
B	One (1) FSM Screenings Wash Press Model SPW 300-1300	$ 81,500

Validity:
Prices are valid for a period of 30 days from the date of this proposal.

Warranty Statement and Term:
Enviro-Care Company, Inc. warrants the supplied equipment to the original end user against defects in workmanship or material under normal use and service in compliance with the original design specifications and the maintenance requirements and instructions as found in the Operations & Maintenance Manual. All Enviro-Care supplied equipment is warranted for 12 months from date of start-up or 18 months from date of shipment, whichever occurs first.

Warranty Exclusions:
This warranty does not cover costs for standard and/or scheduled maintenance performed, nor does it cover consumables and Enviro-Care parts that, by virtue of their operation, require replacement through normal wear (aka: Wear Parts), unless a defect in material or workmanship can be determined by Enviro-Care. Wear parts are defined as brushes, rollers, spray nozzles, drum seals and other items specifically identified in the Operations & Maintenance Manual.

Warranty Coverage:
Enviro-Care's liability is limited to the supply or repair of defective parts returned, freight prepaid by buyer to a location specified by Enviro-Care. Repaired or replacement parts will be shipped to buyer prepaid via standard ground freight. Express or expedited shipments will be at the expense of the buyer.

Exclusions and Exceptions:
This Warranty excludes damage or wear to equipment caused by misapplication of product, improper maintenance, accident, abuse, unauthorized alteration or repair, Acts of God, or installation or operation that is non-compliant with Enviro-Care installation and operations instructions.

Limited Liability:
Enviro-Care shall not under any circumstances be liable for any incidental or consequential damages arising from loss, damage to property, personal injury or other damage or losses owing to the failure of Enviro-Care's equipment. The liability of Enviro-Care Company, Inc. is limited as set forth above within the time period set forth above.

Term: 15% with Submittal Approval
80% Net 30 Days after Shipment
5% Net 30 days after Startup. Startup not to exceed 180 days from equipment delivery.

Taxes: No sales or use taxes have been included in our pricing.

Freight: Prices quoted are F.O. B. shipping point with freight allowed to a readily accessible location nearest jobsite. Any claims for damage or loss in shipment to be initiated by purchaser.

Submittals: Full submittals will be supplied approximately **4 to 6 weeks** after receipt and acceptance of purchase order at the Enviro-Care offices.

Shipment: Shipment time is approximately **20 to 22 weeks** after receipt of approved submittal is received at the Enviro-Care offices. Under no circumstances will verbal approval be accepted.

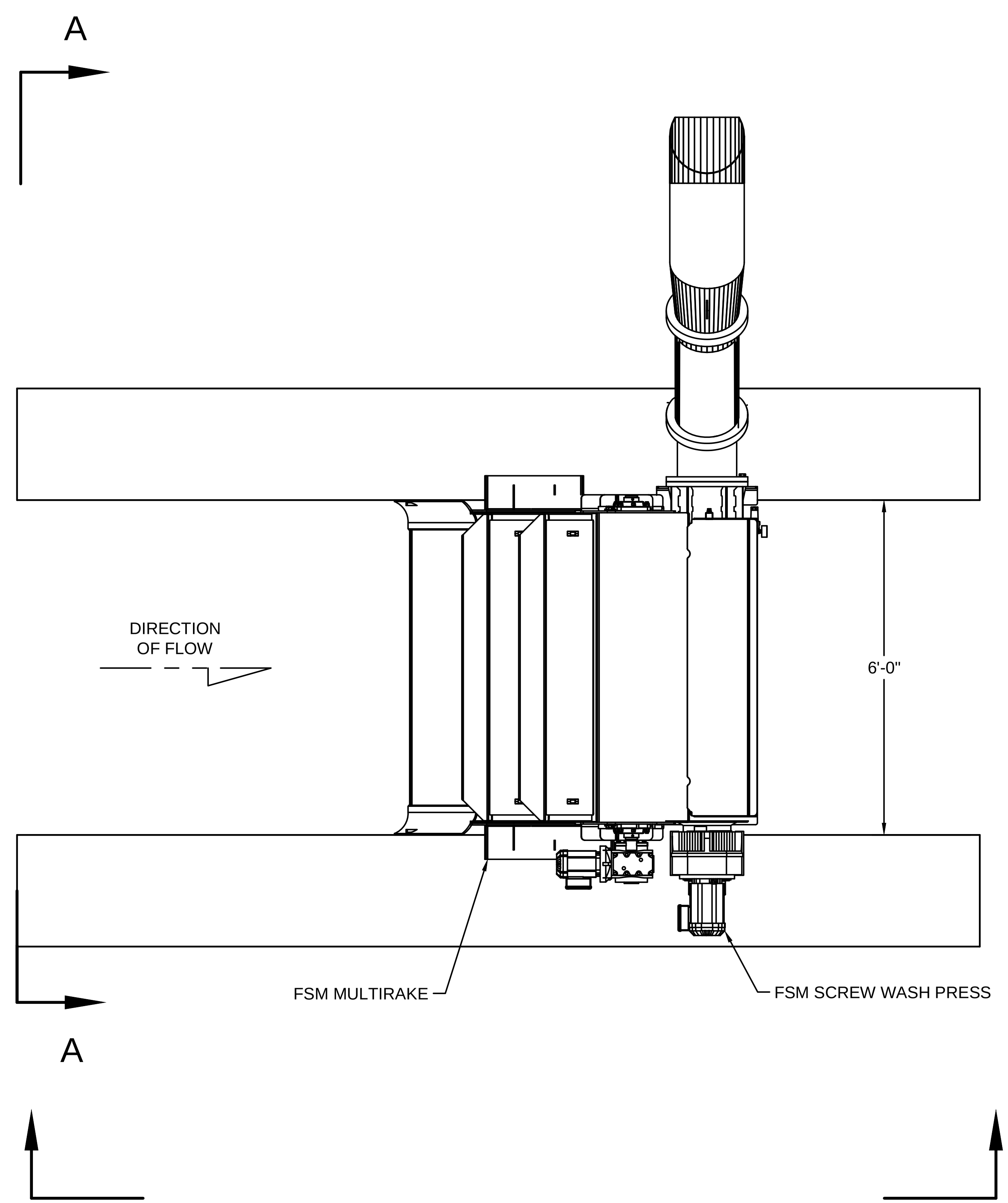
Additional Field Service: This service may be scheduled at $1,250.00 per day plus expenses or is available through a yearly service contract.

Material of Construction: Enviro-Care is providing the equipment from the type of material specified for this project. If from 304L stainless steel the concentration of chloride and hydrogen sulfide (H2S) in the equipment operating environment shall be kept below the following values:

- Chloride <200 mg/L
- Hydrogen Sulfide (H2S) <6ppm

If not already done so, Enviro-Care can provide the equipment from 316L stainless steel for a price adder for environments that exceed the values noted above.

NOTES:
1. DRAWING NOT FOR CONSTRUCTION



PLAN
SCALE: 3/8" = 1'-0"

PROCESS DESIGN INFORMATION (EACH SCREEN):

APPLICATION:	MUNICIPAL WASTEWATER SCREENING
PEAK DESIGN FLOW:	18.0 MGD
CHANNEL WIDTH:	6.0 FEET
CHANNEL DEPTH:	5.0 FEET
ANGLE OF INCLINATION:	75 DEGREES FROM HORIZONTAL
DISCHARGE HEIGHT:	4.0 FEET FROM TOP OF CHANNEL

Rev	Revision Description	Date	Rev By	Approver
D				
C				
B				
A				

Enviro-Care
A WAMGROUP® Company

Status: INFORMATION ONLY

Title
GENERAL ARRANGEMENT: TRAVERSE CITY WWTP
MODEL: HUR1500X75 FSM MULTIRAKE
SPW300-1300 FSM SCREW WASH PRESS

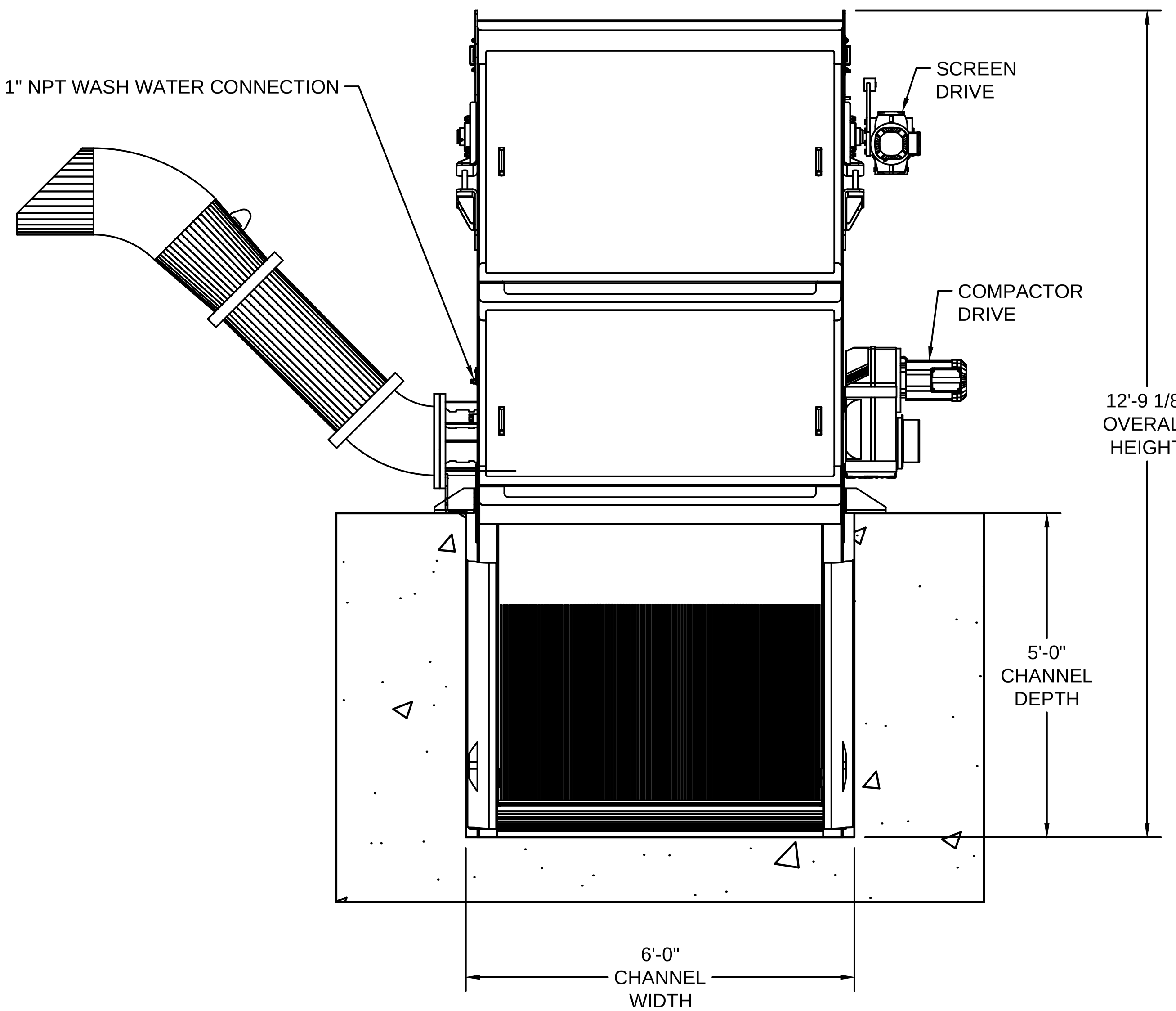
Designer	Checker	Date	Sheet
JW24	BE26	10-05-2019	1 of 2

Third Angle Projection

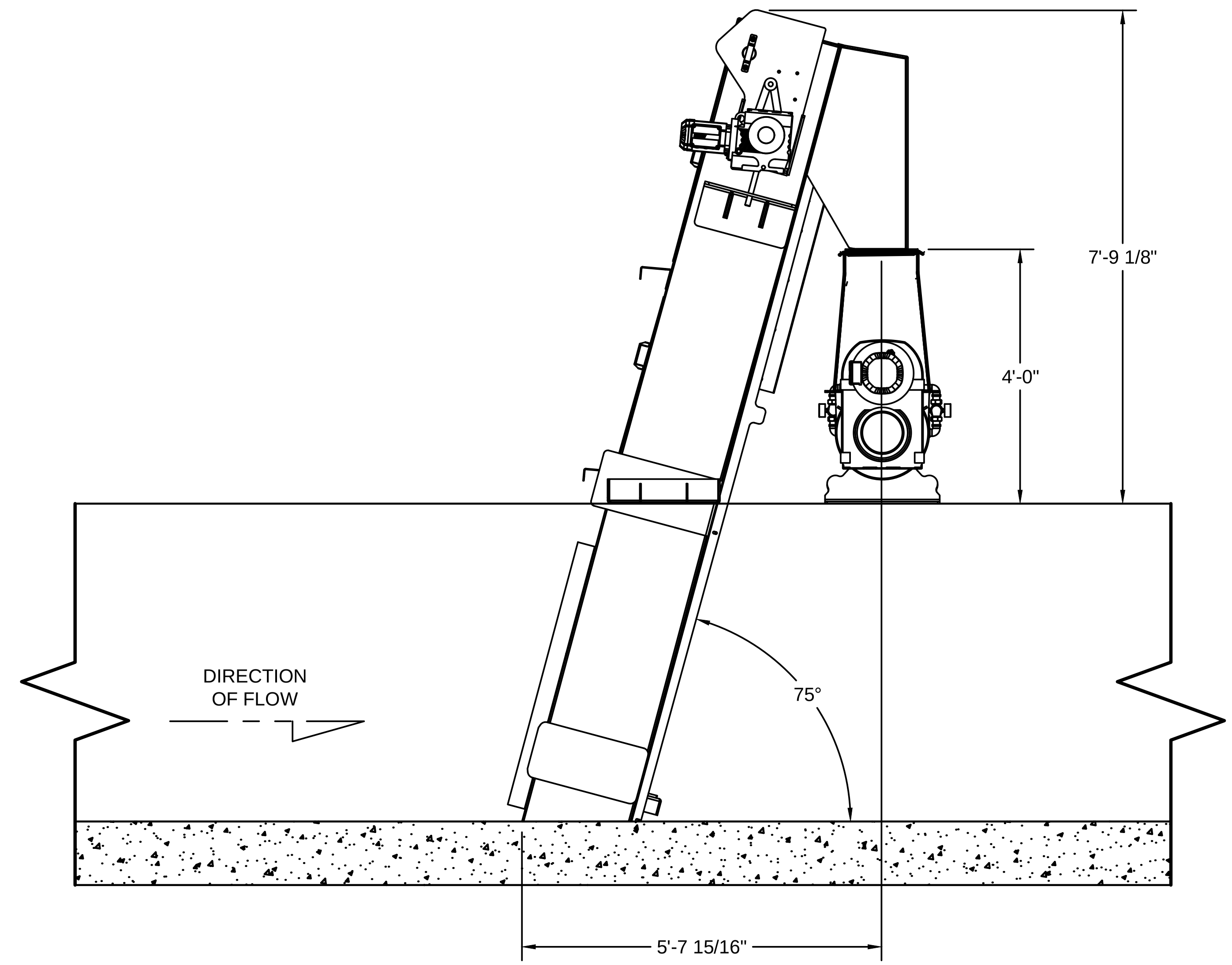
Drawing Number: WEC219343-A

Revision: -

NOTES:
1. DRAWING NOT FOR CONSTRUCTION



VIEW A-A



VIEW B-B

ELEVATION
SCALE: 3/8" = 1'-0"

Rev	Revision Description	Date	Rev By	Approver
D				
C				
B				
A				

Enviro-Care
A WAMGROUP® Company

Status: INFORMATION ONLY

Title
GENERAL ARRANGEMENT: TRAVERSE CITY WWTP
MODEL: HUR1500X75 FSM MULTIRAKE
SPW300-1300 FSM SCREW WASH PRESS

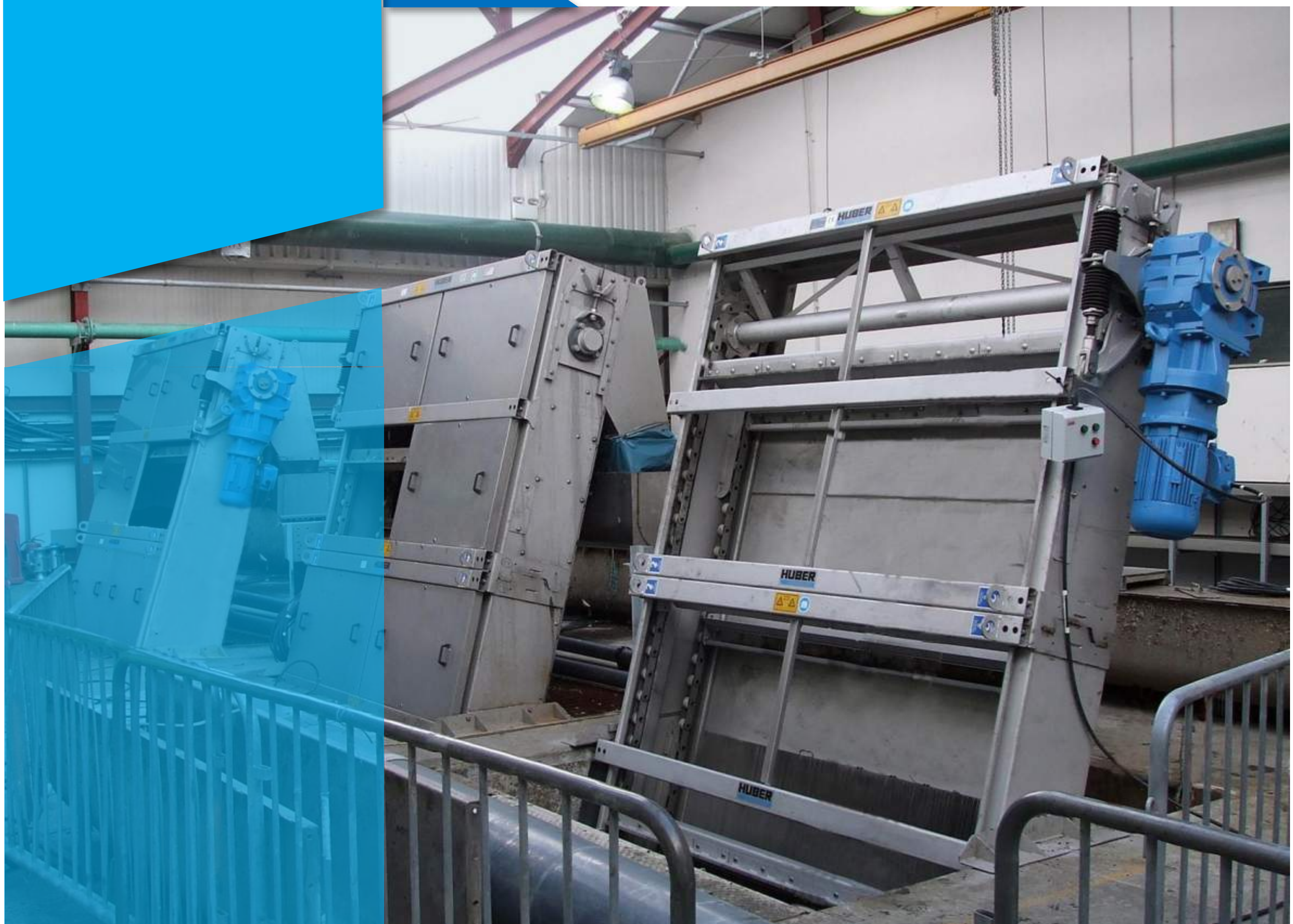
Designer	Checker	Date	Sheet
JW24	BE26	10-05-2019	2 of 2

Third Angle Projection

Drawing Number: WEC219343-A

Revision: -

HUBER TECHNOLOGY
WASTE WATER Solutions



Budgetary Proposal

Huber Technology, Inc.
9735 Northcross Center Ct.
Suite A
Huntersville, NC 28078
Office 704-949-1010
Fax 704-949-1020

Project: Traverse City, MI
Equipment: RakeMax Multi-Rake Bar Screen
Proposal Date: October 8, 2019
Revision: 0

Detailed Scope of Supply

Screen Details

Material	304L Stainless Steel	**Model:**	**RakeMax 3520x1575/6**	
Screening Bars	Teardrop 8/5/60, 304L Stainless Steel	*Quantity*	1	
Chains	316L Links, AISI-431 Pins	*Flow rate (Peak)*	17	MGD
Scraper	Polyethylene Blades	*Channel Depth*	5	ft
Motor	1.5HP, C1D1, 480VAC, 3ph, 60Hz, SF 1.0	*Channel Invert to Op. Floor*	5	ft
Control Panel	NEMA 12 Painted Steel Enclosure, Allen Bradley MicroLogix PLC, AB PanelView Plus OIU, Huber Standard Components, Preprogrammed and Factory Tested	*Channel Width*	6	ft
		Screen Frame Width	5.72	ft
		Screen Field Width	5.17	ft
		Bar spacing	1/4	in
Level Controller	HydroRanger 200 Differential (per Screen)	*Installation Angle*	75	[°]
LCS	Included	*Approx. Screen Weight*	3342	lb
Options Selected	None	*Discharge Height*	10.33	ft

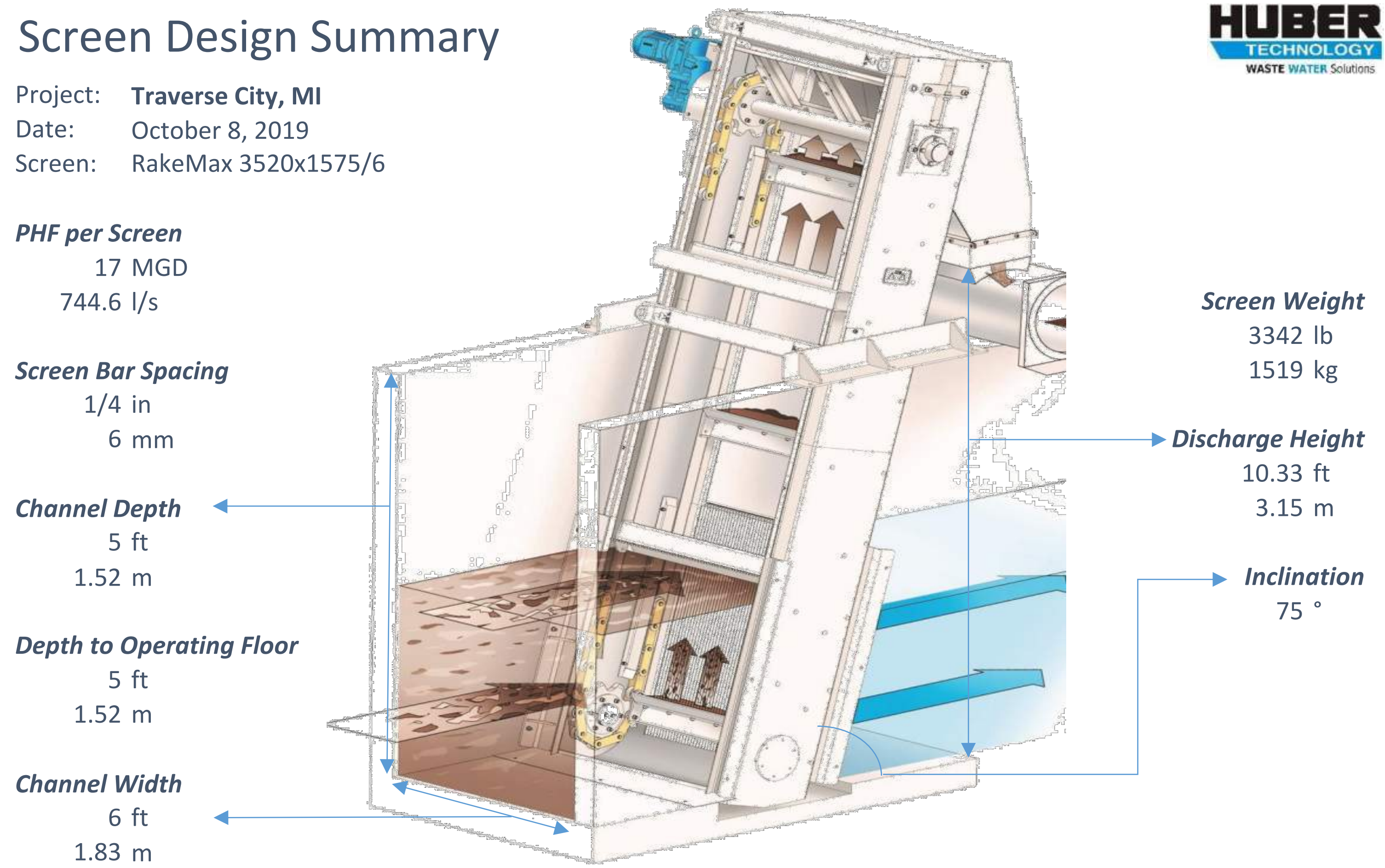
Washer Compactor Details

Body Material	304L Stainless Steel	**Model:**	**WAP2**	
Auger	Shafted, 304L Stainless Steel	*Quantity*	1	
Drain Pan	Latched, 3.5in NPT Connection	*Screenings Capacity*	70	ft3/hr
Inlet Hopper(s)	Inspection Hatch Included	*Wash Water Demand*	13	gpm
Discharge Pipe	Endless Bagger Included	*Wash Water Pressure*	30-60	psi
Drive Motor	5.0HP, C1D1, 480VAC, 3ph, 60Hz, SF 1.15	*Approximate Weight*	660	lbs
Solenoid Valve(s)	Brass-bodied, C1D1, 120VAC, 3ph			
Controls	Included within VCP			
LCS	Included			
Options Selected	None			

HUBER Technology, Inc.
Huber Technology, Inc.· 9735 NorthCross Center Court STE A · Huntersville, NC 28078
Phone (704) 949-1010 · Fax (704) 949-1020 · huber@hhusa.net · www.huber-technology.com
A Member of the HUBER Group

Screen Design Summary

Project: **Traverse City, MI**
Date: October 8, 2019
Screen: RakeMax 3520x1575/6



Blinding	***Headloss (delta h)***		***Upstream Head (ho)***		***Flow Velocity Between Slots (vr)***	
[%]	***[in]***	*[mm]*	***[in]***	*[mm]*	***[ft/sec]***	*[m/sec]*
0	**1**	34	**26**	669	**5.23**	1.59
10	**3**	72	**28**	1560	**5.49**	1.67
20	**5**	116	**30**	1584	**5.82**	1.77
30	**7**	**167**	**32**	**1615**	**6.23**	**1.90**
35	**9**	218	**34**	1649	**6.30**	1.92
40	**11**	270	**36**	1687	**6.44**	1.96
50	**13**	334	**38**	1737	**7.21**	2.20

Given / Assumed Data:

Screen field width	**62.01**	in	[A]
Flow rate (PHF)	**17**	MGD	[Q]
Water level behind screen	**25**	in	[hu]
Flow velocity in channel	**2.10**	ft/s	[vg]
Bar spacing	**1/4**	in	[e]
Bar thickness	**0.31496**	in	[s]
Bar geometry coefficient	**0.84**	[-]	[b]
Installation angle	**75**	[°]	[a]

Calculation Basis:

Free surface factor	ao = e/(s+e)	**42.9%**
Flow velocity between slots	vr = Q/(A*ho*ao*(1-b))*sin(alpha)	
Blinding factor z	z = e - ynet*(e+s)	
Relative flow area	y net = e/(s+e)-b*e/(s+e)	
Headloss	delta h = beta*((s+z)/(e-z))^4/3*sin(alpha)* vo^2/2*g	
Upstream head	ho = hu + delta h	
Velocity in the screen	vo = Q/(ws*ho)	

HUBER Technology, Inc.
Huber Technology, Inc.· 9735 NorthCross Center Court STE A · Huntersville, NC 28078
Phone (704) 949-1010 · Fax (704) 949-1020 · huber@hhusa.net · www.huber-technology.com
A Member of the HUBER Group

Budgetary Pricing

EQUIPMENT	Quantity	Model	Pricing
RakeMax® Multi-Rake Bar Screen	1	RakeMax 3520x1575/6	Included
WAP Screenings Wash Press	1	WAP2	Included
Standard Manufacturer's Services & Freight			Included
		BUDGETARY TOTAL:	**$160,000.00**

Thank you for your interest in Huber Technology, Inc.'s multiple rake bar screen, the RakeMax. Enclosed you will find a detailed scope of supply, hydraulic calculations and technical clarifications. If you have any questions, please do not hesitate to contact our Regional Sales Director or our local sales representative.

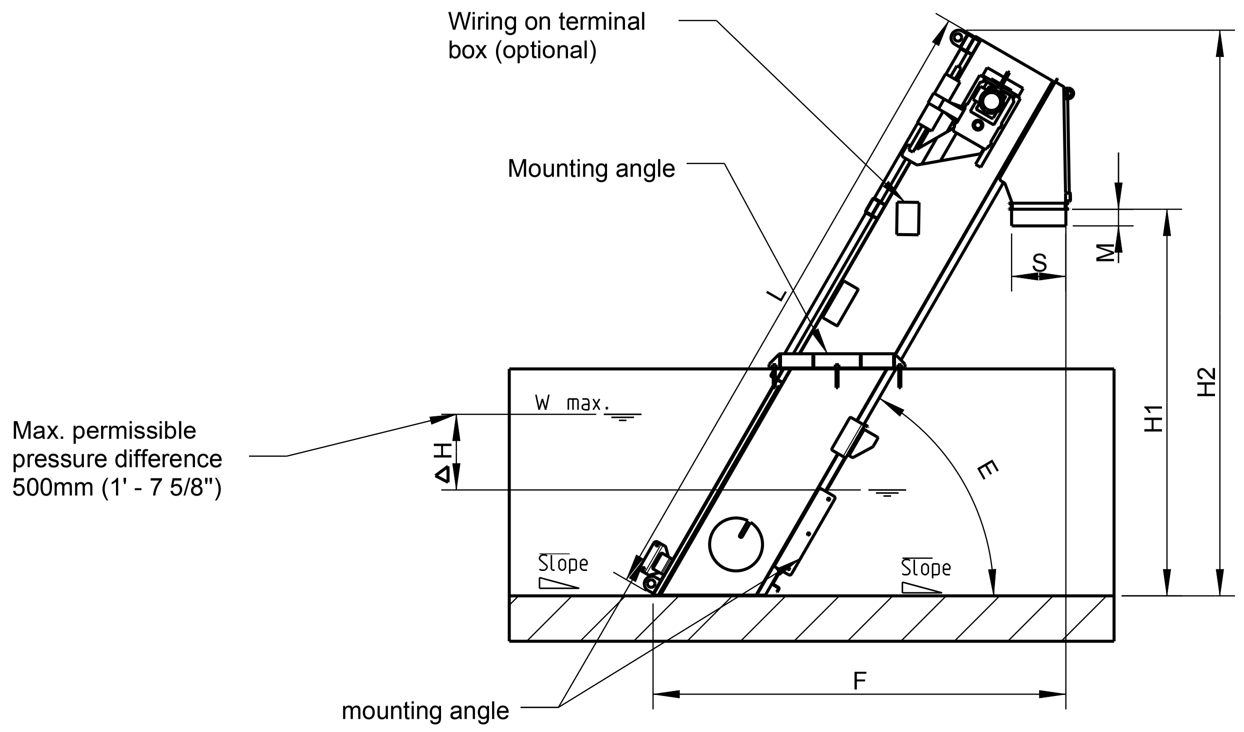
Huber Sales		***Local Sales Representative***	
Name:	Gary Wesselschmidt	Firm:	Hesco
Title:	Regional Sales Director - Central	Name:	Glenn Hummel
Phone:	816-623-9955	Phone:	(586) 978-7200
Email:	Gary@hhusa.net	Email:	glenn@hesco-mi.com

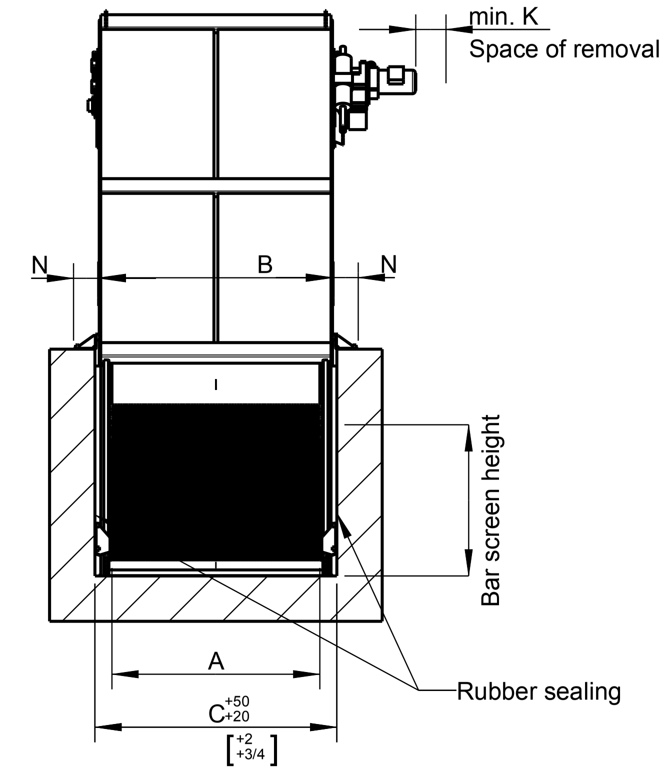
Technical Clarifications

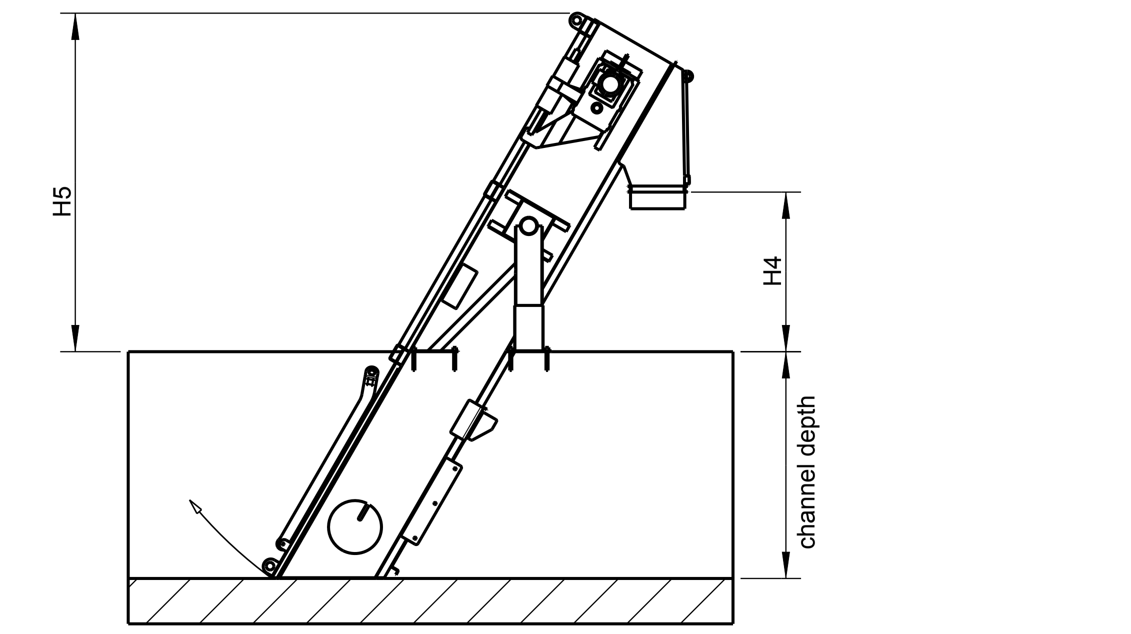
1. Equipment specification is available upon request
2. If there are site-specific hydraulic constraints that must be applied, please consult the manufacturer's representative to ensure compatibility with the proposed system
3. Electrical disconnects required per local NEC code are not included in this proposal
4. Huber Technology warrants all components of the system against faulty workmanship and materials for a period of 12 months from date of start-up or 18 months after shipment whichever occurs first
5. Budget estimate is based on Huber Technology's standard Terms & Conditions and is quoted in US$ unless otherwise stated
6. Huber has estimated the Control Panel cost based information provided with the RFQ. If control panel information is not provided with RFQ Huber will use a cost and scope of supply based on our standard panel. Huber reserves the right to change the price and scope at time of bid based on the final plans and specifications.
7. All items listed as "Available Options" are not included in the budgetary pricing.
8. Equipment that is broken out in "Pricing" tab are only valid when packaged together.

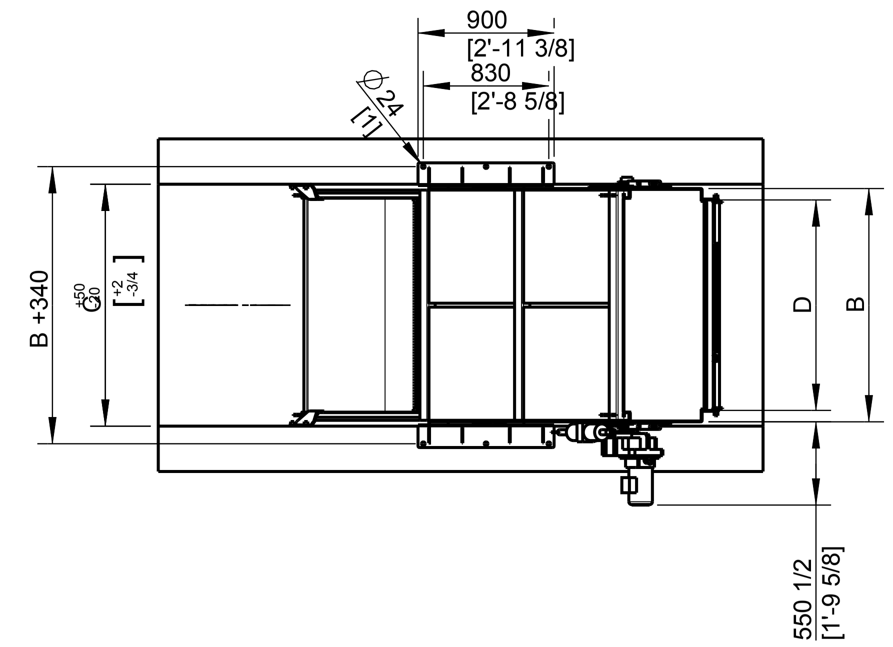
RakeMax® sheet of dimensions

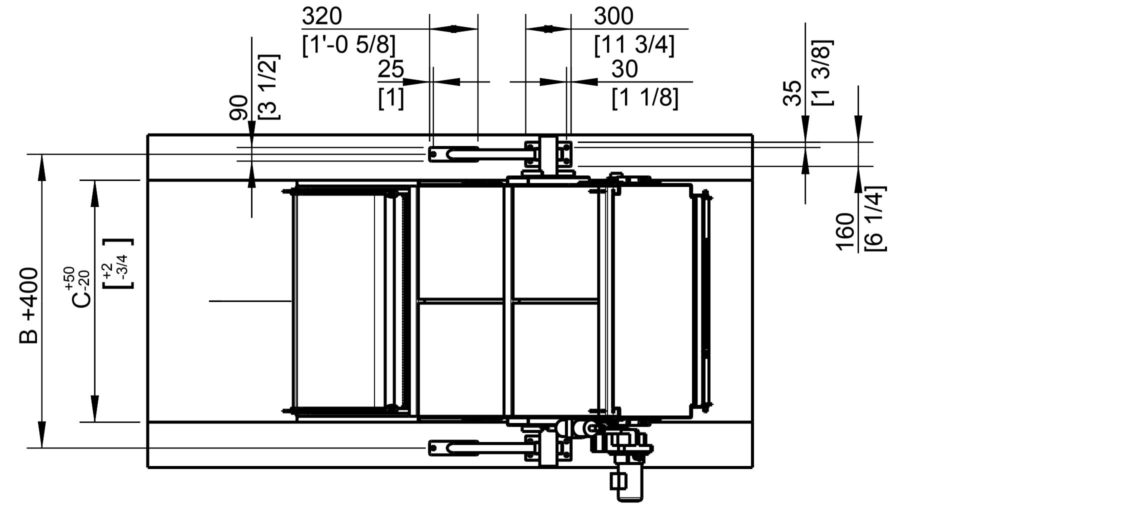
Support instead of the mounting angle
- pivotable versin (size <= 4160)
- discharge height H4 >= channel depth
- H5 >= 3000 mm (9' - 10 1/8")
- installation angle <= 55°











* Trapezoidal channel in front of RakeMax

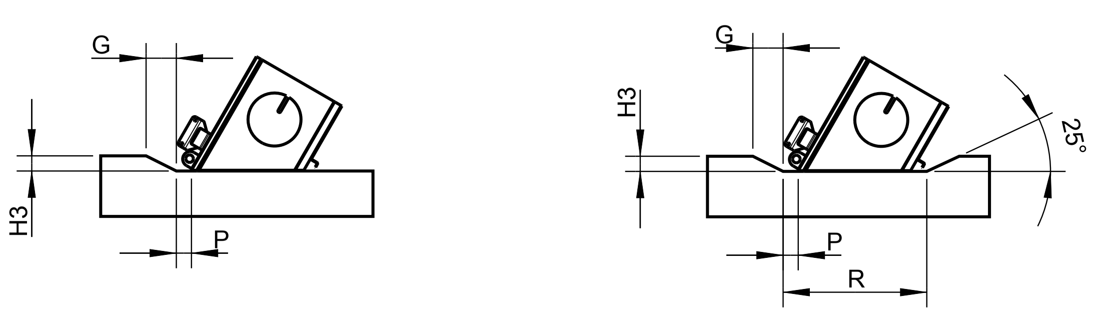
* These anchor bolts are only permissible in concrete with a resistance of >=C20/25<=C50/60

* If there is not sufficient room height we recommend to provide an opening in the roof.

Additional suggestions for hydraulic improvement

Step in channel bottom

Recess in channel bottom



Note:
Channel walls must be absolutely vertical in the area of the screen. In the area of the screen bottom plate the channel surface must be plane with a max. tolerance of +/- 3mm or +/- 0' - 1/8".

Accident prevention acc. GUV and machine directives (railing, cover, ..) or country specific regulations by others.

Pos. Item	Quantity	Specification	Material/Supplier	Annotations
-	-			

Subject to change | ISO 2768-mK

HUBER TECHNOLOGY
Tel.: 704-949-1010

Revi-sion	Modified	Date	Name		Datum/Date	Name
				Rev.	01.03.2016	rwo
-				Appr.	01.03.2016	rwo
				Norm.		
				Scale: 1:50		

HUBER Multi-Rake Bar Screen
Dimension sheet
RakeMax®

Project | number 50963000 | sheet 1/1

GREAT WHITE CENTER FLOW SCREEN & WHITETIP SHARK WASHING COMPACTOR PROPOSAL PACKAGE

FOR: TRAVERSE, MI

ORIGINAL EQUIPMENT MANUFACTURED BY

HYDRO DYNE
ENGINEERING
DESIGNED TO PROTECT. BUILT TO PERFORM.™

4750 118th Avenue North • Clearwater, Florida 33762
Phone: 813-818-0777 • Fax: 813-818-0770
Email: info@hydro-dyne.com

Great White Center Flow Screen Equipment Sizing

HYDRO DYNE ENGINEERING
Tel: 813-818-0777 Fax: 813-818-0770

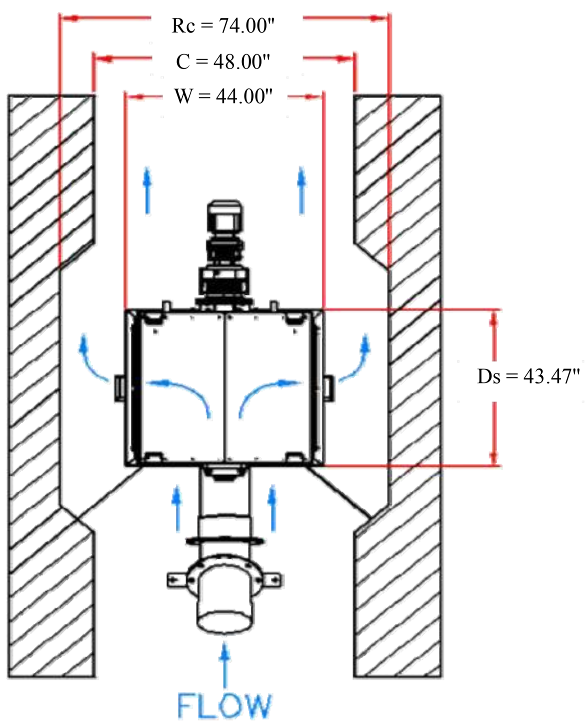
Project: Traverse, MI
Date: 10/11/2019
Rep: Waterworks
By: JMB **Checked:**

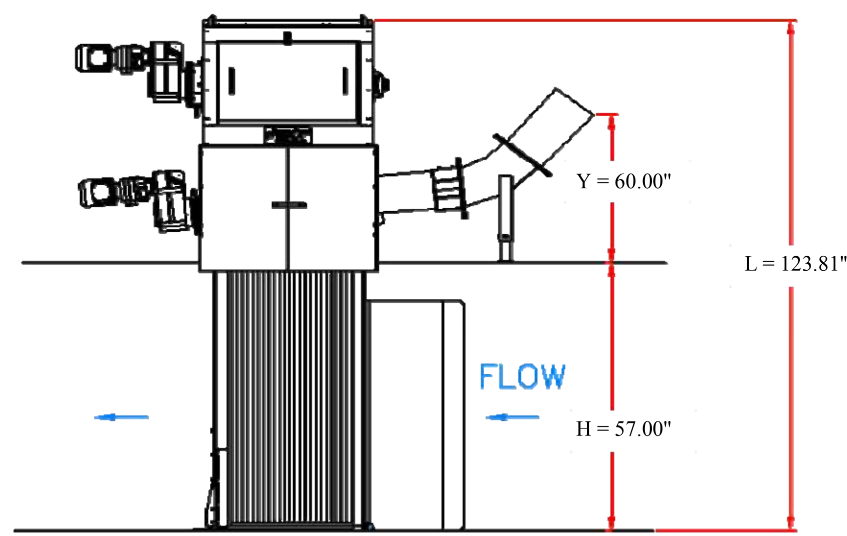
Model # CF 44 – 43 – 124 – 3 – L

Channel Dimensions:		English Units	SI Units
C	Channel Width	48.00 in	1219 mm
H	Channel Height	57.00 in	1448 mm
Rc	Recess Width,	74.00 in	1880 mm
Rd	Channel Recess Depth	72.60 in	1844 mm
TC	Height from Grade to Top of Channel	0.00 in	0 mm

Equipment Dimensions:		English Units	SI Units
L	Length of Screen	123.81 in	3145 mm
W	Width of Screen	44.00 in	1118 mm
Ds	Depth of Screen	43.47 in	1104 mm
Y	Discharge Height from the Compactor	60.00 in	1524 mm

Screen Grid Parameters:				
S	Grid Opening Spacing		3mm Link	
Obs	Percent of Screen Obstructed	50 %	Hook Link	16 ga
OA_{eff}^{*}	Effective Percent of Grid Opening	34.73 %	Straight Link	18 ga





NOTE: * Effective Percent of Grid Opening = Percent of Grid Opening at 3mm Opening × (1 - Proposed 50% of Screen Obstructed).

Great White Center Flow Screen Hydraulic Performance

HYDRO DYNE ENGINEERING
Tel: 813-818-0777 Fax: 813-818-0770

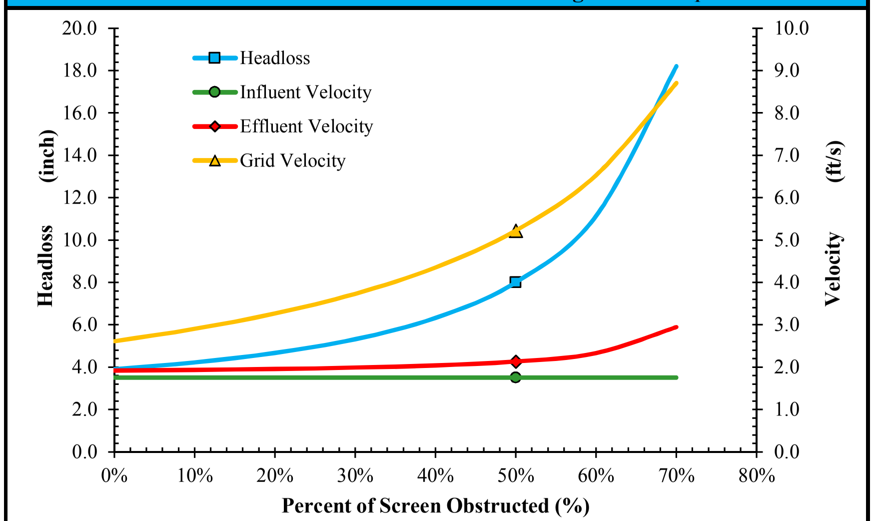
Project: Traverse, MI
Date: 10/11/2019
Rep: Waterworks
By: JMB **Checked:**

Model # **CF** 44 – 43 – 124 – 3 — L

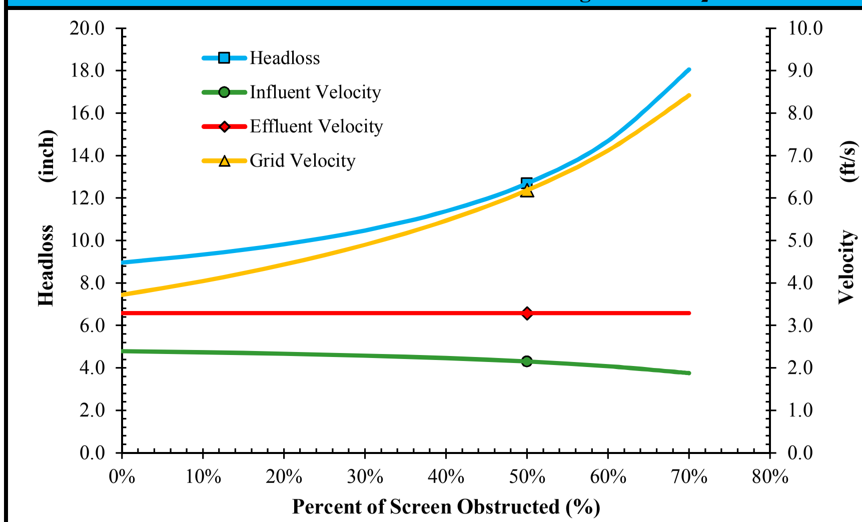
Fixed D_1 Condition @ 50% Obs		English Units		SI Units	
Q	Flow Rate	17.00 MGD	11806 gpm	745 L/s	64352 m^3/d
D_1	Upstream Water Depth	45.00 in		1143 mm	
D_2	Downstream Water Depth	37.00 in		940 mm	
ΔH	Total Headloss	8.00 in		203 mm	
F	Freeboard	12.00 in		305 mm	
V_1	Influent Channel Velocity	1.75 ft/s		0.53 m/s	
V_T	Throat Velocity of Screen	3.17 ft/s		0.97 m/s	
V_G	Velocity Through Grid	5.22 ft/s		1.59 m/s	
V_{Re}	Recess Zone Velocity	2.95 ft/s		0.90 m/s	
V_2	Effluent Channel Velocity	2.13 ft/s		0.65 m/s	

Fixed D_2 Condition @ 50% Obs		English Units		SI Units	
Q	Flow Rate	17.00 MGD	11806 gpm	745 L/s	64352 m^3/d
D_1	Upstream Water Depth	36.69 in		932 mm	
D_2	Downstream Water Depth	24.00 in		610 mm	
ΔH	Total Headloss	12.69 in		322 mm	
F	Freeboard	20.31 in		516 mm	
V_1	Influent Channel Velocity	2.15 ft/s		0.66 m/s	
V_T	Throat Velocity of Screen	4.10 ft/s		1.25 m/s	
V_G	Velocity Through Grid	6.18 ft/s		1.88 m/s	
V_{Re}	Recess Zone Velocity	4.20 ft/s		1.28 m/s	
V_2	Effluent Channel Velocity	3.29 ft/s		1.00 m/s	

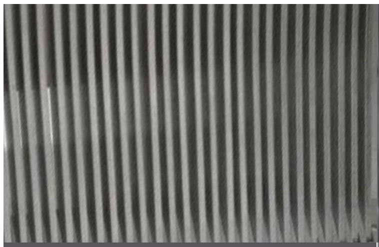
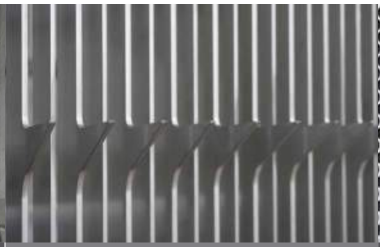
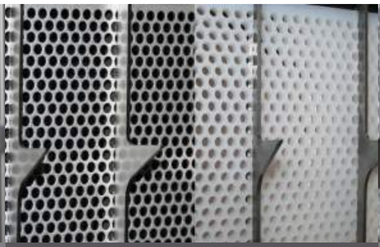
Screen Performance VS. Screen Blocking at Fixed D_1



Screen Performance VS. Screen Blocking at Fixed D_2



Screen Grid Options


	Stainless Steel Bars Rectangular Openings from 5-300mm	**Stainless Steel Laced Links** Rectangular Openings from 1-75mm	**Stainless Steel & UHMWPE Perforated Panels** Round Openings from 1-9mm	**Stainless Steel Woven Mesh Panels** Square Openings from 0.5-25mm
Applications	Municipal water and wastewater Combined storm overflow Pump and lift systems Food processing	Municipal water and wastewater Prisons and correctional facilities Combined storm overflow Pump and lift systems Sludge and septage receiving Food processing	Municipal water and wastewater Membrane Bioreactor (MBR) Protection Pulp and paper plants Food Processing	Water intakes Industrial processes Membrane Bioreactor (MBR) Protection Cooling water intake Algae removal
Advantages	Extremely strong grid Dry unloading of screenings Wide range of opening sizes Versatile and proven Easily handles large flows	Strongest grid available Excellent unloading of screenings Highest open area percentage/ very efficient Smaller footprint Wide range of opening sizes Versatile and proven Easily handles large flows	Highest Screening Capture Ratio Patented grid design maintains strength and openings tolerances for life Effectively removes hairs/fibrous material	High Screening Capture Ratio Patented grid design maintains strength and openings tolerances for life High open area percentage
Limitations	Less efficient capture of hair and fibrous material Lower Screening Capture Ratio Large solids can jam bottom and if reversing cannot clear, they must manually be removed	Less efficient capture of hair and fibrous material Lower Screening Capture Ratio	Greater water pressure/volume requirements Significant collection of fecal matter in municipal wastewater Higher headlosses	Greater water pressure/volume requirements Difficulty in unloading stringy/ fibrous material

Stainless Steel Laced Links & Bars
Rectangular Openings from 1-300mm

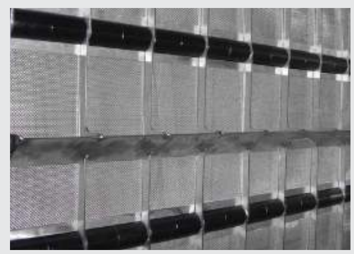
Stainless Steel & UHMWPE Perforated Panels
Round Openings from 1-9mm

Stainless Steel Woven Mesh Panels
Square Openings from 0.5-25mm

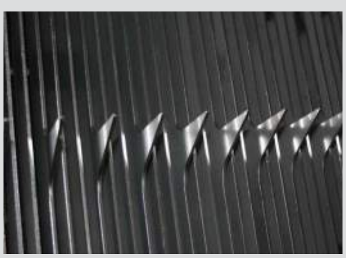
3mm Laced Link

2mm Stainless Steel

1mm

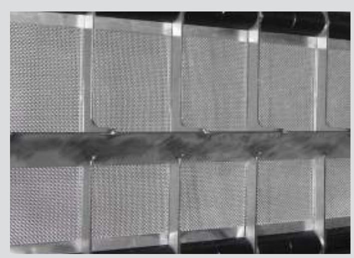


6mm Laced Link



5mm Stainless Steel

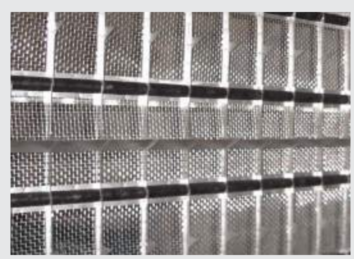
2mm



25mm Laced Link

6mm UHMWPE

6mm



To learn more visit: www.hydro-dyne.com
sales@hydro-dyne.com | +1 (813) 818-0777

Coarse Screens | Fine Screens | Screenings Handling | Grit Removal Equipment

Designed & Manufactured in the USA

4750 118th Avenue North Clearwater, FL 33762

ISO 9001:2015 Certified

HYDRO DYNE® ENGINEERING
Designed to Protect. Built to Perform.™

Great White Center/Dual Flow Screen

Highest Screenings Capture Ratio Available

- Independently certified[1] highest SCR water/wastewater screen
  - 93.25% with 2mm opening
  - 84% with 6mm opening
- Continuous band screen design eliminates bypass and carryover
- Excellent sensitive process and membrane protection
- Proprietary design features easily capture and offload screenings including rags and stringy material
- All T304 or T316 stainless steel fabrication

About the Great White Center/Dual Flow Screen

The Great White Shark is an apex predator that rules almost every body of water around the world. Like the Great White, our Center/Dual Flow Screen is designed and manufactured at the pinnacle of quality and dominates application environments.

The Great White Center/Dual Flow continuous band screen is designed to handle low-to-high flows and has been independently[1] certified to have the highest screenings capture ratio of all band screens on the market. Dual spray wash, patented grid design, proprietary sealing system and UHMWPE guide links make this an exceptional product for the filtering and offloading of water and wastewater screenings.

[1] *UK Water Industry Research in National Screen Evaluation Facility Inlet Screen Evaluation Comparative Report (1999-2011)*

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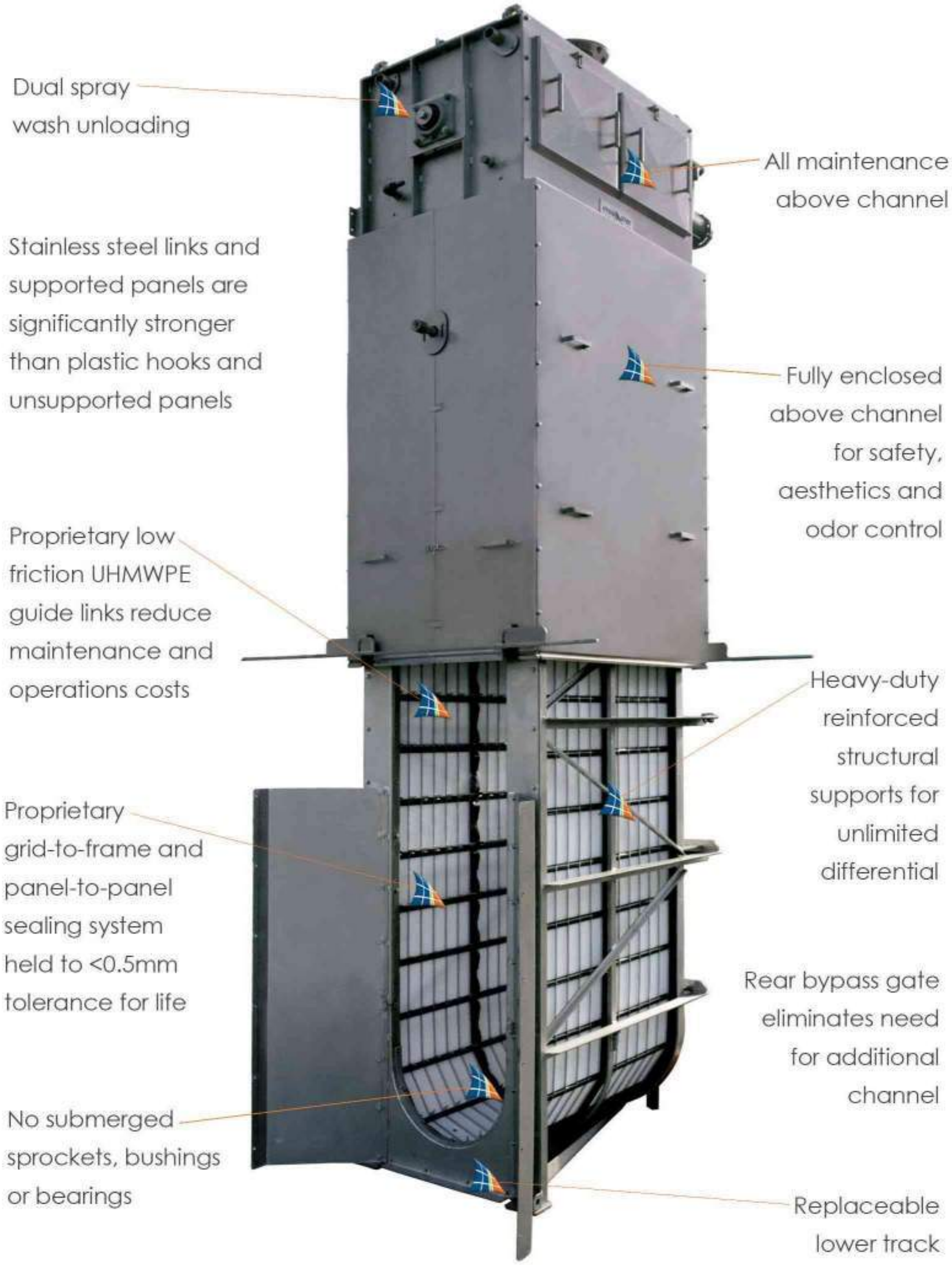

At-a-glance

models
Center Flow (center entrance/side exit)
Dual Flow (side entrance/rear exit)

grid opening range
0.5-25mm

flow capacity
0.1mgd (5 L/s) to 125+mgd (5,500+ L/s)

grid types
Stainless steel laced link
Stainless steel wire mesh
Stainless steel perforated panel
UHMWPE perforated panel

Patented Drive Features

- Grid does not contact drive or unloading mechanism
- Direct drive uses no chains or sprockets
- Fully supports grid for negligible wear
- Fractional hp requirements

Optional Equipment

- Specialty stainless steel construction
- Cold weather/freeze protection
- Basic to sophisticated automation controls
- Sectional construction for restricted area assembly
- Integrated screenings handling equipment
- Electric, hydraulic or explosion-proof drives

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Whitetip Shark Washing Compactors

Effective Design Adapted to your Application

- Multiple models and options to suit individual applications
- Designed to collect, condition, dewater and compact screenings from any screen, launder/sluice or conveyor
- Screenings meet strict landfill requirements
- Returns organics and wash water to channel
- Reduces disposal weight and volume
- All T304 or T316 stainless steel fabrication
- Standard screw diameters: 6", 8", 10", 12" ,16" and 20"

Whitetip Shark Washing Compactors

The Whitetip Shark is a fierce but slow-moving shark, notable for its long, rounded fins which feature an iconic white tip. Hydro-Dyne's family of Whitetip Shark Washing Compactors thoroughly wash and compact screenings to produce the clean, compact white screening plugs they are known for by efficiently returning organics to the channel. Every compactor is custom-designed for individual applications, taking into account the type of flow and solids collected. Multiple models are available to ensure organic material is returned to the treatment plant's process and inorganic materials are separated, cleaned and dewatered in the most effective and efficient way possible. Stainless steel construction provides an enduring solution to exceed ever increasing disposal requirements.

Whitetip Shark Washing Compactor	Whitetip Shark with Additional Wash Cycle	Whitetip Shark with Wash Module
The Whitetip Shark Washing Compactor features screenings washing, compaction and dewatering zones. Spray wash nozzles are recessed to minimize ragging and set at different angles to maximize the rinse cycle. Stainless steel anti-rotation bars improve compaction and significantly increase equipment lifespan.	The Whitetip Shark Washing Compactor with additional wash cycle adds a reversing function to the auger and timers so that the screened material is aggressively agitated during a longer wash cycle. Organic material is further broken down and washed back into the system through the drain.	An average of 80% decrease in the total weight of solids output is achieved by this model with the addition of deluge and washing module zones. The deluge zone significantly improves the separation of organic and inorganic material, and washing module and compression zones thoroughly rinse and compact captured screenings.
Washing Compaction Dewatering	Aggressive Washing Cycle Compaction Dewatering	Up to 80% reduction in solids output weight Deluge zone Wash module zone Compaction Dewatering

Optional Equipment

- Basic rinsing to thorough washing
- Integrated models located within screens
- External models fed via sluice or conveyor
- Trough types: perforated, slotted, wedgewire
- Shafted or shaftless flight
- Electric or hydraulic drive
- Cold weather/freeze protection

Discharge Options

- Dual Bearing: Dewatering
- Reduction Flange: Dewatering and some compaction
- Hinged Gate: Dewatering and compaction
- Press Elbow: Maximum dewater and compaction plus elevation

Screenings Collection Options

- Screenings collection bagging system
- Self-leveling bins
- Stainless steel discharge chute
- Lay flat hose or flexible pipe

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Ph (813) 818-0777 | Fax (813) 818-0770

Made in the USA

Urquhart, Douglas

From: Joe Gentle <joe@peswater.com>
Sent: Friday, October 18, 2019 11:30 AM
To: Benoit Dennis J.
Subject: FW: Traverse City MI WWTP Upgrades
Attachments: GH-46 Submerged Slide Gate.doc; 46-FCE-MTD-hc-med.pdf; 46-FCE-MTD-hw-wb-ped-bltinv.pdf; 46-sc-spigot-mtd-around-rcp-pipe-hw Model (1).pdf

Dennis,

I may have forgotten to send this quote for the Golden Harvest gates. Kusters is also working on the screen quote but they are swamped so I told them that we are very early in the project development so if they need a few more days no biggie.

Have a great weekend Dennis. It looks like it's going to be a nice one.

Best,

Joe

From: Thomas Harris [mailto:ThomasH@goldenharvestinc.com]
Sent: Friday, October 11, 2019 11:19 AM
To: Tashia Hart; Joe Gentle; Frank Bazzano
Cc: David Wise; Brian Buchanan
Subject: RE: Traverse City MI WWTP Upgrades

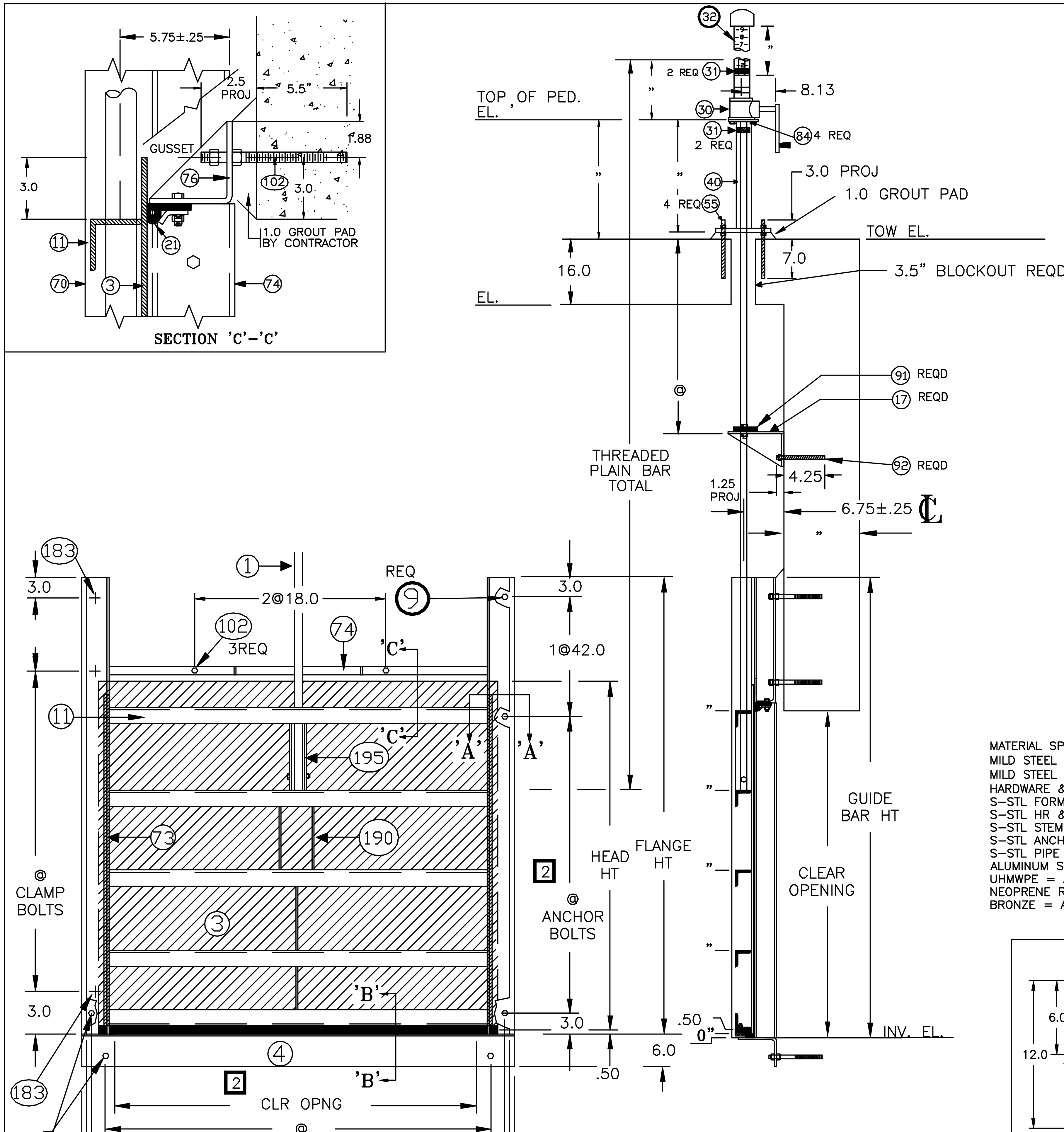
I have attached our spec and a few sample drawings of various configurations for your convenience and review. If you have any questions please let us know.

BUDGETARY PRICE of $40,075.00 FOR:
SEVEN 24" x 24" wall mounted slide gate
304 Stainless steel
yoke mounted hand wheel operator
including shipping

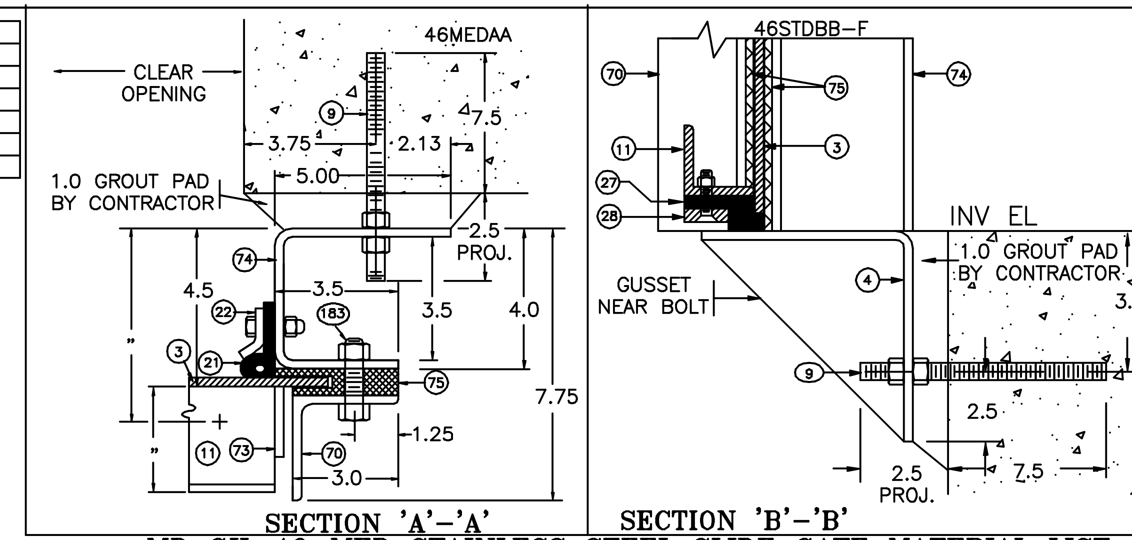
Lead time of 12-18 weeks after submittal approval. Expedited delivery available for a surcharge. (Please specify date needed.)

Thomas Harris
Golden Harvest, Inc.
11944 Westar Lane
Burlington, WA 98233

Phone: (360) 757-4334
Fax: (360) 757-1135
Email: thomash@goldenharvestinc.com
Web: www.goldenharvestinc.com



GOLDEN HARVEST	
ORIGINAL	DW
CHECKED	
CHECKED	
TRANS RET SUB	
CUT SHT CKD	
FINAL RELEASE	

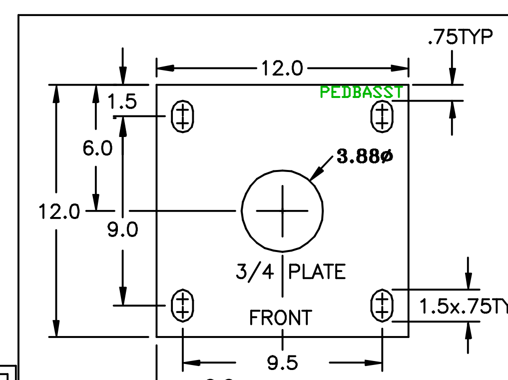


MD GH-46-MED STAINLESS STEEL SLIDE GATE MATERIAL LIST

1	STEM	DIAMETER, S-STL, 4 TPI, W/L HAND SINGLE ACME ROLLED THREADS, 16 MICRO IN. RMS OR LESS FINISH
3	GATE HEAD	1/4" S-STL PLATE
4	INVERT MEMBER	6" X 6" X 1/4" FORMED S-STL ANGLE
*9	ANCHOR BLT	5/8" X 10.0" S-STL ANCHOR ROD, W/2 NUTS
11	STIFFENER	4.0" X 3.0" 1/4" FORMED S-STL ANGLE
17	STEM GUIDE 1-8 HVY	SS, W/UHMW STEM GUIDE BUSHING
21	P-BULB SEAL	NEOPRENE RUBBER
22	P-SEAL RETAINER	3/16" X 2" S-STL FLAT BAR WITH SLOTED HOLES
27	INVERT SEAL	NEOPRENE RUBBER PART# 7509
28	INV. SEAL RETNR.	3/8" X 1 1/4" S-STL FLAT BAR
30	OPERATOR	MG-A03, 2:1 GEAR RED, 15" HANDCRANK, CAST STL HSG, BEVEL GEARS MECH SEALS, ROLLER BRNG SUPT, BRONZE LIFT NUT, GREASE ZERK, OPEN DIRECTION ARROW
31	STOP NUTS	BRONZE
32	STEM COVER	CLEAR BUTYRATE PLASTIC WITH MYLAR STRIP INDICATOR CALIBRATED IN 1/10" & 1" INCREMENTS WITH PVC END CAP
40	STR PED	MILD STEEL
*55	PED. ANCHOR BLT	5/8" X 10" S-STL ANCHOR ROD, W/2 NUTS & 2 F/W
70	GUIDE RAIL	3" X 3" X 1/4" S-STL ANGLE
72	STEM COULPER	S-STL W/HARDWARE
73	VERT. STIFF.	1/4" X 4.0" S-STL FLAT BAR
74	SPIGOT RAIL	5.0" X 4.0" X 3.5" X 1/4" FORMED S-STL CHANNEL
75	GUIDE BEARING BAR	UHMW PE (UHMW-01)
76	TOP SPIGOT	4.13" X 4.0" X 1/4" FORMED S-STL ANGLE
84	OP. MTD BLT	5/8" X 2.0" S-STL HEX HEAD BOLT, L/W & F/W
91	SG MOUNTING BLT	3/8" X 1 3/4" S-STL HEX BOLT, NUT, L/W,
*92	SG ANCHOR BLT	1/2" X 5 1/2" S-STL ANCHOR ROD, W/NUT & F/W
*102	ANCHOR BLT	1/2" X 8.0" S-STL ANCHOR ROD, W/2 NUTS
183	CLAMP BLT	1/2" X 2" S-STL HEX BOLT, W/NUT & L/W
190	CENT. STIFF.	1/4" X 3.0" S-STL FLAT BAR
195	STEM POCKET	3/8" X 3.0" S-STL FLAT BAR

* ANCHOR BOLTS ARE DESIGNED FOR USE WITH HILTI HY 150 ADHESIVE INJECTION SYSTEM OR EQUAL (ADHESIVE BY CONTRACTOR)

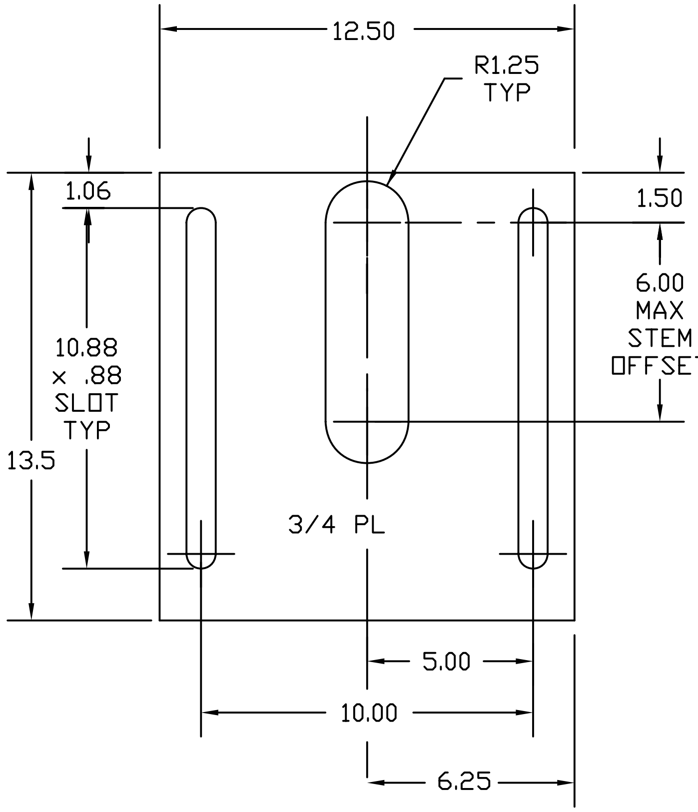
MATERIAL SPECIFICATIONS:
MILD STEEL = ASTM-A36 W/8.0 MILS EPOXY COATING
MILD STEEL PIPE = A-120 W/8.0 MILS EPOXY COATING
HARDWARE & FASTENERS = TYPE 316 SS ASTM-F593 / F594
S-STL FORMED & PLATE = 316L SS ASTM-A240
S-STL HR & FLAT BAR SHAPES = TYPE 316L SS ASTM-A276
S-STL STEM = TYPE 316 SS ASTM-A276
S-STL ANCHOR ROD = TYPE 316 SS ASTM-A276
S-STL PIPE = TYPE 316 ASTM A-312
ALUMINUM SHAPES = 6061-T6
UHMWPE = ASTM-D4020
NEOPRENE RUBBER = ASTM-D2000
BRONZE = ASTM-B584



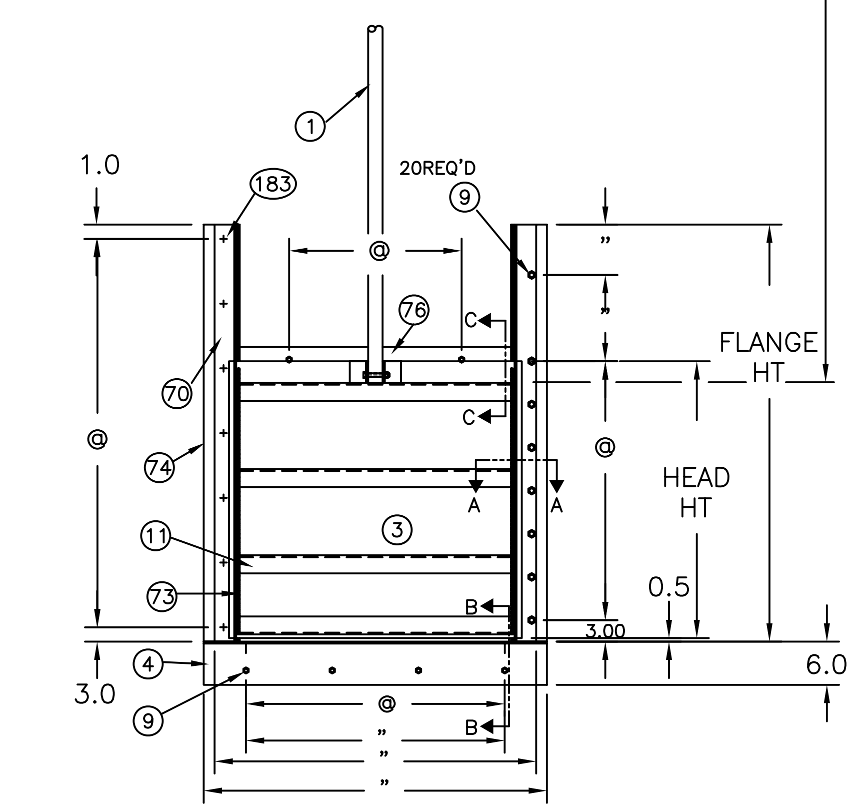
CRANK &
STRAIGHT PED. BASE
ANCHOR BOLT LAYOUT

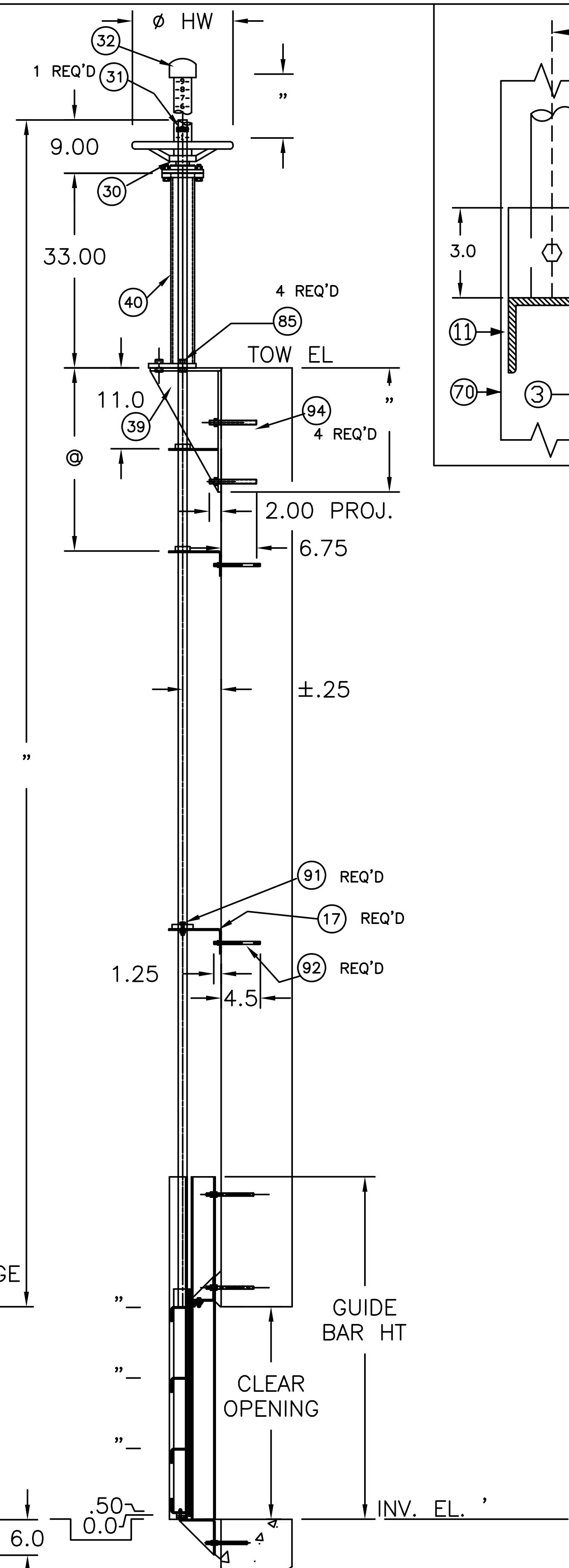
Max Seating Head = 20.0 Ft. - Max Unseating Head = 5.0 Ft.
Max Operating Head = 15.0 Ft. Measured From Gate Invert

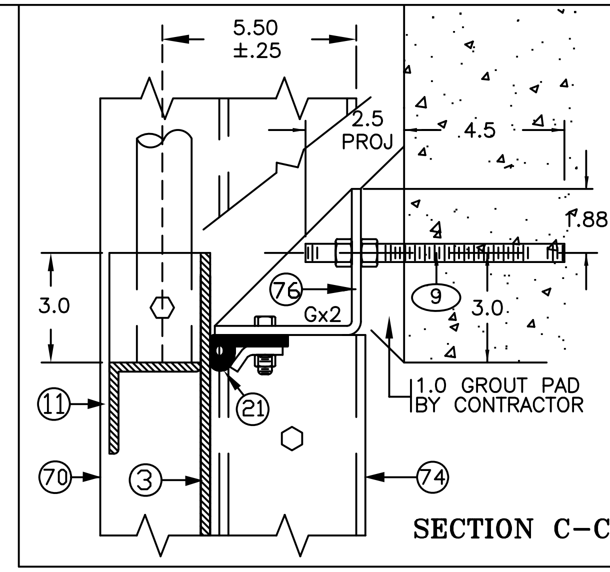
" x " MD GH-46-MED FLANGE MTD S-STL SLIDE GATE	GOLDEN HARVEST GOLDEN GATES 1-800-338-6238 P.O. BOX 287 Burlington, WA 98233	- REQ.	
Project Description:		Date Drawn:	
For:		Revision:	
Contractor:		Revision:	
		Revision:	
Engineer:		G.H. Drawing #:	
Drawn By: DW	X X	FL = # X	Scale: NTS
Job No.:		Contract Sht #:	



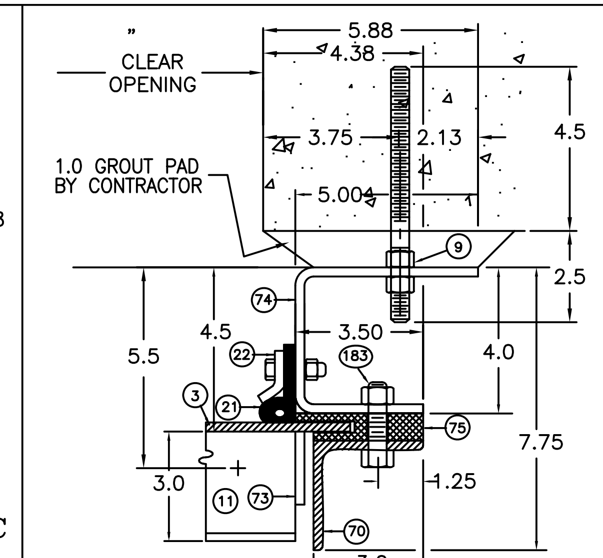
B4-14 WB TO PEDESTAL MOUNTING LAYOUT



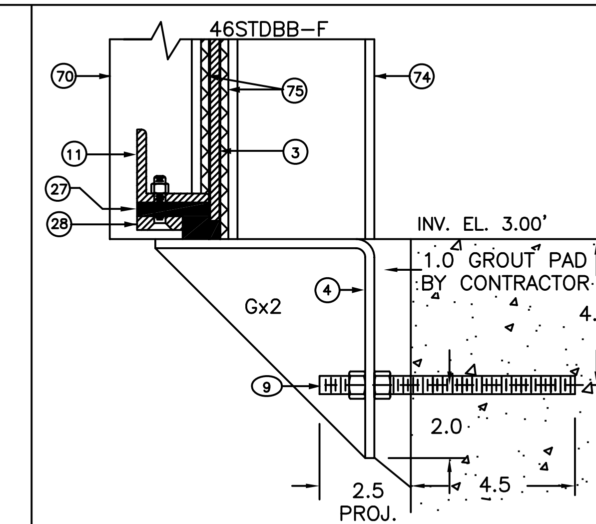




SECTION C-C



SECTION A-A



SECTION 'B'-'B'

MD GH-46 STAINLESS STEEL SLIDE GATE MATERIAL LIST

1	STEM	1.25 DIA S-STL, 4TPI W/LH DOUBLE ACME ROLLED THREADS 16 MICRO IN. RMS OR LESS FINISH
3	GATE HEAD	1/4" S-STL PLATE
4	INV. MEMBER	6.0x6.0x1/4" FORMED SSTL ANGLE
*9	ANCHOR BLT	1/2x7.0 SSTL ANCHOR ROD, W/2 NUTS
11	STIFFENER	3.0x3.0x1/4 FORMED SS ANGLE
17	STEM GUIDE TYPE 1-8	SS W/UHMW STEM GUIDE BUSHING
21	P-BULB SEAL	NEOPRENE RUBBER
22	RETAINER	3/16x2.0 SSTL FLAT BAR, W/SLOTTED HOLES
27	INVERT SEAL	NEOPRENE RUBBER, PART# 7509
28	INV. SEAL RTNR	3/8" X 1 1/4" S-STL FLAT BAR
30	OPERATOR	MD MG-A11 1.5:1 GEAR REDUCTION, CAST STL HOUSING, BVL GEARS, ROLLER BEARING SUPPORTED BRONZE LIFT NUT, GREASE ZERK, GREASE ZERK, OPEN DIRECTION ARROW, HANDWHEEL / QH-1 NON GEARED, ANODIZED ALUM HSG., MECH SEALS, ROLLER BRNG SUPPORTED BRONZE LIFT NUT, OPEN DIRECTION INDICATOR, MECHANICAL SEALS, HANKCRANK
31	STOP NUT	BRONZE
32	STEM COVER	CLEAR BUTYRATE PLASTIC WITH MYLAR STRIP INDICATOR CALIBRATED IN 1/10" INCREMENTS WITH PVC END CAP
39	WALL BRACKET B4-14	STEEL
40	WB PEDESTAL	MILD STEEL
70	GUIDE RAIL	3.0x3.0x1/4 HR SSTL ANGLE
73	VERT. STIFF.	1/4x2.5 SSTL FLAT BAR
74	VERT. SPIGOT RAIL	5.0x4.0x3.5x1/4 FORMED SSTL CHANNEL
75	GUIDE BEARING BAR	UHMW POLYETHYLENE EXT# UHMW-01
76	HORIZONTAL SPIGOT	4.13x4.0x1/4 FORMED SSTL ANGLE
85	PED. MOUNTING BOLT	5/8x2.5 SS HEX HEAD BOLT W/NUT, FW AND LW
91	SG MOUNTING BOLT	3/8x1.75 SS HEX HEAD BLOT W/NUT, LW, (2)3/8" FW & (1)1/2" FW
*92	SG ANCHOR BOLT	1/2x5.5 SS ANCHOR ROD W/NUT & FW
*94	WB ANCHOR BOLT	3/4x8.75 SS ANCHOR ROD W/NUT & FW
183	CLAMP BLT	1/2x2.0 SSTL HEX BOLT, W/NUT & F/W

* ANCHOR BOLTS ARE DESIGNED FOR USE WITH EPCON A-7
ADHESIVE INJECTION SYSTEM OR EQUAL (ADHESIVE BY CONTRACTOR)

MATERIAL SPECIFICATIONS:
HARDWARE & FASTENERS = TYPE 316 SS ASTM-F593 / F594
S-STL FORMED & PLATE = 316L SS ASTM-A240
S-STL HR & FLAT BAR SHAPES = TYPE 316L SS ASTM-A276
S-STL STEM = TYPE 316 SS ASTM-A276
S-STL ANCHOR ROD = TYPE 316 SS ASTM-A276
UHMWPE = ASTM-D1248
NEOPRENE RUBBER = ASTM-D2000
BRONZE = ASTM-B584

GOLDEN HARVEST	
ORIGINAL	RLD
CHECKED	MM
CHECKED	KB

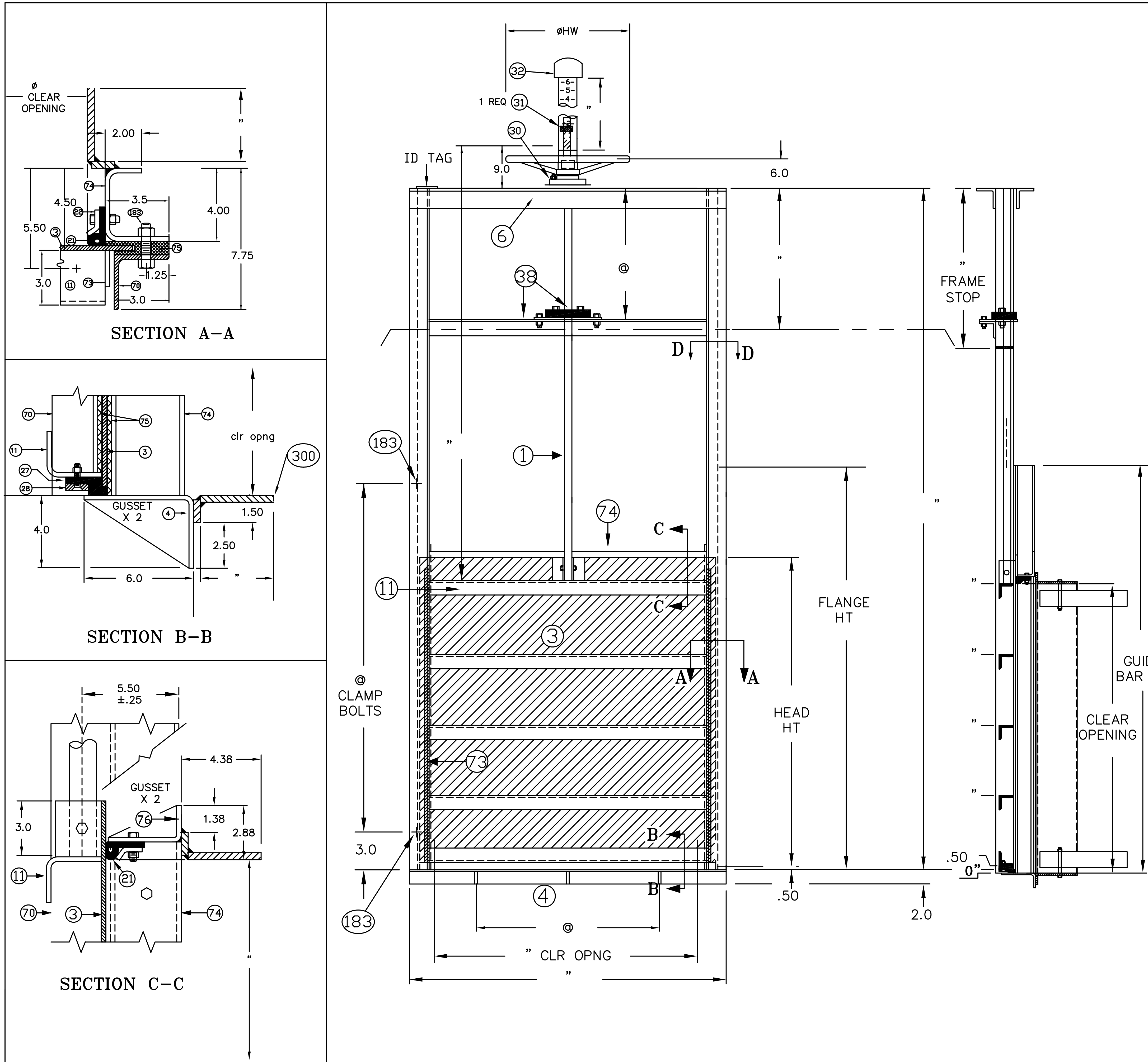
Max Seating Head = Ft. Max Unseating Head = Ft.
Max Operating Head = Ft. Measured From GATE INVERT

X
MD GH-46
WALL MNT
SS SLIDE GATE

GOLDEN HARVEST
GOLDEN GATES
1-800-338-6238
P.O. BOX 287 Burlington, WA 98233

– REQ'D

Project Description:	Date Drawn:
For:	Revision:
Contractor:	Revision:
Engineer:	Revision:
	G.H. Drawing #:
Drawn By:	FL = 59# PO = 1.7
Scale: NTS	Job No.:
Contract Sht #:	



MD GH-46 STAINLESS STEEL SLIDE GATE MATERIAL LIST

1	STEM	DIA SSTL, TPI/LH ROLLED ACME THD, 16 MICRO IN. RMS OR LESS FINISH
3	GATE HEAD	SSTL PLATE
4	INV. MEMBER	FORMED SSTL ANGLE
6	YOKE	FORMED SSTL ANGLE
11	STIFFENER	FORMED SSTL ANGLE
21	P-BULB SEAL	NEOPRENE RUBBER GHI# 7274
22	RETAINER	SSTL FLAT BAR, W/SLOTTED HOLES
27	INVERT SEAL	NEOPRENE RUBBER, PART# 7509
28	INV. SEAL RTNR	SSTL FLAT BAR
30	OPERATOR	GH-1, NON GEARED, ANODIZED ALUM HSG.,MECH SEALS, ROLLER BRNG SUPPORTED BRONZE LIFT NUT, GREASE ZERK, OPEN DIRECTION ARROW, 24"HANDWHEEL
31	STOP NUT	BRONZE
32	STEM COVER	CLEAR BUTYRATE PLASTIC WITH MYLAR STRIP INDICATOR CALIBRATED IN 1/10" INCREMENTS WITH PVC END CAP
38	STEM GUIDE	SSTL HR ANGLE, W/UHMW STEM GUIDE BUSHING
70	GUIDE RAIL	HR SSTL ANGLE
73	VERT. STIFF.	SSTL FLAT BAR
74	VERT. SPIGOT RAIL	FORMED SSTL CHANNEL
75	GUIDE BEARING BAR	UHMW POLYETHYLENE EXT# UHMW-01
76	HORIZONTAL SPIGOT	FORMED SSTL ANGLE
183	CLAMP BLT	SSTL HEX BOLT, W/NUT & F/W
300	125# ADAPTER	SSTL GHI DWG# 4
305	ANCHOR TAB	FORMED SSTL ANGLE GHI DWG# 01Shop

MATERIAL SPECIFICATIONS:
HARDWARE & FASTENERS = TYPE 304/316 SS ASTM-F593 / F594
SSTL FORMED & PLATE = 304/304L/316L ASTM-A240
SSTL HR & FLAT BAR SHAPES = TYPE 304/304L/316 SS ASTM-A276
SSTL STEM = TYPE 304/316 SS ASTM-A276
SSTL ANCHOR ROD = TYPE 304/316 ASTM-A276
UHMWPE = ASTM-D1248
NEOPRENE RUBBER = ASTM-D2000
BRONZE = ASTM-B584

GOLDEN HARVEST	
ORIGINAL	PH
CHECKED	KB
CHECKED	DW

Max Seating Head = Ft. - Max Unseating Head = Ft.
Max Operating Head = 9.0 Ft. Measured From Gate Invert

X
MD GH-46
SPIGOT MTD OVER PIPE
SSTL SLIDE GATE

GOLDEN HARVEST
GOLDEN GATES
1-800-338-6238
P.O. BOX 287 Burlington, WA 98233

–
–
– REQ.

Project Description:	Date Drawn:
For:	Revision:
Contractor:	Revision:
Engineer:	Revision:
	G.H. Drawing #: #

Drawn By:	FL =	Scale:	Job No.:	Contract Sht #:
DW	X	NTS	pq04-0525	

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Thursday, October 24, 2019

To:	Hubbell Roth & Clark Dennis Benoit 801 Broadway NW Suite 215 Grand Rapids, MI 49504 United States	RFQ #:	Verbal
		Quote #:	0719880534HB Please refer to this number when ordering
Phone:	616-454-4286	Quoted by:	Heather Walker
Fax:	616-454-4278		Heather.walker@hesco-mi.com
E-mail:	dbenoit@hrc-engr.com		

PRICE QUOTE
HRC 24" Knife Gate

Item	Description	Qty	Unit Price	Subtotal
1.00	**OPTION #1 STAINLESS STEEL BODY** 24" ITT C37R Bonnetless Knife gate with handwheel 304 Body & gate, integral seat	1	$12,450.00	$12,450.00
2.00	**OPTION #2 DUCTILE IRON BODY** 24" ITT C45D Cast Bonnetless Knife Gate with handwheel Ductile iron body, 304SS Gate, integral seat	1	$8,777.00	$8,777.00

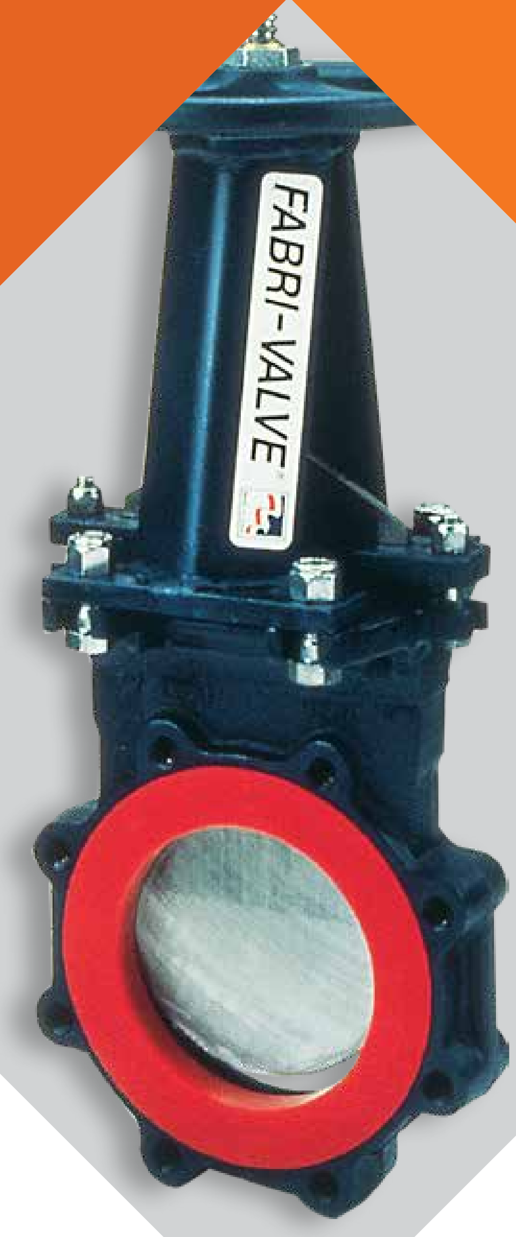
Subtotal	$21,227.00
Taxable Subtotal	$0.00
Sales Tax [0.0000%]	$0.00
Misc. Charge	$0.00
Shipping & Handling Best Way	$0.00
Grand Total	**$21,227.00**

Terms & Conditions			
Proposed Shipping Date	TBD at time of order	**Payment Terms**	Net 30
Shipping Method	Best Way	**Shipping Terms**	Prepaid and Added to Invoice
F.O.B.	Factory	This Quotation is valid until 11/23/2019.	

Thank you for your inquiry!

Engineered Valves

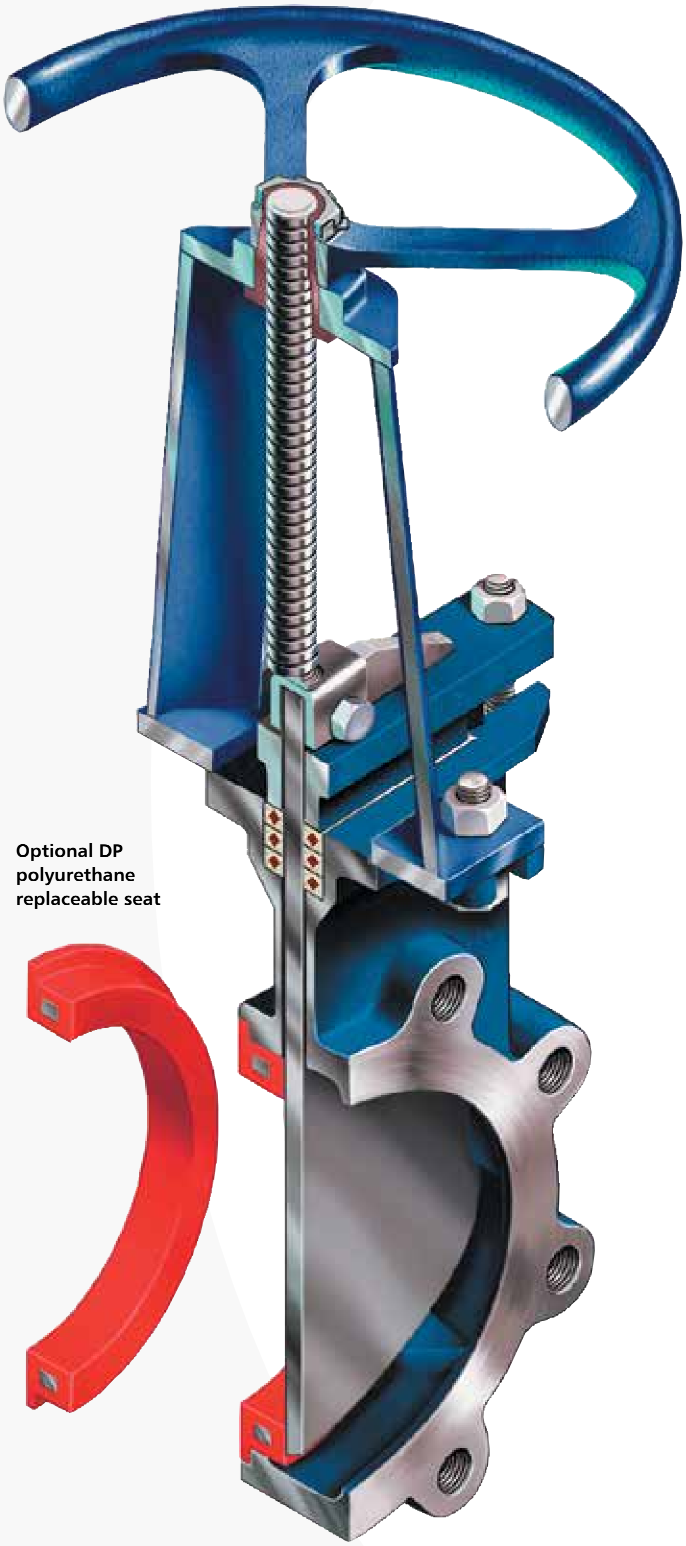
Fabri-Valve C45 Ductile Iron Knife Gate Valve



ITT

ENGINEERED FOR LIFE

C45 Ductile Iron Knife Gate Valve



Optional DP polyurethane replaceable seat

Replaceable seat is held in place by the adjacent mating flange.

Shown with energized cored packing.

Standard with 6"(DN 150) and larger Figure C45 valves.

The basic Fabri-Valve C45 features a solid ductile iron or carbon steel body with an integral cast metal seat. However, this valve is most often used with the patented, pop-in style replaceable seats, which are available in a variety of rubbers, polyurethane, UHMW-P, TFE, and hard-faced metal. The pop-in seats feature a much larger cross section and seating area than conventional knife gate valve seats thus providing a seating surface far removed from the flow stream. Replaceable seats offer a unique advantage; abrasion resistance, long seat life, and the convenience of easy seat replacement.

All C45 knife gate valves with handwheels include a provision for a locking device.
Caution: (Replaceable soft seats)
Review Fabri-Valve gasket/mating flange recommendations.

Specifications

Size Range
2" – 24"
Pressure Rating
150 psi (10.3 bar) CWP (cold working pressure)
Temperature Rating
Maximum temperature 250°F (121°C).
See Materials of Construction (seat section).
Service temperatures above 400°F (204°C) require high temperature fasteners. Specify service imperature on paperwork.
Flange Drilling
Flat faced ANSI 125/150

Testing

Every Fabri-Valve C45 valve is fully tested prior to shipment. Testing includes a body shell test, a seat test, and a cycling test to insure proper functioning of moving parts. Additional testing is also available. Please let us know your requirements.
Standard Shell test:
- Hydro test at 1.5 times the rated CWP (cold working pressure) – Zero allowable leakage

Standard Seat test:
- Metal Seat: Hydro test at 40 psi (2.8 bar) and at the rated CWP
- Resilient Seat: Hydro test at 15 psi (1 bar) and rated CWP

Pressure/Temperature Ratings

The table below is the Maximum Pressure /Temperature Ratings for the metallic components only. When checking pressure/ temperature ratings, check the temperature rating and chemical compatibility of the packing material and, if applicable, the resilient seat material. In a majority of knife gate valve designs, the temperature limit or the chemical compatibility of the seat and/or packing material determines the practical pressure/ temperature limitations.

Figure C45			
Pressure/Temperature Rating - psi			
Temp		Cast Steel WCB A-216	Cast DI A536 GR 65-45-12
°F	°C		
150	66	150	150
200	93	150	150
250	121	150	147
300	149	150	143
350	177	150	139
400	204	150	135
450	232	150	131
500	260	150	127
600	316	150	119
700	371	142	
800	427	103	
900	482	57	
1000	538	21	

Low Pressure Operation

Metal seated knife gate valves are seat tested at 40 psid (2.8 bar) in the preferred flow direction. When pressure falls below the 40 psid (2.8 bar) test pressure, less force is pushing the gate into the seat, which may result in additional seat leakage. When improved low-pressure shutoff performance is required, optional chest buttons should be specified.

Available Options

- "D" Ring Seat
- Lever Operator
- Dual Seats
- Poly Replaceable Seats
- UHMW Replaceable Seats
- PTFE Replaceable Seats
- Rubber Replaceable Seats
- Hard Faced Gate Edge
- Hard Gate Material
- Nickel-TFE Coated Gate
- Epoxy Coating
- Thru Drilled Flanges
- Flush Ports
- Chest Buttons:
  Not available 2" – 6"
- Cast Ni-Hard Deflection Cones: Available sizes 3" – 16"
- Fabricated Deflection Cones
- Locking Devices
- E-Z Spin Handwheel
- Live Loaded Packing
- Self-Supporting Yokes
- Bevel Gear
- Chainwheels
- Cylinder Actuators
- Electric Actuators
- Ratchet
- Extended Stems
- Rod Boots

Shutoff Performance

Metal Seat

- Single integral metal seat
  2" – 24" 40cc / minute / inch of valve size
- Single hardfaced replaceable metal seat
  2" – 24" 80cc / minute / inch of valve size
- Dual hardfaced replaceable metal seats
  Consult factory. All sizes.

Resilient Seat

- Single "D"ring, or single replaceable resilient seat (excluding PTFE)
  Zero leakage. All sizes.
- Dual seats
  Consult factory. All sizes.
- Single replaceable PTFE seat
  Consult factory. All sizes.

Flow Coefficients

The Cv values below represent U.S. gallons per minute 60°F water through a 100% open valve at a pressure drop of 1 psi. The metric equivalent, Kv, is the flow of water at 16°C through the valve in cubic meters per hour at a pressure drop of 1 kg/cm^2. To convert Cv to Kv, multiply the Cv by 0.8569.

Figure C45 Knife Gate Valves							
C_V Ratings, Port Diameter and Area							
		Standard Port			With Replaceable Poly or Replaceable Rubber seat		
Valve Size		C_v	Port I.D. Inches	Port Area Sq. In.	C_v	Port I.D. Inches	Port Area Sq. In.
In.	DN						
2	50	288	2.00	3.1	288	2.00	3.1
3	75	648	3.00	7.1	648	3.00	7.1
4	100	1,152	4.00	12.6	1,152	4.00	12.6
6	150	2,592	6.00	28.3	2,592	6.00	28.3
8	200	4,608	8.00	50.3	4,608	8.00	50.3
10	250	7,208	10.00	78.5	7,208	10.00	78.5
12	300	10,400	12.00	113.1	10,400	12.00	113.1
14	350	12,650	13.25	137.9	10,080	12.00	113.1
16	400	16,750	15.25	182.6	14,200	14.25	159.5
18	450	21,450	17.25	233.7	18,500	16.25	207.4
20	500	26,700	19.25	291.0	22,700	18.00	254.5
24	600	38,900	23.25	424.6	33,900	22.00	380.1

Dimensions: C45 with Handwheel or Cylinder

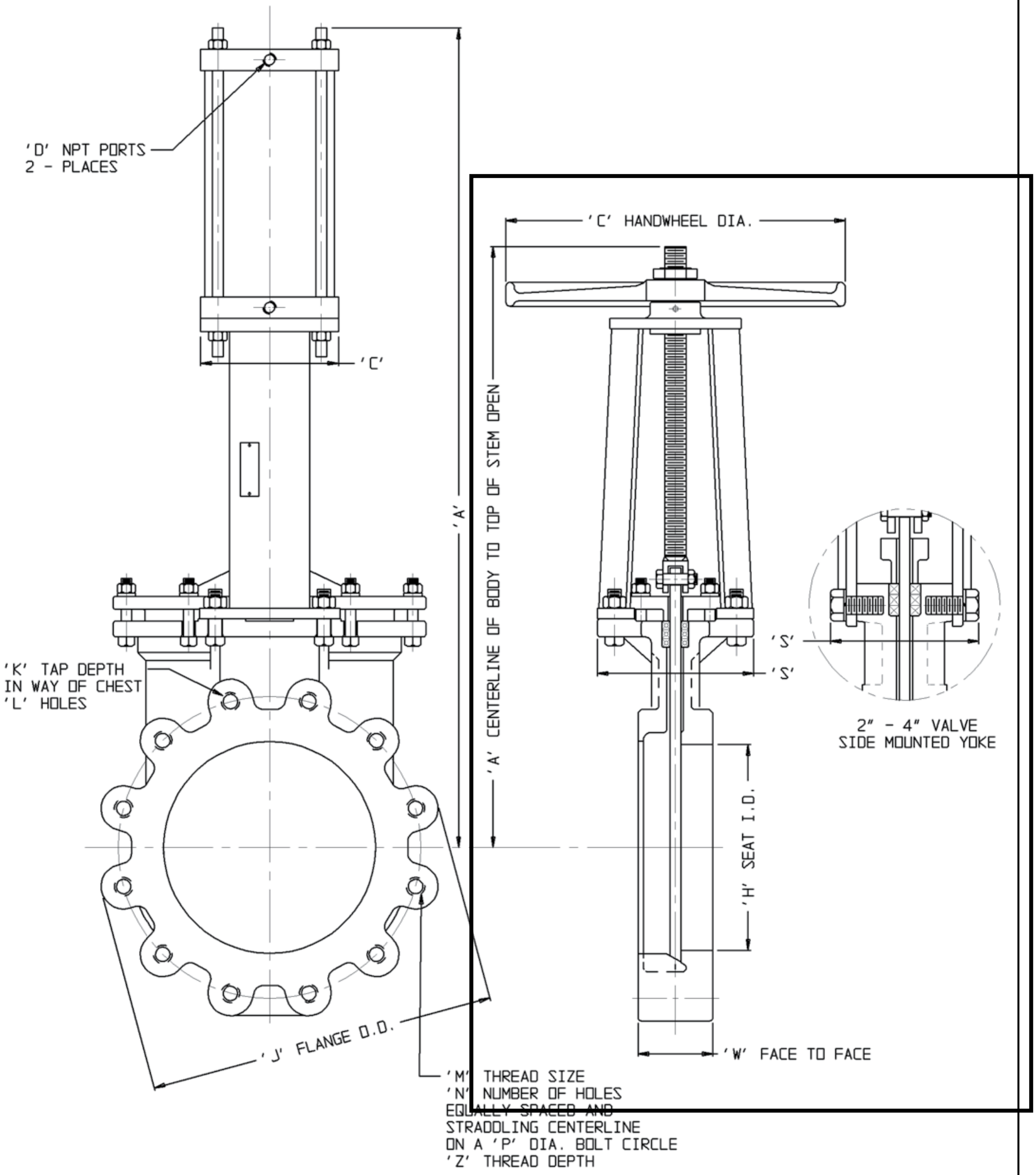
Valve Size		TABLE 1								DIMENSION Inches (mm) C45 with HANDWHEEL OR CYLINDER											
Inches	DN	A			C			D		H	J	K	L	M	N	P	S	W	Z	lb	kg
2	50	HW	2-1/2 CYL	3-1/4 CYL	HW	2-1/2 CYL	3-1/4 CYL	2-1/2 CYL	3-1/4 CYL												
		13-11/16 (348)	18-3/8 (467)	16-7/8 (429)	8 (203)	3 (76)	4 (102)	3/8-18	1/4-18	2 (51)	6 (152)	1/2 (12)	2	5/8-11NC	4	4-3/4 (121)	4 (102)	1-7/8 (48)	9/16 (14)	21	10
3	80	HW	2-1/2 CYL	3-1/4 CYL	HW	2-1/2 CYL	3-1/4 CYL	2-1/2 CYL	3-1/4 CYL												
		16-7/16 (418)	20-7/8 (530)	19-3/8 (492)	8 (203)	3 (76)	4 (102)	3/8-18	1/4-18	3 (76)	7-1/2 (191)	1/2 (12)	2	5/8-11NC	4	6 (152)	4 (102)	2 (51)	5/8 (16)	26	12
4	100	HW	3-1/4 CYL	4 CYL	HW	3-1/4 CYL	4 CYL	3-1/4 CYL	4 CYL												
		19-3/16 (487)	22-1/8 (562)	22-7/8 (581)	8 (203)	4 (76)	4-1/2 (114)	1/4-18	3/8-18	4 (102)	9 (229)	1/2 (12)	2	5/8-11NC	8	7-1/2 (191)	4 (102)	2 (51)	5/8 (16)	31	14
6	150	HW	4 CYL	6 CYL	HW	4 CYL	6 CYL	4 CYL	6 CYL												
		25-5/16 (643)	28-7/8 (733)	29-1/4 (743)	10 (254)	4-1/2 (114)	6-1/2 (165)	3/8-18	3/8-18	6 (152)	11 (279)	9/16 (14)	2	3/4-10NC	8	9-1/2 (241)	7-3/8 (187)	2-1/4 (57)	3/4 (19)	52	24
8	200	HW	6 CYL	8 CYL	HW	6 CYL	8 CYL	6 CYL	8 CYL												
		32-5/8 (829)	35-13/16 (910)	36-5/16 (922)	12 (305)	6-1/2 (165)	8-5/8 (219)	3/8-18	3/8-18	8 (203)	13-1/2 (343)	5/8 (16)	2	3/4-10NC	8	11-3/4 (298)	7-3/8 (187)	2-3/4 (70)	1 (25)	105	48
10	250	HW	8 CYL	10 CYL	HW	8 CYL	10 CYL	8 CYL	10 CYL												
		37-3/4 (959)	41-7/16 (1053)	42-3/16 (1072)	16 (406)	8-5/8 (219)	10-7/8 (276)	3/8-18	1/2-14	10 (254)	16 (406)	5/8 (16)	4	7/8-9NC	12	14-1/4 (362)	7-3/8 187)	2-3/4 (70)	1 (25)	145	66
12	300	HW	8 CYL	10 CYL	HW	8 CYL	10 CYL	8 CYL	10 CYL												
		44-9/16 (1132)	48 (1219)	48-3/4 (1238)	16 (406)	8-5/8 (219)	10-7/8 (276)	3/8-18	1/2-14	12 (305)	19 (483)	5/8 (16)	4	7/8-9NC	12	17 (432)	7-1/2 (191)	3 (76)	1 (25)	205	93
14	350	HW	12 CYL	14 CYL	HW	12 CYL	14 CYL	12 CYL	14 CYL												
		49-1/4 (1251)	54-1/16 (1373)	55-3/16 (1402)	20 (508)	12-3/4 (324)	14-3/4 (375)	1/2-14	3/4-14	13-1/4 (337)	21 (533)	21/32 (17)	4	1-8NC	12	18-3/4 (476)	7-3/4 (197)	3 (76)	1 (25)	235	107
16	400	HW	12 CYL	14 CYL	HW	12 CYL	14 CYL	12 CYL	14 CYL												
		56-1/2 (1435)	61-1/16 (1551)	62-3/16 (1580)	20 (508)	12-3/4 (324)	14-3/4 (375)	1/2-14	3/4-14	15-1/4 (387)	23-1/2 (597)	25/32 (20)	6	1-8NC	16	21-1/4 (540)	11-1/4 (286)	3-1/2 (89)	1-1/4 (32)	390	145
18	450	HW	12 CYL	14 CYL	HW	12 CYL	14 CYL	12 CYL	14 CYL												
		63-5/16 (1608)	66-1/2 (1689)	67-5/8 (1718)	20 (508)	12-3/4 (324)	14-3/4 (375)	1/2-14	3/4-14	17-1/4 (438)	25 (635)	3/4 (19)	6	1-1/8-7NC	16	22-3/4 (578)	11-1/4 (286)	3-1/2 (89)	1-3/8 (35)	515	177
20	500	HW	14 CYL	16 CYL	HW	14 CYL	16 CYL	14 CYL	16 CYL												
		68-5/8 (1743)	72-15/16 (1853)	73-7/16 (1865)	20 (508)	14-3/4 (375)	17 (432)	3/4-14	3/4-14	19-1/4 (489)	27-1/2 (699)	1-1/8 (29)	8	1-1/8-7NC	20	25 (635)	14 (356)	4-1/2 (114)	1-1/2 (38)	690	234
24	600	HW	16 CYL	18 CYL	HW	16 CYL	18 CYL	16 CYL	18 CYL												
		79-13/16 (2027)	84-11/16 (2151)	86-5/8 (2200)	20 (508)	17 (432)	19 (483)	3/4-14	3/4-14	23-1/4 (591)	32 (813)	1-1/16 (27)	8	1-1/4-7NC	20	29-1/2 (749)	14-1/8 (359)	4-1/2 (114)	1-1/2 (38)	923	313

* Valve and Handwheel

Reference Dimensions in (paretheses)

C45 with Handwheel or Cylinder

Refer to table on page 4 for dimensions



Materials of Construction

Part	Materials
Body and Chest	Ductile iron
Flanges	Ductile iron
Seat Rating	Integral metal, D-ring, or replaceable With integral seat 500°F (260°C) With RW seat 140°F (60°C) With RP seat 180°F (82°C) With RH seat 550°F (288°C) standard, 650°F (343°C) with special packing. With RT seat 400°F (204°C)
Gate	304 stainless steel finished to 63 RMS
Yoke	Carbon steel
Yoke Bolting	Plated steel
Packing	Acrylic/PTFE/silicone [1]
Packing Follower	Ductile iron w/plated steel bolting
Stem	304 stainless steel
Stem Nut	Acid resistant bronze
Lubrication Fitting	Plated steel
Handwheel	Cast iron
Handwheel Retaining Nut	Malleable iron
Tab Washer	Stainless steel

[1] Energized cored packing is standard with 6" (DN150) and larger C45 valves

Dimensions: C45 with Bevel Gear

Valve Size		TABLE 2					DIMENSION Inches (mm) C45 with BEVEL GEAR									
Inches	DN	A	B	C	D	E	H	J	K	L	M	N	P	S	W	Z
6	150	25-5/16 (643)	19-11/16 (500)	12 (305)	12-3/8 (314)	6-1/2 (165)	6 (152)	11 (279)	9/16 (14)	2	3/4-10NC	8	9-1/2 (241)	7-3/8 (187)	2-1/4 (57)	3/4 (19)
8	200	32-15/16 (837)	24-5/8 (625)	12 (305)	12-3/8 (314)	6-1/2 (165)	8 (203)	13-1/2 (343)	5/8 (16)	2	3/4-10NC	8	11-3/4 (298)	7-3/8 (187)	2-3/4 (70)	1 (25)
10	250	38-1/16 (967)	27-5/16 (694)	12 (305)	12-3/8 (314)	6-1/2 (165)	10 (254)	16 (406)	5/8 (16)	4	7/8-9NC	12	14-1/4 (362)	7-3/8 (187)	2-3/4 (70)	1 (25)
12	300	44-9/16 (1132)	31-13/16 (808)	12 (305)	12-3/8 (314)	6-1/2 (165)	12 (305)	19 (483)	5/8 (16)	4	7/8-9NC	12	17 (432)	7-1/2 (191)	3 (76)	1 (25)
14	350	49-13/16 (1265)	34-3/4 (883)	12 (305)	12-3/8 (314)	6-1/2 (165)	13-1/4 (337)	21 (533)	21/32 (17)	4	1-8NC	12	18-3/4 (476)	7-3/4 (197)	3 (76)	1 (25)
16	400	56-9/16 (1437)	40-3/8 (1026)	12 (305)	12-1/16 (306)	6-1/2 (165)	15-1/4 (387)	23-1/2 (597)	25/32 (20)	6	1-8NC	16	21-1/4 (540)	11-1/4 (286)	3-1/2 (89)	1-1/4 (32)
18	450	63-5/16 (1608)	43-13/16 (1113)	12 (305)	12-1/16 (306)	6-1/2 (165)	17-1/4 (438)	25 (635)	3/4 (19)	6	1-1/8-7NC	16	22-3/4 (578)	11-1/4 (286)	3-1/2 (89)	1-3/8 (35)
20	500	68-5/8 (1543)	47-15/16 (1218)	12 (305)	12-1/16 (306)	6-1/2 (165)	19-1/4 (489)	27-1/2 (699)	1-1/8 (29)	8	1-1/8-7NC	20	25 (635)	14 (356)	4-1/2 (114)	1-1/2 (38)
24	600	79-7/8 (2029)	55-3/16 (1402)	12 (305)	12-1/16 (306)	6-1/2 (165)	23-1/4 (591)	32 (813)	1-1/16 (27)	8	1-1/4-7NC	20	29-1/2 (749)	14-1/8 (359)	4-1/2 (114)	1-1/2 (81)

Reference dimensions in (parentheses)
6" - 14" valves have a bevel gear ratio of 3:1
16" - 24" valves have a bevel gear ratio of 4:1

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EnviZion, Pure-Flo

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Fabri-Valve®

CF37 Heavy Duty Knife Gate Valve

ITT

ENGINEERED FOR LIFE

CF37 Heavy Duty Knife Gate Valve

Figure C37 with energized cored packing.

Energized cored packing is standard with 6” (DN 150) and larger C37 valves and all F37 valves.

Fabri-Valve Figures C37 and F37 are some of the most popular knife gate valve configurations. Figure C37 knife gate valves through 24”, feature a heavy duty, rugged one-piece cast body, chest and flanges (except 5”, which is fabricated – F37). Sizes larger than 24” are fabricated from heavy plate. The Figure C/F37 is available in all stainless steel (designated “S”) or with alloy steel wetted parts and carbon steel external parts (designated “R”). In sizes 1.5” through 24”, the “S” and the “R” share the same solid cast body. Sizes larger than 24” feature fabricated bodies configured to the service conditions. The Figure C/F37 is available with the widest range of seats in the industry including: integral metal, replaceable hardfaced metal, rubber “D” ring, replaceable rubber, polyurethane, UHMW-P, and PTFE. Standard body materials include 304, 316, and 317L stainless steel. Special alloys such as 254 SMO® are also available. Special flange drillings are also available.

All Figure C/F37 knife gate valves with handwheels include a provision for a locking device. Consult factory for details.

Specifications

Size Range

1.5” – 96”

Pressure Rating

1.5” – 24”:	150 psi (10.3 bar) CWP (cold working pressure)
25” – 48”:	Designs available in 50 psi (3.5 bar), 100 psi (6.9 bar) or 150 psi (10.3 bar) CWP
Larger than 48”:	Manufactured to customer specification

Temperature Rating

1.5” – 48” 450°F (232°C).

Service temperatures above 400°F (204°C) require high temperature fasteners. Specify service temperature on paperwork. Consult factory for sizes larger than 48”(DN 1200) and for service temperatures up to 1500°F (816°C).

Flange Drilling

ANSI 125/150

Testing

Every Fabri-Valve Figure C/F37 valve is fully tested prior to shipment. Testing includes a body shell test, a seat test and a cycling test to insure proper functioning of moving parts. Additional testing is also available. Please let us know your requirements.

Standard Shell test:

- Hydro test at 1.5 times the rated CWP (cold working pressure) – Zero allowable leakage

Standard Seat test:

- Metal Seat: Hydro test at 40 psi (2.8 bar) and at the rated CWP
- Resilient Seat: Hydro test at 15 psi (1 bar) and rated CWP

Pressure/Temperature Ratings

The tables below are the Maximum Pressure/Temperature Ratings for the metallic components only. When checking pressure/temperature ratings, check the temperature rating and chemical compatibility of the packing material and, if applicable, the resilient seat material. In a majority of knife gate valve designs, the temperature limit or the chemical compatibility of the seat and/or packing material determines the practical pressure/temperature limitations.

Figure C37

Pressure/Temperature Rating - psi

Temp °F	Temp °C	Cast 304	Cast 304L	Cast 316	Cast 316L	Cast 317L	Cast WCB A-216	Cast DI
150	66	150	150	150	150	150	150	150
200	93	142	142	150	150	135	150	150
250	121	135	135	142	142	128	150	147
300	149	129	129	134	134	121	150	143
350	177	123	123	128	128	116	150	139
400	204	118	118	123	123	112	150	135
450	232	114	114	118	118	108	150	131
500	260	111	111	114	114	105	150	127
600	316	104	104	108	108	100	150	119
700	371	101	101	104	104	96	142	
800	427	96	96	100	100	92	103	
900	482	93		99			57	
1000	538	89		97			21	
1100	593	64		76				
1200	649	41		46				
1300	704	28		29				
1400	760	20		20				
1500	816	15		14				

Figure F37

Pressure/Temperature Rating - psi

Temp °F	Temp °C	304	304L	316	316L	317L	A 36	A516Gr70
150	66	150	133	150	133	150	150	150
200	93	133	114	141	113	135	137	150
250	121	126	108	133	107	128	135	150
300	149	120	102	124	101	121	133	150
350	177	115	98	119	97	116	131	150
400	204	110	93	114	93	112	128	150
450	232	107	90	110	90	108	125	150
500	260	103	87	106	87	105	121	150
600	316	97	82	101	83	100	111	150
700	371	94	80	97	80	96	108	142
800*	427*	89	77	93	77	92		103
900*	482*	87		92				57
1000*	538*	83		90				21
1100*	593*	78		88				
1200*	649*	49		59				
1300*	704*	30		33				
1400*	760*	18		18				
1500*	816*	11		10				

* "R" Series valves have external, non-wetted, carbon steel components. Standard "R" Series valves are limited to 700°F (371°C); however alternate "R" Series constructions are available to 1000°F (538°C)

NOTE: Each valve is identified by Size-Figure-Series-etc. The "How To Order" section explains the Valve Model Codes.

Shutoff Performance

Metal Seat

- Single integral metal seat
  1.5" – 24" 40cc / minute / inch of valve size
  25" – 48" 60cc / minute / inch of valve size
  Above 48" Consult Factory
- Single hardfaced integral metal seat
  1.5" – 24" 80cc / minute / inch of valve size
  25" – 48" 120cc / minute / inch of valve size
  Above 48" Consult Factory
- Dual metal seats
  Consult factory. All sizes.
- Single hardfaced replaceable metal seat
  1.5" – 24" 80cc / minute / inch of valve size
  Above 24" Consult Factory

Resilient Seat

- Single "D" ring, or single replaceable resilient seat (excluding PTFE)
  Zero leakage. All sizes.
- Dual seats
  Consult Factory. All sizes.
- Single replaceable PTFE seat
  Consult Factory. All sizes.

Low Pressure Operation

Metal seated knife gate valves are seat tested at 40 psid (2.8 bar) in the preferred flow direction. When pressure falls below the 40 psid (2.8 bar) test pressure, less force is pushing the gate into the seat, which may result in additional seat leakage. When improved low-pressure shutoff performance is required, optional chest buttons and/or centerline buttons should be specified.

Available Options

- "D" Ring Seat
- Lever Operator
- Dual Seats
- Poly Replaceable Seats
- UHMW Replaceable Seats
- PTFE Replaceable Seats
- Rubber Replaceable Seats
- Hard Faced Replaceable Seats
- Elastomer Replaceable Seats
- Hard Faced Gate Edge
- Hard Gate Material
- Nickel-TFE Coated Gate
- Epoxy Coating
- Thru Drilled Flanges
- Flush Ports
- Chest Buttons: Not available 2"-6"
- Centerline Buttons
- Backing Ring
- Extra Wedges
- V-Port
- Cast Ni-Hard Deflection Cones Available 3"-16"
- Fabricated Deflection Cones
- Locking Devices
- Live Loaded Packing
- Self-Supporting Yokes
- Alternate Flange Drilling
- Bevel Gear
- Chainwheels
- Cylinder Actuators
- Electric Actuators
- Ratchet
- Extended Stems
- Gate Support Strips
- Rod Boots

Dimensions: C37 with Handwheel or Cylinder

Valve Size		TABLE 1						DIMENSION Inches (mm) Figure C37 with HANDWHEEL OR CYLINDER														Weight **	
Inches	DN	A			C			D		H*	J	K	L	M	N	P	R	S	T	V	W	lb	kg
		HW	2-1/2 CYL	3-1/4 CYL	HW	2-1/2 CYL	3-1/4 CYL	2-1/2 CYL	3-1/4 CYL														
2	50	13-11/16 (348)	18-3/8 (467)	16-7/8 (429)	8 (203)	3 (76)	4 (102)	3/8-18	1/4-18	2 (51)	6 (152)	3/8 (10)	2	5/8-11NC	4	4-3/4 (121)	3-5/8 (92)	4 (102)	1/16 (2)	9/16 (14)	1-7/8 (48)	17	8
		HW	2-1/2 CYL	3-1/4 CYL	HW	2-1/2 CYL	3-1/4 CYL	2-1/2 CYL	3-1/4 CYL														
3	80	16-7/16 (418)	20-7/8 (530)	19-3/8 (492)	8 (203)	3 (76)	4 (102)	3/8-18	1/4-18	3 (76)	7-1/2 (191)	13/32 (10)	2	5/8-11NC	4	6 (152)	5 (127)	4 (102)	1/16 (2)	9/16 (14)	2 (51)	21	10
		HW	3-1/4 CYL	4 CYL	HW	3-1/4 CYL	4 CYL	3-1/4 CYL	4 CYL														
4	100	19-3/16 (487)	22-1/8 (562)	22-7/8 (581)	8 (203)	4 (76)	4-1/2 (114)	1/4-18	3/8-18	4 (102)	9 (229)	13/32 (10)	2	5/8-11NC	8	7-1/2 (191)	6-3/16 (157)	4 (102)	1/16 (2)	11/16 (17)	2 (51)	30	14
		HW	4 CYL	6 CYL	HW	4 CYL	6 CYL	4 CYL	6 CYL														
6	150	25-5/16 (643)	28-7/8 (733)	29-1/4 (743)	10 (254)	4-1/2 (114)	6-1/2 (165)	3/8-18	3/8-18	6 (152)	11 (279)	7/16 (11)	2	3/4-10NC	8	9-1/2 (241)	8-1/2 (216)	7-3/8 (187)	1/16 (2)	5/8 (16)	2-1/4 (57)	75	34
		HW	6 CYL	8 CYL	HW	6 CYL	8 CYL	6 CYL	8 CYL														
8	200	32-5/8 (829)	35-13/16 (910)	36-5/16 (922)	12 (305)	6-1/2 (165)	8-5/8 (219)	3/8-18	3/8-18	8 (203)	13-1/2 (343)	5/8 (16)	2	3/4-10NC	8	11-3/4 (298)	10-5/8 (270)	7-3/8 (187)	1/16 (2)	13/16 (21)	2-3/4 (70)	94	45
		HW	8 CYL	10 CYL	HW	8 CYL	10 CYL	8 CYL	10 CYL														
10	250	37-3/4 (959)	41-7/16 (1053)	42-3/16 (1072)	16 (406)	8-5/8 (219)	10-7/8 (276)	3/8-18	1/2-14	10 (254)	16 (406)	1/2 (13)	4	7/8-9NC	12	14-1/4 (362)	12-3/4 (324)	7-3/8 (187)	1/8 (3)	15/16 (24)	2-3/4 (70)	126	57
		HW	8 CYL	10 CYL	HW	8 CYL	10 CYL	8 CYL	10 CYL														
12	300	44-9/16 (1132)	48 (1219)	48-3/4 (1238)	16 (406)	8-5/8 (219)	10-7/8 (276)	3/8-18	1/2-14	12 (305)	19 (483)	1/2 (13)	4	7/8-9NC	12	17 (432)	15 (381)	7-1/2 (191)	3/16 (5)	1 (25)	3 (76)	177	80
		HW	12 CYL	14 CYL	HW	12 CYL	14 CYL	12 CYL	14 CYL														
14	350	49-1/4 (1251)	54-1/16 (1373)	55-3/16 (1402)	20 (508)	12-3/4 (324)	14-3/4 (375)	1/2-14	3/4-14	13-1/4 (337)	21 (533)	7/16 (11)	4	1-8NC	12	18-3/4 (476)	16-1/4 (413)	7-3/4 (197)	3/16 (5)	15/16 (24)	3 (76)	215	98
		HW	12 CYL	14 CYL	HW	12 CYL	14 CYL	12 CYL	14 CYL														
16	400	56-1/2 (1435)	61-1/16 (1551)	62-3/16 (1580)	20 (508)	12-3/4 (324)	14-3/4 (375)	1/2-14	3/4-14	15-1/4 (387)	23-1/2 (597)	9/16 (14)	6	1-8NC	16	21-1/4 (540)	18-1/2 (470)	11-1/4 (286)	3/16 (5)	1-1/16 (27)	3-1/2 (89)	268	122
		HW	12 CYL	14 CYL	HW	12 CYL	14 CYL	12 CYL	14 CYL														
18	450	63-5/16 (1608)	66-1/2 (1689)	67-5/8 (1718)	20 (508)	12-3/4 (324)	14-3/4 (375)	1/2-14	3/4-14	17-1/4 (438)	25 (635)	5/8 (16)	6	1-1/8-7NC	16	22-3/4 (578)	21 (533)	11-1/4 (286)	3/16 (5)	1-1/16 (27)	3-1/2 (89)	407	185
		HW	14 CYL	16 CYL	HW	14 CYL	16 CYL	14 CYL	16 CYL														
20	500	68-5/8 (1743)	72-15/16 (1853)	73-7/16 (1865)	20 (508)	14-3/4 (375)	17 (432)	3/4-14	3/4-14	19-1/4 (489)	27-1/2 (699)	29/32 (23)	8	1-1/8-7NC	20	25 (635)	23 (584)	14 (356)	3/16 (5)	1-3/16 (30)	4-1/2 (114)	523	237
		HW	16 CYL	18 CYL	HW	16 CYL	18 CYL	16 CYL	18 CYL														
24	600	79-13/16 (2027)	84-11/16 (2151)	86-5/8 (2200)	20 (508)	17 (432)	19 (483)	3/4-14	3/4-14	23-1/4 (591)	32 (813)	13/16 (21)	8	1-1/4-7NC	20	29-1/2 (749)	27-1/4 (692)	14-1/8 (359)	3/16 (5)	1-5/16 (33)	4-1/2 (114)	713	321

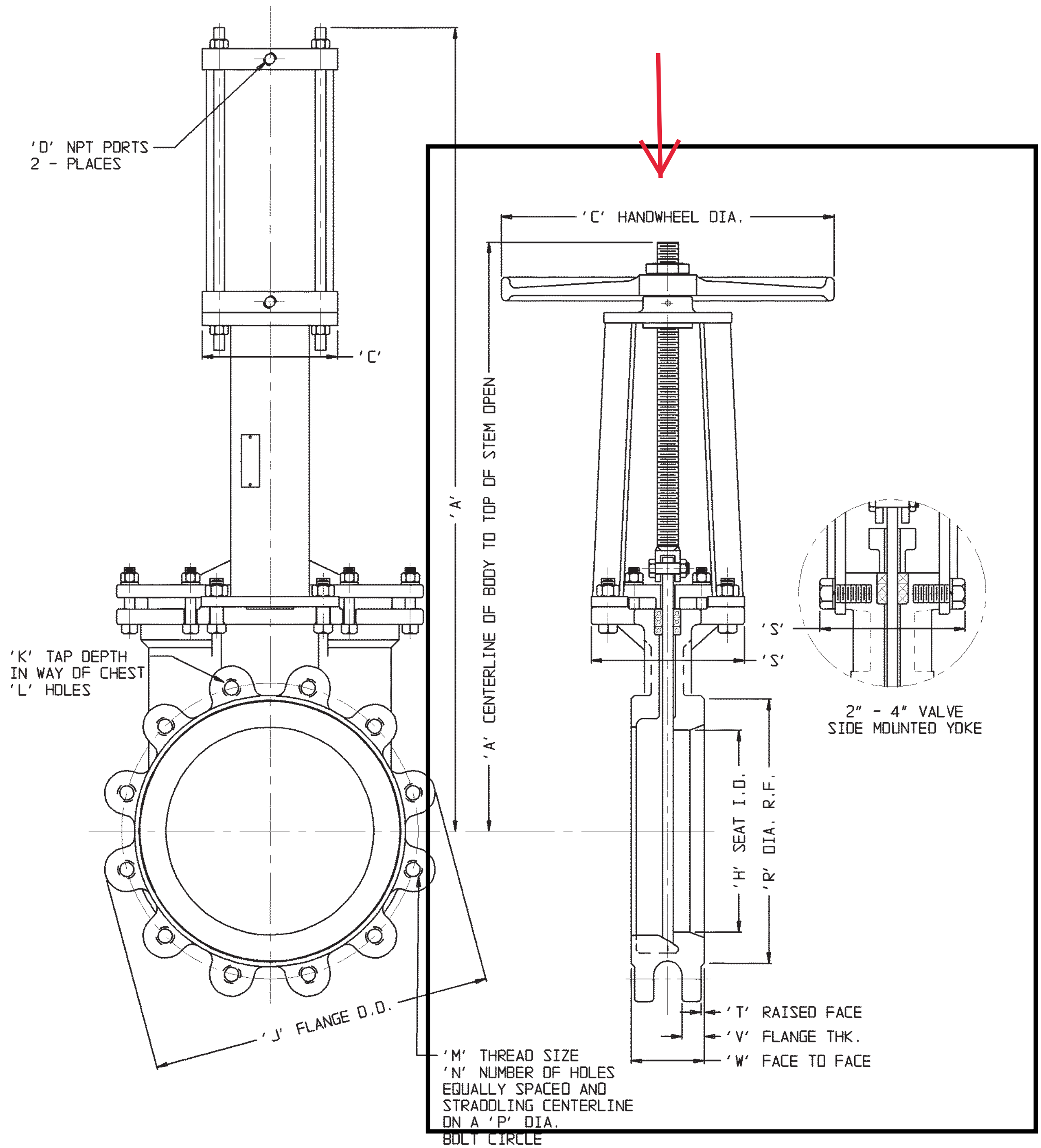
Reference dimensions in (parentheses)

* For 14" - 24" valves with rubber replaceable seats, use the port I.D. dimensions show in the Flow Coefficients Table (see last page).

** Figures C37R and C37S with Handwheels

C37 with Handwheel or Cylinder

Refer to TABLE 1 for dimensions



with Cylinder

with Handwheel

Dimensions: C37 with Bevel Gear

Valve Size		TABLE 2						DIMENSION Inches (mm) Figure C37 with BEVEL GEAR										
Inches	DN	A	B	C	D	E	H	J	K	L	M	N	P	R	S	T	V	W
6	150	25-5/16 (643)	19-11/16 (500)	12 (305)	12-3/8 (314)	6-1/2 (165)	6 (152)	11 (279)	7/16 (11)	2	3/4-10NC	8	9-1/2 (241)	8-1/2 (216)	7-3/8 (187)	1/16 (2)	5/8 (16)	2-1/4 (57)
8	200	32-15/16 (837)	24-5/8 (625)	12 (305)	12-3/8 (314)	6-1/2 (165)	8 (203)	13-1/2 (343)	5/8 (16)	2	3/4-10NC	8	11-3/4 (298)	10-5/8 (270)	7-3/8 (187)	1/16 (2)	13/16 (21)	2-3/4 (70)
10	250	38-1/16 (967)	27-9/16 (700)	12 (305)	12-3/8 (314)	6-1/2 (165)	10 (254)	16 (406)	1/2 (13)	4	7/8-9NC	12	14-1/4 (362)	12-3/4 (324)	7-3/8 (187)	1/8 (3)	15/16 (24)	2-3/4 (70)
12	300	44-9/16 (1132)	31-13/16 (808)	12 (305)	12-3/8 (314)	6-1/2 (165)	12 (305)	19 (483)	1/2 (13)	4	7/8-9NC	12	17 (432)	15 (381)	7-1/2 (191)	3/16 (5)	1 (25)	3 (76)
14	350	49-5/16 (1252)	34-3/4 (883)	12 (305)	12-3/8 (314)	6-1/2 (165)	13-1/4 (337)	21 (533)	7/16 (11)	4	1-8NC	12	18-3/4 (476)	16-1/4 (413)	7-3/4 (197)	3/16 (5)	15/16 (24)	3 (76)
16	400	56-9/16 (1437)	40-3/8 (1026)	12 (305)	12-1/16 (306)	6-1/2 (165)	15-1/4 (387)	23-1/2 (597)	9/16 (14)	6	1-8NC	16	21-1/4 (540)	18-1/2 (470)	11-1/4 (286)	3/16 (5)	1-1/16 (27)	3-1/2 (89)
18	450	63-5/16 (1608)	43-13/16 (1113)	12 (305)	12-1/16 (306)	6-1/2 (165)	17-1/4 (438)	25 (635)	5/8 (15)	6	1-1/8-7NC	16	22-3/4 (578)	21 (533)	11-1/4 (286)	3/16 (5)	1-1/16 (27)	3-1/2 (89)
20	500	68-5/8 (1543)	47-15/16 (1218)	12 (305)	12-1/16 (306)	6-1/2 (165)	19-1/4 (489)	27-1/2 (699)	29/32 (23)	8	1-1/8-7NC	20	25 (635)	23 (584)	14 (356)	3/16 (5)	1-3/16 (30)	4-1/2 (114)
24	600	79-7/8 (2029)	55-3/16 (1402)	12 (305)	12-1/16 (306)	6-1/2 (165)	23-1/4 (591)	32 (813)	13/16 (21)	8	1-1/4-7NC	20	29-1/2 (749)	27-1/4 (692)	14-1/8 (359)	3/16 (5)	1-5/16 (33)	4-1/2 (114)

Reference dimensions in (parentheses) 6" - 14" valves have a bevel gear ratio of 3:1 16" - 24" valves have a bevel gear ratio of 4:1

Materials of Construction

Parts	Materials	
	C37R & F37R	C37S & F37S
Body and Chest	1.5" – 24"(except 5") solid one piece. C37R-304: Cast 304 stainless steel C37R-316: Cast 316 stainless steel C37R-317L: Cast 317L stainless steel Larger than 24" and the 5" are fabricated with stainless steel wetted parts and carbon steel exterior parts.	1.5" - 24" (except 5") solid one piece. C37S-304: Cast 304 stainless steel C37S-316: Cast 316 stainless steel C37S-317L: Cast 317L stainless steel Larger than 24" and the 5" are fabricated of all stainless steel
Seat	Integral seat to 1500°F (816°C) with appropriate packing RH: Replaceable hardfaced seat to 750°F (399°C) standard Up to 1600°F(871°C) with proper packing and gaskets RT: Replaceable PTFE seat to 400°F (204°C) RW: Replaceable UHMWP seat to 140°F (60°C) RP: Replaceable polyurethane seat to 180°F (82°C)	
Gate	Stainless steel of same grade used in body, finished to 32 RMS	
Yoke	1.5" - 4", Cast ductile iron 6" and above fabricated carbon steel	1.5" - 4", cast 304 stainless steel 6" and above fabricated 304 stainless steel
Yoke Fasteners	Plated steel	Stainless steel
Stem	304 stainless steel	
Stem Nut	Acid resistant bronze	
Lubrication Fitting	Plated steel	
Packing	Acrylic/PTFE/silicone[1]	
Packing Follower	Ductile iron/carbon steel with plated steel bolts	304 stainless steel with stainless steel bolts
Handwheel	Cast iron	
Handwheel Retaining Nut	Malleable iron	Stainless steel
Tab Washer	Stainless steel	

[1] Energized cored packing is standard with 6" (DN150) and larger C37 valves and all F37 valves.

Flow Coefficients

The Cv values below represent U.S. gallons per minute 60°F water through a 100% open valve at a pressure drop of 1 psi. The metric equivalent, Kv, is the flow of water at +16°C through the valve in cubic meters per hour at a pressure drop of 1 kg/cm2. To convert Cv to Kv, multiply the Cv by 0.8569.

Figures C37 and F37
Cv Ratings, Port Diameter, and Area

Valve Size		Standard Port			With V-Seat			With Replaceable Poly or Replaceable Rubber seat		
In.	DN	Cv	Port I.D. Inches	Port Area Sq. In.	Cv	Port Inside Inches	Port Area Sq. In.	Cv	Port I.D. Inches	Port Area Sq. In.
2	50	288	2.00	3.1	165	2.00	2.8	288	2.00	3.1
3	75	648	3.00	7.1	355	3.00	6.3	648	3.00	7.1
4	100	1,152	4.00	12.6	515	4.00	9.5	1,152	4.00	12.6
6	150	2,592	6.00	28.3	1,350	6.00	24.9	2,592	6.00	28.3
8	200	4,608	8.00	50.3	2,050	8.00	38.1	4,608	8.00	50.3
10	250	7,208	10.00	78.5	3,200	10.00	59.0	7,208	10.00	78.5
12	300	10,400	12.00	113.1	4,450	12.00	82.3	10,400	12.00	113.1
14	350	12,650	13.25	137.9	5,350	13.25	98.8	10,080	12.00	113.1
16	400	16,750	15.25	182.6	6,950	15.25	128.4	14,200	14.25	159.5
18	450	21,450	17.25	233.7	10,700	17.25	198.2	18,500	16.25	207.4
20	500	26,700	19.25	291.0	13,250	19.25	245.4	22,700	18.00	254.5
24	600	38,900	23.25	424.6	15,400	23.25	284.7	33,900	22.00	380.1
30*	750*	49,850	26.69	559.4	Consult Factory					
36*	900*	74,800	32.69	839.2						
42*	1050*	104,800	38.69	1175.5						
48*	1200*	136,700	44.19	1533.5						

*50 psi (3.5 bar) CWP valve design. Contact factory for higher pressure designs.

ITT
ENGINEERED FOR LIFE

Engineered Valves, LLC
1110 Bankhead Ave
Amory, MS 38821
662.256.7185
www.engvalves.com

E & I CORPORATION
DIVISION OF McNish CORPORATION
214 Hoff Rd. - Suite M
Westerville, Ohio 43082
1-614-899-2282 (Phone)
1-614-899-0304 (Fax)

October 22, 2019

Project:	PRIMARY SETTLING TANK EQUIPMENT REPLACEMENT
Location:	TRAVERSE CITY, MI
Budgetary Proposal No:	G-8779 S
Subject:	CHAIN & FLIGHT SLUDGE COLLECTION MECHANISMS

We are pleased to submit this Budgetary Proposal to furnish the following equipment:

SCOPE OF SUPPLY

Four (4) - Primary 4-SHAFT Rectangular Collectors – 16'-0" W x 58'-6" L
Four (4) - Primary 4-SHAFT Rectangular Collectors – 14'-0" W x 52'-6" L
Four (4) – Rotating Scum Skimmer Pipes – 12" Dia. x 16'-0" L
Four (4) – Rotating Scum Skimmer Pipes – 12" Dia. x 14'-0" L

These units are to be supplied complete with all machinery parts including:

- Head Shafts, C-1018 Carbon Steel
- Idler Shafts, C-1018 Carbon Steel
- Head Shaft Sprockets, Split Type, 23 Tooth, Cast Nylon
- Drive Sprocket, Shear Pin Type, 11 Tooth, Cast Nylon with 316 Stainless Steel Hub
- Driven Sprocket, Split Type, Offset Type, 40 Tooth, Cast Nylon
- Idler Sprockets, 19 Tooth, Cast Nylon
- Drive Units, Helical Gear Reducer, ½ HP Motor, TEFC, 460 volts, 3-phase, 60 hertz
- Chain Guards, #14 Gauge, 304 Stainless Steel
- Drive Chains, NH-78, Non Metallic
- Snap Idle Chain Tighteners
- Limit Switches, NEMA IV
- Shaft Bearings, Cast Iron, Peak Cap, UHMW-PE lined, Self-Aligning
- Set Collars, Split Type, UHMW-PE
- Flights, FRP, 3"x8" nominal
- Filler Blocks, Polypropylene
- Collector Chain, NCS 720, Non Metallic
- Return Rail Angles, FRP, 3" x 3" x 3/8"
- Return Rail Wall Brackets, non-metallic co-polymer
- Wear Shoes, UHMW-PE
- Floor & Return Rail Wear Strips, UHMW-PE (virgin material)

- Skimmer Pipes, 12” Dia., 304 Stainless Steel, Schedule 30
    - Wall Bearings with UHMW-PE liners, 304 Stainless Steel
    - Worm Gear, Brass
    - Pinion half-wheel, toothed, 304 Stainless Steel
    - Handwheel Operator, Cast Iron
    - Gaskets, neoprene
    - O-ring Seals, oil resistant, Buna-N
- Anchors & Fasteners, 316 Stainless Steel

Not Included: Field paint, finish paint, field installation, controls, field control wiring, cross collectors, weirs and troughs, wall sleeves

<u>PRICE</u>:

Budgetary Price: Approximately $<u>396,500</u> FOB factory with freight allowed to jobsite.

<u>FIELD SERVICE</u>:

The services of a factory field service technician for checkout, initial start-up, testing, commissioning, and/or instruction of plant personnel will be provided as follows:

Four (4) trips, Twelve (12) days of Service

<u>EXISTING STRUCTURE NOTE:</u>

The Owner or Contractor shall be solely responsible for measuring and providing E & I Corporation, a division of McNish Corporation with accurate as built dimensions for all existing structures where E & I Corporation is furnishing equipment. This information must be made available to E & I Corporation in a timely manner to avoid delaying the equipment delivery schedules outlined within this budgetary proposal. In the event dimensions are not provided or the provided dimensions are in error which results in modifications to either the equipment or the adjacent structures, the Owner shall be solely responsible for all labor, materials and associated costs to correct the resulting situation.

<u>SHOP PAINTING</u>:

All fabricated carbon steel shall be prime paint - SSPC-SP10 surface preparation with one (1) prime coat Tnemec Series 1 Omnithane, 2.5-3.5 mils DFT. Carbon steel shafts will not be painted but will be coated with a protective grease coating.

All standard machinery items i.e. reducers, motors, controls, bearings, sprockets, couplings etc. will be furnished with the vendor’s standard paint.

Aluminum, stainless steel, galvanized steel, plastic and other special materials will not be shop painted.

<u>SPARE PARTS</u>:

Not Included

<u>FASTENERS</u>:

All fasteners will be Type 304 stainless steel.

ANCHORAGE:

All anchorage will be Type 316 stainless steel.

ESTIMATED SCHEDULE:

Based on current deliveries by suppliers and our projected work load, we estimate that we can ship fabricated materials in accordance with the schedules listed below. Approval Schedule is shown in weeks after receipt of order with complete information. SCHEDULE COMMITMENTS ARE SUBJECT TO REVISION AND MUST BE CONFIRMED AT TIME OF ORDER.

Submittal of Approval Drawings . . . . 6 - 8 weeks
Shipment, after Receipt of Approval . . . . 12 - 16 weeks

EXCLUSIONS:

Although they may be shown on the plans and/or specified, the following are not included in this offering:

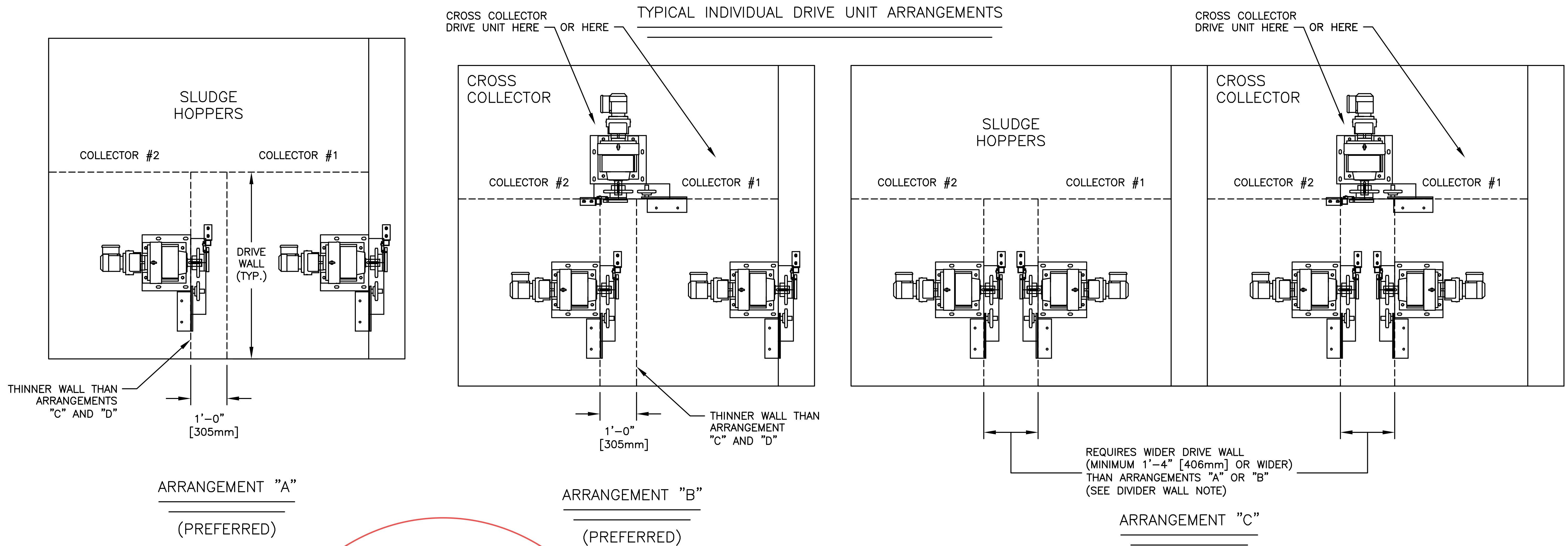
1. Unloading, hauling or storage
2. All electrical controls, alarms and wiring except as specified above
3. Lubricating oil or grease
4. Piping unless specifically noted above
5. Field painting
6. Welding
7. Concrete work or erection
8. Embedded items
9. Shims/Shim Sets
10. Labor and materials to repair defects in galvanized or painted surfaces caused from shipping, handling or installation
11. Tools (no special tools required)

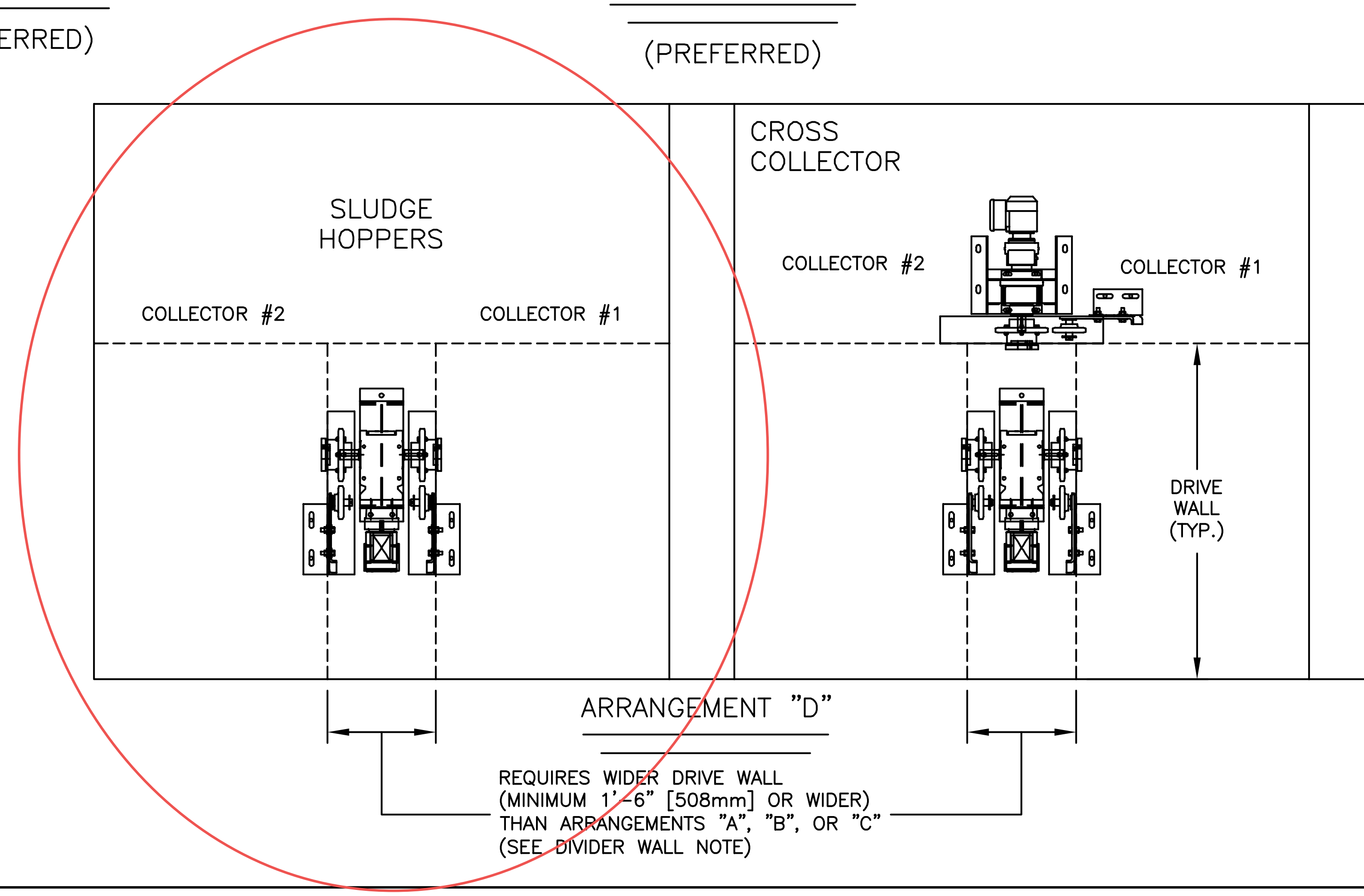
If we can furnish any clarifications or additional information, please contact our Representative, Dave Conners, Waterworks Systems & Equipment, at 989-860-9816. We look forward to the opportunity of working with you during the course of this project.

Sincerely,
E & I Corporation
Division of McNish Corporation

Kevin L. Strohl

Kevin L. Strohl, P.E.
Applications Engineer





DIVIDER WALL NOTE:

IF NARROWER DIVIDER WALLS (COLUMNS AND BEAMS) ARE DESIRED FOR THE REMAINING TANK LENGTH, 8 INCH (203mm) HIGH CONCRETE CORBELS (AT WATER LEVEL) AND CURBS (AT FLOOR LEVEL) ARE REQUIRED ON BOTH SIDES OF THE DIVIDER WALL.

CORBELS AND CURBS ARE ALSO REQUIRED ON THE NON-DRIVE SIDE WALL TO MAKE FLIGHTS SYMETRICAL AND INTERCHANGABLE BETWEEN TANKS.

MASTER REVISION JULY 2014

TITLE: ENVIREX CHAIN AND SCRAPER SLUDGE COLLECTORS
GENERAL ARRANGEMENT
SUGGESTED DRIVE ARRANGEMENTS

CUST.:
LOC.:
ENG.:

EVOQUA WATER TECHNOLOGIES
WATER TECHNOLOGIES
WAUKESHA, WI
262-547-0141

PROJECT	CODE	DRAWING	SHEET	REV
	4001	1.310D	OF	

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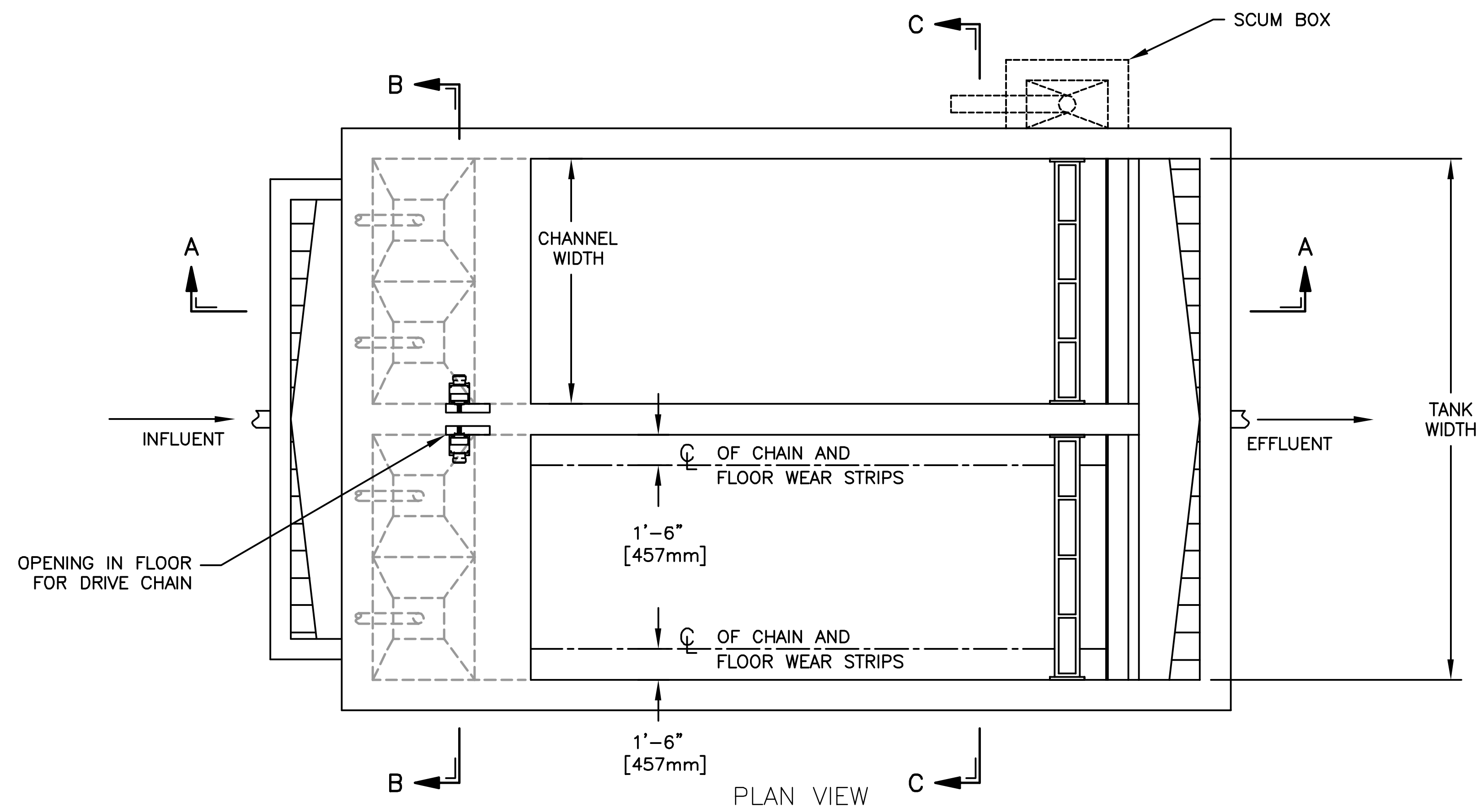
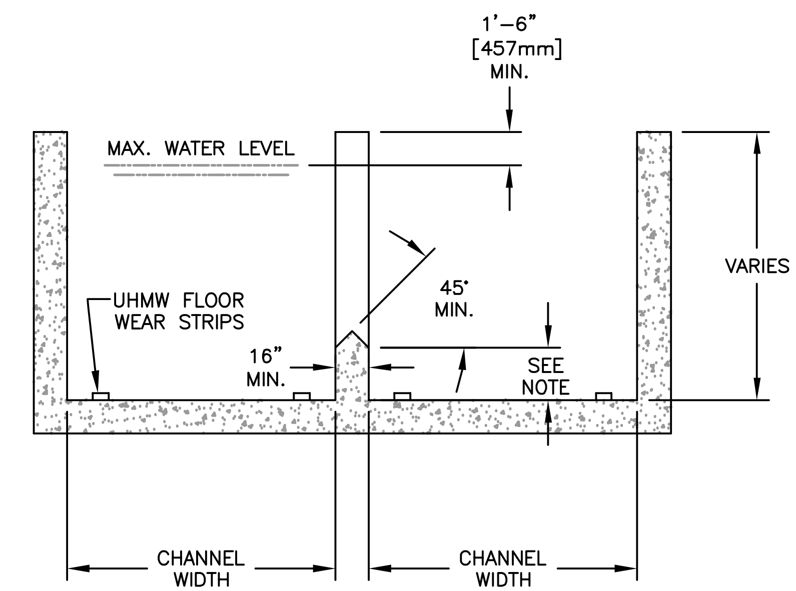


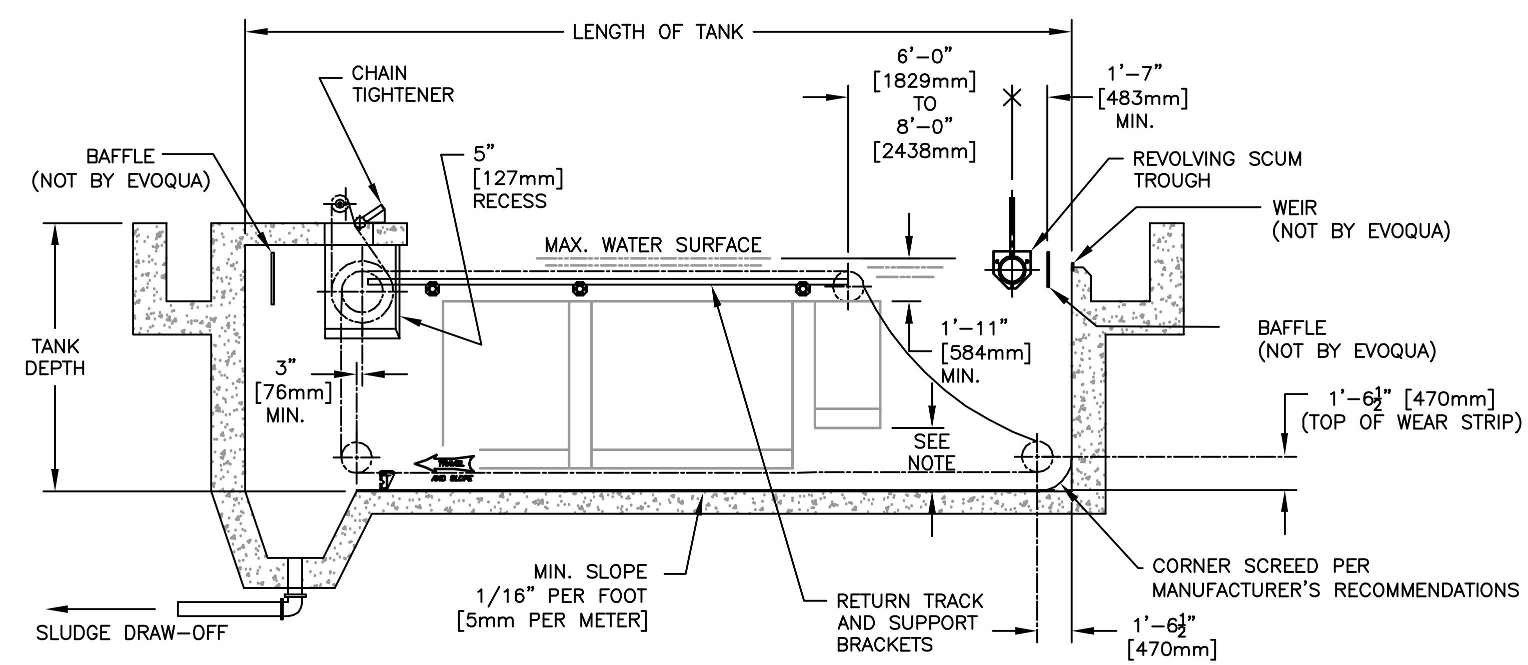
PLAN VIEW



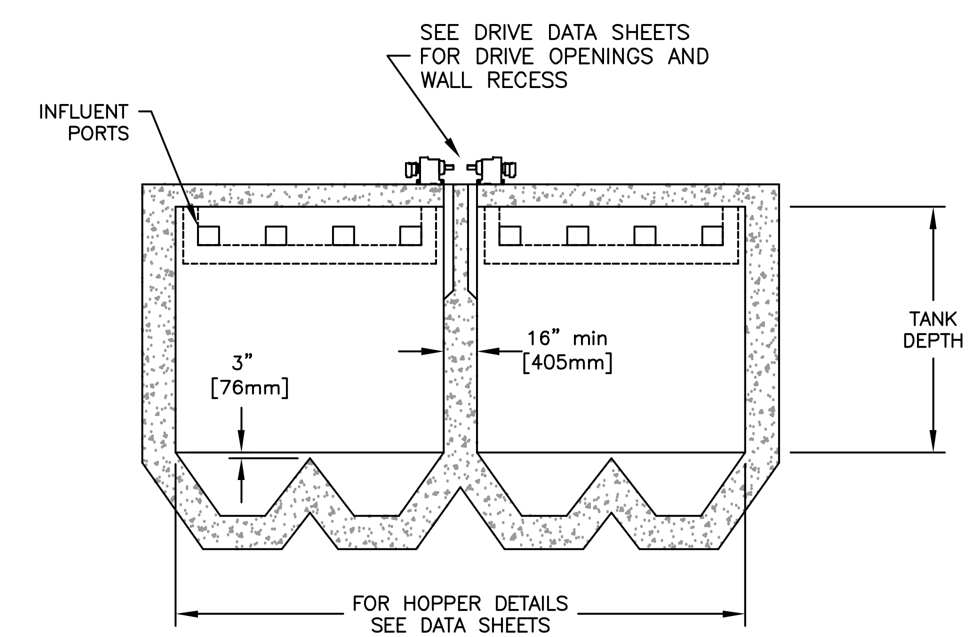
SECTION "C–C"

NOTE:

MINIMUM CENTER WALL VERTICAL HEIGHT IS 2'–10" (864mm) WHERE THE LOWER RETURN TRACK SUPPORT BRACKETS ARE MOUNTED AT THE EFFLUENT END OF CHANNEL AND EFFLUENT CORNERSHAFT LOCATION. AFTER THESE AREAS THE CENTER WALL CAN BE LOWERED TO 1'–0" (300mm).



SECTION "A–A"



SECTION "B–B"

NOT FOR CONSTRUCTION

DEFINITIONS:

BASIN = ONE OR MORE TANKS THAT SHARE COMMON INFLUENT AND EFFLUENT. ANY TANK CAN BE TAKEN OUT OF SERVICE.

TANK = ONE OR MORE CHANNELS HYDRAULICALLY COMMON TO EACH OTHER. MOST OFTEN THERE IS ONLY ONE CROSS COLLECTOR PER TANK.

CHANNEL = COLLECTOR BAY CONTAINING ONE COLLECTOR MECHANISM.

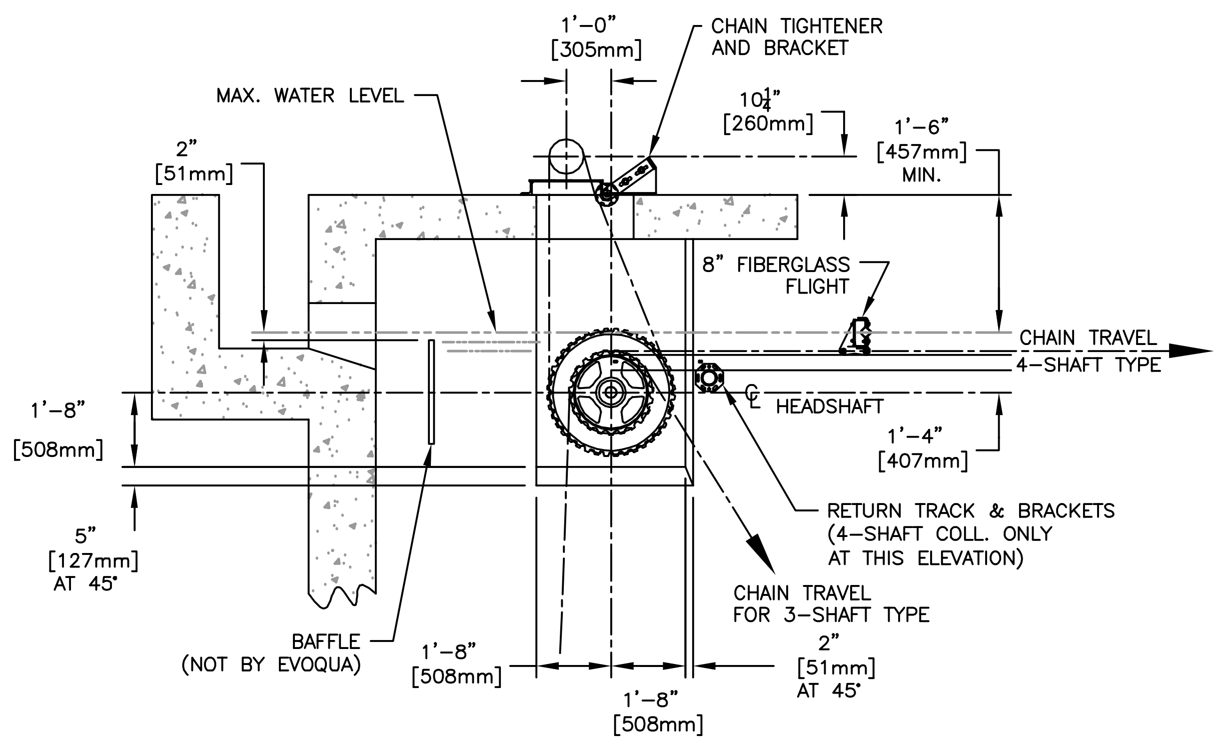
MASTER REVISION JULY 2014

TITLE: ENVIREX CHAIN & SCRAPER SLUDGE COLLECTORS
GENERAL ARRANGEMENT
DOUBLE TANK – 4–SHAFT WITH COMMON DRIVE WALL

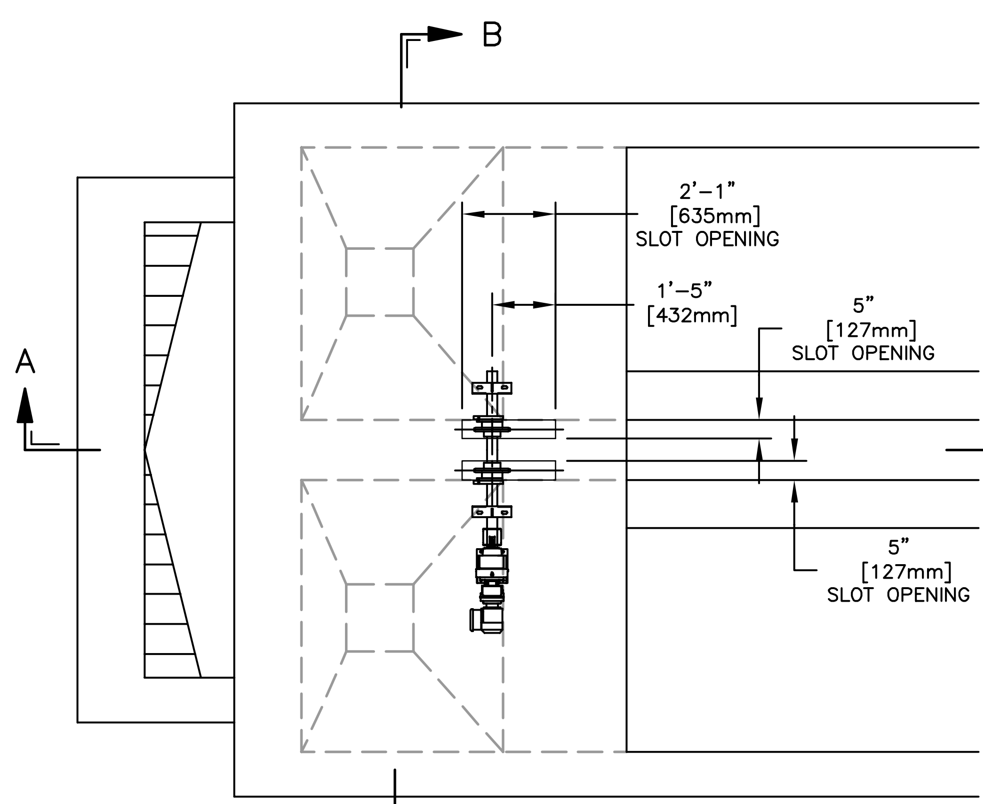
CUST.:
LOC.:
ENG.:

EVOQUA WATER TECHNOLOGIES
WATER TECHNOLOGIES
WAUKESHA, WI
262–547–0141

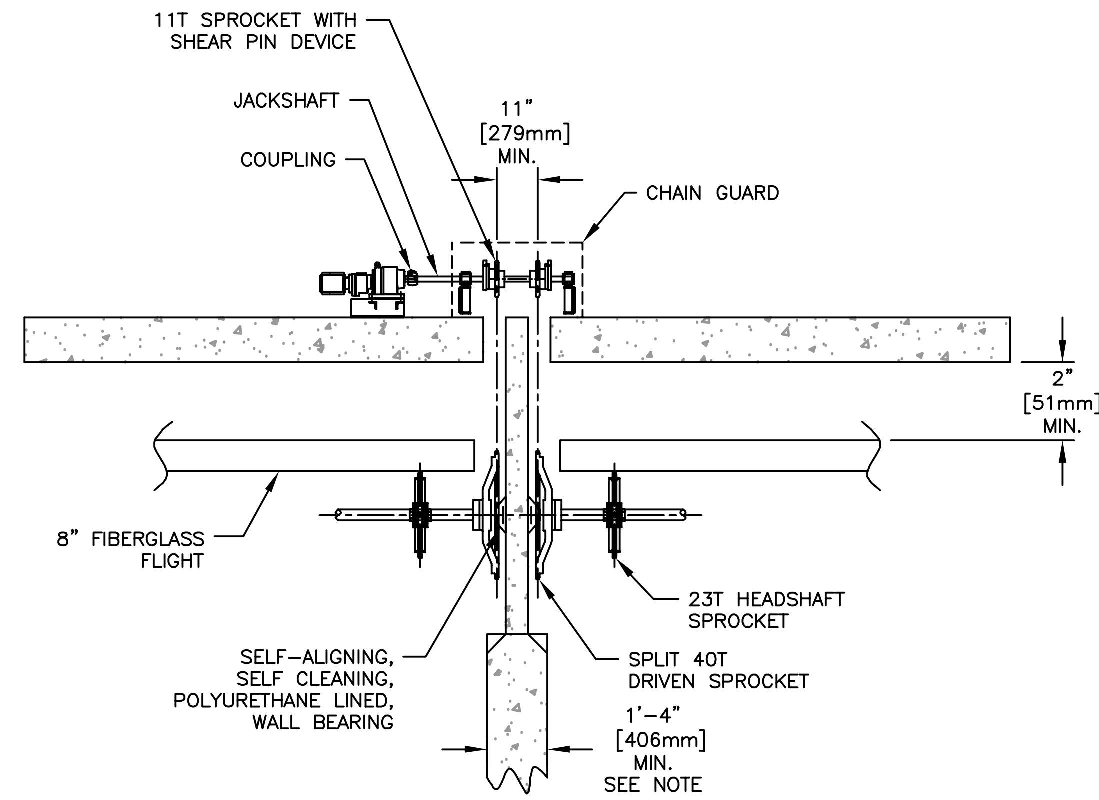
PROJECT	CODE	DRAWING	SHEET	REV
	4001	1.303	OF	



SECTION "A-A"



PLAN VIEW



SECTION "B-B"

NOTE: IF NARROWER DIVIDER WALLS (COLUMNS AND BEAMS) ARE DESIRED FOR THE REMAINING TANK LENGTH, 8 INCH (203mm) HIGH CONCRETE CORBELS (AT WATER LEVEL) AND CURBS (AT FLOOR LEVEL) ARE REQUIRED ON BOTH SIDES OF THE DIVIDER WALL.

CORBELS AND CURBS ARE ALSO REQUIRED ON THE NON-DRIVE SIDE WALL TO MAKE FLIGHTS SYMETRICAL AND INTERCHANGABLE BETWEEN TANKS.

MASTER REVISION JULY 2014

NOT FOR CONSTRUCTION

TITLE: ENVIREX CHAIN & SCRAPER SLUDGE COLLECTORS DRIVE ARRANGEMENT - DOUBLE TANK W/COMMON WALL JACKSHAFT WITH SOLID DIVIDING WALL

CUST.:
LOC.:
ENG.:

EVOQUA WATER TECHNOLOGIES
WATER TECHNOLOGIES
WAUKESHA, WI
262-547-0141

PROJECT	CODE	DRAWING	SHEET	REV
	4001	1.313	OF	

EVOQUA WATER TECHNOLOGIES CONFIDENTIAL ALL RIGHTS RESERVED	**Budget and Equipment Data Sheet** **Primary Tanks** **COLLECTOR MECHANISMS**	**Installation:** Traverse Cy, Mich. **Engineer:** Hubbell, Roth & Clarke **Proposal No.:** 14' x 66.5' 4-sh **Date:** October 2, 2019 **By:** Steve Ihde **Equipment No.:** **2**

Rev1

A. CHARACTERISTICS

Manufacturer	Evoqua Water Technologies LLC (Evoqua) - Waukesha, Wisconsin USA						
Equipment Description	Envirex® Sludge Collecting Equipment for Primary Sedimentation Basin - Wastewater Plant						
Basin Quantity	2						
Each Basin Contains	1	Tank					
Each Tank Contains	2	Longitudinal Collector Mechanism					
Total Sludge Collector Mechanisms	4						
Collector Scraping Width	14.00 ft		**Overall Channel Width**	14.00 ft	**Dividing Wall Type**	N/A	**Dividing Wall(s') Thickness** None
Tank Length	66.5 ft						
Max. WATER Depth (Measured at point nearest edge of hopper)	11.50 ft						
New or Existing Tanks	Existing						

Budget Information

(4) ea Longitudinal Sludge Collectors

Scum Pipes (4) ea 10 Inch Dia X 14.0 ft Lg

Field Service Included:
Trips: **2**
8 Hr Days at Site: **4**

Estimated Freight included
FOB Shipping Point

$191,900 Total USD

Budget
Preliminary budget is based on limited information, Evoqua standard equipment selection, and standard terms of sale and warranty terms. Any variations from these standards may affect this budget. Additionally, please note that this budget is for review and informational purposes only and does not constitute an offer for acceptance. A copy of our standard Terms & Conditions are available upon request.
Budget based on delivery within one (1) year from date of this submittal.

Est (2) Truck loads

Pairs of Sprockets per Collector	4	
Flight Speed	2.0 ft/min	
Flight Spacing - Longitudinal	10.0 ft	
Sludge Load (Average)	4.0 lb/ft	Primary at 4% sludge concentration with 8 inch (200mm) tall flights = 4 lb/ft
Friction Factors	0.20 to 0.30 (UHMW-PE on UHMW-PE - water lubricated) 0.05 to 0.10 (UHMW-PE on Stn. Stl. - water lubricated)	
Bearing Friction Factors	0.05 per shaft assembly	
Shaft Deflection	Less than 0.033 inches/ft of shaft length	

B. MATERIALS

CHAIN	
Flight Carry Chain	NCS720S-NX - Non-metallic, unfilled acetal resin chain and reinforced nylon resin pins, 3/8 inch (10mm) flight fasteners, working load 3100 lbf (13.8 kN), minimum ultimate 6,000 lbf (27 kN), weight 1.3 lb/ft (1.9 kg/m)
Drive Chain	NH78 - Unfilled acetal links, SS pin, working load 1750 lb (7.78 kN), min. ultimate 4,000 lb (17.79 kN), weight 1.4 lb/ft (2.1 kg/m)
FLIGHTS	
Flights	Sigma Plus FRP 3 x 8 inch (75 x 200 mm) - Modulus of elasticity (E, psi) x moment of inertia (I, in^4) >/= 6.83 x 10^6 lb-in^2 (19.5 kN-m^2) about its minor axis, 50 to 60% glass content
WEAR SHOES	
Wear Shoes - Return Track	UHMW-PE with lug every flight Wear shoe (track) - Virgin Black UHMW-PE, ASTM D-4020, w/ lug 4.5 x 3 x 0.5 inch (114 x 76 x 12.7mm), min. 62 Shore "D" ASTM D-2240, 6,000 psi (41,400 KPA) ultimate tensile
Wear Shoes - Floor	Wear shoe (floor) - Virgin Black UHMW-PE, ASTM D-4020 5.5 wide x 3 x 0.5 inch (140 x 76 x 12.7mm), min. 62 Shore "D" ASTM D-4020, 6,000 psi (41,400 KPA) ultimate tensile
WEAR STRIPS	
Floor	UHMW-PE 5/8 X 2 5/8 inch (16 x 67mm) - 2 lines per tank
Attachment	316SS convex washer, #14 x 1-1/2 inch (6 x 38mm) 316SS pan head self tapping screw and vinyl anchor
Return Tracks	UHMW-PE 5/8 X 2 5/8 inch (16 x 67mm)
Attachment	316SS convex washer, 1/4 inch (6mm) 410SS, zinc plated self-drilling & tapping pan head screw
RETURN TRACKS	3 x 3 x 3/8 inch (76 x 76 x 9.5mm) — **Track Mat'l:** FRP
Supports	Non-metallic - Polypropylene and Schedule 80 CPVC Pipe — **Support Mat'l:** Non-metallic
Support Spacing	10.0 ft (3.0m)
DEFLECTOR ANGLES	3 x 3 x 3/8 inch (76 x 76 x 10mm) with UHMW-PE wear strips and 316SS fasteners — **Track Mat'l:** Carbon Steel
Supports	A500 Sch. 40 steel pipe with 1/4 inch (6mm) steel end plates — **Support Mat'l:** Carbon Steel Note: Deflector angles will be furnished only if it is determined by Evoqua at time of drawing submittal that
SHAFTING	**Shaft Material:** 1018 CRS with LPS-3 Rust Veto **Idler Shaft Material:** 304SS **Idler Shaft Bracket Material:** Cast Iron

			Shafting Outside Diameter
Head Shaft	Solid cold rolled steel with keyways for Head Shaft sprockets		3 inch (76mm)
Lower Influent Idler Shaft	Stub shaft with cast iron base	**Shaft** Sch. 40S pipe	3.5 inch (89mm)
Lower Effluent Idler Shaft	Same as Lower Influent Idler Shaft	**Shaft** Sch. 40S pipe	3.5 inch (89mm)
Upper Effluent Idler Shaft	Same as Lower Influent Idler Shaft	**Shaft** Sch. 40S pipe	3.5 inch (89mm)
Set Collars for Head Shaft	Split UHMW set collar with 316SS band clamp		

COLLECTOR BEARINGS	
Head Shaft	Cast steel split housing, polyurethane, self-aligning bearing, water lubricated with provisions for greasing when unsubmerged — Solid Hub Ball
Upper Effl & Lower Effl Idler Shafts	Sprocket bore rotates on Virgin UHMW-PE sprocket sleeve bearing, sprocket position retained by UHMW-PE set collar
Upper Effluent	Same as Lower Influent Idler Shaft
GREASING PROVISIONS	
Greasing Provisions	Grease line for driven side Head Shaft bearing only, remaining bearings grease fitting in housing.
Type / Material	Head Shaft driven side bearing with rubber flex line with Alemite grease fitting, 1/8 inch NPT, material
COLLECTOR SPROCKETS	
Head Shaft	NCS720S, 23T-22.24 inch (565mm) PD w/ chain saver rim, split cast nylon, bolted hub with 316SS hdw. and set screws
Idler Shaft	NCS720S, 17T-16.61 inch (422mm) PD w/ chain saver rim, solid cast nylon

DRIVE SPROCKET and TORQUE LIMITER	N78-11T-9.26 inch (235mm) PD polyurethane tooth segments and shear pin torque limiter **Hub Material:** 316SS Torque Limiter
DRIVEN SPROCKET	N78-40T-33.25 inch (845mm) PD, split polyurethane hub, deep dished and replaceable polyurethane tooth segments, 316 SS hdw.
DRIVE UNIT	
SPEED REDUCER	
Each reducer will drive	two (2) longitudinal collectors
Longitudinal reducer will be	jackshaft with sprocket and shear pin torque limiter for each collector
Manufacturer	Eurodrive or equal
Specifications:	Helical gear, fully housed, running in oil, anti-friction bearings throughout
Sizing of reducer	Torque rated at minimum 1.25 S.F. of calculated sludge load
Motor attachment	C-face
Paint	Original factory finish
MOTOR	
Manufacturer	Baldor (C-face) or equal
HP (kw)	0.5 HP (0.37kw)
Service Factor	1.25
V / Ph / Hz	230/460 V 3 Ph 60 Hz
RPM	1750
Encl. / Insul. / NEMA (IP) Design	TEFC (IP55) Enclosure / Class F Insulation / NEMA Design B
Efficiency	Premium Efficient
Paint	Original factory finish
Torque Overload Protection Device	Shear pin torque limiter with combination NEMA 4X (IP67) / NEMA 7 (IEC Zone 0 and 1) limit switch
Drive Base	304SS
Chain Guard	14 Ga. (3mm) 304SS
Drive Chain Tightener	316SS bracket, self-aligning, self-lubricated with N78-7T Polyurethane Sprocket
ELECTRICAL CONTROLS	
Controls	Over torque indicating switches only - all other controls NOT by Evoqua
HARDWARE	
Flights	316SS HHCS's, flat washers, and locknuts
Miscellaneous connections	316SS
Thread Standard	Unified American Standard
Anchors	Stud anchors for all locations except adhesive for stub shaft brackets
Anchor material	316SS
PAINT	
Surface prep (Non-Subm)	Shop blast to SSPC-SP10
Surface prep (Submerged)	Shop blast to SSPC-SP10
Shop prime - Non-submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Shop prime - Submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Finish paint - Non-submerged	Field applied coating by others
Finish paint - Submerged	Field applied coating by others
Paint Note:	All non-stainless steel shafting, including Head Shafts, Idler Shafting and exposed machined surfaces are solvent wiped followed by one (1) coat of Evoqua standard shop preservative. Wood, stainless steel, nonferrous materials and galvanized surfaces are unpainted. Unless specified, structural stainless steel is not passivated.
SKIMMING EQUIPMENT	Scum pipes by Evoqua **See Separate Equipment Data Sheet (EDS)**
SPARE PARTS	Spare parts are Not included.

EXCLUSIONS

Our equipment does NOT include any controls except as specifically stated within this Proposal, tools (except chain tool for NCS720S chain), grease lines, troughs, weirs, baffles, pumps, valves, weir gates, floor or wall sleeves, shims, grout, anchor templates, setting of anchor bolts, lubricants, finish painting, installation, taxes or duties, or material excluded under the General Items of this Proposal.

NOTE:

Evoqua will furnish equipment as proposed for the Contractor to install. Labor, equipment necessary for alterations and/or installation of our equipment, repair, alterations or cleaning of the existing structures, is the responsibility of the Contractor. Evoqua is not responsible for the locations, condition or dimensions of existing concrete, anchors, or any equipment not furnished by Evoqua. For existing sludge collector mechanism installations, concrete modifications may be required to accommodate newer style components. Example: The driven sprocket recess may need to be made deeper and/or larger.

EVOQUA WATER TECHNOLOGIES 	**Equipment Data Sheet** **Primary Tanks** **SCUM PIPES**	**Installation:** Traverse Cy, Mich. **Engineer:** Hubbell, Roth & Clarke **Proposal No.:** 14' x 66.5' 4-sh **Date:** September 30, 2019 **By:** SDI **Equipment No.:** **2**

A. CHARACTERISTICS

Manufacturer	Evoqua Water Technologies LLC (Evoqua) - Waukesha, Wisconsin USA
Equipment Description	Envirex® Scum Pipes Manual Lever
Total Scum Pipes	4
Scum Pipe Diameter	10 inch
Scum Pipe Length	14.00 ft
New or Existing Tanks	Existing
Budget Information	Scum Pipes are included in the Chain and Flight budget

B. MATERIALS

PIPE	
Material	Carbon steel - ASTM A53, Grade B, black
Size	10 inch
Wall Thickness	0.25 inch
Specifications	0.25 inch (6mm) wall thickness, 60 degree slotted weir openings and 2 inch (50mm) wide full periphery stiffening bands every 2 ft (610mm)
END SUPPORTS and SET COLLARS	
Material	Carbon steel
Specifications	Adjustable end plate with rolled collar and replaceable UHMW-PE bearing liner. Set collars, same material as end plate, secures pipe and seal position.
Seals - Wall to open end support	Plywood - 1/2 inch (12mm) thick, Marine Grade
Seals - Pipe to open end support	Hycar - Buna N synthetic rubber
OPERATOR	
Type	Manual Lever
Lever Material	Carbon steel - ASTM A53, Grade B, black
Lubrication	No lubrication required
Specifications	1.5 inch (38mm) dia. Sch. 40 pipe lever
Min. Pipe Rotation Each Direction	30 degrees
HARDWARE	
Miscellaneous connections	316SS
Thread Standard	Unified American Standard

Anchors	Stud anchors at all locations
PAINT	
Surface prep (Non-Subm)	Shop blast to SSPC-SP10
Surface prep (Submerged)	Shop blast to SSPC-SP10
Shop prime - Non-submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Shop prime - Submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Finish paint - Non-submerged	Field applied coating by others
Finish paint - Submerged	Field applied coating by others
Paint Note:	All non-stainless steel shafting and exposed machined surfaces are solvent wiped followed by one (1) coat of Evoqua standard shop preservative. Wood, stainless steel, nonferrous materials and galvanized surfaces are unpainted.

EXCLUSIONS

Our scum pipe(s) do NOT include any controls, tools, spray headers, nozzles, effluent troughs, baffles, wall sleeves, pipe sleeves, setting of anchor bolts, special or finish painting, equipment installation, taxes or duties, equipment installation, or materials noted under the General items of our Proposal.

CONTRACTOR NOTE:

Evoqua will furnish equipment as proposed for the Contractor to install. Labor, equipment necessary for alterations and/or installation of our equipment, repair, alterations or cleaning of the existing structures, is the responsibility of the Contractor. Evoqua is not responsible for the locations, condition or dimensions of existing concrete, anchors, or any equipment not furnished by Evoqua. For existing sludge collector mechanism installations, concrete modifications may be required to accommodate newer style components. Example: The driven sprocket recess may need to be made deeper and/or larger.

EVOQUA WATER TECHNOLOGIES 	**Budget and Equipment Data Sheet** **Primary Tanks** **COLLECTOR MECHANISMS**	**Installation:** Traverse Cy, Mich. **Engineer:** Hubbell, Roth & Clarke **Proposal No.:** 16' x 66.5' 4-sh **Date:** September 30, 2019 **By:** Steve Ihde **Equipment No.: 1**

A. CHARACTERISTICS

Manufacturer	Evoqua Water Technologies LLC (Evoqua) - Waukesha, Wisconsin USA
Equipment Description	Envirex® Sludge Collecting Equipment for Primary Sedimentation Basin - Wastewater Plant
Basin Quantity	2
Each Basin Contains	1 Tank
Each Tank Contains	2 Longitudinal Collector Mechanism
Total Sludge Collector Mechanisms	4
Collector Scraping Width	16.00 ft
Tank Length	66.5 ft
Max. WATER Depth (Measured at point nearest edge of hopper)	10.00 ft
New or Existing Tanks	Existing

Overall Channel Width		**Dividing Wall Type**		**Dividing Wall(s') Thickness**	
	16.00 ft		N/A		None

Budget Information

(4) ea Longitudinal Sludge Collectors

Scum Pipes (4) ea 10 Inch Dia X 16.0 ft Lg

Field Service Included:

Trips: **2**

8 Hr Days at Site: **4**

Estimated Freight included

FOB Shipping Point

Est (2) Truck loads

$197,100 Total USD

Budget

Preliminary budget is based on limited information, Evoqua standard equipment selection, and standard terms of sale and warranty terms. Any variations from these standards may affect this budget. Additionally, please note that this budget is for review and informational purposes only and does not constitute an offer for acceptance. A copy of our standard Terms & Conditions are available upon request.
Budget based on delivery within one (1) year from date of this submittal.

Pairs of Sprockets per Collector	4	
Flight Speed	2.0 ft/min	
Flight Spacing - Longitudinal	10.0 ft	
Sludge Load (Average)	4.0 lb/ft	Primary at 4% sludge concentration with 8 inch (200mm) tall flights = 4 lb/ft
Friction Factors	0.20 to 0.30 (UHMW-PE on UHMW-PE - water lubricated) 0.05 to 0.10 (UHMW-PE on Stn. Stl. - water lubricated)	
Bearing Friction Factors	0.05 per shaft assembly	
Shaft Deflection	Less than 0.033 inches/ft of shaft length	

B. MATERIALS

CHAIN	
Flight Carry Chain	NCS720S-NX - Non-metallic, unfilled acetal resin chain and reinforced nylon resin pins, 3/8 inch (10mm) flight fasteners, working load 3100 lbf (13.8 kN), minimum ultimate 6,000 lbf (27 kN), weight 1.3 lb/ft (1.9 kg/m)
Drive Chain	NH78 - Unfilled acetal links, SS pin, working load 1750 lb (7.78 kN), min. ultimate 4,000 lb (17.79 kN), weight 1.4 lb/ft (2.1 kg/m)
FLIGHTS	
Flights	Sigma Plus FRP 3 x 8 inch (75 x 200 mm) - Modulus of elasticity (E, psi) x moment of inertia (I, in^4) >/= 6.83 x 10^6 lb-in^2 (19.5 kN-m^2) about its minor axis, 50 to 60% glass content
WEAR SHOES	
Wear Shoes - Return Track	UHMW-PE with lug every flight Wear shoe (track) - Virgin Black UHMW-PE, ASTM D-4020, w/ lug 4.5 x 3 x 0.5 inch (114 x 76 x 12.7mm), min. 62 Shore "D" ASTM D-2240, 6,000 psi (41,400 KPA) ultimate tensile
Wear Shoes - Floor	Wear shoe (floor) - Virgin Black UHMW-PE, ASTM D-4020 5.5 wide x 3 x 0.5 inch (140 x 76 x 12.7mm), min. 62 Shore "D" ASTM D-4020, 6,000 psi (41,400 KPA) ultimate tensile
WEAR STRIPS	
Floor	UHMW-PE 5/8 X 2 5/8 inch (16 x 67mm) - 2 lines per tank
Attachment	316SS convex washer, #14 x 1-1/2 inch (6 x 38mm) 316SS pan head self tapping screw and vinyl anchor
Return Tracks	UHMW-PE 5/8 X 2 5/8 inch (16 x 67mm)
Attachment	316SS convex washer, 1/4 inch (6mm) 410SS, zinc plated self-drilling & tapping pan head screw
RETURN TRACKS	3 x 3 x 3/8 inch (76 x 76 x 9.5mm) **Track Mat'l:** FRP
Supports	Non-metallic - Polypropylene and Schedule 80 CPVC Pipe **Support Mat'l:** Non-metallic
Support Spacing	10.0 ft (3.0m)
DEFLECTOR ANGLES	3 x 3 x 3/8 inch (76 x 76 x 10mm) with UHMW-PE wear strips and 316SS fasteners **Track Mat'l:** Carbon Steel
Supports	A500 Sch. 40 steel pipe with 1/4 inch (6mm) steel end plates **Support Mat'l:** Carbon Steel Note: Deflector angles will be furnished only if it is determined by Evoqua at time of drawing submittal that
SHAFTING	**Shaft Material:** 1018 CRS with LPS-3 Rust Veto **Idler Shaft Material:** 304SS **Idler Shaft Bracket Material:** Cast Iron **Shafting Outside Diameter**
Head Shaft	Solid cold rolled steel with keyways for Head Shaft sprockets — 3.5 inch (89mm)
Lower Influent Idler Shaft	Stub shaft with cast iron base — **Shaft** Sch. 40S pipe — 3.5 inch (89mm)
Lower Effluent Idler Shaft	Same as Lower Influent Idler Shaft — **Shaft** Sch. 40S pipe — 3.5 inch (89mm)
Upper Effluent Idler Shaft	Same as Lower Influent Idler Shaft — **Shaft** Sch. 40S pipe — 3.5 inch (89mm)
Set Collars for Head Shaft	Split UHMW set collar with 316SS band clamp
COLLECTOR BEARINGS	
Head Shaft	Cast steel split housing, polyurethane, self-aligning bearing, water lubricated with provisions for greasing when unsubmerged — Solid Hub Ball
Upper Effl & Lower Effl Idler Shafts	Sprocket bore rotates on Virgin UHMW-PE sprocket sleeve bearing, sprocket position retained by UHMW-PE set collar
Upper Effluent	Same as Lower Influent Idler Shaft
GREASING PROVISIONS	
Greasing Provisions	Grease line for driven side Head Shaft bearing only, remaining bearings grease fitting in housing.
Type / Material	Head Shaft driven side bearing with rubber flex line with Alemite grease fitting, 1/8 inch NPT, material
COLLECTOR SPROCKETS	
Head Shaft	NCS720S, 23T-22.24 inch (565mm) PD w/ chain saver rim, split cast nylon, bolted hub with 316SS hdw. and set screws
Idler Shaft	NCS720S, 17T-16.61 inch (422mm) PD w/ chain saver rim, solid cast nylon

DRIVE SPROCKET and TORQUE LIMITER	N78-11T-9.26 inch (235mm) PD polyurethane tooth segments and shear pin torque limiter **Hub Material:** 316SS Torque Limiter
DRIVEN SPROCKET	N78-40T-33.25 inch (845mm) PD, split polyurethane hub, deep dished and replaceable polyurethane tooth segments, 316 SS hdw.
DRIVE UNIT	
SPEED REDUCER	
Each reducer will drive	two (2) longitudinal collectors
Longitudinal reducer will be	jackshaft with sprocket and shear pin torque limiter for each collector
Manufacturer	Eurodrive or equal
Specifications:	Helical gear, fully housed, running in oil, anti-friction bearings throughout
Sizing of reducer	Torque rated at minimum 1.25 S.F. of calculated sludge load
Motor attachment	C-face
Paint	Original factory finish
MOTOR	
Manufacturer	Baldor (C-face) or equal
HP (kw)	0.5 HP (0.37kw)
Service Factor	1.25
V / Ph / Hz	230/460 V 3 Ph 60 Hz
RPM	1750
Encl. / Insul. / NEMA (IP) Design	TEFC (IP55) Enclosure / Class F Insulation / NEMA Design B
Efficiency	Premium Efficient
Paint	Original factory finish
Torque Overload Protection Device	Shear pin torque limiter with combination NEMA 4X (IP67) / NEMA 7 (IEC Zone 0 and 1) limit switch
Drive Base	304SS
Chain Guard	14 Ga. (3mm) 304SS
Drive Chain Tightener	316SS bracket, self-aligning, self-lubricated with N78-7T Polyurethane Sprocket
ELECTRICAL CONTROLS	
Controls	Over torque indicating switches only - all other controls NOT by Evoqua
HARDWARE	
Flights	316SS HHCS's, flat washers, and locknuts
Miscellaneous connections	316SS
Thread Standard	Unified American Standard
Anchors	Stud anchors for all locations except adhesive for stub shaft brackets
Anchor material	316SS
PAINT	
Surface prep (Non-Subm)	Shop blast to SSPC-SP10
Surface prep (Submerged)	Shop blast to SSPC-SP10
Shop prime - Non-submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Shop prime - Submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Finish paint - Non-submerged	Field applied coating by others
Finish paint - Submerged	Field applied coating by others
Paint Note:	All non-stainless steel shafting, including Head Shafts, Idler Shafting and exposed machined surfaces are solvent wiped followed by one (1) coat of Evoqua standard shop preservative. Wood, stainless steel, nonferrous materials and galvanized surfaces are unpainted. Unless specified, structural stainless steel is not passivated.
SKIMMING EQUIPMENT	Scum pipes by Evoqua **See Separate Equipment Data Sheet (EDS)**
SPARE PARTS	Spare parts are Not included.

EXCLUSIONS

Our equipment does NOT include any controls except as specifically stated within this Proposal, tools (except chain tool for NCS720S chain), grease lines, troughs, weirs, baffles, pumps, valves, weir gates, floor or wall sleeves, shims, grout, anchor templates, setting of anchor bolts, lubricants, finish painting, installation, taxes or duties, or material excluded under the General Items of this Proposal.

NOTE:

Evoqua will furnish equipment as proposed for the Contractor to install. Labor, equipment necessary for alterations and/or installation of our equipment, repair, alterations or cleaning of the existing structures, is the responsibility of the Contractor. Evoqua is not responsible for the locations, condition or dimensions of existing concrete, anchors, or any equipment not furnished by Evoqua. For existing sludge collector mechanism installations, concrete modifications may be required to accommodate newer style components. Example: The driven sprocket recess may need to be made deeper and/or larger.

EVOQUA WATER TECHNOLOGIES CONFIDENTIAL ALL RIGHTS RESERVED	**Equipment Data Sheet** **Primary Tanks** **SCUM PIPES**	**Installation:** Traverse Cy, Mich. **Engineer:** Hubbell, Roth & Clarke **Proposal No.:** 16' x 66.5' 4-sh **Date:** September 30, 2019 **By:** SDI **Equipment No.:** **1**

A. CHARACTERISTICS

Manufacturer	Evoqua Water Technologies LLC (Evoqua) - Waukesha, Wisconsin USA
Equipment Description	Envirex® Scum Pipes Manual Lever
Total Scum Pipes	4
Scum Pipe Diameter	10 inch
Scum Pipe Length	16.00 ft
New or Existing Tanks	Existing
Budget Information	Scum Pipes are included in the Chain and Flight budget

B. MATERIALS

PIPE	
Material	Carbon steel - ASTM A53, Grade B, black
Size	10 inch
Wall Thickness	0.25 inch
Specifications	0.25 inch (6mm) wall thickness, 60 degree slotted weir openings and 2 inch (50mm) wide full periphery stiffening bands every 2 ft (610mm)
END SUPPORTS and SET COLLARS	
Material	Carbon steel
Specifications	Adjustable end plate with rolled collar and replaceable UHMW-PE bearing liner. Set collars, same material as end plate, secures pipe and seal position.
Seals - Wall to open end support	Plywood - 1/2 inch (12mm) thick, Marine Grade
Seals - Pipe to open end support	Hycar - Buna N synthetic rubber
OPERATOR	
Type	Manual Lever
Lever Material	Carbon steel - ASTM A53, Grade B, black
Lubrication	No lubrication required
Specifications	1.5 inch (38mm) dia. Sch. 40 pipe lever
Min. Pipe Rotation Each Direction	30 degrees
HARDWARE	
Miscellaneous connections	316SS
Thread Standard	Unified American Standard

Anchors	Stud anchors for all locations except adhesive for stub shaft brackets
PAINT	
Surface prep (Non-Subm)	Shop blast to SSPC-SP10
Surface prep (Submerged)	Shop blast to SSPC-SP10
Shop prime - Non-submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Shop prime - Submerged	Sherwin-Williams Dura-Plate 235NSF red oxide epoxy 4-8 mil DFT or Equal
Finish paint - Non-submerged	Field applied coating by others
Finish paint - Submerged	Field applied coating by others
Paint Note:	All non-stainless steel shafting and exposed machined surfaces are solvent wiped followed by one (1) coat of Evoqua standard shop preservative. Wood, stainless steel, nonferrous materials and galvanized surfaces are unpainted.

EXCLUSIONS

Our scum pipe(s) do NOT include any controls, tools, spray headers, nozzles, effluent troughs, baffles, wall sleeves, pipe sleeves, setting of anchor bolts, special or finish painting, equipment installation, taxes or duties, equipment installation, or materials noted under the General items of our Proposal.

CONTRACTOR NOTE:

Evoqua will furnish equipment as proposed for the Contractor to install. Labor, equipment necessary for alterations and/or installation of our equipment, repair, alterations or cleaning of the existing structures, is the responsibility of the Contractor. Evoqua is not responsible for the locations, condition or dimensions of existing concrete, anchors, or any equipment not furnished by Evoqua. For existing sludge collector mechanism installations, concrete modifications may be required to accommodate newer style components. Example: The driven sprocket recess may need to be made deeper and/or larger.

Urquhart, Douglas

From:	Joe Gentle <joe@peswater.com>
Sent:	Tuesday, October 15, 2019 1:29 PM
To:	Benoit Dennis J.
Subject:	FW: Traverse City, MI Primary Clarifier Rehab AMWELL SO# 93061 and 93062 Budget Pricing October 2019 G-4555
Attachments:	AMWELL Typical PSG Fabricated Pipe Skimmers.pdf

Dennis,

Here's Amwell's quote for the primaries, working on the rest now.

Joe

From: Paul Haizman [mailto:phaizman@amwell-inc.com]
Sent: Tuesday, October 15, 2019 12:02 PM
To: 'Joe Gentle'
Subject: RE: Traverse City, MI Primary Clarifier Rehab AMWELL SO# 93061 and 93062 Budget Pricing October 2019 G-4555

Joe,

In around 1995, AMWELL furnished the following chain and flight collection equipment to this facility:

- SO# 93061 - **Four (4)** Chain and flight collectors for tanks approximately 14' wide x 52' long x 11'-3" AWD **(Tanks 1N,2N, 1S & 2S)**
- SO# 93062 - **Four (4)** Chain and flight collectors for tanks approximately 16' wide x 65' long x 9'-4" AWD **(Tanks 3N,4N, 3S & 4S)**

The budget scope of supply for completely replacing this chain and flight collector equipment would be as follows:

- Anchorage, SS
- Gearmotor with Overload Protection device
- Drive Chain, NH-78 Non -metallic
- Shafts, Steel
- Bearings, CI with UHMW liner
- Sprockets, UHMW or Nylon
- Main Chain, 720S non-metallic Hydrolink
- Return Track and support brackets, FRP
- Sludge Flights, FRP
- Wear Shoes and Wear strips, UHMW
- Assembly fasteners, SS
- Delivery
- Approval Drawings
- I,O & M's

- Field Service

The approximate budget cost for replacing chain and flight equipment in all of these **eight (8)** tanks would be between **$ 295,000 – $ 325,000 complete.**

We did not supply any new scum troughs during the last contract. They used their existing units.

If needed, a budget scope for the required gear and handwheel operated pipe skimmers would be as follows:

- Anchorage
- Wall Seals, neoprene
- Bearings,304 SS
- Sleeves, 304 SS
- D Ring Seals, neoprene
- Slotted trough,304 SS
- Operator, 304 SS
- Hand Wheel, CI
- Approval Drawings
- Delivery
- Spare Parts

The approximate budget cost for replacing the gear and handwheel operated pipe skimmers (assume 10" dia. for budget purposes) in all of these **eight (8)** tanks would be between **$ 110,000 - $122,000 complete.**

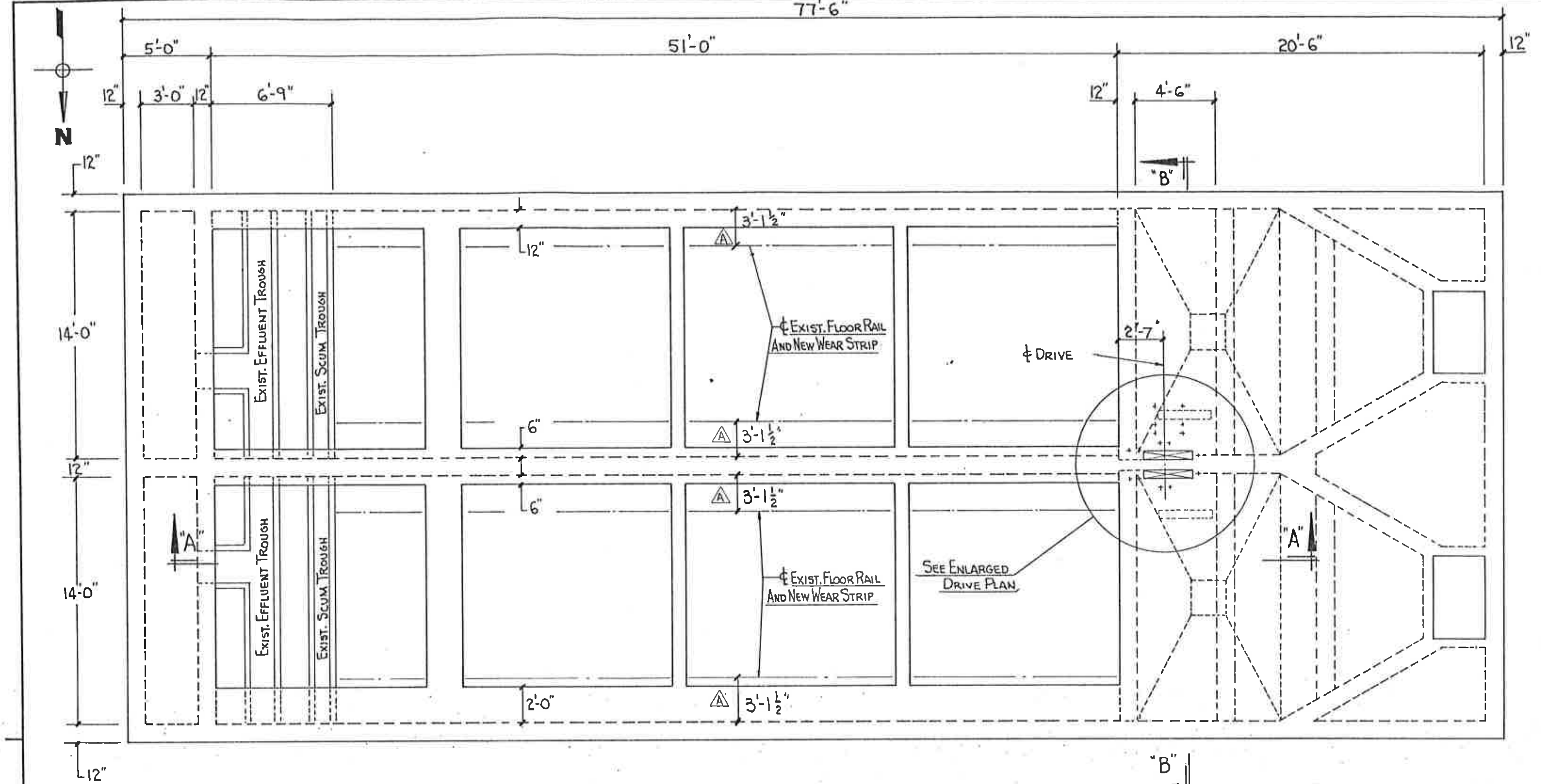
I have attached a general arrangement drawing of the gear and handwheel operated pipe skimmers in side by side tanks for your reference.

Let me know if you have any further questions.

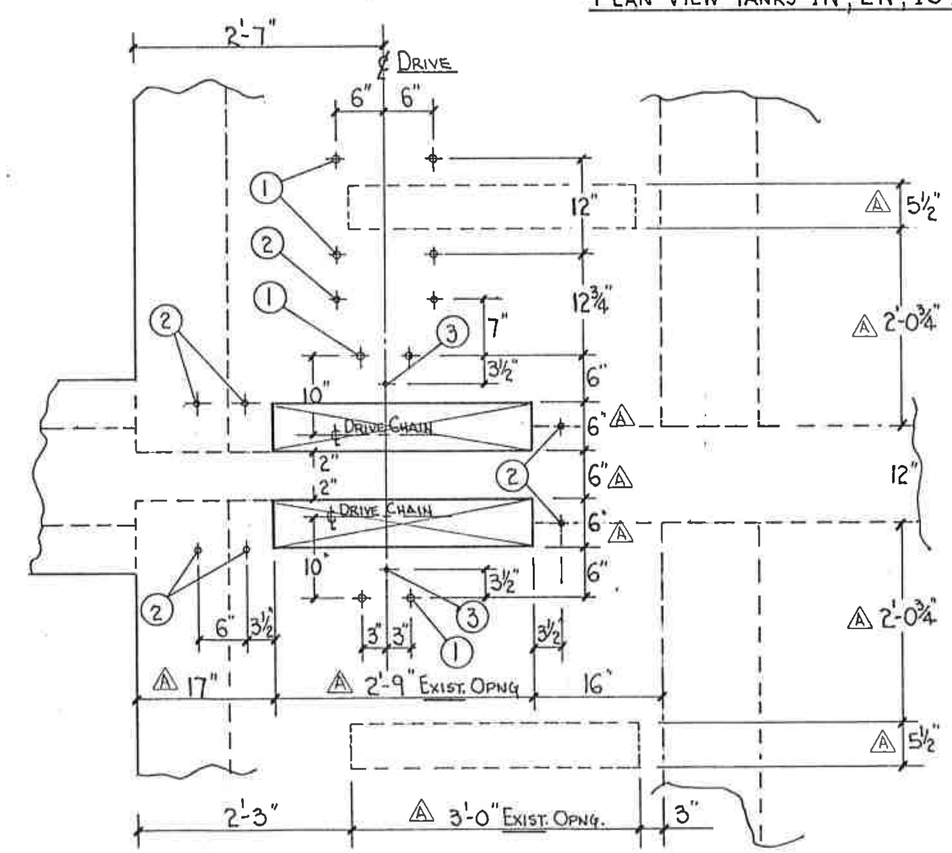
Regards,

Paul Haizman
AMWELL – A Division of McNish Corporation
600 North Commons Drive, Suite 116
Aurora, IL 60504
P: 630-898-6900 x3914
C: 630-347-9506
F: 630-898-1647

NO.	DESCRIPTION	MAT'L	QTY.	PART NO.



Plan View Tanks 1N, 2N, 1S & 2S



Enlarged Drive Plan

Notes:
1) Section "A-A" Shown On Dwg. D101-42721-162.
2) Section "B-B" Shown On Dwg. D101-42722-162.
3) Anchor Bolt Schedule Shown On Dwg. D101-42721-162.

Project: Traverse City, MI.

SYM.	REVISIONS	BY	CK'D.	DATE
A	DIM'S CONFIRMED, CORRECTED, OR PROVIDED BY CONTRACTOR	RON		9/26/95

AMWELL FURNISHES MECHANISM TO FIT TANK OF DIMENSIONS GIVEN. BUT IS NOT RESPONSIBLE FOR CONCRETE DESIGN. CUSTOMER TO FURNISH NECESSARY REINFORCING STEEL AND TO DETERMINE SIZE AND PLACEMENT OF FOOTINGS TO SUIT LOCAL CONDITIONS.

AMWELL DOES NOT FURNISH PIPING (EXCEPT AS NOTED) FLOOR RAILS, TROUGHS, GRATINGS, WEIR PLATES, OIL OR GREASE FOR LUBRICATION. ANY WIRING OR CONDUITS BETWEEN MOTORS, CONTROLS AND ALARMS OR ANY ELECTRICAL EQUIPMENT OF ANY KIND EXCEPT AS SPECIFICALLY STATED IN AMWELL SPECIFICATIONS.

MICROFILMED

PATT. NO.

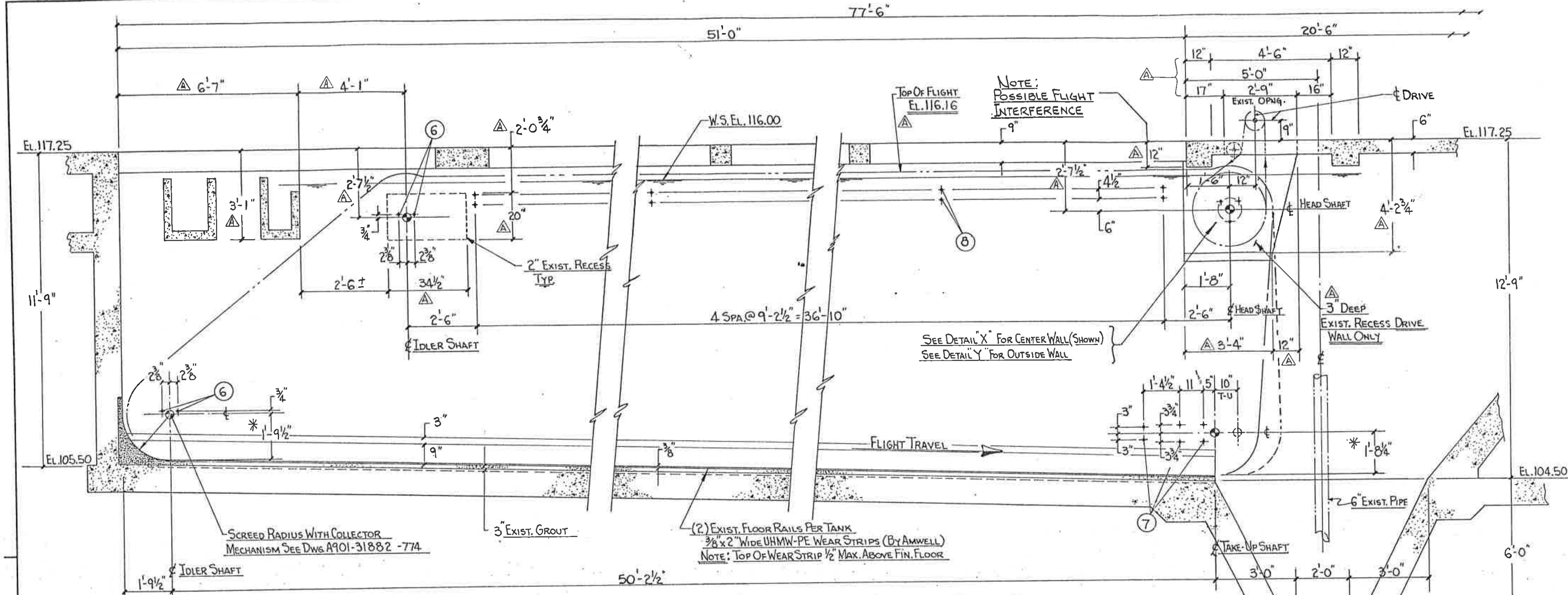
LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL
2 DECIMAL
3 DECIMAL
ANGULAR

AMWELL
AURORA, ILLINOIS, USA
(ORIGINALLY AMERICAN WELL WORKS — EST. 1868)

DRAWN Ron
CHECKED
APP'D.
DATE 1/17/95
S.O. 93061-11
SCALE —

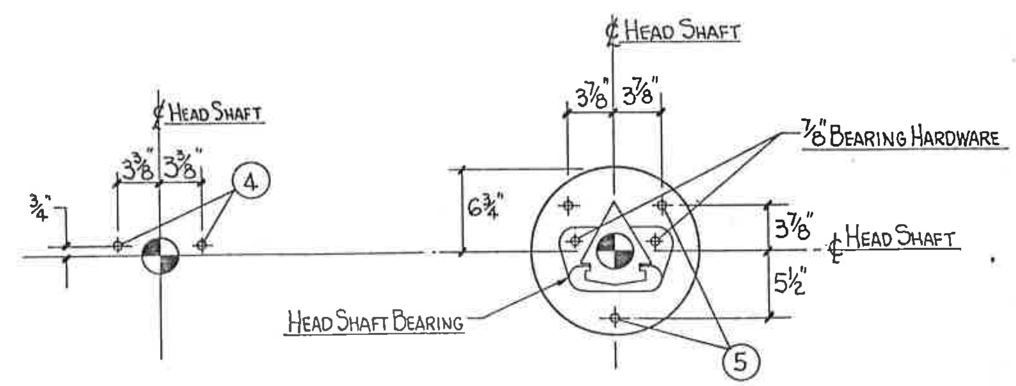
DESCRIPTION
General Arrangement Model "CHP-42"
Rectangular Collectors

DRAWING NO. D101-42720-162 REV. A



Section "A-A"
(From Dwg. D101-42720-162)

*= Measured Above Top Of Wear Strip.
Note That A Larger Radius Is Required At Lower Back Idler.



Detail "Y"
@ Outside Wall Only

Detail "X"
3/4" Thk. Head Shaft Bearing Mounting Plate Each Side Of Center Wall (Drive Wall)

Expansion Anchor Bolt Schedule (304 Stnls. Stl.)

Nº	Size	Hole Size & Depth	Location	Total Qty.
1	5/8" x 6" Lg.	5/8"⌀ x 4" Dp.	Drive Base & Bearing Pedestal	16
2	1/2" x 3 3/4" Lg.	1/2"⌀ x 3" Dp.	Drive Chain Take-Up & Guards	16
3	3/8" x 3" Lg.	3/8"⌀ x 2 1/4" Dp.	Shear Pin Limit Switch Bracket	4
4	7/8" x 8" Lg.	7/8"⌀ x 5 1/2" Dp.	Head Shaft Bearing	8
5	3/4" x 12" Thrd. Rod	3/4"⌀ Thru	Head Shaft Bearing Mounting Plate	6
6	3/4" x 6 1/4" Lg.	3/4"⌀ x 4 1/4" Dp.	Idler Shaft Bearing	32
7	3/4" x 5 1/2" Lg.	3/4"⌀ x 4 1/2" Dp.	Main Chain Take-Up Ass'y.	48
8	5/8" x 5" Lg.	5/8"⌀ x 3 1/2" Dp.	Return Track Support Bracket	96

Project: Traverse City, MI.

Sym.	Revisions	By	Ck'd.	Date
A	Dim's. Confirmed, Corrected or Provided By Contractor	Ron		9/26/95

Amwell furnishes mechanism to fit tank of dimensions given but is not responsible for concrete design. Customer to furnish necessary reinforcing steel and to determine size and placement of footings to suit local conditions.

Amwell does not furnish piping (except as noted) floor rails, troughs, gratings, weir plates, oil or grease for lubrication, any wiring or conduits between motors, controls and alarms or any electrical equipment of any kind except as specifically stated in Amwell specifications.

Microfilmed

Patt. No.

Limits unless otherwise specified
Fractional
2 Decimal
3 Decimal
Angular

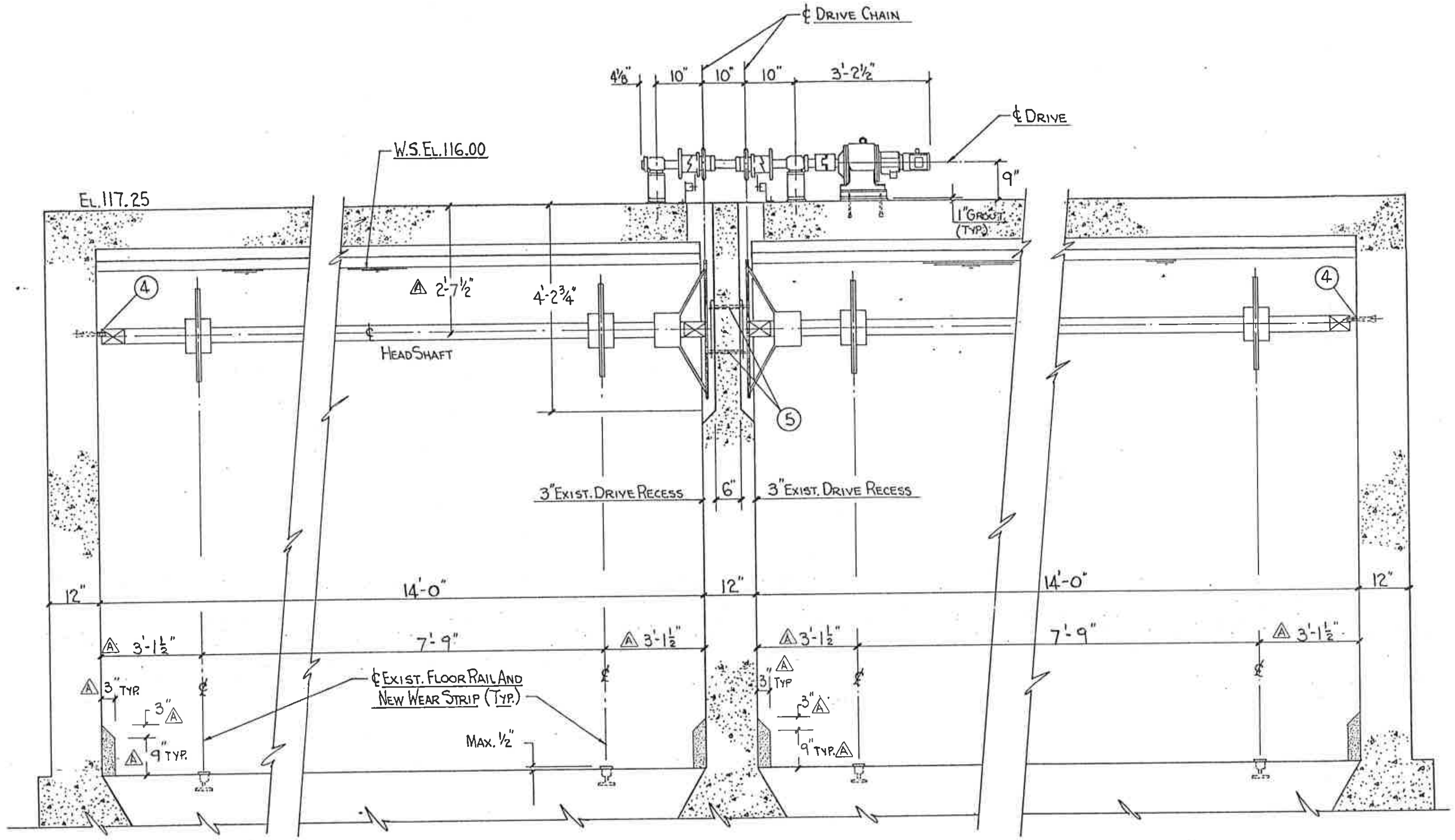
AMWELL
Aurora, Illinois, USA
(Originally American Well Works — Est. 1868)

Drawn Ron
Checked
App'd.
Date 1/19/95
S.O. 93061-11
Scale ~

Description: General Arrangement

Drawing No. D101-42721-1162 Rev. A

NO.	DESCRIPTION	MAT'L	QTY.	PART NO.



SECTION "B-B"
(FROM DWG. D101-42720-162)

NOTE:
1.) ANCHOR BOLT SCHEDULE SHOWN ON DWG. D101-42721-162.

PROJECT: TRAVERSE CITY, MI.

SYM.	REVISIONS	BY	CK'D.	DATE
A	DIM'S CONFIRMED, CORRECTED OR PROVIDED BY CONTRACTOR	RON		6/26/95

AMWELL FURNISHES MECHANISM TO FIT TANK OF DIMENSIONS GIVEN, BUT IS NOT RESPONSIBLE FOR CONCRETE DESIGN. CUSTOMER TO FURNISH NECESSARY REINFORCING STEEL AND TO DETERMINE SIZE AND PLACEMENT OF FOOTINGS TO SUIT LOCAL CONDITIONS.

AMWELL DOES NOT FURNISH PIPING (EXCEPT AS NOTED) FLOOR RAILS, TROUGHS, GRATINGS, WEIR PLATES, OIL OR GREASE FOR LUBRICATION, ANY WIRING OR CONDUITS BETWEEN MOTORS, CONTROLS AND ALARMS OR ANY ELECTRICAL EQUIPMENT OF ANY KIND EXCEPT AS SPECIFICALLY STATED IN AMWELL SPECIFICATIONS.

MICROFILMED

PATT. NO.

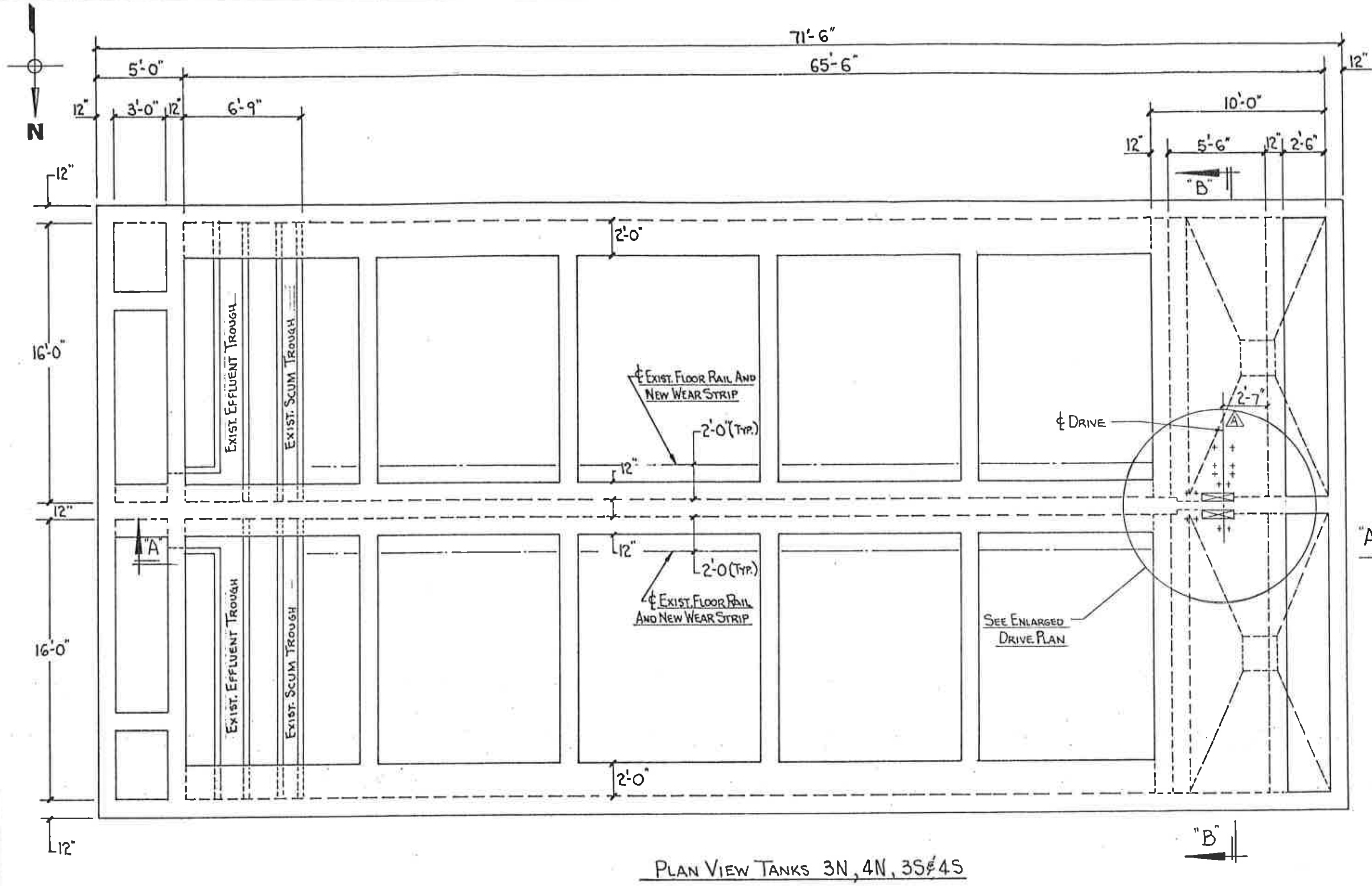
LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL
2 DECIMAL
3 DECIMAL
ANGULAR

AMWELL
AURORA, ILLINOIS, USA
(ORIGINALLY AMERICAN WELL WORKS — EST. 1868)

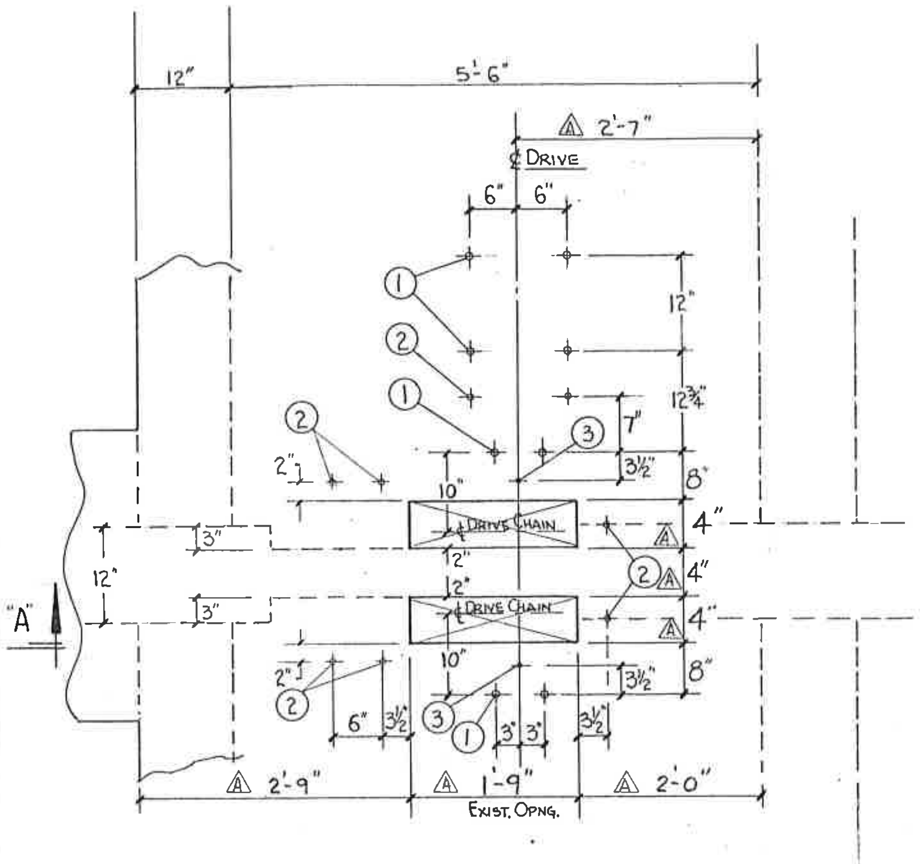
DRAWN RON
CHECKED
APP'D.
DATE 1/20/95
S.O. 93061-11
SCALE —

DESCRIPTION: GENERAL ARRANGEMENT

DRAWING NO. D101-42722-162 REV. A



Plan View Tanks 3N, 4N, 3S & 4S



Enlarged Drive Plan

Notes:
1.) Section "A-A" Shown On Dwg. D101-42726-162.
2.) Section "B-B" Shown On Dwg. D101-42727-162.
3.) Anchor Bolt Schedule Shown On Dwg. D101-42726-162.

Project: Traverse City, MI.

NO.	DESCRIPTION	MAT'L.	QTY.	PART NO.

SYM.	REVISIONS	BY	CK'D.	DATE
A	DIM'S. CONFIRMED, CORRECTED OR PROVIDED BY CONTRACTOR.	Ron		7/26/95

AMWELL FURNISHES MECHANISM TO FIT TANK OF DIMENSIONS GIVEN, BUT IS NOT RESPONSIBLE FOR CONCRETE DESIGN. CUSTOMER TO FURNISH NECESSARY REINFORCING STEEL AND TO DETERMINE SIZE AND PLACEMENT OF FOOTINGS TO SUIT LOCAL CONDITIONS

AMWELL DOES NOT FURNISH PIPING (EXCEPT AS NOTED) FLOOR RAILS, TROUGHS, GRATINGS, WEIR PLATES, OIL OR GREASE FOR LUBRICATION, ANY WIRING OR CONDUITS BETWEEN MOTORS, CONTROLS AND ALARMS OR ANY ELECTRICAL EQUIPMENT OF ANY KIND EXCEPT AS SPECIFICALLY STATED IN AMWELL SPECIFICATIONS

MICROFILMED

PATT. NO.

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL
2 DECIMAL
3 DECIMAL
ANGULAR

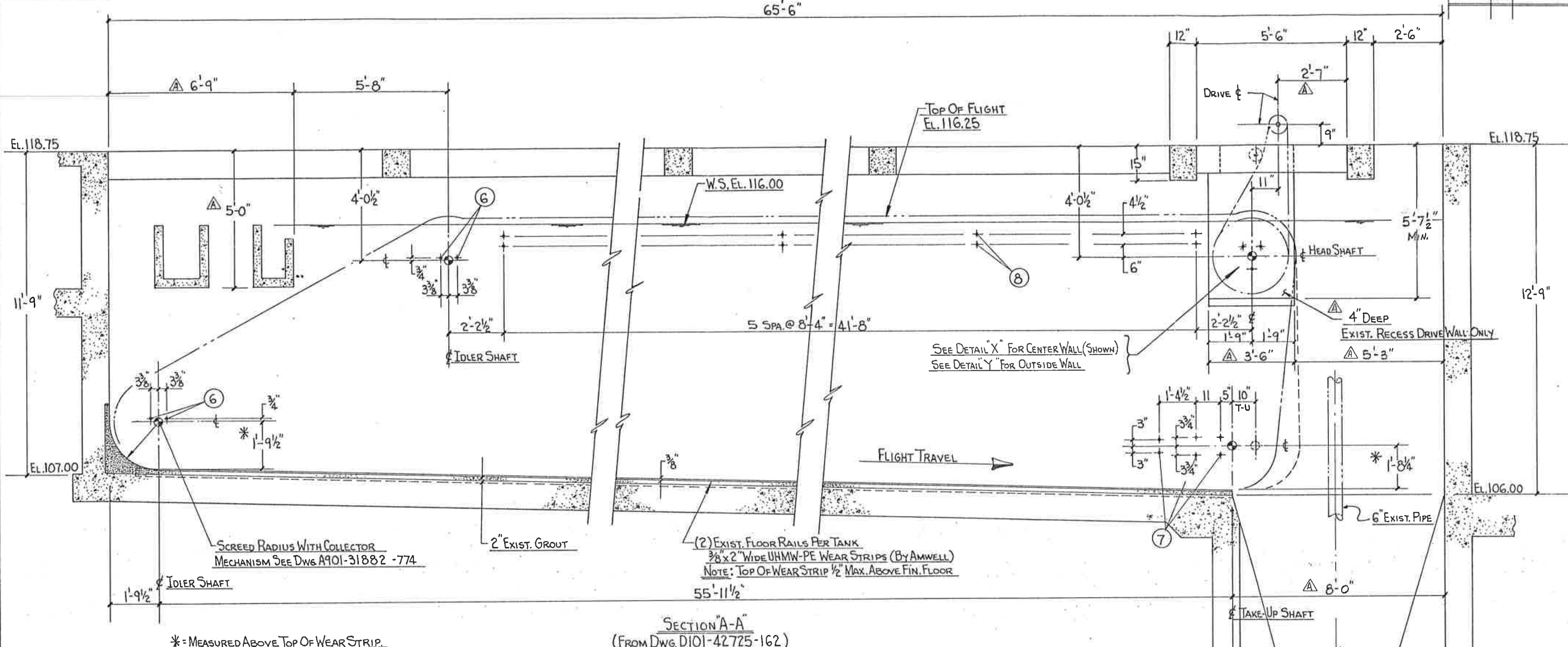
AMWELL
AURORA, ILLINOIS, USA
(ORIGINALLY AMERICAN WELL WORKS — EST. 1868)

DRAWN	Ron
CHECKED	
APP'D.	
DATE	1/17/95
S.O.	93062-11
SCALE	

DESCRIPTION
General Arrangement Model "CHP-42"
Rectangular Collectors

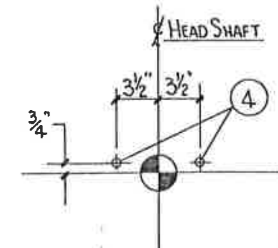
DRAWING NO. D101-42725-162 REV. A

MAT'L.	QTY.	PART NO.

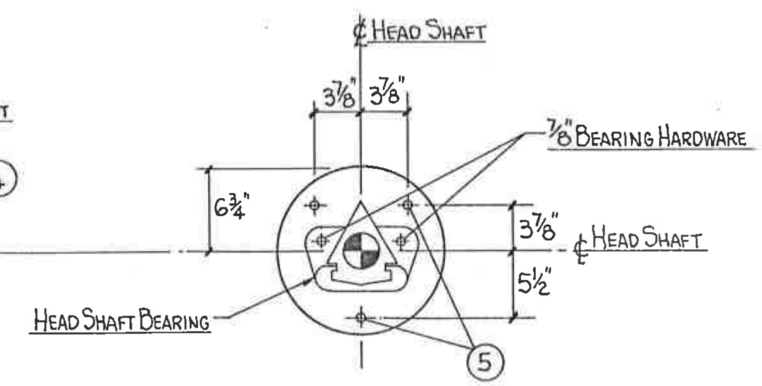


Section "A-A"
(From Dwg. D101-42725-162)

* = Measured Above Top Of Wear Strip.
Note That A Larger Radius Is Required
At Lower Back Idler.



Detail "Y"
@ Outside Wall Only



Detail "X"
¾" Thk. Head Shaft Bearing Mounting
Plate Each Side Of Center Wall (Drive Wall)

Expansion Anchor Bolt Schedule (304 Stnls. Stl.)

	№	Size	Hole Size & Depth	Location	Total Qty.
	1	⅝"x6" Lg.	⅝"Ø x 4" Dp.	Drive Base & Bearing Pedestal	16
	2	½"x3¾" Lg.	½"Ø x 3" Dp.	Drive Chain Take-Up & Guards	16
	3	⅜"x3" Lg.	⅜"Ø x 2¼" Dp.	Shear Pin Limit Switch Bracket	4
	4	⅞"x8" Lg.	⅞"Ø x 5½" Dp.	Head Shaft Bearing	8
A	5	¾"x10" Thrd. Rod	¾"Ø Thru	Head Shaft Bearing Mounting Plate	6
	6	⅞"x8" Lg.	⅞"Ø x 5½" Dp.	Idler Shaft Bearing	32
	7	¾"x5½" Lg.	¾"Ø x 4½" Dp.	Main Chain Take-Up Ass'y.	48
	8	⅝"x5" Lg.	⅝"Ø x 3½" Dp.	Return Track Support Bracket	

Project: Traverse City, MI.

SYM.	REVISIONS	BY	CK'D.	DATE
A	DIM'S. CONFIRMED, CORRECTED OR PROVIDED BY CONTRACTOR	RON		9/26/95

AMWELL FURNISHES MECHANISM TO FIT TANK OF DIMENSIONS GIVEN, BUT IS NOT RESPONSIBLE FOR CONCRETE DESIGN. CUSTOMER TO FURNISH NECESSARY REINFORCING STEEL AND TO DETERMINE SIZE AND PLACEMENT OF FOOTINGS TO SUIT LOCAL CONDITIONS.

AMWELL DOES NOT FURNISH PIPING (EXCEPT AS NOTED) FLOOR RAILS, TROUGHS, GRATINGS, WEIR PLATES, OIL OR GREASE FOR LUBRICATION. ANY WIRING OR CONDUITS BETWEEN MOTORS, CONTROLS AND ALARMS OR ANY ELECTRICAL EQUIPMENT OF ANY KIND EXCEPT AS SPECIFICALLY STATED IN AMWELL SPECIFICATIONS.

MICROFILMED

PATT. NO.

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL
2 DECIMAL
3 DECIMAL
ANGULAR

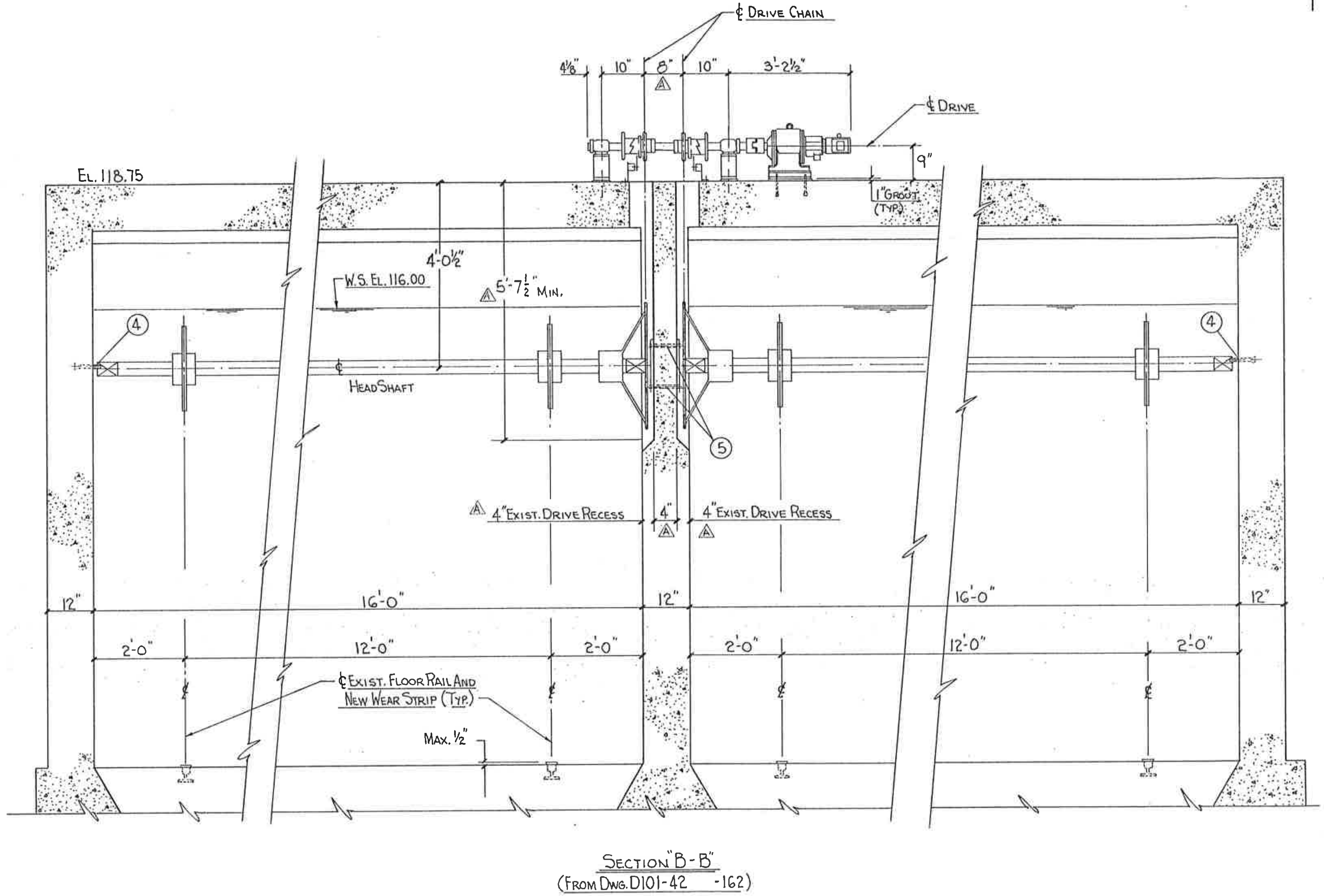
AMWELL
AURORA, ILLINOIS, USA
(ORIGINALLY AMERICAN WELL WORKS — EST. 1868)

DRAWN Ron
CHECKED
APP'D.
DATE 1/18/95
S.O. 93062-11
SCALE —

DESCRIPTION
General Arrangement

DRAWING NO. D101-42726-162 REV. A

NO.	DESCRIPTION	MAT'L	QTY.	PART NO.



Section "B-B"
(From Dwg. D101-42 -162)

Note:
1.) Anchor Bolt Schedule Shown On Dwg. D101-42726-162.

Project: Traverse City, MI.

SYM.	REVISIONS	BY	CK'D.	DATE
A	Revised Per Appr.	Ron		6/28/95

AMWELL FURNISHES MECHANISM TO FIT TANK OF DIMENSIONS GIVEN, BUT IS NOT RESPONSIBLE FOR CONCRETE DESIGN. CUSTOMER TO FURNISH NECESSARY REINFORCING STEEL AND TO DETERMINE SIZE AND PLACEMENT OF FOOTINGS TO SUIT LOCAL CONDITIONS.

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PATT. NO.

LIMITS UNLESS OTHERWISE SPECIFIED
FRACTIONAL
2 DECIMAL
3 DECIMAL
ANGULAR

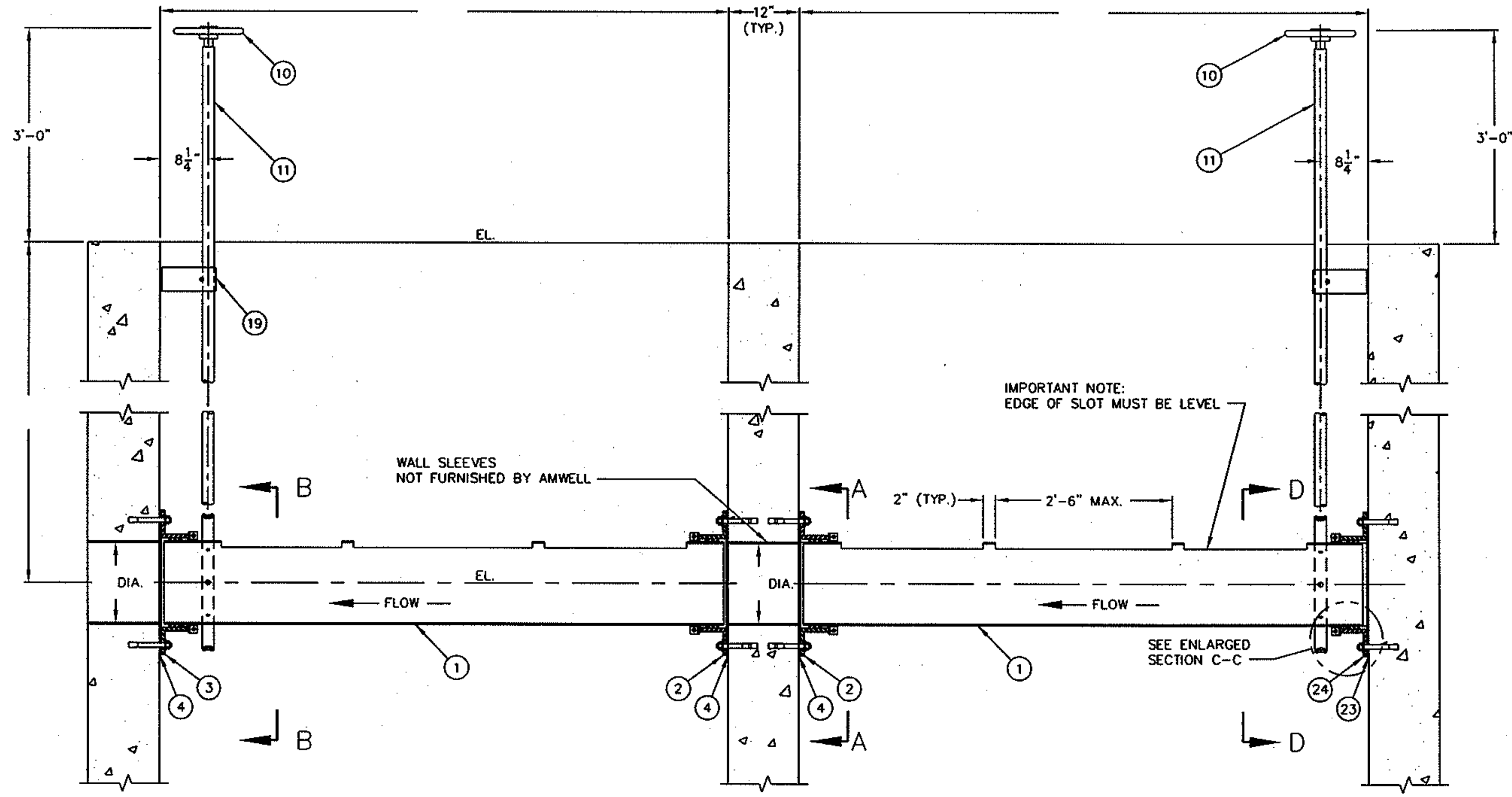
THIS PRINT IS SUBJECT TO RETURN UPON DEMAND AND IS LOANED UPON THE EXPRESS CONDITION THAT IT IS NOT TO BE USED DIRECTLY OR INDIRECTLY IN ANY WAY DETRIMENTAL TO THE INTERESTS OF:

AMWELL
AURORA, ILLINOIS, USA
(ORIGINALLY AMERICAN WELL WORKS — EST. 1868)

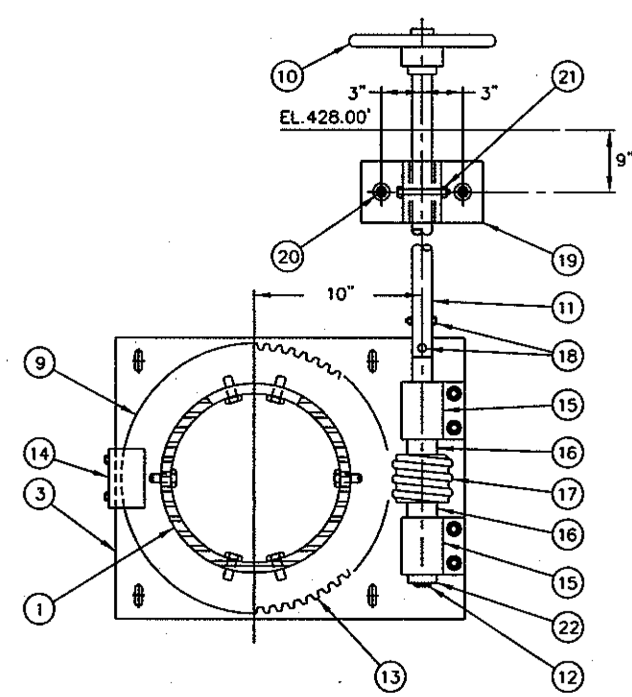
DRAWN Ron	DESCRIPTION General Arrangement
CHECKED	
APP'D.	
DATE 1/20/95	
S.O. 93062-11	DRAWING NO. D101-42727-162
SCALE	REV. A

NOMENCLATURE

1. SKIMMER PIPE
2. WALL BEARING
3. OPERATOR WALL BEARING – R.H.
4. 1/4" THICK NEOPRENE GASKET
5. SET COLLAR
6. BUNA–N RING SEAL
7. WEAR BAR UHMW–PE
8. ADHESIVE ANCHORS, 3/4" X 8" LG. DRILL 3/4" X 6" DEEP HOLE (4 PER WALL BEARING)
9. GUIDE LUG
10. HANDWHEEL
11. SHAFT EXTENSION
12. WORM SHAFT
13. WORM GEAR
14. RETAINER
15. BABBITTED BEARING
16. SPACER
17. WORM
18. CAPSCREW, 3/8" X 2 1/2" LG. W/ LOCKNUT
19. SHAFT EXTENSION GUIDE (IF REQUIRED)
20. ADHESIVE ANCHORS, 5/8" X 6" LG. DRILL 5/8" X 5" DEEP HOLE (2 REQ'D.)
21. CAPSCREW, 3/8" X 2 3/4" LG. W/ LOCKNUT
22. SET COLLAR
23. 1/4" THICK NEOPRENE GASKET (CLOSED END)
24. OPERATOR WALL BEARING – L.H.

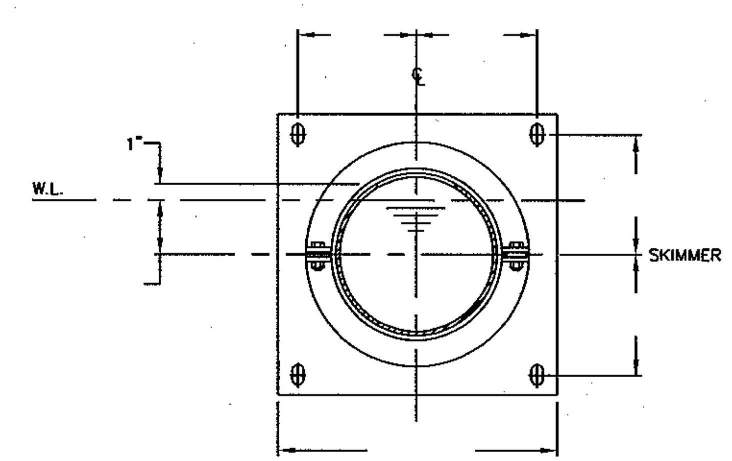


SECTIONAL ELEVATION

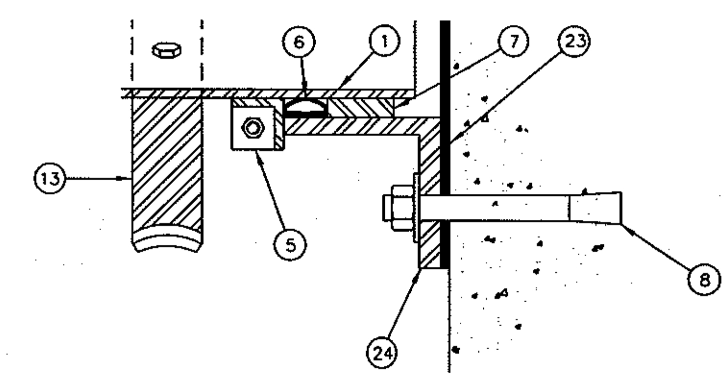


SECTION B–B (AS SHOWN)

SECTION D–D (OPP. HAND)



SECTION A–A



SECTION C–C

INFORMATION ONLY

SYM	REVISION	BY	DATE	CHKD

AMWELL FURNISHES MECHANISM TO FIT TANK OF DIMENSIONS GIVEN, BUT IS NOT RESPONSIBLE FOR CONCRETE DESIGN. CUSTOMER TO FURNISH NECESSARY REINFORCING STEEL AND TO DETERMINE SIZE AND PLACEMENT OF FOOTINGS TO SUIT LOCAL CONDITIONS.

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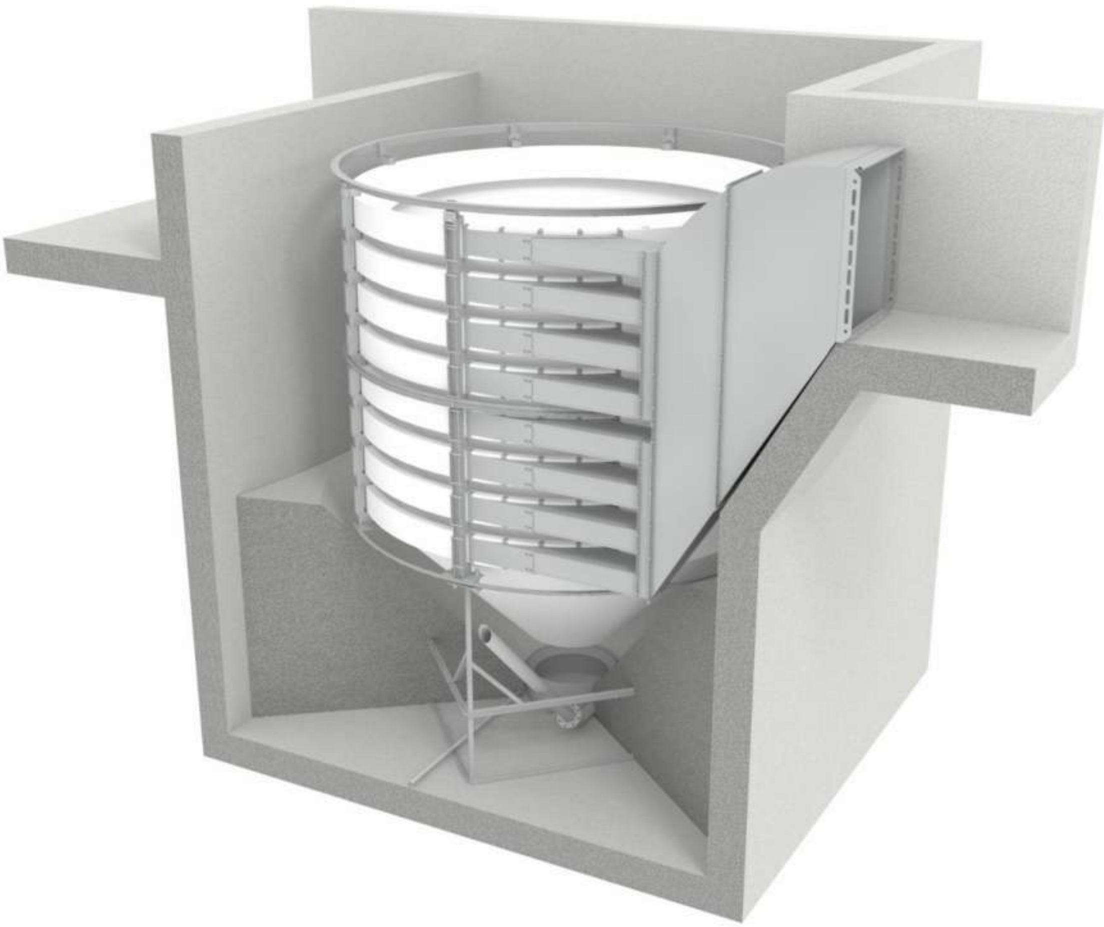
MICROFILMED

AMWELL
A Division of McNish Corporation
AURORA, ILLINOIS, USA
(ORIGINALLY AMERICAN WELL WORKS – EST. 1868)

DRAWN	DESCRIPTION: TYPICAL ARRANGEMENT FOR WORM GEAR OPERATED PIPE SKIMMER
CHECKED	
APP'D.	
DATE	
S.O.	DRAWING NO. PROP. #710
SCALE NONE	REV.

MASTER D-59350

CAD FILE: PROP.#710



Grit Removal System Proposal Package
Traverse City, MI WWTP
Hubble, Roth & Clark

Manufacturer

Hydro International
2925 NE Aloclek Suite 140
Hillsboro, OR 97124
(866) 615-8130 ph
(503) 615-2906 fax
hydro-int.com

Representative

Waterworks Systems & Equipment Inc.
5275 Redding Drive
Lakeland, MI 48143
(810) 231-1200 ph
(810) 231-1331 fax
waterworkssystems.com

Water & Wastewater Solutions

February 26, 2020

Mr. Dennis Benoit
Hubble, Roth & Clark, Inc.
801 Broadway NW, Suite 215
Grand Rapids, MI 49504

RE: Primary Clarification
Travers City, MI WWTP
File #19_11_0513 D

Dear Mr. Benoit:

Thank you for your interest in Hydro International. We are pleased to present our proposal for a HeadCell® Grit Removal, Classification, Washing, and Dewatering System. Hydro International is dedicated to providing innovative, high performance advanced grit management systems grit removal equipment. Supported by over 30 years of research, testing both in our lab and in the field, product development and superior engineering we pride ourselves on providing high-quality products and unmatched customer service. Our extensive experience includes thousands of installations throughout the world.

Grit is continually introduced into collection systems, but is not uniformly carried to treatment facilities. As flows increase, the grit load entering the plant elevates. Once in the treatment plant, where velocities are slower, grit will deposit in processes, disrupting systems, decreasing equipment longevity, and increasing maintenance costs. The HeadCell® Grit Removal System offers many benefits over conventional grit removal systems including:

- Complete system designed to process the solids load as well as the hydraulic load through each step of the process, collection, washing/classification and dewatering and producing a clean, dry product.
- Removing fine and slowly settling grit, protecting equipment and processes from abrasive wear and sedimentation
- All-hydraulic design with no moving parts, minimizing operating and maintenance costs
- Small footprint yet capable of high efficiency solids capture and removal
- Robust design allowing long component life with minimal wear

We sincerely appreciate your interest in our equipment and look forward to working with you on this project. As you progress with the design, we can quickly generate CAD drawings, budget updates, and specifications as well as provide review of equipment layouts and specifications for your particular application. Reference lists are available through your local representative. If you have any questions or concerns, do not hesitate to contact us.

Regards,
Hydro International

Nathaniel McArthur
Nate McArthur
Applications Engineer

Hydro International
2925 NE Aloclek Suite 140 · Hillsboro, OR 97124
Tel: (866) 615-8130 Fax: (503) 615-2906 Web: hydro-int.com

Performance Objective

Hydro International is pleased to propose the following HeadCell® grit removal, washing, and dewatering system to be installed in an existing plant which has flows of 8.5 mgd average and 17 mgd peak. Each component of the grit removal systems performance shall be outlined below.

Proposed Equipment Summary

HeadCell® Grit Concentrator Unit

The HeadCell® is an all-hydraulic grit concentrator, which uses vortex flow and a stacked tray design to efficiently capture and settle fine grit via large surface area and short settling distances. The unit can be installed into the process flow, downstream of screening, in any system where limited head is available. The unit requires no external power source, has no internal moving parts, is self-cleaning, and has a compact modular construction. Wide turndown ratios can be accommodated in the HeadCell® when it is combined with Hydro's high performance washing system.

Specifications

Quantity:	2 (1 online during average flow, 2 online during peak)
Size:	9' diameter
Number of Tray/Unit:	8
Surface Area/Unit:	509 ft^2
Loading Rate @ Peak Flow/Unit:	11.6 gpm/ft^2
Performance @ Peak Flow:	95% removal of all grit (SG 2.65) ≥ 106 microns
Performance @ Average Flow:	95% removal of all grit (SG 2.65) ≥ 106 microns
Peak Flow/Unit:	8.5 mgd with 12" headloss
Average Flow/Unit:	8.5 mgd with 12" headloss
Discharge:	Weir
Underflow Connection:	4" flanged pipe
NPW Connection:	2" NPT
NPW Requirement/Unit:	Intermittent 80 gpm @ 50 psig
Material of Construction:	304 SS Support Structure/Duct/Underflow Polyethylene Trays
Weight Dry (approximate):	2400 lbs

Hydro GritCleanse™ Grit Washing / Dewatering Unit

The Hydro GritCleanse™ is a fully automated, high efficiency unit that effectively removes, washes, and dewaters fine grit, sugar sand, and high density fixed solids from grit slurries. The large conical clarifier with tangential inlet and internal baffle enhances the settling of fine particles and the fluidized sand bed scrubs off and separates attached organics, resulting in a dry grit with extremely low organic content suitable for landfill disposal.

Specifications

Quantity:	2 (1 online during average flow, 2 online during peak)
Size:	8412
Design Flow/Unit:	250 gpm with 2" headloss
Influent Solids Concentration:	≤1.5%
Influent Connection:	6" flanged pipe
Capacity:	up to 1.5 cy/hr
Screw Diameter:	12"
Clarifier Size:	84"
Min. Free Water Surface Area:	38.5 ft^2
Auger Motor:	1.5hp, TENV, 480V/3 phase/ 60 Hz
Agitator Motor:	1hp, TENV, 480V/3 phase/ 60 Hz
Effluent Connection:	8" flanged pipe

Organics Discharge Connection:	4” flanged pipe
Drain Connection:	3” NPT pipe
NPW Connection:	1” NPT (2 No.)
NPW Requirement Fluidized Bed:	25 gpm @ 50 psig Continuous
NPW Requirement Organics Flush:	25 gpm @ 50 psig (20-30 sec. hourly)
Operation:	Continuous or a minimum of 10-15 minutes
Body Material:	304 SS
Weight Dry/Wet (approximate):	3,600/10,400 lbs.
Performance:	95% removal of all grit (specific gravity 2.65) ≥ 106 microns with less than 5% volatile solids and greater than 85% total solids

Grit Pump

The grit pump shall be designed to convey grit slurry from the HeadCell® grit concentrator unit to GritCleanse™ grit washing/ dewatering equipment. The grit pump shall be a recessed impeller, vortex-type unit, specifically designed to pump slurries of grit, debris and organic solids without clogging. The parts exposed to abrasive wear (case, impeller and wearplate) shall have a minimum 650 Brinell hardness for maximum wear resistance.

Specifications

Quantity:	2
Style:	Dry- Pit
Nominal Size:	TBD
Design Flow Rate:	250 gpm
Design TDH:	30’
Power Supply:	480V/3-phase
Horsepower:	TBD

Control Panel

The panel shall contain all timers, VFDs, switches, and indicator lights to operate one (1) HeadCell® NPW unit, one (1) GritCleanse™ unit, and one (1) grit pump in either fully automated or manual mode.

Specifications

Quantity:	2
Enclosure Material:	304 SS
Enclosure Type:	NEMA 4X
Power Supply:	480V/3-phase
Control Logic:	AB MicroLogix 1400 PLC, PanelView 600 Plus OIU
Grit Pump Control:	VFD
Hydro GritCleanse™ Motor Control:	VFDs (2 No.)

System Hydraulics

System hydraulics is the responsibility of the design engineer. Hydro International can provide information on HeadCell® hydraulics, flow vs. headloss curves and pumping and piping FAQ’s to assist the engineer in determining system hydraulics and pump requirements, upon request.

Design Recommendations

- 1/2” or finer screening prior to the grit removal system
- Velocity through bar screen openings/slots/apertures should not exceed 4 ft/s at peak flow as recommended by industry design manuals.
- Estimated grit load at peak flow is 0.19 yd^3/hr.
- Stated output grit quality (total solids/volatile solids) is based on a minimum plant influent grit quantity of 50 pounds FS/million gallon.
- All piping connected to Hydro equipment must be supported by other means than the Hydro equipment
- 2 – 3 ft/s channel velocities at peak flow as recommended by industry design manuals
- 4 – 7 ft/s grit slurry pipe velocities as recommended by industry design manuals
- Incorporate a drain line, piped to a floor drain, in the grit dumpster to allow for further dewatering prior to disposal
- A minimum 18” of access clearance around all equipment and minimum 3’ of access clearance above equipment
- Operators find that it is useful to locate a spray hose adjacent to the equipment so that they can spray all equipment down during an inspection
- Incorporate a minimal access platform to facilitate inspection access to the top of the equipment
- Discharge chutes for grit should be at a minimum 45° incline if it is open chute. If it is an enclosed chute/pipe/tube then a minimum angle of 60° is required to ensure plugging does not occur.
- Grit pumps may require NPW for seal flushing. Requirements for flushing are dependent on the make, model, and seal type of the pump specified by the engineer.

Start-up

One (1) factory trained representative, two (2) trips, for start-up and instruction services as required totaling four (4) days.

Quote Validity: 30 days After expiration of validity Hydro International reserves the right to adjust pricing to account for any significant increases in material costs.

Exclusions

Any item(s) not specifically described above are excluded and are not to be supplied by Hydro International including but not limited to the following:

- Field assembly, erection and installation
- Anchor Bolts
- Interconnecting piping and valving not expressly stated above
  Pipe connections and fittings not expressly stated above
- All pipe supports, hangers and braces
- Controls, switches, control panels and instrumentation of any kind not expressly stated above
- Wiring and conduit
- Grit pump associated piping, valving, gauges
- Covers and access hatches
- Field or touch-up paint, painting, blasting and touch-up of surface finish
- Spare parts not specifically stated above
- Unloading, hauling and storage charge
- Lubricating oil and greases
- Grit study, field performance testing, laboratory testing and sample collection and analysis
- All concrete and grouting work
- Insulation and heat tracing of any kind
- Structural / Seismic analysis
- Performance, Warranty, Efficacy and/or Supply Bond(s)
- Grit dumpsters
- Translation Services

Options

Quotes will be provided upon request for the following optional features:

- Stainless steel valve bodies
- Additional field days for startup or training
- Explosion proof upgrade
- Upgrade 304 to 316 Stainless Steel
- Structural / Seismic Anchorage Certification
- Field performance testing, laboratory testing and sample collection and analysis
- Service & maintenance contract
- Extended warranty

Warranty

Hydro International's Standard Warranty shall apply per the Terms and Conditions of Sale.

Delivery

Please allow 4 to 6 weeks after receipt of purchase order for approval drawings. Shipment is typically a maximum of 12-16 weeks after receipt of "Approved" or "Approved As Noted, Resubmittal Not Required" submittal package. Price includes truck freight to jobsite, but does not include any state or local taxes if required.

Terms & Conditions

This proposal is made pursuant to Hydro International's standard Terms & Conditions of Sale, attached hereto and made a part hereof.

Contacts

Plant Representative:

Mr. Dave Connors

Waterworks Systems & Equipment

5275 Redding Drive

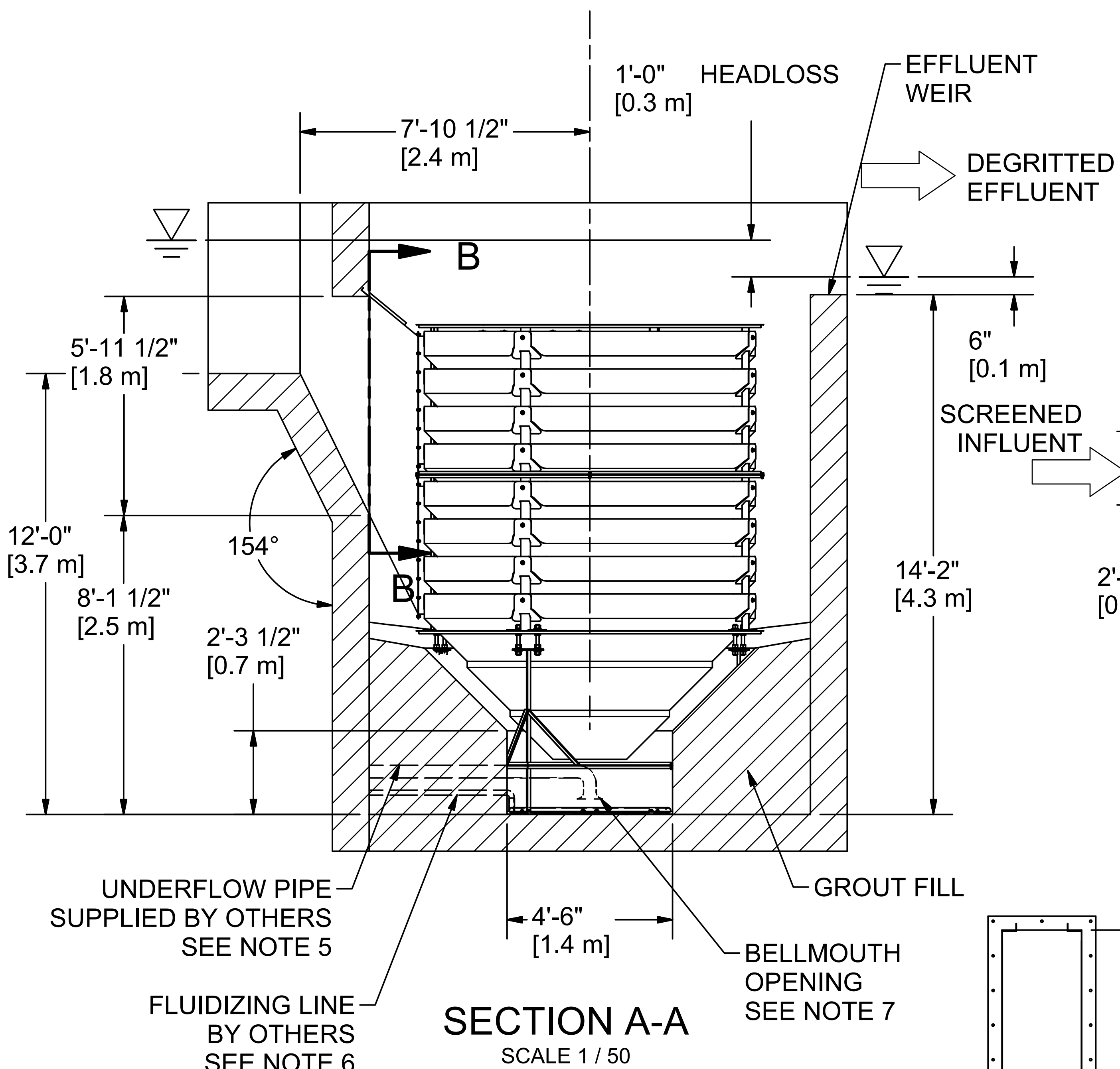
Lakeland, MI, 48143

(810) 231-1200 ph

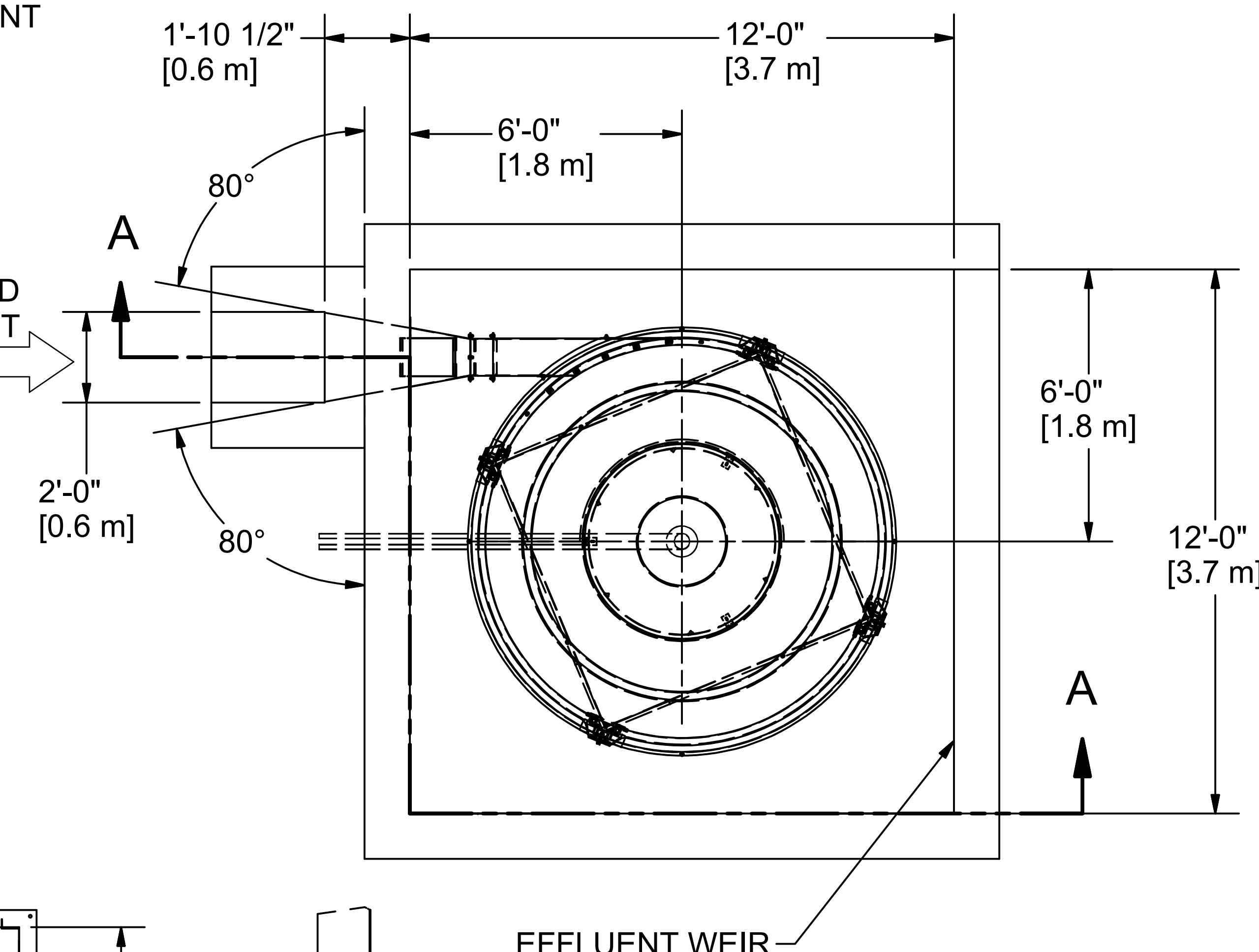
(810) 231-1331

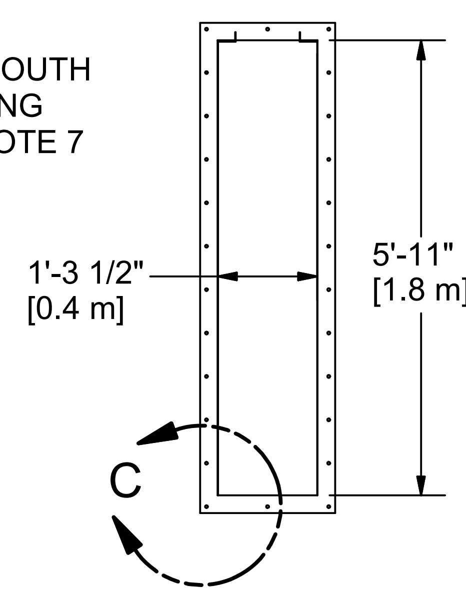
dconnors@waterworkssystems.com

DO NOT CHANGE DUCT LAYOUT OR PIPE ORIENTATION
WITHOUT CONSULTING HYDRO INTERNATIONAL

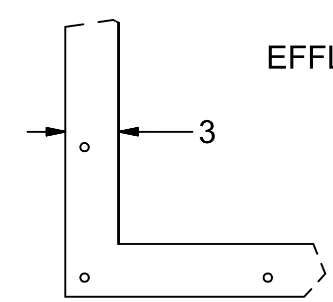


SECTION A-A
SCALE 1 / 50





SECTION B-B
SCALE 1 / 30



DETAIL C
SCALE 1 / 10

PROJECTION

COMMENTS:
1. ALLOW GRIT PUMP TO FULLY DRAIN HEADCELL TANK.
2. PLANT FLOW BYPASS RECOMMENDED TO ALLOW THE HEADCELL TO BE TAKEN OUT OF SERVICE FOR MAINTENANCE.
3. CLOCKWISE & COUNTERCLOCKWISE UNITS ARE AVAILABLE.
4. ALTERNATE EFFLUENT CONFIGURATIONS ARE AVAILABLE.
5. THE GRIT PUMP SUCTION LINE SHOULD BE DESIGNED FOR A 4-7 FT/S [1.2-2.2 M/S LINE VELOCITY.
6. FLUIDIZING WATER REQUIREMENTS 32 GPM [2.0 L/S] FOR 9' HEADCELL AT 50PSI
7. DISTANCE BETWEEN BELL MOUTH AND BOTTOM OF TANK 1.25 X SUCTION PIPE DIAMETER

REVISION HISTORY

REV	BY	DESCRIPTION	DATE
-		FIRST RELEASE	

DATE:	SCALE: 1 / 50

DRAWN BY:	CHECKED BY:	APPROVED BY
JMC	LS	JG

Title
HEADCELL
9' DIAMETER
8 TRAYS
CONCRETE DUCT
INTERMITTENT UNDERFLOW

Proposal

Hydro International®

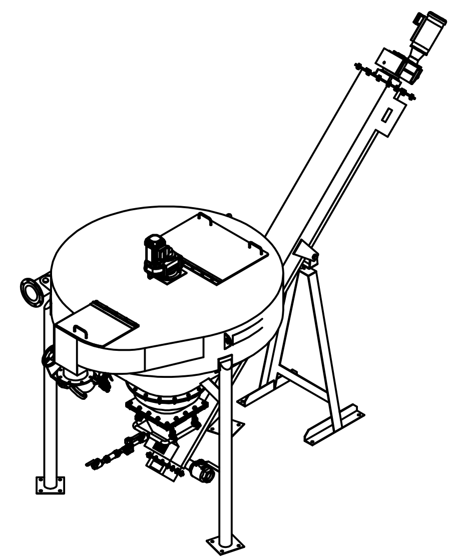
2925 NW Aloclek Drive
Suite 140
Hillsboro, OR 97124
Tel: +1 (503) 615-8130
Fax: +1 (503) 615-2906
hydro-int.com

DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES.
TOLERENCES ARE:
FRACTIONS ± 1/16
DECIMALS:
X.X ± .06
X.XX ± .03
X.XXX ± .015
ANGLES: ± .5°

WEIGHT:	MATERIAL:
N/A	

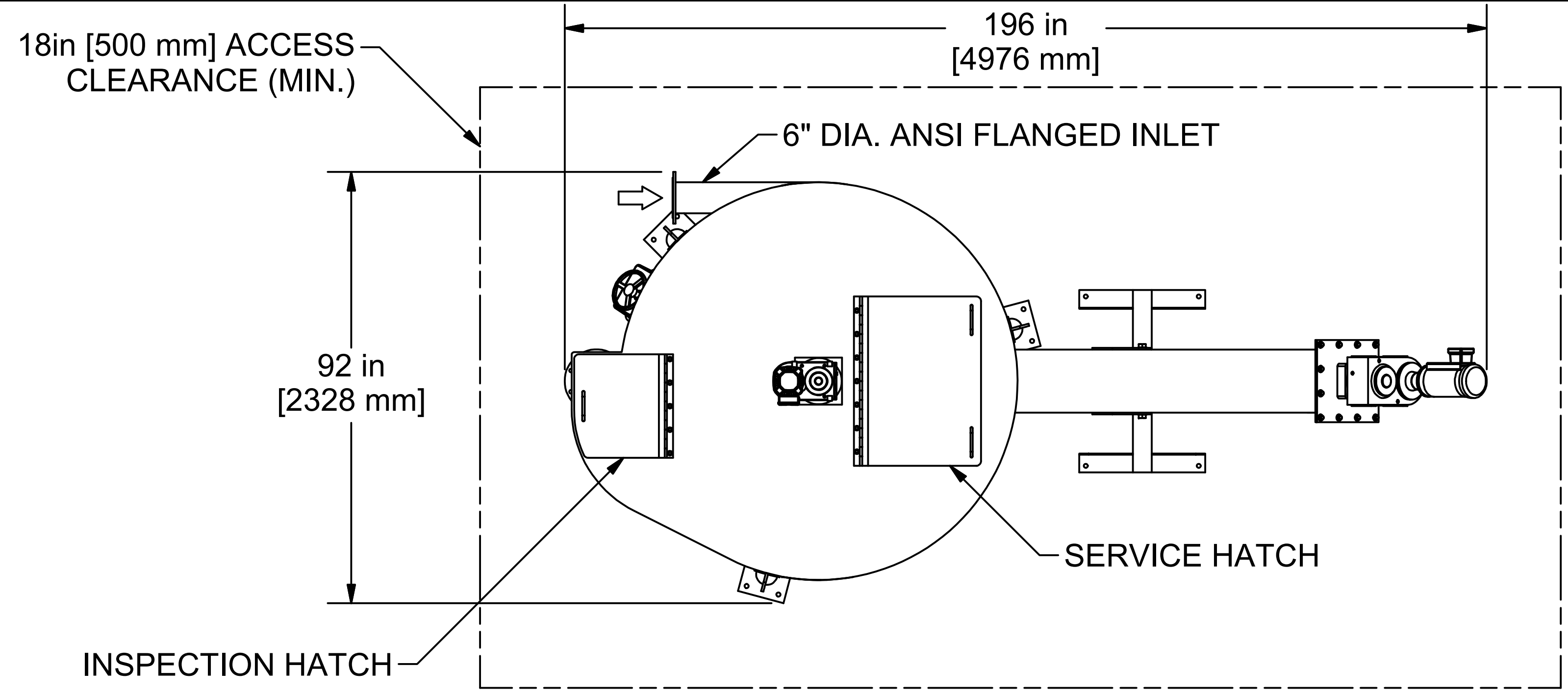
DRAWING NO.:
9FT/8/1.08/INT/CON

SHEET SIZE:	SHEET:	Rev:
B	1 OF 1	-

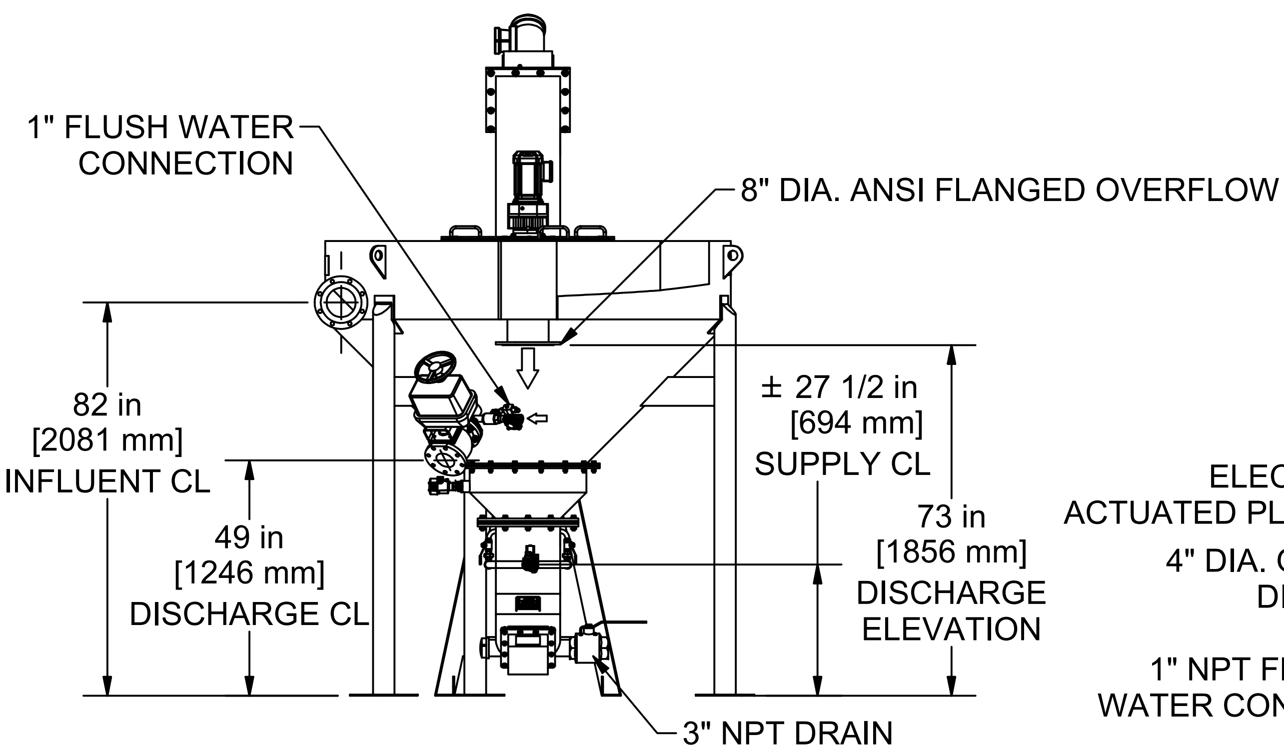


ISOMETRIC VIEW

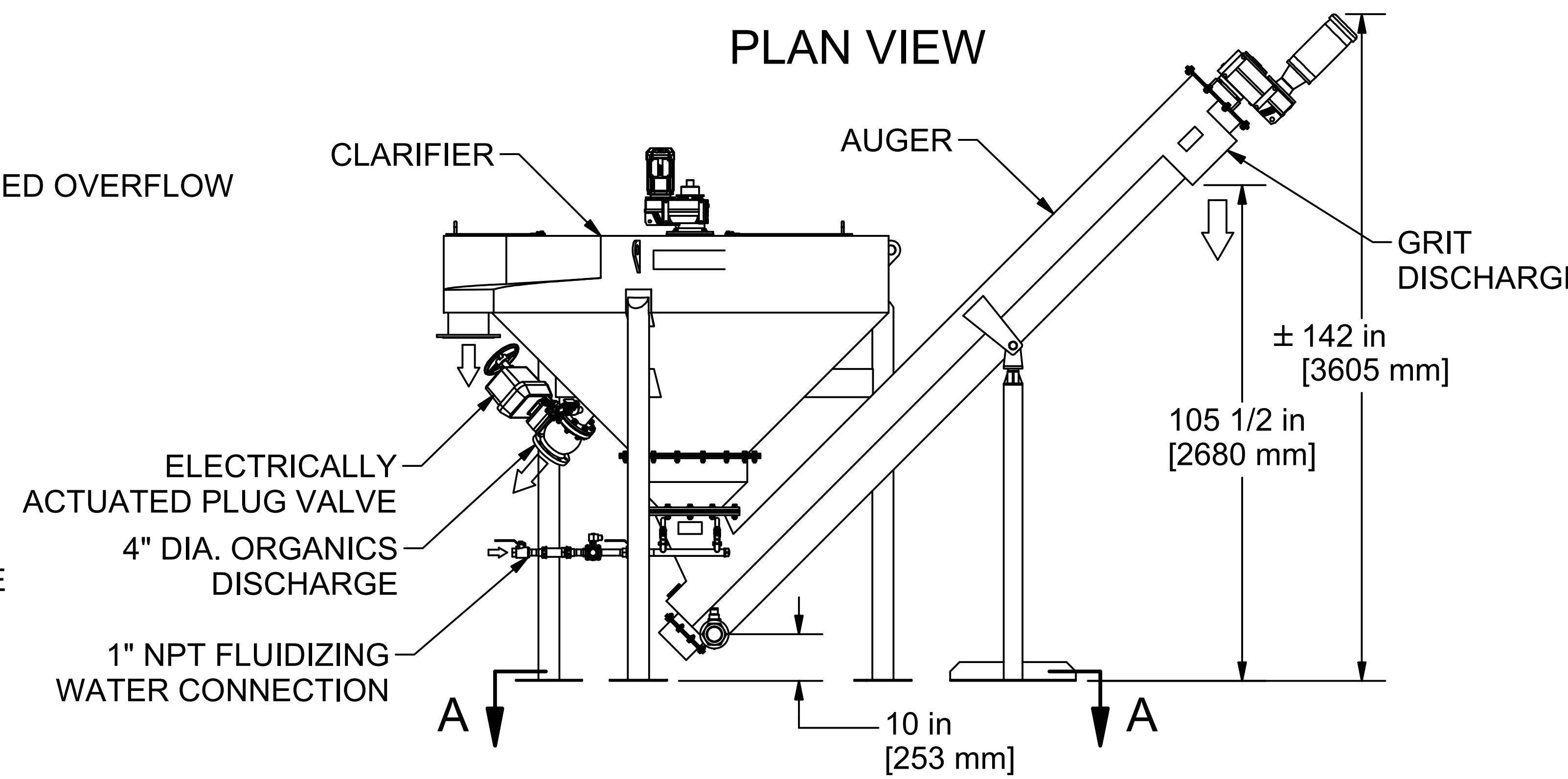
NTS



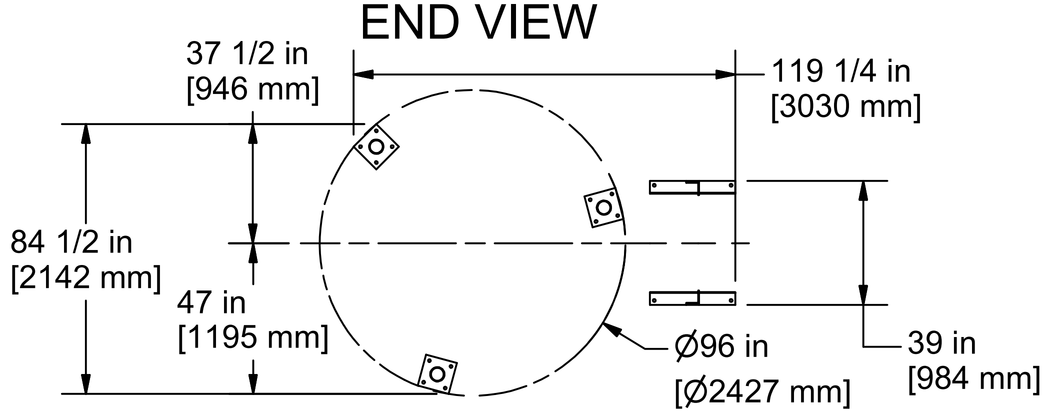
PLAN VIEW



END VIEW



SIDE VIEW



FOOTPRINT A-A

NTS

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES.

TOLERENCES ARE:
FRACTIONS ± 1/16
DECIMALS:
X.X ± .06
X.XX ± .03
X.XXX ± .015
ANGLES: ± .5°

PROJECTION

COMMENTS:

1. PROVIDE ADEQUATE CLEARANCE FOR SERVICE AND MAINTENANCE ACCESS

2. NPW REQUIREMENTS:
25 GPM @ 50 PSI CONTINUOUS
50 GPM @ 50 PSI INTERMITTENT

3. EQUIPMENT WEIGHTS:
DRY: 3,600 LBS [1,630 KG]
WET: 10,400 LBS [4,700 KG] (MAX)

REVISION HISTORY

REV	BY	DESCRIPTION	DATE
A	SR	3-INCH DRAIN	17-Jul-19
-		FIRST RELEASE	

DATE: 19-Jun-18	SCALE: 1 / 40	
DRAWN BY: SR	CHECKED BY: SR	APPROVED BY

Title
HYDRO GRITCLEANSE
8412

COMPLETE UNIT

PROPOSAL DRAWING

Hydro International®

2925 NW Aloclek Drive
Suite 140
Hillsboro, OR 97124
Tel: +1 (503) 615-8130
Fax: +1 (503) 615-2906
hydro-int.com

WEIGHT: 3513.1 lbmass	MATERIAL:	
NEXT ASSEMBLY: N/A		
DRAWING NO.: PROPOSAL		
SHEET SIZE: B	SHEET: 1 OF 1	Rev: A

North American Grit Gradations

Hydro International is pleased to announce the availability of national and regional grit gradation data. This data, which has been compiled from over 120 tests across North America, contains average physical size data as well as settling velocity (SES) data, making it the most comprehensive information available on grit and its behavior.

Virtually all conventional grit removal processes rely on gravity sedimentation to achieve the separation of grit from wastewater. Most conventional grit removal processes are designed based on the assumption that grit is spherical and has a specific gravity 2.65. However, not all grit maintains a specific gravity of 2.65 and other factors such as shape and encapsulation by fats, oils and grease significantly impact its settling velocity. Therefore, the best means to analyze grit is to determine the settling velocity for given particle size ranges. Settling velocity data can be correlated to the measured settling velocity of a clean sand sphere. The settling velocity is expressed as the Sand Equivalent Size (SES), which is the sand particle size having the same settling velocity as the more buoyant grit particle. The correlated particle size, or Sand Equivalent Size can then be used for design of the grit removal process.

When settling velocity is considered in the design actual removal efficiency of grit particles can be estimated more realistically.

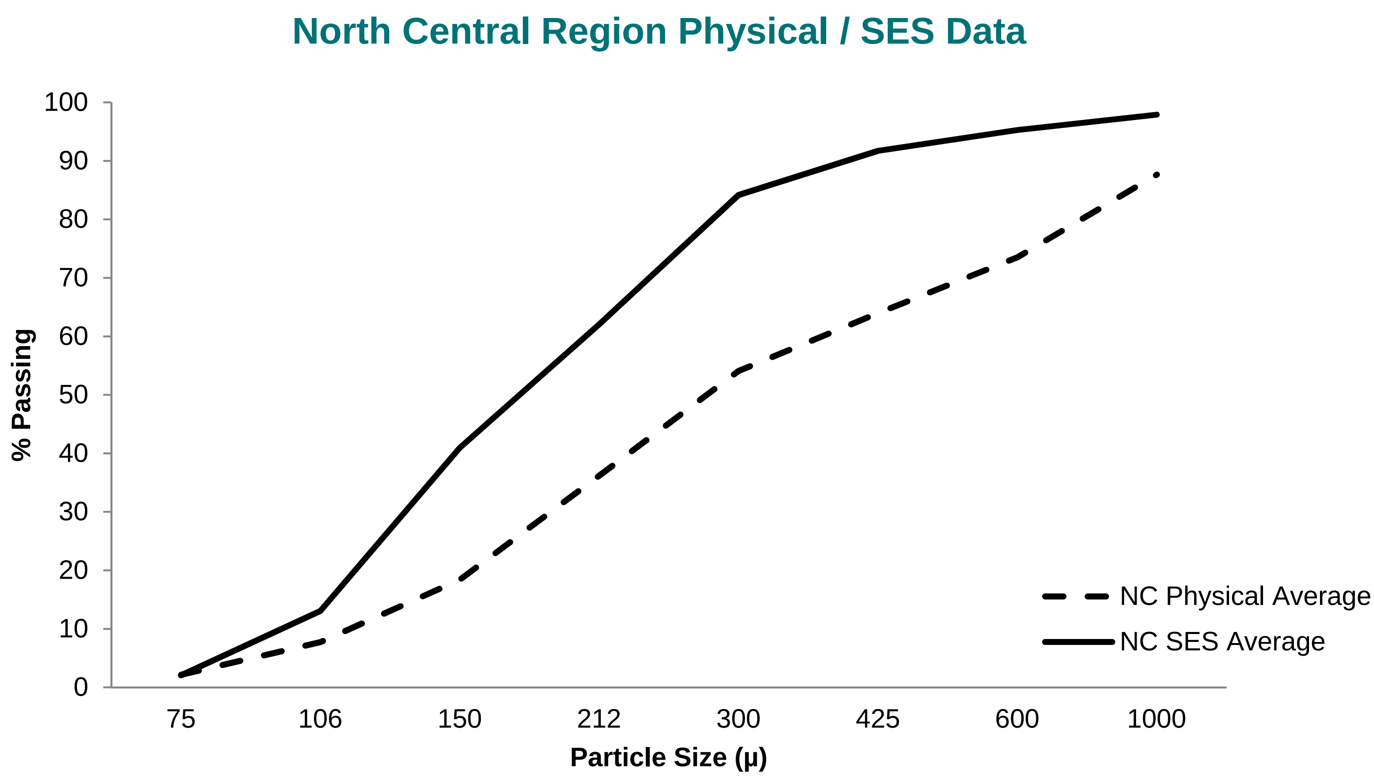
Data is available for the following regions:

Region	States / Provinces Included
Northeast	ME, VT, NH, MA, RI, NY, CT
Mid-Atlantic	PA, NJ, MD, DE, DC, VA, WV
Southeast	NC, SC, GA, AL, FL, MS
North Central	MO, KS, KY, IN, OH, IL, MI, WI, IA, MN, ND, SD, NE
South Central	TN, AR, OK, TX, LA
West	WA, OR, CA, AK, HI, AZ, NV, NM, CO, ID, MT, UT, WY
Western Canada	AB, MB, SK
Ontario Canada	ON

State data is available for individual states where more than 5 data points are available; those states currently include: Georgia, Texas, Florida, California, and Virginia.

Hydro International – Water & Wastewater
2925 NW Aloclek Suite 140, Hillsboro, OR 97124
Tel: (503) 615-8130 Fax: (503) 615-2906 Web: www.hydro-int.com

North Central Regional Gradation



	% Passing								
Micron	**75**	**106**	**150**	**212**	**300**	**425**	**600**	**1000**	
NC Physical Average	2.2	7.8	18.4	36.2	54.1	64.0	73.5	87.7	*Physical*
NC SES Average	2.0	13.0	41.0	62.0	84.2	91.7	95.3	97.9	*SES*

The above table shows the % of grit passing through various sieve sizes based on physical size (unshaded) and Sand Equivalent Size (SES) (shaded). SES provides the settling velocity distribution of the grit particles.

Appendix C — Structural Inspection Report

HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

Memorandum

To: Mr. Art Krueger
Director of Municipal Utilities

From: Christa K. Crist, P.E.
Hubbell, Roth & Clark, Inc.

Date: December 18, 2020

Subject: Rectangular Primary Tank Structural Inspections HRC Job No. 20190115

General Background

On October 14, 2020, Hubbell, Roth, & Clark, Inc. (HRC) was on site at the Traverse City Wastewater Treatment Plant to conduct a structural inspection of the Primary Tanks. Using visual and non-destructive inspection methods, HRC's structural inspection was conducted as part of an effort to provide a more conclusive and definitive course of action relative to options for the rehabilitation of the existing Primary Tanks or construction of new circular clarifier tanks.


Photo 1- Aerial view of the Traverse City WWTP

In addition, HRC arranged for concrete compressive strength testing and petrographic analysis of core samples, the locations of which were determined based on the structural inspection observations. Reports on the compressive strength testing and petrographic analysis are included as part of the complete study package.

Based on the observations made by HRC on 10/14/2020, the structural condition of the concrete in Tanks 1S and 3N was sound. Together with the results and conclusions of the compressive strength tests and petrographic analyses of the cores taken as part of the study scope, HRC recommends that the Primary Tanks are good candidates for reuse provided the service and exposure types are not changed significantly from current. Minor to moderate structural repairs are recommended to extend the service life of the tanks.

The Primary Tanks were constructed at different times, the first set in the 1930s and the second set in the 1950s. The four compartments in the '30s vintage tanks are referred to herein as Tanks 1S through 4S. Similarly, the four compartments in the '50s vintage tanks are referred to as Tanks 1N through 4N.

On October 14th, HRC inspected the interiors of Tanks 1S and 3N. The above grade portions of all the tanks were also inspected as were the below grade galleries at the sump ends (west) of each tank.

Below is a detailed summary of findings, conclusions, and recommendations, including photographic documentation.

Summary of Findings

Tank 1S

The tanks were covered with fiberglass covers, identifiable by their turquoise green color in Photo 1. Installed in the mid-1990s, the covers have degraded since that time and are no longer suitable for the support of foot traffic. However, they can be lifted and moved around minimally to facilitate entry into the tanks.

The interior of Tank 1S was inspected first. The concrete walls, base slab and underside of top slab were in good condition. The grout infill in the boxouts around the mechanical drive on the east end were sound. HRC observed what looked like a repaired diagonal crack in the south wall near the boxout (Photo 2). Potential repairs along vertical full height joints or cracks were noted in two additional locations along the south wall. Patch repairs were observed in four locations on the north wall at approximately five feet down from the top of the wall. No efflorescence was noted at any of the repaired areas. Areas of concrete local to the repairs were "sounded" with a chipping hammer. All returned with a healthy ringing sound, as opposed to a flat or hollow sound, which would indicate delaminated concrete beneath the surface.

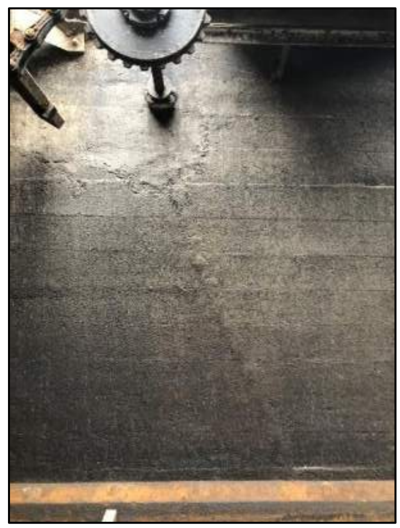


Photo 2- Grout infill and crack repair at boxout

Patterns from the lumber formwork used in the original construction of the tank were evident throughout (Photo 2). No signs of cement paste or aggregate loss were noted anywhere on the wall surfaces. In multiple locations, HRC wire brushed debris from the concrete, revealing a uniform shiny surface below. HRC concluded that the walls may have been coated at some point in their lifetime.


Photo 3- Concrete slab beneath hardened sludge

The underside of the scum trough on the east end of the tank was in fair condition for the most part, as were the strut beams and cantilevered walkways on the sides of 1S. A few exceptions were noted. Along the underside of the cantilevered walkways on the sides nearest the concrete scum and FRP troughs, heavy sludge buildup was observed with isolated locations of delaminated concrete. No exposed rebar was evident.

On the west end, an isolated location of deterioration on the underside of a beam spanning over the sump was noted. The

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CONSULTING ENGINEERS SINCE 1915

degree of deterioration was similar to that noted on the east end. A minor spall was recorded on a different beam on the west end. Neither were of structural concern but may merit surface repair to protect the steel reinforcement within the beams.

Photo 4- Deteriorated concrete along top slab of grit chamber

Along the strut beams, localized areas of patching with a cementitious repair material were noted. All repairs looked sound.

The base slab was inspected both visually and physically by dragging chains across it. Chain dragging is another method for detecting areas of delaminated concrete in a concrete slab, similar to using the chipping hammer on the walls. No areas of delamination were noted anywhere across the base slab. The concrete surface of the base slab was also wire brushed after first removing a crust of hardened sludge. The wire brush removed a black powdery layer, revealing a uniform surface with lightly exposed aggregate, likely due to mechanical wear from the grit in the water that has been processed through the tank over its lifetime (Photo 3).

Photo 5- Standing water across top slab on west end of Tanks 1 and 2S

The concrete across the top sides of Tanks 1 and 2S was also inspected. Cracked concrete with efflorescence was noted along the top slab and walls of the grit chamber at each the east and west ends (Photo 4).

The top slab across the sump ends (west) of both Tanks 1S and 2S was covered with standing water on the day of the inspection (Photo 5). The concrete was deteriorated across the surface in multiple locations. Loose aggregate was observed all around. Sludge-like material was also observed in the water though the exact source was not confirmed. The top slab for Tanks 3 and 4S, which is adjacent to Tanks 1 and 2S was higher by a couple of feet leading to somewhat of a “bathtub” effect at 1 and 2S, where water collected and did not readily drain away. Similar deterioration was noted across the top slab on the east end of Tanks 1 and 2S. It is worth noting that while Tanks 1 and 2N were at a similarly low elevation relative to adjacent Tanks 3 and 4N, the top slabs at both the east and west ends of 1N and 2N were dry.

Photo 6- Cement paste loss and exposed aggregate at scum troughs

The fiberglass covers over the scum troughs on the east end of Tanks 1S were opened revealing heavy cement paste loss along the surface of the concrete. Uniformly exposed aggregate and localized locations of missing concrete were observed along the length of the trough (Photo 6).

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Tank 3N

The condition of the concrete in Tank 3N was similar to Tank 1S. Generally, the condition of the walls, base slab and underside of top slab were in good to fair condition.

The most notable deterioration was observed at the waterline where it appeared that the original concrete coating had failed, leading to localized shallow spalls on the surface. This water surface elevation was approximately three feet below the top of wall. Peeling coating and spalls were noted regularly along the full length of both walls of the tank (Photo 7). Frequent locations of peeling coating were noted on the faces of the strut beams as well.

The grout infill in the boxouts around the mechanical drive on the east end were sound. Repair of a full height vertical crack was noted on the north wall and was in good condition. The area of concrete local to the repair was “sounded” with a chipping hammer and returned a healthy ringing sound.

Photo 7- Coating failure at waterline

The underside of the concrete scum trough on the east end of the tank showed deterioration of the concrete. The coating had failed, and aggregate exposure was moderate to severe particularly along the beam that spanned across the opening to the inlet chamber. The contoured concrete at the base slab under the scum trough had a crack in it, which was damp on the day of the inspection.

On the west end, deterioration of the coating on the underside of the beams spanning over the sump was noted. This was similar to what was observed along the faces of the strut beams.

The base slab was inspected both visually and physically by dragging chains across it. No areas of delamination were noted anywhere across the base slab.

The concrete across the top sides of Tanks 1 through 4N was also inspected. Stone bedding covered the transition between Tanks 1/2N and the taller Tanks 3/4N to the north. A section of sunken concrete slab was noted on the west end of this transition.

Photo 8- Deterioration along grit chamber walls

Concrete deterioration along the top slab and walls of the grit channel along Tank 1N was like that which was observed along 1S though evidence of previous repair attempts were noted (Photo 8).

Cracks were noted at regular intervals across the tops of the cantilevered walkways between the tanks. These cracks continued down and around the undersides of the walkway slabs and could be seen from inside Tank 3N. This was typical for the full length of the interior. The cracks across the tops of the walkways at 4N also continued down the outside face of the tank's north wall, which was exposed approximately three feet above grade for the full length (Photo 9). The cracks across the tops of the slabs and down the sides of the walls at all the "north" tanks had been routed out and filled with sealant and were in good condition.

Photo 9- Repairs along north wall of Tank 4N

Gallery

HRC also inspected the below grade gallery on the west end of the tanks. The walls and underside of top slab throughout the gallery were in fair condition. Cracks with efflorescence were noted throughout, which is typical of a below grade structure such as this. Structural modifications were made to the original 1930s vintage gallery when the new tanks were built in the '50's, extending the gallery to the north and south. The structural modifications were in fair condition and showed a moderate degree of deterioration.

Photo 10- Deteriorated concrete w/ exposed reinforcement at column base

Measures to capture water leaking from overhead were noted, particularly under the area where HRC observed standing water and deteriorated concrete across the top slab on the west end of Tanks 1S and 2S.

Of particular note was the condition of the bottoms of the concrete columns near the floor. In multiple locations, the concrete was deteriorated to the extent that the steel reinforcement ties were exposed and corroded (Photo 10). The floor was wet in many areas throughout the gallery, including around the deteriorated columns.

Conclusions and Recommendations

Based on the observations made by HRC on 10/14/2020, the structural condition of the concrete in Tanks 1S and 3N was sound. Together with the results and conclusions of the compressive strength tests and petrographic analyses of the cores taken as part of the study scope, HRC recommends that the Primary Tanks are good candidates for reuse provided the service and exposure types are not changed significantly from current. Minor to moderate structural repairs are recommended to extend the service life of the tanks.

It should be noted that the interiors of Tanks 1S and 3N were inspected as a representative sample of the whole. Therefore, it is assumed that the other tanks that were not entered by HRC are of similar condition.

HRC recommends that the following structural concrete rehabilitation items be addressed as part of an improvements project:

Concrete Scum Trough/Inlet Boxes

If the concrete scum troughs are to be reused as part of the future function of the tanks, they will require a combination of structural rebuilding and repair. The limits and extents of both the rebuilding and repair would be determined during a more in-depth inspection of the trough and inlet areas. Deep repair of the undersides of the walkway slabs local to the trough are also recommended.

Walls and Beams

Walls and beams whose condition is like that which was observed in Tank 3N, should be cleaned to remove the existing coating followed by localized shallow repairs with a cementitious structural concrete material, particularly along the waterline. Any cracks that may become visible after removal of the surface debris and coating should be pressure injected with a structural epoxy adhesive.

Protective Coating

To aid in extending the service life of the Primary Tanks, application of a protective coating to all or many of the concrete surfaces on the interiors of the tanks is recommended following the reconstruction at the trough/ inlets and completion of the structural repairs to the walls and beams. HRC has successfully utilized a select few coating systems, each of which uses a different type of technology for protecting the concrete. Recommendations as to which system is most appropriate for the Primary Tanks would be based on consult with a few of these trusted manufacturers who specialize in this type of application. HRC would present the results of the compressive testing and petrographic analysis to the manufacturers as a valuable aid in determining the best choice for a coating system.

Gallery Repairs

Cracks in the walls and slabs should be injected with structural epoxy adhesive. At the columns where spalls were observed, the exposed steel reinforcement should be cleaned of rust and then protected with an application of a corrosion inhibitor. The surfaces of the columns should then be rebuilt with a cementitious structural concrete. Measures to mitigate standing water on the gallery floor will help to limit future deterioration of these column repairs.

Attachments: HRC 10/14/20 field notes

Looks like interior may have been coated @ some pt. Wire brushing surface debris off reveals somewhat shiny surface below. Looks "painted". Dimensional lumber formwork lines evident throughout.

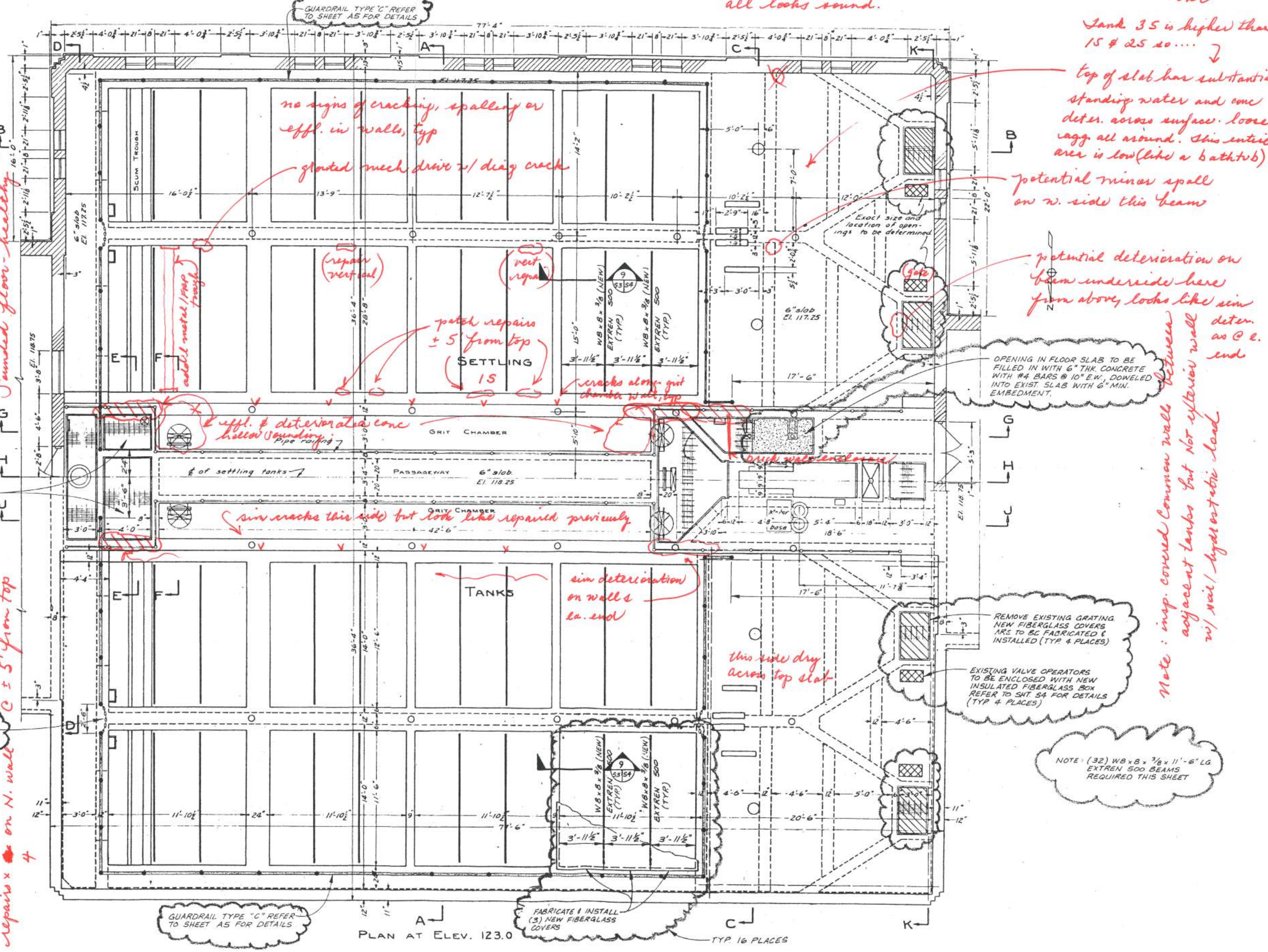
trough underside fair as are undersides of strut beams and cantilevered walkways on sides. EXCEPTION: underside cantilevered walkway on side nearest trough. heavy sludge build up but looks like conc may be delam'd. Rebar observed. Sounded cracks/jts, patch repairs - all healthy. Sounded floor - healthy.

grouted bypass @ mech drive on east end w/ possible repaired diag crack on S. wall "Repair" looks sound. Add'l potential repairs @ full ht jts or cracks (nearly 100% vertical) on 2 locations ± 15' o.c. on S. wall. Also good condition. Patch repairs × 4 on N. wall @ ± 5' from top

20170115

10.14.20

rkc



PLAN AT ELEV. 123.0

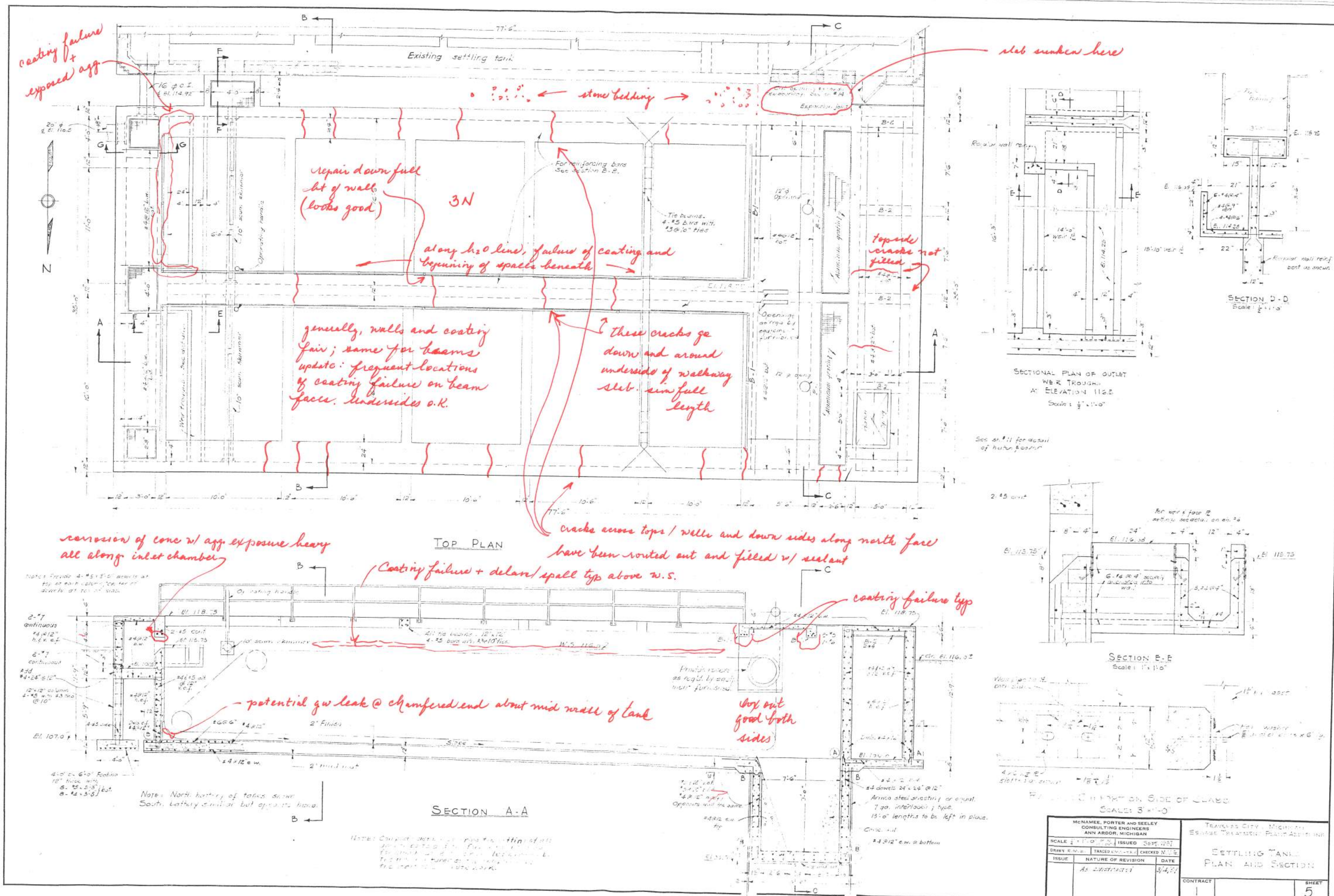
WW Engineering & Science
A Summit Company

CITY OF TRAVERSE CITY
GRAND TRAVERSE COUNTY, MICHIGAN
1994 WWTP CAPITAL IMPROVMENTS
PRIMARY TANKS FIBERGLASS COVERS – PLAN

DESIGNED BY	R.T.B.	DATE	MAR. '94
DRAWN BY	R.J.S.	DATE	MAR '94
CHECKED BY	D.J.E.	DATE	JULY '94
FILE	89936S3	EDIT	RJS060194
SCALE	AS NOTED	DRAWING	1:1
PROJECT	89936		

S3

10.14.20 ckc


coating failure + exposed agg.
Existing settling tank
stone bedding
slab sunken here
repair down full ht of wall (looks good)
3N
along h2o line, failure of coating and beginning of spalls beneath
topside cracks not filled
generally, walls and coating fair; same for beams
update: frequent locations of coating failure on beam faces. undersides o.K.
These cracks go down and around underside of walkway slab. sim full length
cracks across tops / walls and down sides along north face have been routed out and filled w/ sealant
Top Plan
corrosion of conc w/ agg exposure heavy all along inlet chamber
Coating failure + delam/spall typ above W.S.
coating failure typ
potential gw leak @ chamfered end about mid wall of tank
box out good both sides
Section A-A
Sectional Plan of Outlet Weir Trough at Elevation 112.8
Section D-D
Section E-E
McNamee, Porter and Seeley
Consulting Engineers
Ann Arbor, Michigan
Issued Sept. 1957
Nature of Revision
As constructed
Settling Tank
Plan and Section
Contract 1
Sheet 5

CONSULTING
GROUP

December 16, 2020

Ms. Christa K. Crist, P.E.
Hubbell, Roth & Clark, Inc.
555 Hulet Drive
Bloomfield Hills, Michigan 48303-0824

Re: Letter on Structural Concrete Evaluation
Traverse City Regional Wastewater Treatment Plant
606 Franklin Street
Traverse City, Michigan
G2 Project No. 200895

Dear Ms. Crist:

As requested, G2 Consulting Group, LLC (G2) has obtained, tested, and evaluated samples of the existing reinforced concrete settling tanks at the wastewater treatment plant in Traverse City, Michigan. The concrete testing and evaluation program reported herein is part of a larger study being conducted by Hubbell, Roth & Clark, Inc. (HRC) to evaluate possible facility improvements. The purpose of the concrete testing and evaluation program is to provide both quantitative and qualitative information regarding concrete strength, aggregate properties, engineering properties, and overall concrete quality relative to the remaining service life of the subject structures.

SCOPE OF SERVICES

The field operations, laboratory testing, and engineering report preparation were performed under the direction and supervision of a licensed professional engineer. Our services were performed according to generally accepted standards and procedures in the practice of construction materials engineering and testing in this area. Our scope of services for this project consists of the following specific items:

1. We discussed the condition of the structures with the HRC site inspection team, reviewed original construction plans for the structures along with photographs taken during site inspections by HRC, and developed a concrete sampling plan in consultation with HRC.
2. We obtained four concrete samples for this project. All of the samples were obtained by core drilling. Two core samples, 1S-1 and 2S-1, were taken from the horizontal top surface of the concrete wall that divides tank 1S from tank 2S. The remaining two samples, 3N-1 and 3N-2 were taken from the north wall of tank 3N/4N. These samples were taken from exterior vertical wall surface. All of the core samples were delivered to our laboratory in Troy, Michigan for measurements and photographs. Samples 1S-1 and 3N-2 were tested in axial compression.
3. Samples 3N-1 and 1S-1 were shipped to Lankard Materials Laboratory in Columbus, Ohio for petrographic examination. Dr. David Lankard's evaluation report is included with this submittal.

FIELD OPERATIONS

G2 in consultation with HRC selected the location of the concrete samples. The locations are noted on Plates 1 and 2 contained in the Appendix. Cores samples were obtained by core drilling using an electric core drill with a 4-inch diameter diamond tipped barrel. As noted, the core barrel was advanced vertically downward through the top surface of the wall at tank 1S/2S and horizontally inward through the exterior vertical surface of the north wall at tank 3N/4N. The samples obtained represent a partial thickness, nominally 7-1/2 inches to 8 inches, of the structural element in each case with the exception of sample 2S-1 which was retrieved in fragments and represents nominally 5 inches of the structure at that location. At completion of the core sampling, the core holes were patched with a quick set hydraulic cement patching material and the sites cleaned up as necessary.

LABORATORY TESTING

Photographs of the concrete samples prior to testing are shown in Figures 1 and 2 in the Appendix. Core samples 1S-1 and 3N-2 were trimmed using a diamond saw, capped with a sulfur based compound, and tested in axial compression in accordance with ASTM C42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. Test results are provided in the following table:

Concrete Core Sample Compressive Strength Test Results

Sample ID	Length (in.)	Diameter (in.)	L/D	Total Load (lbs.)	Correction Factor	Compressive Strength (psi)
1S-1	6.45	3.70	1.74	90,700	0.98	8,260
3N-2	7.33	3.70	1.98	90,540	1.00	8,420

PETROGRAPHIC EVALUATION

As noted, two samples were shipped to Lankard Materials Laboratory for evaluation. Dr. Lankard's general conclusion is that the "concretes are in sound condition and are of good quality". This conclusion is consistent with observations made by HRC's site inspection crew and the results of observations and compression tests conducted by G2. Rather than further characterize Dr. Lankard's report herein, the reader is encouraged to read the report in its entirety (Appendix).

As always, we appreciate the opportunity to be of service to Hubbell, Roth & Clark, Inc. In the meantime, if you have any questions regarding our concrete evaluation and testing program or any other matter pertaining to the project, please contact us.

Sincerely,

G2 Consulting Group, LLC

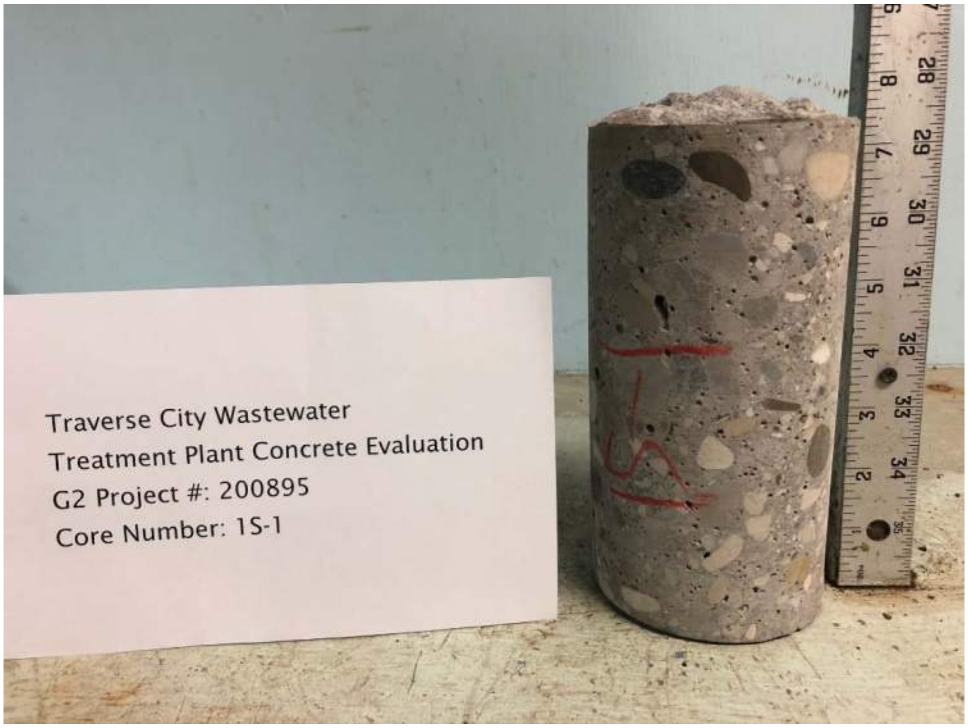
Grant Beahlen, P.E.
Project Engineer

James Berry, P.E.
Project Manager

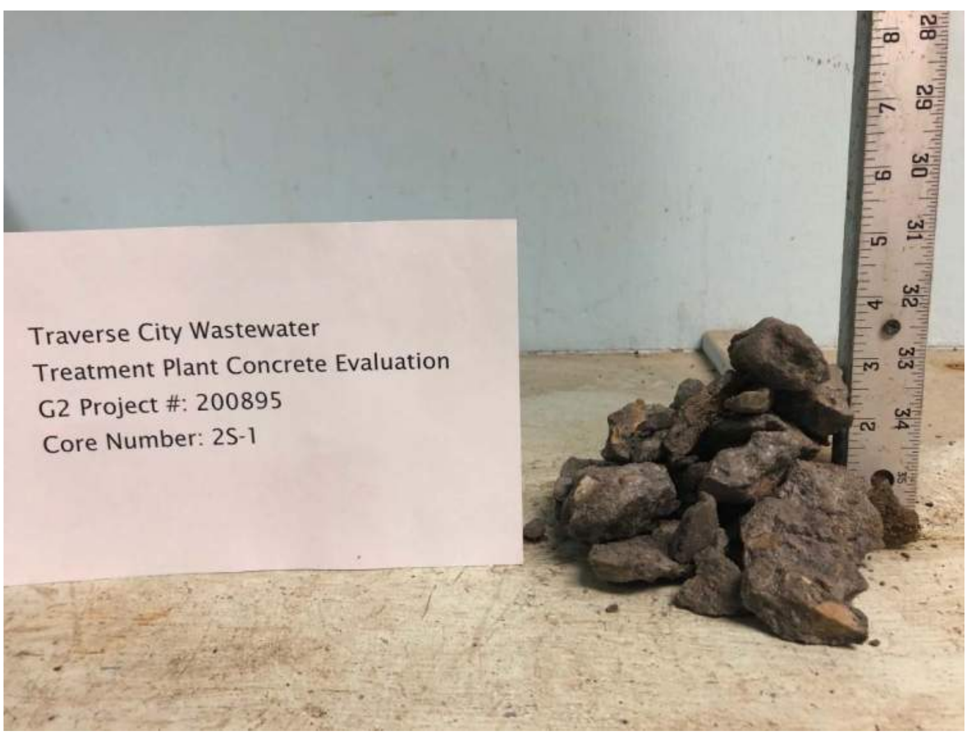
GMB/JLB/mlt

Encl: Core Sample Photographs — Figure Nos. 1 and 2
Core Sample Location Plans — Figure Nos. 3 and 4
LML Report No. 5060

Photographic Documentation
Traverse City Wastewater Treatment Plant Concrete Evaluation
G2 Project No. 200895



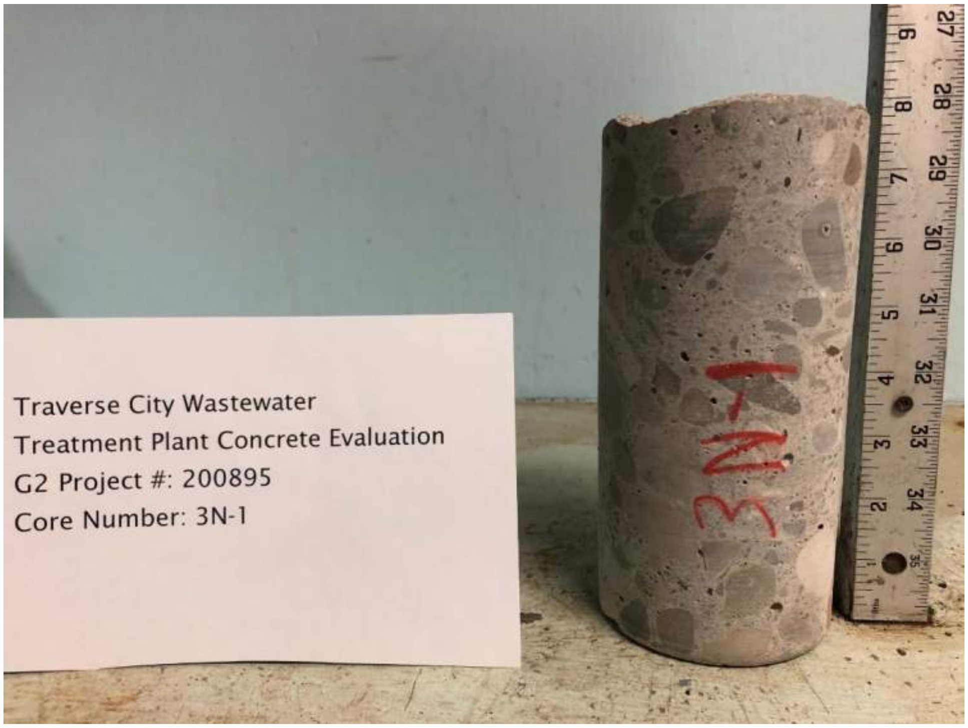
Concrete Core: 1S-1



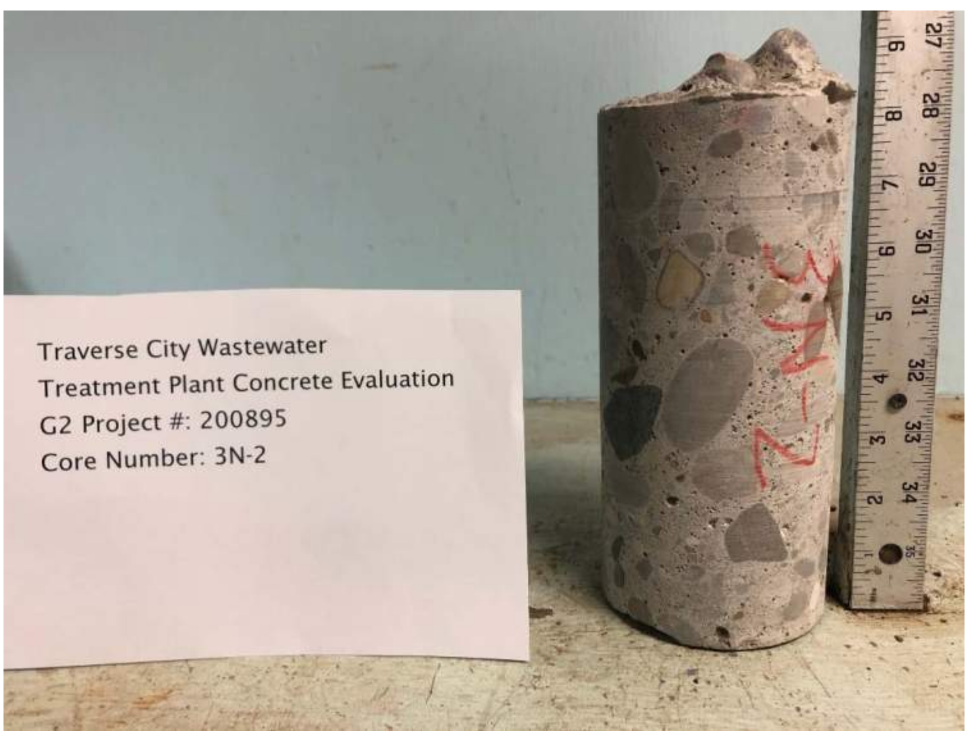
Concrete Core 2S-1

Figure No. 1

Photographic Documentation
Traverse City Wastewater Treatment Plant Concrete Evaluation
G2 Project No. 200895



Concrete Core: 3N-1

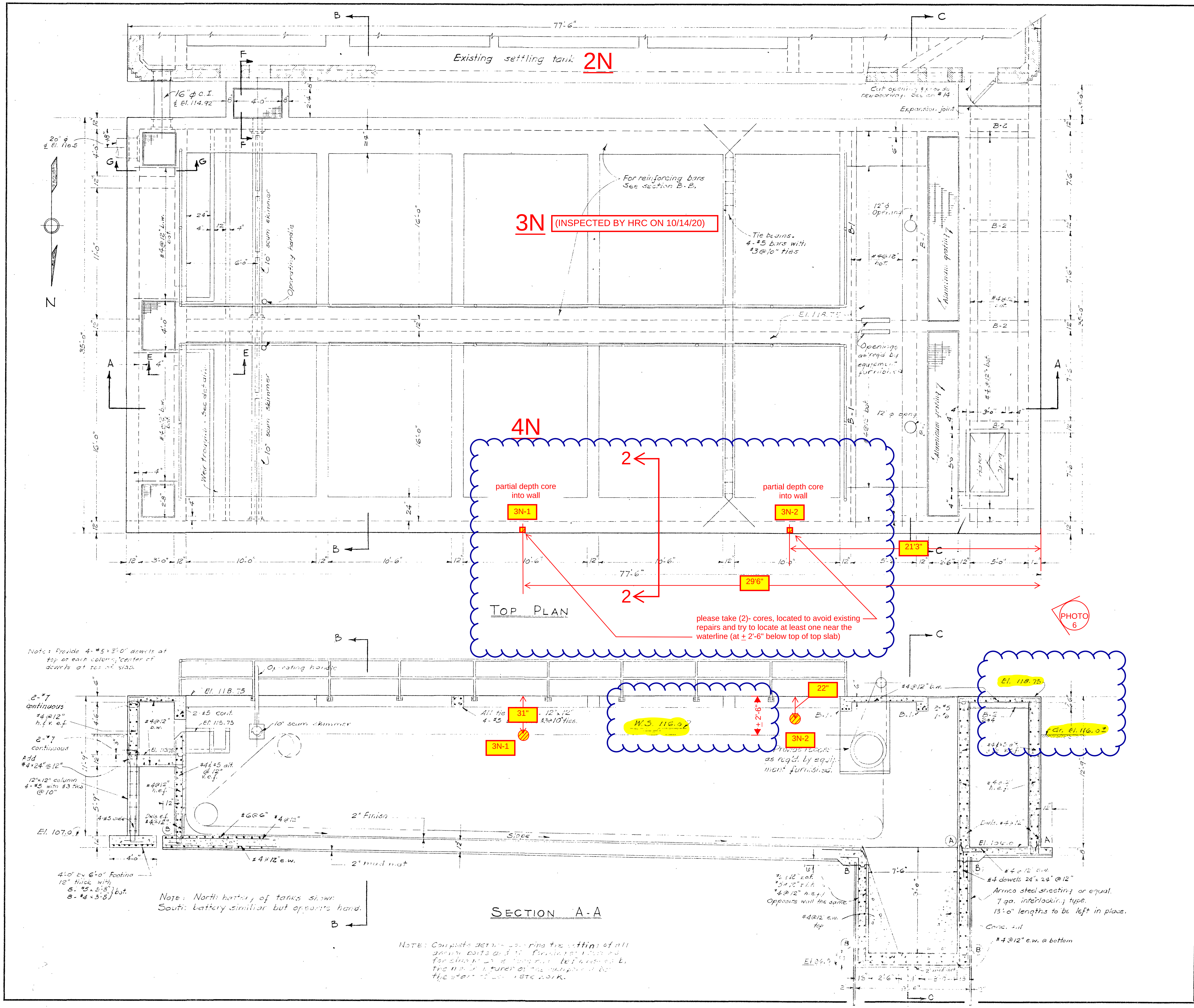


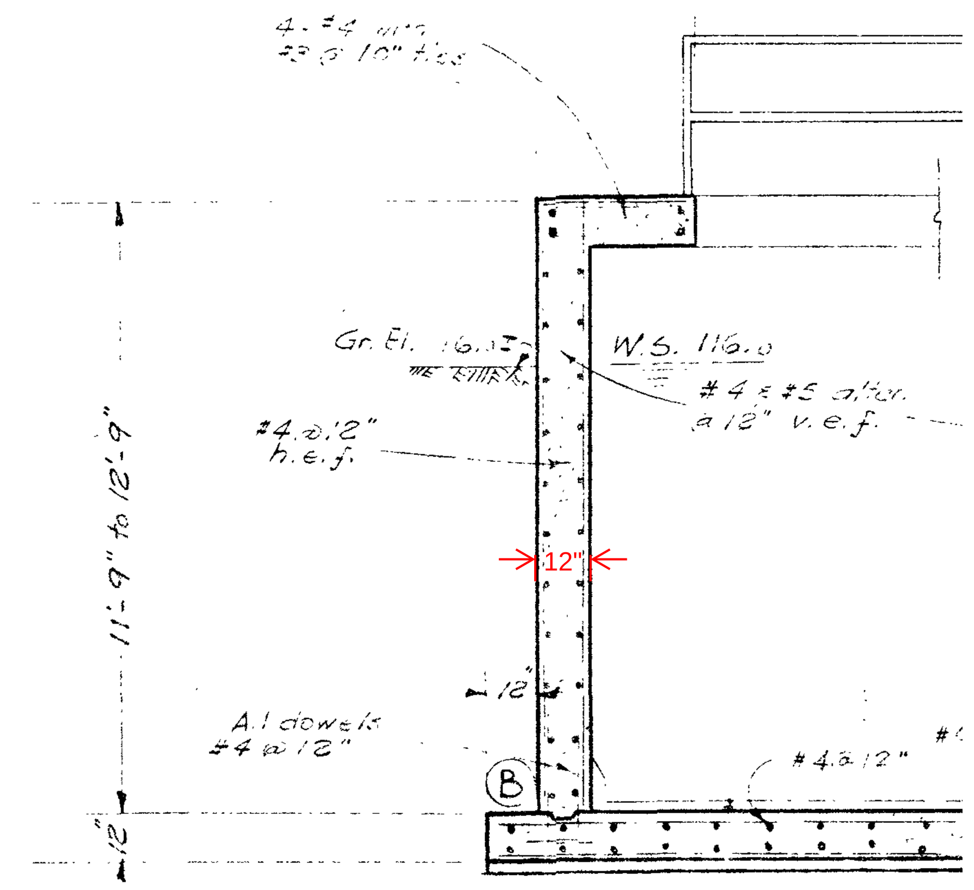
Concrete Core 3N-2

Figure No. 2


2S
1S
(INSPECTED BY HRC ON 10/14/20)
1N
2N
SETTLING
TANKS
GRIT CHAMBER
PASSAGEWAY
PHOTO 1
PHOTO 2
1S-1
2S-1
14'5"
2'6"
14'6"
SECTION 1-1
core through top slab and into wall below
NOTE: SCUM TROUGHS NOT SHOWN FOR CLARITY
NOTES:
1. THIS DRAWING IS FOR REFERENCE ONLY AND DOES NOT REFLECT THE MOST RECENT MODIFICATIONS TO THE TANKS. IT IS PROVIDED AS A SUFFICIENT MEANS FOR LOCATING THE CONCRETE SAMPLE LOCATIONS.
2. EXISTING FIBERGLASS PANELS ARE NOT RATED FOR FOOT TRAFFIC. DO NOT STAND ON OR PLACE ANY EQUIPMENT ON PANELS.
3. HRC CONTACTS-
CHRISTA CRIST (248) 535-1027 (CELL)
SEAN HERRLE (248) 496-8064 (CELL)
4. PLANT OPERATOR CONTACT (JACOBS)-
ANDREW WALDRON (231) 409-2842
Traverse City, Michigan
Sewage Disposal System
Sewage Treatment Plant
Settling Tanks - Floor Plan
Scale in Feet
February 1932
Plan at Elev. 123.0
C.E. Sawyer, City Engineer.
Hoad, Decker, Shoecraft and Drury, Consulting Engineers.
Fry and Kasurin, Consulting Architects.
9

Figure Nos. 3





SECTION 2-2

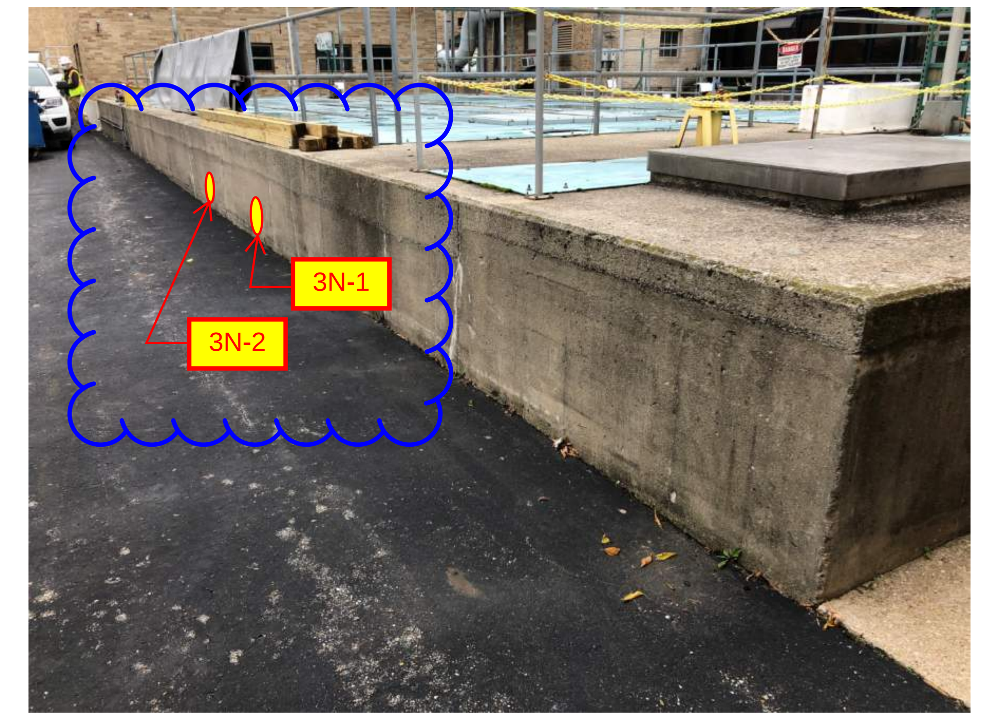


PHOTO 6

NOTES:

1. THIS DRAWING IS FOR REFERENCE ONLY AND DOES NOT REFLECT THE MOST RECENT MODIFICATIONS TO THE TANKS. IT IS PROVIDED AS A SUFFICIENT MEANS FOR LOCATING THE CONCRETE SAMPLE LOCATIONS.
2. EXISTING FIBERGLASS PANELS ARE NOT RATED FOR FOOT TRAFFIC. DO NOT STAND ON OR PLACE ANY EQUIPMENT ON PANELS.
3. EXACT LOCATION OF SAMPLES 3N-1 & 3N-2 MAY BE FIELD ADJUSTED TO AVOID EXISTING CRACK REPAIR AREAS.

Figure No. 4

McNAMEE, PORTER AND SEELEY
CONSULTING ENGINEERS
ANN ARBOR, MICHIGAN

Traverse City, Michigan
Sewage Treatment Plant Additions

Settling Tanks
Plan and Section

ISSUED Sept. 1957

As constructed

Sheet 5

REPORT NO. 5060

ON

PETROGRAPHIC EXAMINATION OF TWO CONCRETE CORE SAMPLES TAKEN AT A WASTE WATER TREATMENT FACILITY IN TRAVERSE CITY, MI.

TO

G2 CONSULTING GROUP
TROY, MICHIGAN|
(G2 PROJECT NO. 200895)

DECEMBER 14, 2020

DR. DAVID LANKARD
LANKARD MATERIALS LABORATORY
COLUMBUS, OHIO

LML REPORT NO. 5060

CONTENTS

REPORT NO. 5060

ON

PETROGRAPHIC EXAMINATION OF TWO CONCRETE CORE SAMPLES TAKEN AT A WASTE WATER TREATMENT FACILITY IN TRAVERSE CITY, MI.

TO

G2 CONSULTING GROUP
TROY, MICHIGAN|
(G2 PROJECT NO. 200895)

DECEMBER 14, 2020

LANKARD MATERIALS LABORATORY
COLUMBUS, OHIO

INTRODUCTION

On November 20, 2020, I received two concrete cores from James Berry, Project Manager of G2 Consulting Group in Troy, Michigan. The cores were taken from reinforced concrete tank structures at the Traverse City Michigan Waste Water Treatment Plant.

Following their inspection of the tank structures in October 2020, personnel of Hubbell, Roth, and Clark Consulting Engineers (Bloomfield Hills, MI) are proceeding with the concept that the concrete structures can be retained with relatively minor upgrades and repairs. As a confirmation and backup to the results of their visual inspection of the tanks, HRC has requested a qualitative evaluation of representative samples of the concrete from the tanks. G2 Engineering is assisting HRC in this effort. To this end, I was requested by Mr. Berry to conduct a petrographic examination of the cited cores. The objectives of my examination are (1) to provide a characterization of the overall quality and the current condition of the core concretes, and (2) to provide an assessment of the prospects for future service.

DESCRIPTION OF THE TANK STRUCTURES AND SAMPLING SITES

Of the four rectangular tanks at the facility, two, the largest were constructed in the 1960s. The two smaller tanks were built in the 1930s. One of the cores sent to me (Core 1S-1) was taken from one of the 1930s tanks, the other (Core 3N-1) from one of the 1960s tanks. Figure 1 shows current views of the cited tank structures.

Figure 1. Views of the Traverse City WWTP facility in October 2014. The top view shows the tanks labeled 1S and 2S. Core 1S-1 was taken from the vertical wall separating Chamber 1S from 2S (1930s construction). The bottom view shows Tanks 3N and 4N. Core 3N-1 was taken from Tank 3N, which was constructed in the 1960s.

DESCRIPTION OF THE CORES

Core 3N-1, shown in Figure 2 as received at LML, has a diameter of 3.7 in. and a length of 7.8 in. This core was taken horizontally through the exposed vertical exterior surface of the outer 12 in. thick wall of Tank 3N/4N. The wall surface is above grade and is not in contact with the tank water. A companion core (3N-2) was taken for a compressive strength test.

Core 1S-1 (photograph taken at G2), has a diameter of 3.7 in. and a length of around 7.5 in. The core was taken from the top surface of the 12 in. thick vertical wall, which separates Chambers 1S and 2S. The wall surface is above grade and is not in contact with the tank water. The core was tested for compressive strength at G2, and the fracture pieces were provided to LML for the petrographic examination.

Figure 2. Cores 3N-1 and 1S-1 provided for the petrographic examination. Core 3N-1 was received intact. Core 1S-1 was tested for compressive strength at G2, following which the fracture pieces were provided for the petrographic examination.

CORE EXAMINATION PROCEDURES

My examination was conducted in accordance with relevant guidelines of ASTM C856, the Standard Practice for Petrographic Examination of Hardened Concrete.

Examination of the Cores in the As-Received Condition

The as-received concrete samples were examined visually and microscopically. An Olympus SZX-16 stereomicroscope was used on fracture surfaces and cored-surfaces. Observations were made and noted on (1) the mode of fracture in the strength test for Core 1S-1 (aggregate pull-out or fracture), and on (2) the presence or absence of secondary deposits and distress features.

Further Examination of the Cores

Following the preliminary examination, the cores were saw-cut for further examinations and tests. Core 3N-1 was saw-cut as shown in Figure 3.

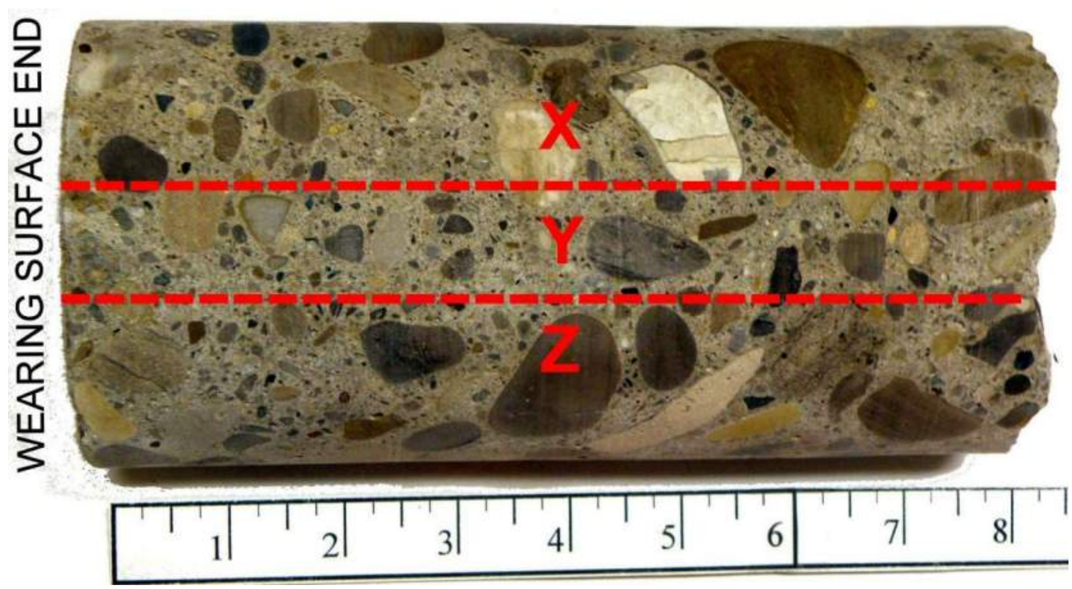


Figure 3. The dashed lines show where saw-cuts were made on Core 3N-1. Features of interest are discussed below.

Features of Interest in Figure 3

1. Sample Piece Y is a 1 in. thick slab. Both saw-cut surfaces of the piece are lapped (polished) for subsequent reflected light microscope examinations. Observations made and tests conducted during the examination provide (1) an identification of the cementitious and aggregate constituents of the concretes, (2) an estimate of the water-cement ratio (w/c) of the cementitious phase, (3) a characterization of the size and distribution of air voids and other types of voids, (4) information on the quality of the cement paste/aggregate bond, and (5) an opportunity to identify evidence of distress in the concrete.

Features of Interest in Figure 3 (Cont'd)

2. The fresh saw-cut surface of Core Piece X is sprayed with a pH indicating solution (phenolphthalein) to assess the presence and extent of carbonation of the concrete. Following this step, the piece is used to measure the density of the concrete, using relevant procedures of ASTM C642, the Standard Test Method for Specific Gravity, Absorption, and Voids in Hardened Concrete.

3. A fresh fracture surface is created in Core Piece Z using a modification of ASTM C496, the splitting tensile strength test. The examination of the newly-created fracture surface provides additional information on (1) the cement paste/aggregate bond strength, (2) the quality of the cement paste phase, and (3) the presence of distress features that could otherwise be missed.

Core 1S-1 was received in pieces and could not be saw-cut as shown in Figure 3. Saw-cuts were made in the pieces to provide for the preparation of lapped surfaces, for the assessment of carbonation, and for a density measurement.

Secondary Deposits

Particular attention was paid to the question of the presence and extent of secondary deposits in the core concretes. The search for secondary deposits was done on as-received surfaces, lapped surfaces, and newly-created fracture surfaces of the cores. What are secondary deposits and why are they important?

During wetting and drying episodes, water moves from one location to another in hardened concrete in service. It is an inevitable occurrence that soluble constituents located at an original site are transported and deposited at a new site. Such deposits are referred to as secondary deposits. The most common internal sites for their deposition are in air void cavities and along any pre-existing fracture surfaces. Two of the most common secondary deposits are calcium hydroxide and ettringite (a hydrous calcium sulfoaluminate mineral). The presence of secondary deposits is a innocuous diagnostic feature which confirms that there has been moisture movement into and out and through the concrete. An abundance of secondary deposits confirms that there has been extensive moisture cycling. This condition can (1) lead to freeze/thaw damage if the concrete is not adequately air entrained, or (2) lead to destructive cement/aggregate reactions if such aggregates are present.

On the other hand, the absence or dearth of secondary products confirms that the examined concrete did not experience any significant episodes of moisture cycling.

The findings of the examination and tests of the cores follow.

CORE 3N-1: EXAMINATION AND TEST RESULTS

Core 3N-1 represents the concrete that was used in the 1960s construction of the tanks at the Traverse City WWTP facility. The core, with a diameter of 3.7 in. and a length of 7.8 in. was taken horizontally (parallel to grade) through an exposed vertical exterior surface of the outer wall of Tank 3N. Figure 4 shows a lapped surface of the core.

Figure 4. This lapped surface of Core 3N-1 shows the appearance of the concrete. Features and properties of the core concrete are described below.

Cementitious Constituent (Core 3N-1)

The cementitious phase is composed solely of well hydrated portland cement. There is no standard test procedure for measuring the water-cement ratio (w/c) of hardened concrete. The water-cement ratio is estimated by qualified petrographers through observations and measurements of features and properties of the cement paste that are affected by w/c, including color, hardness, rate of water absorption, and abundance of residual cement grains. For the Core 3N-1 concrete, the w/c is estimated at 0.42, and is uniform from top to bottom in the core.

Carbonation of the Cement Paste (Core 3N-1)

A pH indicating solution (phenolphthalein) was sprayed on a fresh saw-cut surface of the core, with the result shown in Figure 5.

Figure 5. This view shows the appearance of a saw-cut surface of Core 3N-1 following the application of phenolphthalein solution. Features of interest are described below.

<u>Features of Interest in Figure 5</u>

1. The red coloration shows the area on the concrete that is not carbonated. When phenolphthalein contacts a carbonated concrete surface (pH below 10) there is no color change.

2. The only carbonation is a thin layer of the concrete at the wearing surface (where there is contact with the atmosphere). In this 2-dimensional view, a portion of the wearing surface layer shows 0 to 0.5 mm depth of carbonation (no color). Below this region in the figure, the depth of carbonation (indicated by the arrows) is 6 mm to 8 mm. A minor degree of incomplete consolidation has contributed to the carbonation in this region. There is no other carbonation in the core concrete.

3. The absence of any significant carbonation of the concrete at this sampling site after 60 years of service is attributed in large part to the good quality of the cement paste phase (low w/c, low permeability).

Fine and Coarse Aggregates (Core 3N-1)

The aggregate constituent in the core concrete is from a single sand/gravel source type, and is composed of both limestone and siliceous/silicate rock and mineral types.

Coarse Aggregate

The dominant coarse aggregate rock type is limestone, which includes finely-crystalline limestone, with smaller amount of micritic limestone and finely crystalline dolomitic limestone.

The limestone rock types comprise an estimated 80 to 90 percent of the coarse aggregate constituent. Within the category of limestone rocks, these limestone particles are hard and dense, and show a low rate of water absorption. The remainder of the coarse aggregate suite includes particles of quartz, quartzites, chert, igneous rock types, and occasional shale.

The particle size of the coarse aggregate constituent best fits the grading requirements of the ASTM C33, No. 57 classification (The Standard Specification for Concrete Aggregates). In this classification 90 to 100 % of the particles pass the 1 in. sieve. As seen in Figures 4 and 5, the rounded gravel particles range from roughly equiaxed to elongate and bladed in shape.

Fine Aggregate

The ASTM C33 gradation for fine aggregate shows 95 to 100 percent passing the No. 4 sieve (4.75 mm) and 0 to 10 percent passing the No. 100 sieve (0.15 mm). The fine aggregate in the Core 3N-1 concrete is a natural sand composed of the same siliceous and limestone rock and mineral types as the coarse aggregate. Quartz particles in the range of 0.05 mm to 0.5 mm form an estimated 70 to 80 percent of the sand, along with small amounts of sand-sized limestone particles, chert, igneous lithics, and trace amounts of shale. Figure 6 shows the dominance of small, clear quartz particles in the fine aggregate in the core concrete.

Figure 6. Photograph, taken at a magnification of 16X, on an acid-etched lapped surface of Core 3N-1. The arrows point to several of the small, clear quartz particles, which form an estimated 70 to 80 percent of the fine aggregate constituent. The darker particles include limestones and igneous rock constituents.

Cement Paste/Aggregate Bond (Core 3N-1)

Microscopic examinations made on lapped surfaces of Core 3N-1 reveal a tight, uninterrupted cement paste/aggregate bond. The examination of intentionally created fracture surfaces in pieces of the core confirm this condition as shown in Figure 7.

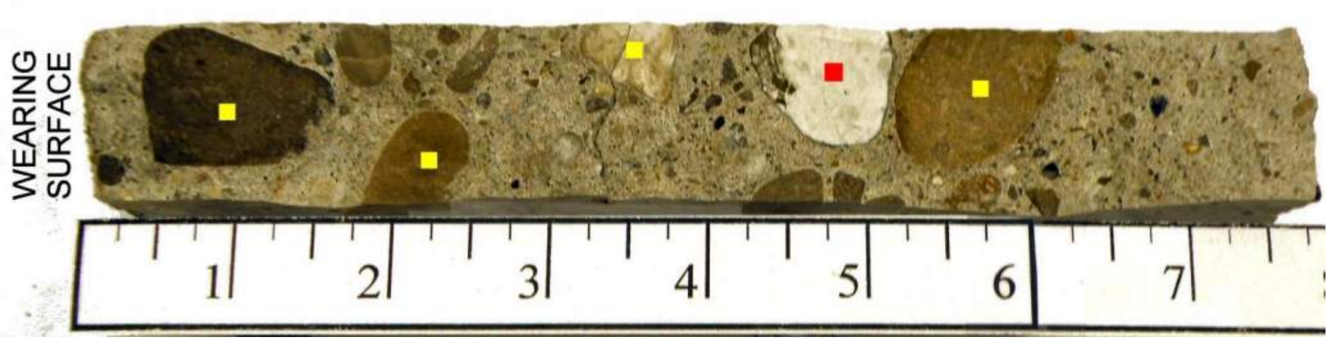


Figure 7. This view shows the appearance of the fracture surface that was intentionally created in Piece Z of Core 3N-1, in the ASTM C496 splitting tensile test. All of the coarse aggregate particles (dots on several) in the view fractured in the test, rather than pulling out intact. The red dot is on a chert aggregate particle that shows evidence of ASR activity (discussed in a later section). Other features of interest are discussed below.

Features of Interest in Figure 7

1. All of the coarse aggregate particles and many of the largest fine aggregate particles fractured in the test. This confirms (1) the good quality and strength of the cement paste/aggregate bond, and (2) the good quality of the cement paste phase (low w/c, low level of porosity, good strength).

2. The mode of failure predicts a high level of compressive strength for the core concrete. A companion core to Core 3N-1, Core 3N-2 had a measured compressive strength of 8420 psi, when tested by G2.

Cement/Aggregate Reactions (Core 3N-1)

There is a low level of alkali-silica reaction activity (ASR) associated with the chert aggregate particles in the coarse and fine aggregates. This condition is discussed in detail in a later section of the report

Air Voids and Consolidation (Core 3N-1)

The concrete represented by Core 3N-1 is non-air entrained, with an entrapped air void content estimated at 2 percent to 3 percent. The air voids typically range in size from a low value of 0.2 mm to a high value of 2 mm.

As can be seen on the lapped surface of Core 3N-1 in Figure 4, the core concrete is well consolidated. The only evidence of incomplete consolidation is in isolated, discrete and small regions of mortar at the wearing surface elevation (to a depth into the wearing surface of around 6 mm. This condition has not affected the performance or durability of the core concrete.

Core 3N-1 represents around an 8 in. thickness of the 12 in. thick tank wall, with the wearing surface being the exterior surface of the wall. The wall is not in contact with the tank water. The access of water in the form of precipitation is from the top and vertical side of the wall. Virtually all of the entrapped air void cavities are either free of any secondary deposits, or contain minute amounts. The overall dearth of secondary deposits confirms a low level of water ingress and moisture cycling episodes over the 60 years of service of the wall.

Core Concrete Density (Core 3N-1)

The density of pieces of Core 3N-1 was measured following a 48-hour water soaking period at room temperature (per relevant procedures of ASTM C642). A density measurement made on water-saturated hardened concrete is expected to correlate reasonably well with the original unit weight of the fresh concrete. The measured water-saturated density of the Core 3N-1 concrete is 151.9 lb/ft^3, which is in the range of expected values for non-air entrained concrete containing a good quality sand/gravel aggregate.

Core Concrete Compressive Strength (Cores 3N-1 and 3N-2)

Core 3N-2, the companion core to 3N-1, was tested for compressive strength at G2, with a measured value of 8420 psi. The mode of intentional failure of the Core 3N-1 concrete in the present study indicates a similar level of strength.

Current Condition of the Core 3N-1 Concrete

The Core 3N-1 concrete is in excellent condition following 60 years in an exposed freeze/thaw environment. There has been a minor amount of cement paste lost from the exposed wearing surface of the wall (a normal expectation), and low-level ASR activity that has not been destructive. Beyond these features, there is no evidence of distress of any type from any source exhibited by the core concrete.

A characterization of the ASR activity in the Core 3N-1 concrete is discussed in detail in a later section of the report.

CORE 1S-1: EXAMINATION AND TEST RESULTS

Core 1S-1 represents the concrete used in the 1930s construction of the tanks. As taken, the core had a diameter of 3.7 in. and a length of around 7.5 in. The core was taken (top down) in the middle of the 12 in. wide vertical wall separating the two tank chambers S1 and S2. After a compressive strength test at G2, the core pieces were provided for the petrographic examination. Figure 8 shows a lapped surface of one of the pieces of Core 1S-1 from the strength test.

Figure 8. This view shows a lapped surface of one of the Core 1S-1 pieces from the compressive strength test. Features and properties of the core concrete are described below.

Cementitious Constituents (Core 1S-1)

The cementitious phase is composed solely of well-hydrated portland cement. The water-cement ratio (w/c) is estimated at 0.42 and is reasonably uniform as observed on the fracture surfaces and lapped surfaces of the core pieces.

Carbonation of the Cement Paste (Core 1S-1)

A phenolphthalein solution was sprayed onto fresh saw-cut surfaces of the core pieces with the result shown in Figure 9.

Figure 9. This view shows the appearance of saw-cut surfaces of two pieces of Core 1S-1, following the application of phenolphthalein solution. Features of interest are described below.

Features of Interest in Figure 9

1. Virtually the entire saw-cut surface area of the core pieces shows the red coloration, confirming no carbonation of the concrete. The only carbonation is at the wearing surface end of the right-hand core piece in the figure, where the maximum thickness of no color change (carbonation) is 0.5 mm.

2. The shallow depth of carbonation at this sampling site after 90 years of service is attributed in large part to the good quality of the cement paste phase (low w/c, low permeability).

Fine and Coarse Aggregates (Core 1S-1)

The fine and coarse aggregate in the core concrete are from a single sand/gravel source type, and is composed of both limestone and siliceous/silicate rock and mineral types. The aggregate in this 1930s concrete is very similar to the sand/gravel aggregate in the 1960s concrete represented by Core 3N-1.

Coarse Aggregate (Core 1S-1)

The particle size of the coarse aggregate best fits the grading requirements of the ASTM C33 No. 67 classification. In this classification 100 percent of the particles pass the 1 in. sieve, with 95 to 100 percent passing the 0.75 in. sieve.

The dominant coarse aggregate rock type is finely-crystalline limestone, with small amount of micritic limestone and finely crystalline dolomitic limestone. Within the category of limestone rocks, these coarse aggregate particles are very hard and dense, and show a very low rate of water absorption. The limestone rock types comprise an estimated 80 to 90 percent of the coarse aggregate constituent. The remainder of the coarse aggregate suite includes quartz, quartzites, chert, igneous rock types, and shale.

Fine Aggregate (Core 1S-1)

The fine aggregate in the Core 1S-1 concrete is a natural sand composed of both siliceous and limestone rock and mineral types. Quartz particles in the range of 0.1 mm to 0.5 mm form an estimated 70 to 80 percent of the sand, along with small amounts of sand-sized limestone particles, chert, igneous lithics, and trace amounts of shale. Figure 10 shows the dominance of small quartz particles in the fine aggregate in the core concrete.

Figure 10. Photograph, taken at a magnification of 16X, on an acid-etched lapped surface of Core 3N-1. The arrows point to several of the small clear quartz particles, which form an estimated 70 to 80 percent of the fine aggregate.

Cement Paste/Aggregate Bond (Core 1S-1)

Microscopic examinations made on lapped surfaces of Core 1S-1 reveal a tight, uninterrupted cement paste/aggregate bond. The examination of the fracture surfaces created in the compressive strength test of Core 1S-1 confirm this condition as shown in Figure 11.

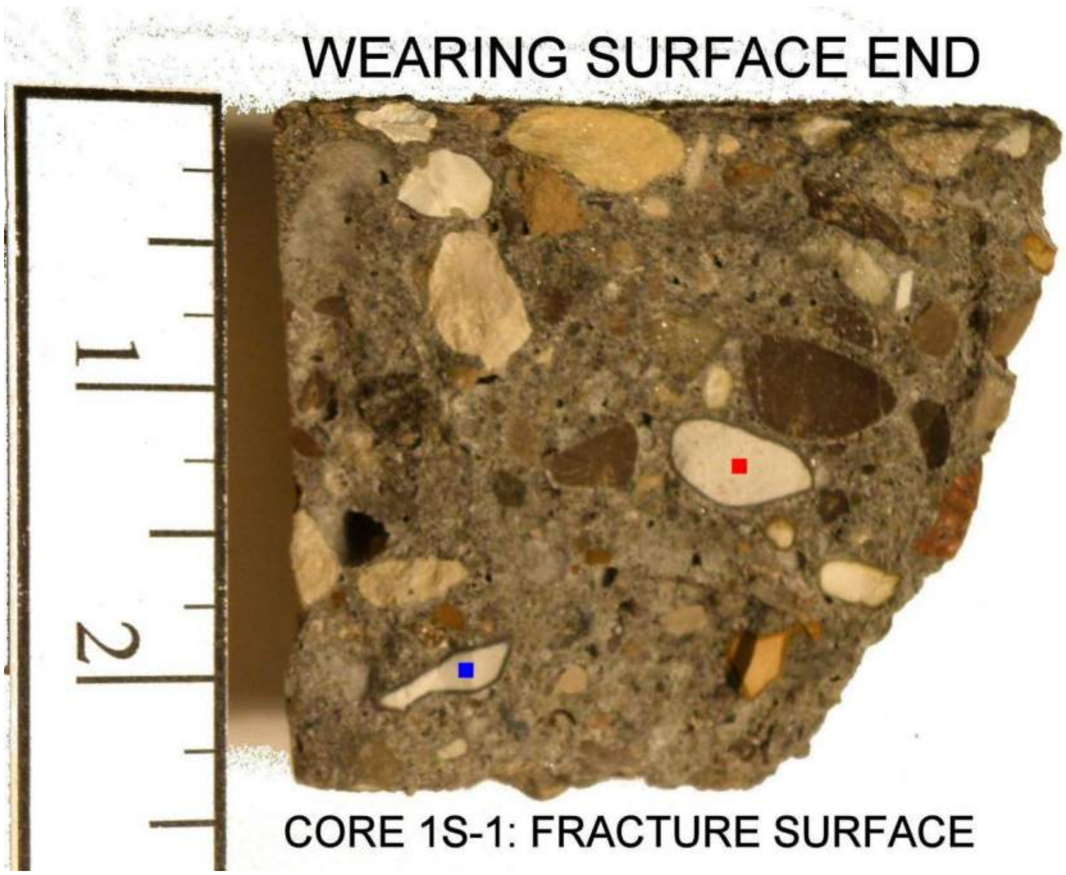


Figure 11. This view shows the appearance of a fracture surface that was created in the compressive strength test of Core 1S-1. All of the coarse aggregate particles in the view fractured in the test, confirming the good paste/aggregate bond, and the quality of the cement paste phase (low w/c, good level of strength). The colored dots are on chert coarse aggregate particles that show evidence of ASR activity (to be discussed).

Cement/Aggregate Reactions (Core 1S-1)

There is a low level of alkali-silica reaction activity (ASR) associated with the chert particles (8 % to 10 % of total aggregate count) in the core concrete.

Air Voids and Consolidation (Core 1S-1)

The concrete represented by Core 1S-1 is non-air entrained. The entrapped air content is estimated at 2 to 3 percent, which includes spherical entrapped air voids, and irregularly-shaped voids resulting from incomplete consolidation. Examples of the consolidation-related voids are shown in Figure 12.

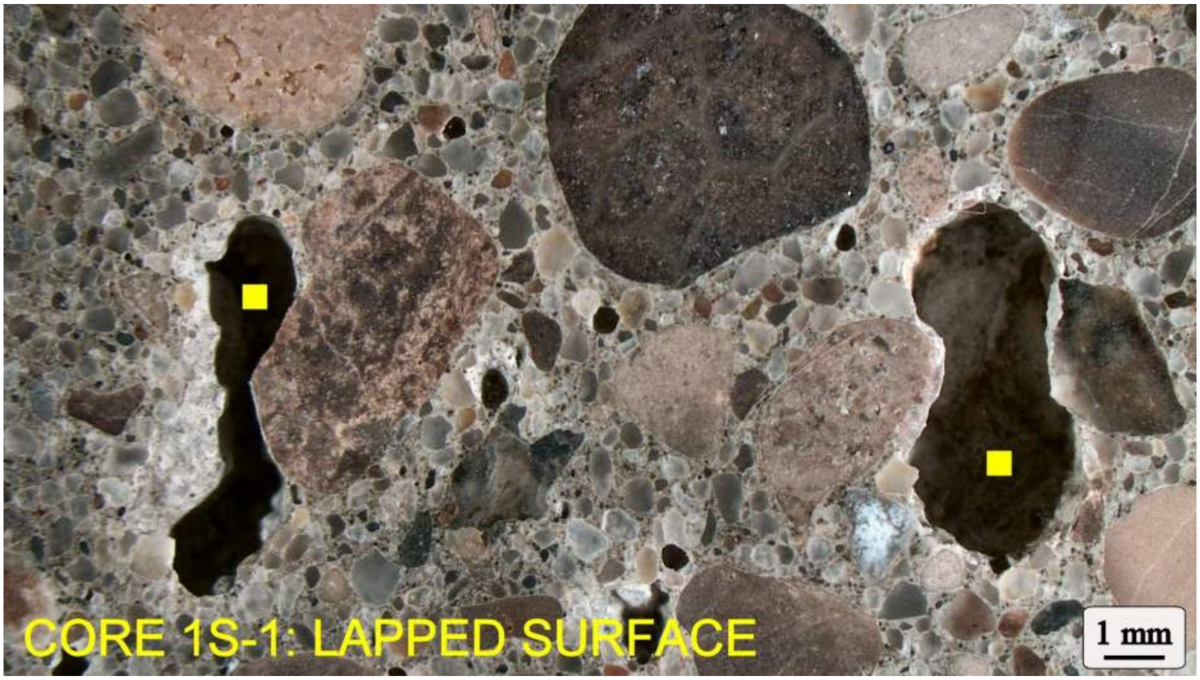


Figure 12. Photograph, taken at a magnification of 7X, on a lapped surface of Core 1S-1, showing two of the consolidation voids that are present in a minor amount in the core. Other than these innocuous artifacts, the core concrete is well-consolidated.

As discussed previously for the Core 3N-1 concrete, the air voids and other voids in Core 1S-1 are either free of secondary deposits, or contain only a very light coating or small, spotty deposits.

Core Concrete Density (Core 1S-1)

The water-saturated density (ASTM C642) of the Core 1S-1 concrete is 149.9 lb/ft^3, which is in the expected value range for non-air entrained concrete containing a good quality sand/gravel aggregate.

Core Concrete Compressive Strength (Core 1S-10

The compressive strength of Core 1S-1 was measured at G2, resulting in a value of 8260 psi.

Current Condition of the Core 1S-1 Concrete

The Core 1S-1 concrete is in excellent condition following 90 years in an exposed freeze/thaw environment. There has been a minor amount of cement paste lost from the exposed wearing surface (a normal expectation), and isolated ASR activity that has not been destructive. Beyond these features, there is no evidence of distress of any type from any source exhibited by the core concrete.

Additional detail on the ASR activity in Cores 1S-1 and 3N-1 is presented next.

ALKALI-SILICA REACTION ACTIVITY IN THE CORE CONCRETES

Core 1S-1 was taken from a concrete tank that was constructed at the Traverse City waste water treatment plant in the 1930s. Core 3N-1 was taken from a concrete tank that was constructed at the same facility in the 1960s.

Despite the 30-year difference in construction dates, the sand/gravel aggregate in the core concretes is either from the same source, or from a similar source in the area. The sand/gravel aggregate contains both limestone rock types and silica/silicate rock types and minerals. A minor constituent of this aggregate is a microcrystalline form of quartz known as chert. Chert is present in small amounts in both the fine and coarse aggregate fractions of both cores.

Chert is one of the silica-based rock types that is prone to participation in alkali-silica reactions in portland cement concretes. In many historical cases, the ASR activity is non-destructive, creating no distress in the affected concrete. In other cases, the ASR activity is destructive, with the degree of distress ranging from insignificant to threatening the satisfactory performance and service life of the affected concrete.

The factors influencing the onset and severity of ASR activity in any given case include, (1) the alkali content of the portland cement used in the concrete, (2) the form and amount of chert (or other reactive aggregate) in the concrete, and (3) the degree of water saturation and moisture cycling in the concrete.

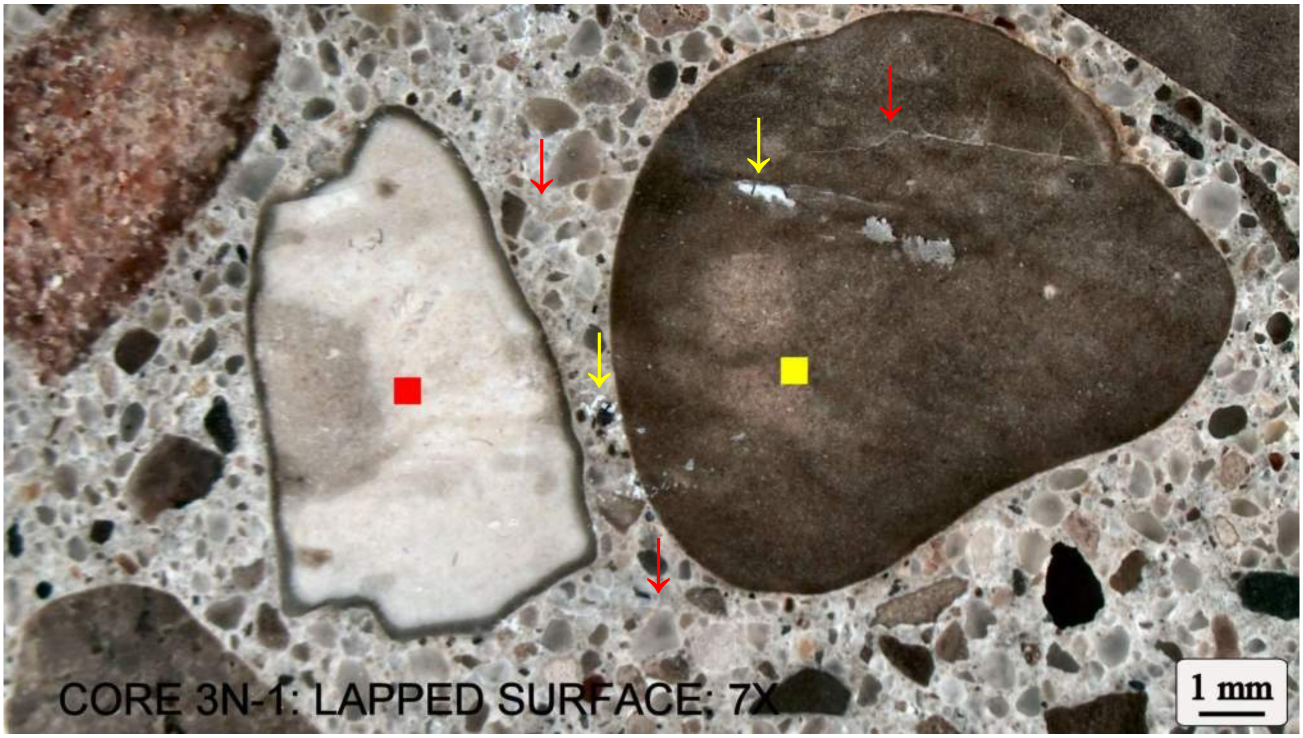
For the cores examined here, the form of ASR activity is the destructive form, but the degree of distress is of the insignificant variety. Examples from both core concretes are shown and discussed below.

ASR Activity in the Core 3N-1 Concrete

Core 3N-1 was taken horizontally through the exposed vertical exterior surface of the outer wall of Tank 3N/4N. As such, it was not a surface on which precipitation water would be expected to accumulate and pond.

Chert particles account for an estimated 3 to 4 percent of the total aggregate particle count in the core concrete. The diagnostic features of ASR activity include (1) a darkened rim around the perimeter of the reacting aggregate particle, where it is in contact with the cement paste, (2) the presence of white ASR gel reaction product in cracks, or in air void cavities adjacent to the reacting aggregate particle, (3) cracks in the reacting aggregate, which can extend into the adjacent mortar and nearby aggregate particles.

Figure 13 shows enlarged view of a lapped surface of Core 3N-1, which shows these features of interest. The reacting chert aggregate particle is located around 7 in. below the exposed tank wall surface.



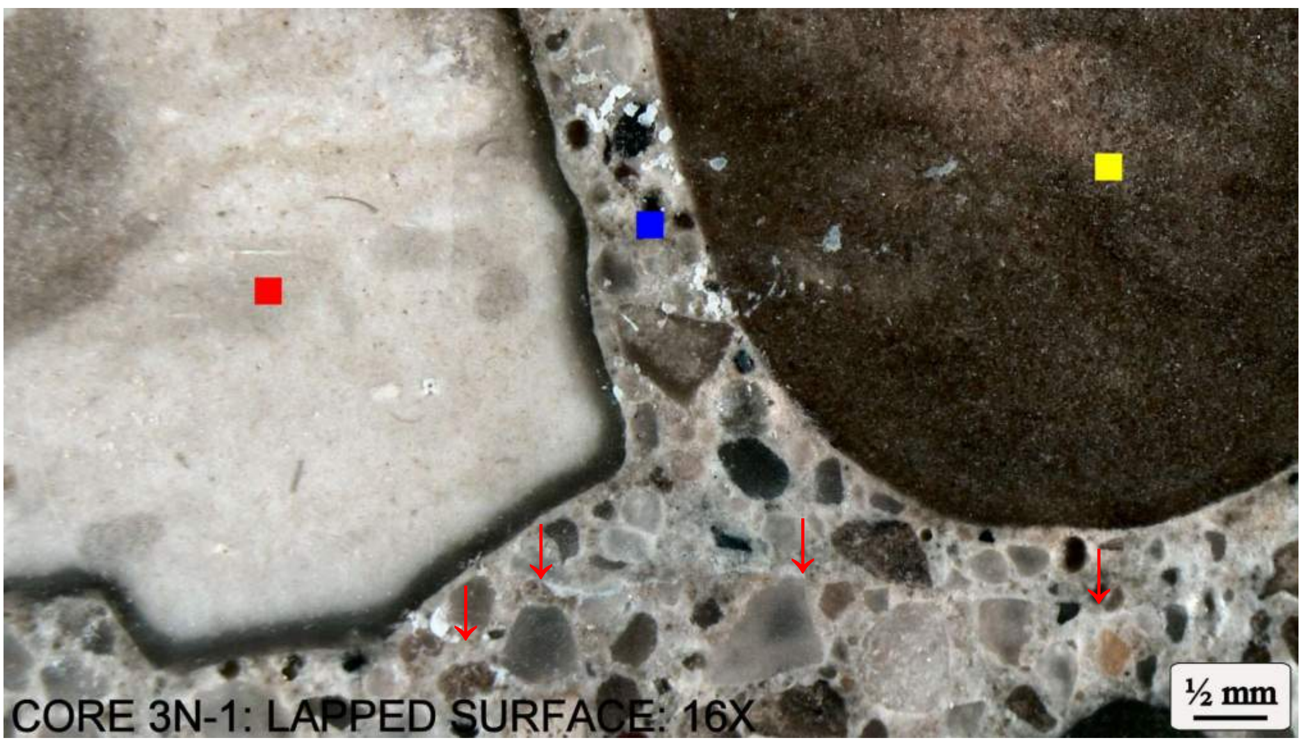


Figure 13. These are photographs, taken at a magnification of 7X and 16X, on a lapped surface of Core 3N-1. The red arrows point to ASR-related microcracks. Features of interest are discussed below.

Features of Interest in Figure 13

1. Reaction Rim: ASR Gel: Microcracks: The red dot is on a chert coarse aggregate particle that shows evidence of ASR activity. The evidence is in the form of (1) a darkened reaction rim around the perimeter of the particle, (2) the presence of ASR gel, and (3) microcracks emanating from the particle into the adjacent mortar and an adjacent limestone aggregate particle.

2. ASR-Related Cracks: The red arrows point to the microcracks, which emanate from the reacted chert particle and pass into the adjacent mortars. The cracks are very tight and are difficult to see even under the microscope. The filling of the cracks with white ASR gel renders them visible.

3. ASR Gel: The white material on the limestone particle (yellow arrow) is ASR gel, which exuded onto the lapped surface following the drying-out period after the lapping step. ASR gel also exudes from the cement paste adjacent to the reacted chert particle (blue dot)

4. Destructive and Non-Destructive ASR: When the cracking is confined to the reacting aggregate particle, the distress is characterized as "non-destructive ASR". When the cracks pass into the adjacent mortar, the distress is characterized as "destructive ASR".

5. Degrees of Destructive ASR: In the example shown for Core 3N-1 in Figure 13, the microcracks are very tight and extend into the adjacent mortar and aggregate particle a short distance (a few millimeters). In this 60-year old concrete this condition has probably prevailed for decades. The cracking distress shown in this example of the 1960s concrete at the WWTP is insignificant as related to the durability and performance of the concrete. In historical worst-case situations, destructive ASR activity has resulted in expansive stresses and cracking that required removal and replacement of the concrete.

6. The chert particle shown in Figure 13 is 7 in. below the exterior wearing surface in this view. The estimated percent of chert particles in the Core 3N-1 concrete is 3 to 4 percent of the total aggregate particle count. The majority of chert particles that could be seen on lapped surfaces and fracture surfaces show only a reaction rim (non-destructive ASR activity) and gel. There is no evidence of any significant destructive ASR activity in the Core 3N-1 concrete

ASR Activity in the Core 1S-1 Concrete

Chert particles account for an estimated 8 to 10 percent of the total aggregate particle count in the Core 1S-1 concrete. Reacted chert coarse aggregate particles are exposed on the fracture surfaces from the compressive strength test (8260 psi) of Core 1S-1, as shown in the example in Figure 14.

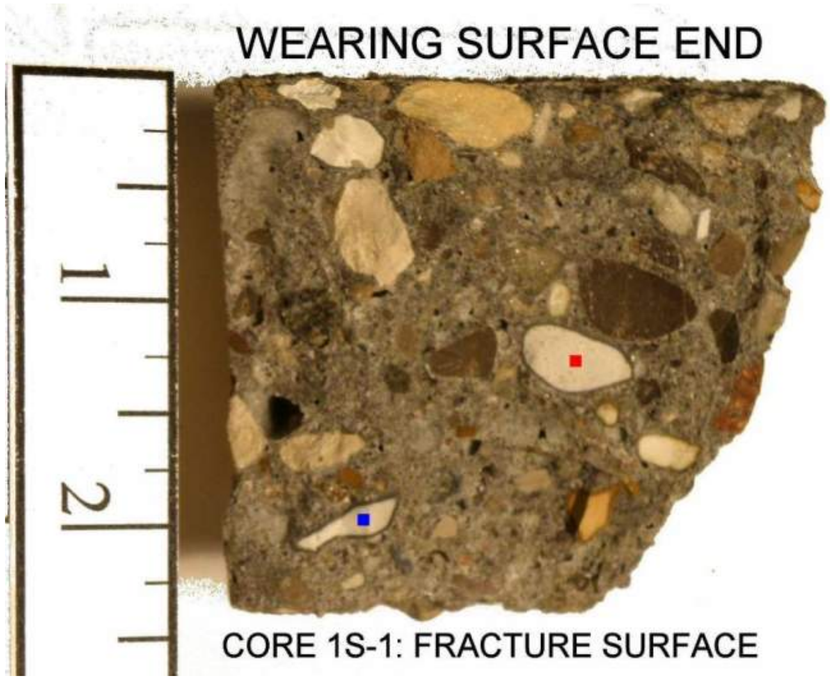


Figure 14. This view shows a fracture surface of Core 1S-1 resulting from the compressive strength test. All of the coarse aggregate particles exposed on the surface are fractured. The dots are on two chert particles that have evidence of ASR activity.

Enlarged views of the reacted chert particles shown in Figure 14 are shown in Figure 15. Features of interest in Figure 15 are discussed below.

Features of Interest in Figure 15

1. Both chert aggregate particles show darkened reaction rims, confirming the ASR activity.

2. The red arrows point to microcracks emanating from the chert particles that pass into the adjacent mortar. The microcracks are tight and travel only a few millimeters into the mortar.

3. The yellow arrows point to air voids, which are virtually free of any secondary deposits. This condition indicates that there has been very little moisture access or moisture cycling in the concrete. The scenario has implications for the performance of the tank concretes.

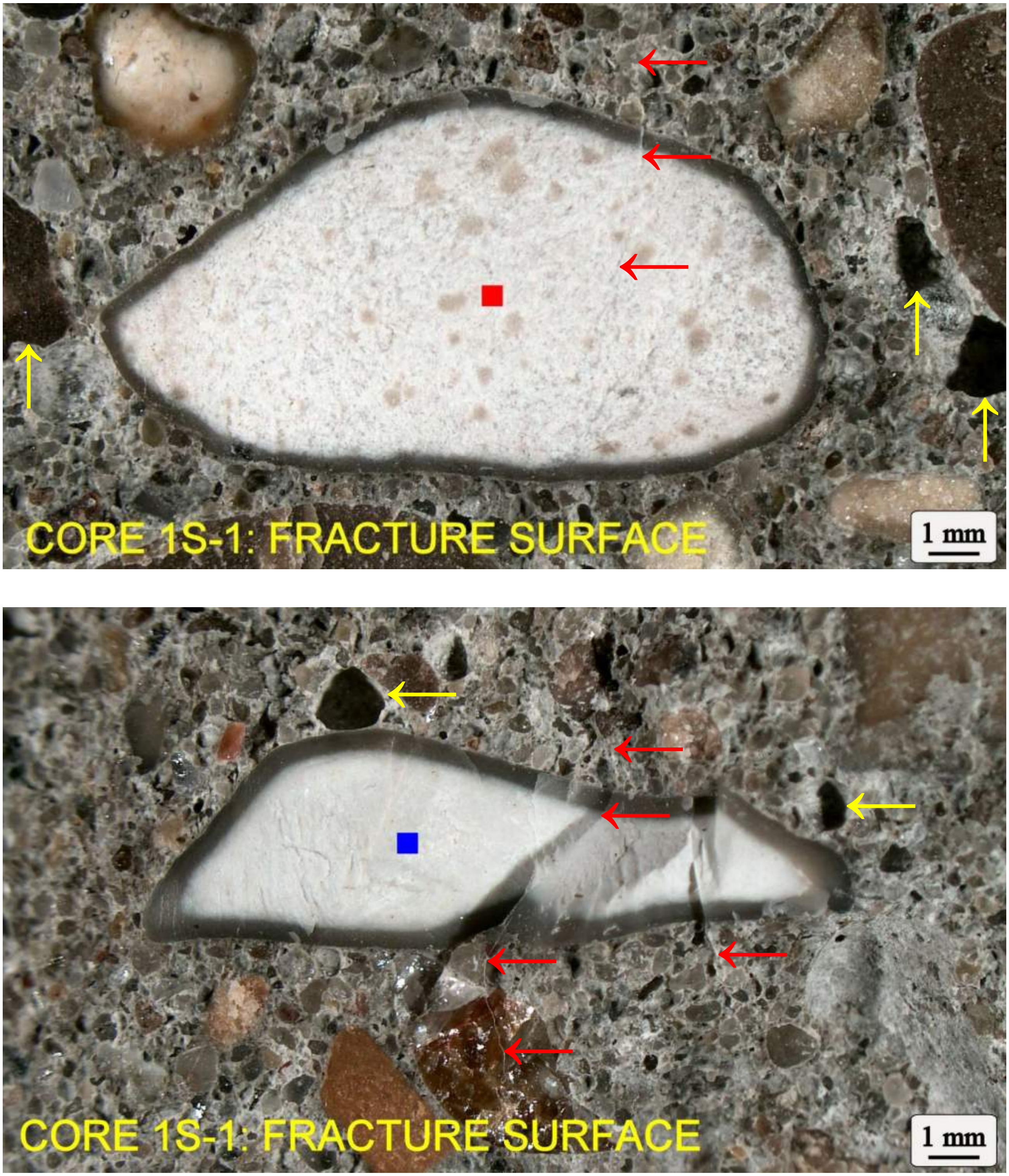


Figure 15. Photographs, taken at a magnification of 7X, on the fracture surface of Core 1S-1 shown in Figure 14. These views show the reacted chert coarse aggregate particles that are cited in Figure 14. The particles are 1 to 2 in. below the wearing surface. Features of interest in Figure 15 are discussed on Page 21.

Other examples of the ASR activity associated with the chert aggregate particles in the Core 1S-1 concrete are shown in Figure 16, which are enlarged views of a lapped surface of the core.

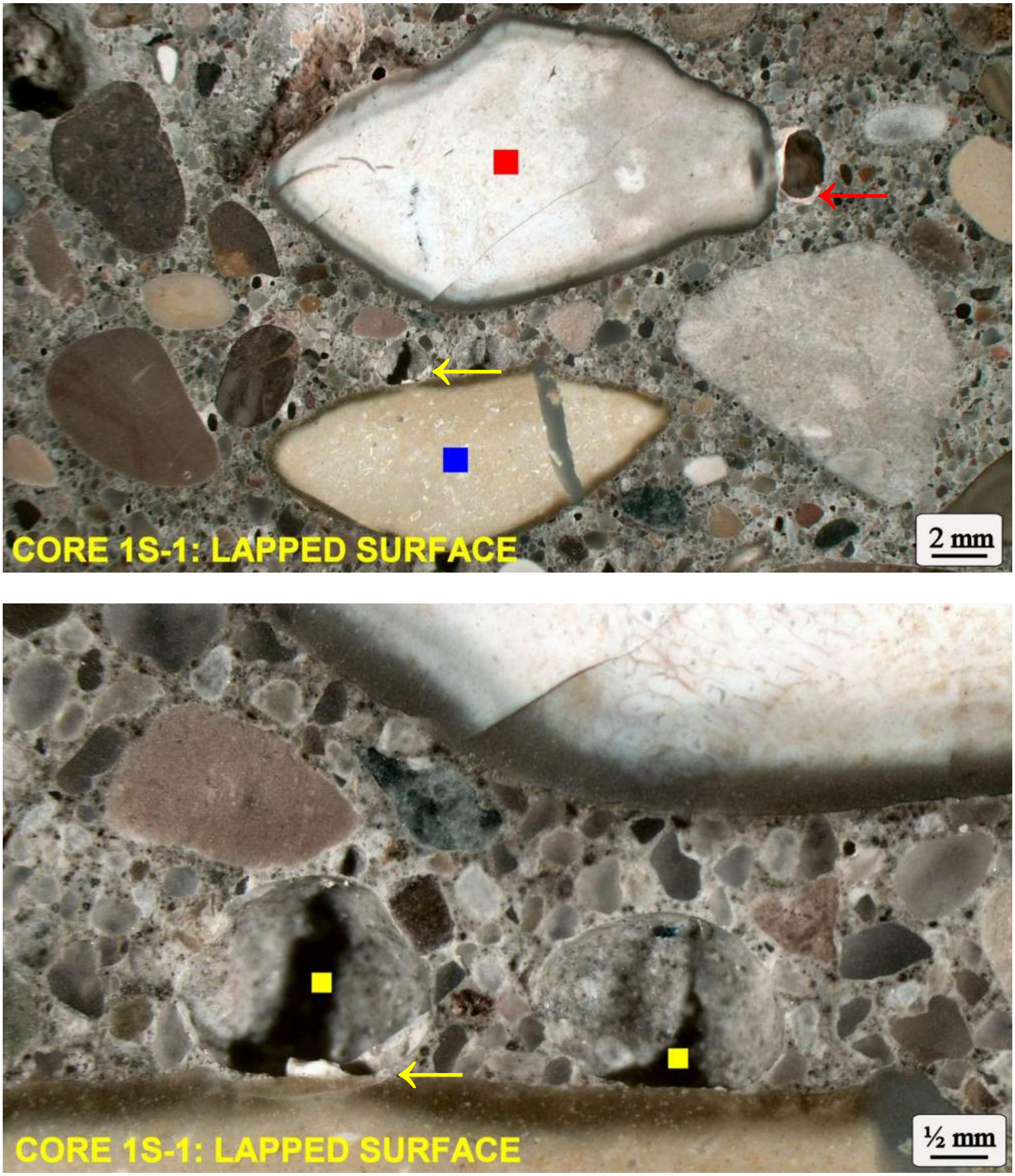


Figure 16. This shows two enlarged views of a lapped surface of Core 1S-1. The photographs were taken at magnifications of 3.5X (top) and 16X. Features of interest are discussed below.

Features of Interest in Figure 16

1. The dots are on reacted chert aggregate particles, which show reaction rims.

2. The arrows in the top photograph point to air voids, which contain a small amount of white ASR gel.

3. The yellow arrow in the bottom photograph points to the same feature of interest as the yellow arrow in the top photograph. This is a short microcrack in the reaction rim of the blue dot particle, along which is a tiny deposit of white ASR gel.

4. Of particular interest in the bottom photograph is that, with the exception of the tiny ASR gel deposit cited in Point 3 above, the air void cavities are empty; free of any other secondary deposits. As discussed previously, this condition confirms that there has been very little moisture access or moisture cycling in the concrete at this sampling site. The scenario has implications for the performance of the tank concretes as discussed in the next section of the report.

THE ROLE OF WATER IN THE PERFORMANCE OF THE CONCRETES

Water plays a key role in the creation of distress in exposed concrete is service including creation of the potential for distress associated with alkali-silica reaction activity (ASR), and the potential for distress associated with freeze/thaw cycling. The 1930s and the 1960s tank concretes at the Traverse City waste water treatment plant are candidates for both of these forms of distress.

Chert, an ASR-prone form of quartz is a minor constituent of the sand/gravel aggregate in the concretes. Neither concrete has a satisfactory entrained air void system, making them vulnerable to freeze/thaw damage. Despite these scenarios, the concretes represented by the cores examined here show no evidence of freeze/thaw damage, and no significant damage from destructive ASR activity. These outcomes are attributed in large part to the fact that water-saturation and water cycling episodes have not occurred with any great frequency in the concrete at these sampling sites.

The relatively dry condition of the concrete at the 1S-1 and 3N-1 sampling sites is somewhat puzzling, as the walls from which the cores were taken have been exposed to the elements for 90 years and 60 years respectively. Water has not penetrated deeply into the concrete at these locations. There are several factors that could be playing a role in this outcome.

Factors Affecting the Relatively Dry Condition of the Core Concretes

1. The concrete walls from which the cores were taken (1) are above grade, and (2) are not in contact with the water in the tanks. The primary source of water is precipitation in contact with the top surface of the walls and the vertical wall surfaces. Water can accumulate on the top surface of the walls, but not on the vertical side surfaces. There has been some loss of a few millimeter thickness of cement paste from the wearing surfaces of both cores, revealing the tops of fine aggregate particles and a few coarse aggregate particles. Beyond this expected weathering outcome there is no evidence of any near-surface distress in either core.
2. For water to enter the concrete it has to pass through the hardened cement paste phase. In both cores examined here the water-cement ratio is estimated at 0.42. At this low level of w/c, the expected permeability of the cement paste is quite low, as shown in Figure 17.

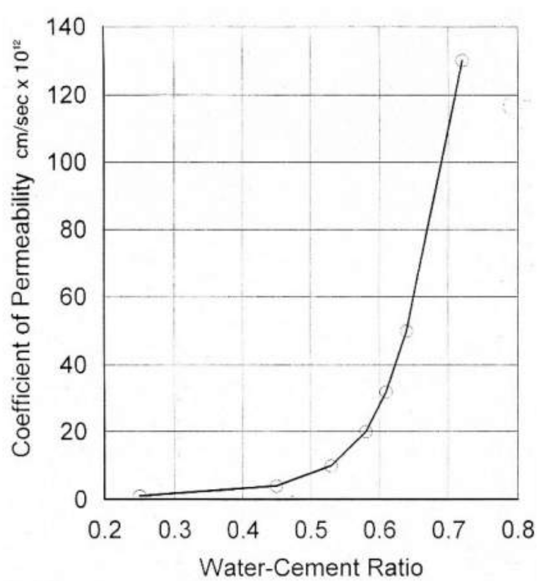


Figure 17. Cement paste permeability as a function of water-cement ratio. (T.C. Powers & R.A. Helmuth, Proceedings of the Highway Research Board, 32nd Annual Meeting, 1953).

3. Although the water in the tanks is not intentionally heated, it is reportedly generally above freezing temperature. With the tanks buried approximately 12 ft. deep, this condition may have helped to limit the freezing episodes of the concrete above grade.

SUMMARY AND CONCLUSIONS

Reinforced concrete tanks at the Traverse City, Michigan waste water treatment plant have been in service for around 60 to 90 years. Following their inspection of the tanks in October 2020, Hubbell, Roth, and Clark Consulting Engineers believe the structures can remain in service with minor upgrades and repairs. As a confirmation of the visual inspection, HRC has requested an evaluation of representative samples of concrete from the tanks. G2 Consulting Group is working with HRC in this effort. To this end, on November 20, 2020 I was provided with two tank concrete cores by G2 for petrographic examinations. The findings of the examinations, discussed in this report, provide a characterization of the overall quality and the current condition of the core concretes, and provide an assessment of the prospects for future service.

Description of the Cores

Of the four concrete tanks at the WWTP facility, two were constructed in the 1930s and two in the 1960s. I received one core from one of the 1930s tanks (Core 1S-1) and one from a 1960s tank (Core 3N-1). The cores, with a diameter of 3.7 in. and a length of around 8 in., were taken in above-grade walls of the tanks. One end surface of the cores is the exterior exposed wearing surface of the walls. The other end surface is a fresh fracture surface, made in sound concrete as a planned break-off point during coring.

Core Examination Procedures

Visual and microscopic examinations were conducted in accordance with relevant guidelines of ASTM C856, the Standard Practice for Petrographic Examination of Hardened Concrete. A pH indicating solution (phenolphthalein) was used to assess the presence and extent of carbonation. A density measurement was made following relevant procedures of ASTM C642, the Standard Test Method for Specific Gravity, Absorption, and Voids in Hardened Concrete.

Reporting Protocol

The coring sites for the examined cores were selected to be representative of the tank concretes. However, the finding of the present investigation can be strictly applied only to the concretes represented by the examined cores.

Characterization of the Core Concretes

Despite a 30-year difference in construction dates, the constituents, as well as many features and properties of the core concretes share much in common. A summary is provided below.

Core Concrete Description and Constituents

These are non-air entrained portland cement concretes, containing a natural sand/gravel fine and coarse aggregate. The cement paste phase is of good quality, with a water-cement ratio estimated at 0.42.

The aggregate is composed of both limestone and siliceous rock and mineral types. The aggregates in the two core concretes either came from the same source or from similar source types. The aggregates are of good quality based on the criteria of hardness, rate of water absorption, soundness, and current condition. In the 1930s concrete (Core 1S-1), the coarse aggregate gradation falls within the ASTM C33 classification of No. 67 (3/4 in. to No. 4 sieve). The 1960s aggregate is coarser, falling within the gradation-requirements of ASTM C33 No. 57 (1 in. to No. 4). Chert, a microcrystalline form of quartz, is present as a minor phase of the aggregate in both core concretes.

The core concretes are not air entrained. The entrapped air content is estimated at 2 to 3 percent. Reflecting the low air void content, the water saturated density is 150 lb/ft^3 in the Core 1S-1 concrete, and 152 lb/ft^3 in the Core 3N-1 concrete.

Core compressive strength measurements made on single cores at G2 showed 8260 psi for the 1930s concrete, and 8420 psi for the 1960s concrete.

Viewed from the perspective of the above characterization, the lack of an adequate entrained air void system, and the presence of an aggregate constituent that is potentially prone to alkali-silica reaction activity (chert), raise warning flags as regards the durability of the concrete in service. However, neither of these conditions have had any adverse effect on the durability of the core concretes to date.

Current Condition of the Core Concretes

Both of the cores examined here were retrieved intact and in sound condition (as can be seen in Figure 2). The subsequent petrographic examinations revealed no evidence of any distress related to the effects of freeze/thaw cycling.

The examinations did reveal the presence of ASR activity associated with the chert aggregate particles in both the 1930s concrete and the 1960s concrete. However, as described in detail in the report, the presence of ASR activity is not necessarily a death sentence for concrete.

Most of the reacted chert particles in the core concretes show what is characterized as “non-destructive ASR activity”. In a minority of the particles there is evidence of “destructive ASR activity”, which on a scale of “insignificant” to “life-threatening”, is characterized as “insignificant” for the core concretes.

As discussed in detail in the report, a condition of water-saturation, and well as frequent episodes of water cycling in the concrete is a requirement for both freeze/thaw-related damage, and for high levels of destructive ASR activity. The petrographic evidence confirms that neither of these conditions was in play for the core concretes. The possible reasons for this positive outcome are discussed in the report, and include an expected low value of permeability of the concretes due to the low water-cement ratio.

In summary, the core concretes are in sound condition and are of good quality based on the criteria of (1) the quality of the cementitious phase (a low water-cement ratio, (2) the absence of any significant regions of carbonation, (3) the quality of the aggregates, and (4) the quality of the cement paste/aggregate bond.

Future Service Outlook

It is prudent here to reiterate the caveat that the findings of the present study can be strictly applied only to the concretes represented by the two cores examined here. However, it is reasonable to expect that exposed tank concrete that shows, in a site survey, the same visual appearance and sound condition as that seen at the coring sites, will show similar features to those described here for the core concretes.

The most compelling argument supporting a claim of continued satisfactory performance is the 60-year and 90-year satisfactory performance of the tank concretes to date. This assumes that none of the modifications planned for the facility will increase the accessibility of water to the concrete.

Finally, if there is any of the tank concrete that currently does show cracking or spalling damage, the logical suspects would be either freeze/thaw damage, or a more destructive form of ASR activity.

Dr. David Lankard, President & Petrographer

Traverse City Regional Wastewater Treatment Plant

APPENDIX F: COST ESTIMATES

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CONSULTING ENGINEERS SINCE 1915

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1925 Breton Road SE, Suite 100; Grand Rapids, MI 49506 — Telephone: (616) 454-4286

PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Lower Boardman River Wall Sanitary Sewer**	CHECKED BY:	**DIU**
	100 & 200 Block	CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
	GENERAL				
1	Mobilization	1	LS	$96,247	$96,247
	SITE PREPARATION, EROSION CONTROL, AND DEMOLITION				
2	Tree Removal	4	Ea	$500	$2,000
3	Sidewalk Removal	8600	SF	$2	$17,200
4	Asphalt Removal	36075	SF	$2	$54,113
5	Lanscape Removal	3500	SF	$1	$3,500
6	Curb Removal	835	LF	$4	$3,340
7	Old Wall Removal	480	LF	$75	$36,000
8	Storm and Sanitary Removal/Abandonment	1545	LF	$25	$38,625
9	Manhole/Catch Basin Removal	7	Ea	$500	$3,500
10	Miscellaneous Demo and Removal	2	LS	$15,000	$30,000
	UTILITY SYSTEMS				
11	Existing Utility Structure Elevation Adjustment	24	Ea	$250	$6,000
12	Storm Manholes and Catch Basins	10	Ea	$3,000	$30,000
13	Storm Piping	500	LF	$90	$45,000
14	Storm Lead Excavation and Installation	160	LF	$50	$8,000
15	Swirl Chambers/Infiltration Beds	2	EA	$20,000	$40,000
16	Sanitary Manholes	3	EA	$4,000	$12,000
17	Sanitary By-pass and Trench Dewatering	1	LS	$80,000	$80,000
18	Sanitary Sewer Pipe	465	LF	$250	$116,250
19	Sanitary Lead Excavation and Installation	300	LF	$65	$19,500
	EARTHWORK AND WALL REHAB				
20	Soil Erosion Control Measures	2	LS	$15,000	$30,000
21	Cut and Haul Soil	3,600	CY	$20	$72,000
22	Aggregate Backfill	495	CY	$50	$24,750
23	New Sheet Pile Wall	545	LF	$1,200	$654,000
24	Tremied Concrete	545	CY	$200	$109,000
25	Rip Rap at Wall Base	525	CY	$75	$39,375

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PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Lower Boardman River Wall Sanitary Sewer**	CHECKED BY:	**DIU**
	100 & 200 Block	CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
	HARDSCAPE IMPROVEMENTS				
26	Sidewalk, Conc, 6 inch	10,750	Sft	$8	$80,625
27	Heavy duty concrete, 10 inch	600	Sft	$10	$5,700
28	Concrete Road Curb	755	LF	$25	$18,875
29	Finish Grading	51,965	SF	$1	$38,974
30	HMA Pavement	24,765	SF	$3	$74,295
	LIGHTING AND ELECTRICAL SYSTEMS				
31	Replacement Pedestrian Scaled Lighting	7	EA	$4,000	$28,000
32	Relocate Conduit and Wire	960	LF	$50	$48,000
	SIGNAGE AND PAVEMENT MARKINGS				
33	Traffic Management	2	LS	$5,000	$10,000
34	Street Marking and Signage	2	LS	$5,000	$10,000
	LANDSCAPING				
35	Landscape habitat area/rain garden	16,450	SF	$8	$123,375
36	Trees	26	Ea	$600	$15,600
37	Demarcation Layer and Erosion Control Fabric	16,450	SF	$1	$12,338
	Construction Subtotal				**$2,037,000**
	Contingencies	20	%		$408,000
	Engineering, Legal, and Administrative	20	%		$408,000
	TOTAL PROJECT COST				**$2,853,000**

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PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Headworks and Primary Treatment Improvements**	CHECKED BY:	**DIU**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
	HEADWORKS				
1	42-inch wide Mechanically Raked Fine Bar screen and wash/compact	1	EA	$427,500	$427,500
2	Demo Exist Manual Screen	1	LS	$12,000	$12,000
3	Conveyance Duct to Dumpster	10	LF	$800	$8,000
4	Grating Modifications	24	SF	$125	$3,000
5	Handrail Additions	12	LF	$120	$1,440
6	Concrete Rehab Allowance	20	SF	$100	$2,000
7	72-inch wide Channel - Mech Fine Bar screen and washer/compactor	1	EA	$465,500	$465,500
8	Demo Exist Rotamat Screen	1	LS	$20,000	$20,000
9	Conveyance Duct to Dumpster	8	LF	$800	$6,400
10	Slide Gate Actuators for Grit Flow Control	2	EA	$18,500	$37,000
11	Controls Modifications and Programming	1	LS	$20,000	$20,000
12	Misc Metal	1%	%	$1,002,840	$11,000
13	Misc Mechanical	1%	%	$1,002,840	$11,000
14	Misc Painting	1%	%	$1,002,840	$11,000
15	Electrical Allowance	15%	%	$1,002,840	$151,000

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Telephone: (616) 454-4286

PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Headworks and Primary Treatment Improvements**	CHECKED BY:	**DIU**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
	GRIT REMOVAL				
17	Demo Old West Detritor	1	LS	$35,000	$35,000
18	Concrete Floors and Footings on Grade	126	CY	$800	$101,096
19	Concrete Walls	243	CY	$1,000	$242,667
20	Concrete Oper Floor & Struts	99	LS	$1,200	$118,933
21	Superstructure	2,172	SF	$250	$543,000
22	Grit Weirs/Baffles	24	LF	$100	$2,400
23	Isolation Slide Gates	7	EA	$32,000	$224,000
24	Tank Covers	1,008	SF	$80	$80,640
25	Soil or Flowable Fill Below and Around Channels	506	CY	$75	$37,949
26	FRP Foul Air Ductwork (just in this building)	102	LF	$200	$20,400
27	FRP Foul Air Registers and Grilles	1	LS	$20,000	$20,000
28	Site Improvements (Minor)	1	LS	$50,000	$50,000
29	Excavation and Backfill	400	CY	$200	$80,000
30	Influent 24 Valves	6	EA	$12,000	$72,000
31	24" RS Extension/Revisions	200	LF	$250	$50,000
32	Influent Meters (s)	2	EA	$36,000	$72,000
33	Influent Sampler and piping	1	EA	$20,000	$20,000
34	Grit Tank Equipment Package	1	LS	$967,500	$967,500
35	Handrails	46	LF	$150	$6,900
36	Stairs	25	VLF	$1,500	$36,750
37	Misc Metal	2%	%	$2,781,235	$56,000
38	Misc Mechanical (Pl HVAC)	5%	%	$2,781,235	$140,000
39	Painting	2%	%	$2,781,235	$56,000
40	Electrical	15%	%	$2,781,235	$418,000

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PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Headworks and Primary Treatment Improvements**	CHECKED BY:	**DIU**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
	PRIMARY TREATMENT				
41	Floor Fill	2,133	CY	$100	$213,333
42	Concrete Floor	372	CY	$800	$297,719
43	Concrete Walls	228	CY	$1,000	$227,941
44	Concrete Weirs Struts	98	LS	$1,200	$117,227
45	12-inch Knife Gate Valves	4	EA	$21,400	$85,600
46	Weirs/Baffles	440	LF	$100	$43,960
47	Concrete Wall Demo (Partial)	344	CY	$400	$137,600
48	Covers	7,693	SF	$80	$615,440
49	Collection Mechanisms	2	EA	$288,000	$576,000
50	30-inch Influent / Effluent Piping	400	LF	$350	$140,000
51	Handrails	879	LF	$150	$131,880
52	Stairs	40	VLF	$1,500	$60,000
53	Relocating PE Screens and Channels	1	LS	$1,000,000	$1,000,000
54	Misc Metal	2%	%	$3,646,699	$73,000
55	Misc Mechanical	5%	%	$3,646,699	$183,000
56	Misc Painting	2%	%	$3,646,699	$73,000
57	Electrical	15%	%	$3,646,699	$548,000

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PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Headworks and Primary Treatment Improvements**	CHECKED BY:	**DIU**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
	PRIMARY EFFLUENT PUMPING				
58	Submersible Pump Package with Prerostal Basin	3	EA	$222,400	$667,200
59	Concrete Core for Basin Install	3	EA	$4,000	$12,000
60	Concrete Grout around Basin and Base Elbow Install	33	CY	$2,000	$66,667
61	Discharge Piping 24-inch	48	LF	$300	$14,400
62	Pump VFDs	3	EA	$60,000	$180,000
63	Control Panel and Programming	1	LS	$70,000	$70,000
64	Misc Metal	3%	%	$1,010,267	$31,000
65	Misc Mechanical	2%	%	$1,010,267	$21,000
66	Misc Painting	1%	%	$1,010,267	$11,000
67	Misc. Electrical	15%	%	$1,010,267	$152,000
	Construction Subtotal				**$10,388,000**
	Contingencies	20	%		$2,078,000
	Engineering, Legal, and Administrative	20	%		$2,078,000
	TOTAL PROJECT COST				**$14,544,000**

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PROJECT:	Traverse City CWSRF	DATE:	3/25/2021
LOCATION:	Traverse City, Michigan	PROJECT NO.	20210140
		ESTIMATOR:	ARH
WORK:	Sewer Rehabilitation (I/I Alternative 1)	CHECKED BY:	DIU
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	18-inch CIPP	2000	LF	$150	$300,000
2	24-inch CIPP	1500	LF	$160	$240,000
3	8-inch to 12-inch CIPP	4000	LF	$125	$500,000
4	Manhole Rehabilitation	75	EA	$2,500	$187,500
	Construction Subtotal				**$1,228,000**
	Contingencies	20	%		$246,000
	Engineering, Legal, and Administrative	20	%		$246,000
	TOTAL PROJECT COST				**$1,720,000**

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PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Flow Diversion (I/I Alternative 2)**	CHECKED BY:	**DIU**
	Lift Station and FM	CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	8-inch FM	5000	LF	$200	$1,000,000
2	New Lift Station to Intercept High Flow Area	1	LS	$2,000,000	$2,000,000
	Construction Subtotal				**$3,000,000**
	Contingencies	20	%		$600,000
	Engineering, Legal, and Administrative	20	%		$600,000
	TOTAL PROJECT COST				**$4,200,000**

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PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**Wet Weather Equalization (I/I Alternative 3)**	CHECKED BY:	**DIU**
	Retention Basin	CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	8-inch FM	1	LS	$100,000	$100,000
2	500,000 gallon Retention Basin	1	LS	$2,500,000	$2,500,000
3	Pump Station	1	LS	$250,000	$250,000
4	Miscelaneous Equipment	1	LS	$100,000	$100,000
5	Electrical Allowance	20	%	$250,000	$50,000
	Construction Subtotal				**$3,000,000**
	Contingencies	20	%		$600,000
	Engineering, Legal, and Administrative	20	%		$600,000
	TOTAL PROJECT COST				**$4,200,000**

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PROJECT: **Traverse City CWSRF**
LOCATION: **Traverse City, Michigan**
WORK: **UV Disinfection Update**
Trojan UV3000PLUS*
*Based on a 5 year inflation rate

DATE: **3/25/2021**
PROJECT NO. **20210140**
ESTIMATOR: **ARH**
CHECKED BY: **DIU**
CURRENT ENR:

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Equipment Installation and Construction	1	LS	$1,426,472	$1,426,472
2	Other Improvements / Hydraulic Improvements	1	LS	$500,000	$500,000
	Construction Subtotal				**$1,927,000**
	Contingencies	20	%		$386,000
	Engineering, Legal, and Administrative	20	%		$386,000
	TOTAL PROJECT COST				**$2,699,000**

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PROJE **Traverse City CWSRF**
LOCAT **Traverse City, Michigan**
WORK: **US-31 Reconstruction - Utility Replacement**

DATE: **3/25/2021**
PROJECT NO. **20210140**
ESTIMATOR: **ARH**
CHECKED BY: **DIU**
CURRENT ENR:

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Garfield Ave to Hope St - Sewer Lead Transfer from north to south sewer	38	Ea	$5,000	$190,000
2	Remove existing 8-inch sanitary sewer after transfer are complete	3300	Ft	$16	$52,800
3	Hall St to 350' West - 8-inch Sewer Open Cut	350	Ft	$150	$52,500
	Construction Subtotal				**$296,000**
	Contingencies	20	%		$60,000
	Engineering, Legal, and Administrative	20	%		$60,000
	TOTAL PROJECT COST				**$416,000**

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Telephone: (616) 454-4286

PROJECT:	**Traverse City CWSRF**	DATE:	**3/25/2021**
LOCATION:	**Traverse City, Michigan**	PROJECT NO.	**20210140**
		ESTIMATOR:	**ARH**
WORK:	**East Front Sewer Improvements**	CHECKED BY:	**DIU**
		CURRENT ENR:	

ITEM NO.	DESCRIPTION	QUANT.	UNIT	UNIT AMOUNT	TOTAL AMOUNT
1	Mobilization	1	LS	$25,000	$25,000
2	Traffic Control	1	LS	$20,000	$20,000
3	Bypass Pumping	1	LS	$75,000	$75,000
4	Sewer Cleaning (Pre-lining), 24-inch Pipe	720	LF	$7.00	$5,040
5	Abandon 24-inch Sewer (Southern Sewer on East Front)	527	LF	$20	$10,540
6	CCTV Inspection (Pre-&-Post Lining) incl. Sewer to Abandon	1,250	LF	$5.0	$6,250
7	24-inch Cured-In-Place Pipe Lining	720	LF	$120	$86,400
8	Replace Sewer Leads on East Front	20	EA	$10,000	$200,000
9	New Manholes	1	EA	$20,000	$20,000
10	Connect to Existing Manhole	2	EA	$10,000	$20,000
11	24-inch Sewer	100	LF	$400	$40,000
12	20-inch Force Main (East Front LS)	300	LF	$350	$105,000
	Construction Subtotal				**$614,000**
	Contingencies	20	%		$123,000
	Engineering, Legal, and Administrative	20	%		$123,000
	TOTAL PROJECT COST				**$860,000**

APPENDIX G: WASTEWATER ASSET MANAGEMENT PLAN

TRAVERSE CITY

Sanitary Sewer System Asset Management Plan

May 2017

OHM Advisors®

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Acronyms

AMP – Asset Management Plan or Program

BRE – Business Risk Exposure

CIP – Capital Improvement Plan

CIPP – Cured-in-Place Pipe

CMMS – Computerized Management and Maintenance System

CoF – Consequence of Failure

GIS – Geographic Information Systems

I/I – Inflow and Infiltration

MACP – Manhole Assessment Certification Program

MDEQ – Michigan Department of Environmental Quality

NASSCO – National Association of Sewer Service Companies

O&M – Operations and Maintenance

PACP – Pipeline Assessment Certification Program

PoF – Probability of Failure

SAW – Wastewater Asset Management and Wastewater Grant

WWTP – Wastewater Treatment Plant

EXECUTIVE SUMMARY

The wastewater infrastructure system of Traverse City provides a critical service to its residents and businesses, providing for the collection and treatment of wastewater and protecting Grand Traverse Bay by discharging clean water through an advanced treatment process. Recognizing the importance of this wastewater system, Traverse City initiated a comprehensive assessment of its wastewater infrastructure.

This Asset Management Plan summarizes this assessment and includes key recommendations for future funding levels. This document was prepared using grant funding from the State of Michigan Stormwater, Asset Management and Wastewater (SAW) Grant Program and is intended to accomplish the following key goals:

- Provide the City with a new framework for collecting, organizing, and storing data for their wastewater collection system using the latest available hardware and software.
- Survey key system components to augment the City's existing Geographic Information System (GIS) database and to make it easier for future generations to access infrastructure data with greater ease.
- Add information for sewer material type, size, age, and depth to the GIS database.
- Physically evaluate the structural condition of all publicly-owned system components, including sanitary sewer pipes, manholes, pump stations, and force mains. Store the data in the City's GIS database.
- Analyze the flow capacity of the City's sanitary sewer pipes and identify where pipes should be enlarged to minimize overflow potential.
- Identify long-term operations and maintenance strategies to maintain a reasonable structural condition into perpetuity, including:
    - Regularly-scheduled sewer inspection (televising)
    - Repair and rehabilitation to address structural problems resulting from aging infrastructure
- Provide recommendations for developing a prioritized Capital Improvement Plan to be funded through the City's wastewater enterprise fund.

Mission Statement

One important element to an asset management program is a mission statement, which identifies the overarching purpose of the City's asset management program. The purpose of the City's asset management program is summarized by the following mission statement:

Enhance the safety, health, and quality of life for the people of Traverse City through the effective management and maintenance of its wastewater infrastructure.

Asset Management Team Leaders

The team leaders listed in Figure 1 are committed to the asset management mission statement and were instrumental in the progress made and findings outlined in this report. Further questions on the City's asset management program can be directed to these team members.

Larry LaCross

- GIS Coordinator
- llacross@traversecitymi.gov
- 231.922.4900 ext 130

Dave Green

- Director of Public Services
- dgreen@traversecitymi.gov
- 231.922.4900

Timothy Lodge, PE

- City Engineer
- tlodge@traversecitymi.gov
- 231.922.4455

Christine Black

- Asset Management/GIS Analyst
- cblack@traversecitymi.gov
- 231.922.4900 ext 131

John Travis

- Asset Management Technician
- jtravis@traversecitymi.gov
- 231.922.4900 ext 127

Figure 1 : Asset Management Team

Infrastructure Technology & Know-How

The City has made investments in updating their existing GIS database to make it easier for future generations to access infrastructure knowledge. These upgrades include the following:

- Surveyed key system components to augment the City's existing GIS database
- Procured and implemented Lucity, a computerized maintenance management system (CMMS), to not only house work order and call request information but also infrastructure condition information
- Added information for sewer material type, size, age, and depth to the GIS database
- Purchased tablets and mobile devices to improve access to real-time asset information and enhance field data collection
- Provide staff training on new hardware and software

Asset Inventory

An asset inventory is a list of the City's assets and their attributes. The City inventoried and digitized the majority of its sanitary sewer infrastructure, including manholes, sanitary sewers, force mains, and pumping stations. The City is continuing to populate the attributes of the inventory using observations in the field while performing condition assessment. This inventory resides in the City's GIS and CMMS systems. The GIS framework was enhanced as part of this effort, making it easier for the City to store critical data for the location, size, material, install date, and condition of each wastewater asset.

Condition Assessment

Through a methodical sampling procedure, a representative sample of the City's sanitary sewer infrastructure (sanitary sewer pipes and manholes) has been assessed. The condition of the infrastructure is based on the National Association of Sewer Service Companies (NASSCO) condition grading system, which uses a scale of zero to five. Zero indicates the infrastructure is in very good condition, while five indicates the infrastructure is in very poor condition or has already failed. About 42% of the approximately 1,902-structure manhole network and about 47%[1] of the approximately 69 miles[2] of sanitary sewer pipe infrastructure has been condition assessed. City staff indicates that there are 81 miles of sanitary sewer in Traverse City; this difference is due to OHM identifying only those sewer segments noted as Traverse City-owned assets instead of including all public assets from the geodatabase provided to OHM in April 2017, and it does not impact the findings of this Asset Management Plan. The assets within the City's nine pumping stations were also inventoried and assessed. The major components inventoried within each station include but are not limited to pumps, check/control valves, motors, level control systems, backup power, structure, wet well, valve vault, and telemetry. An analysis of force main age, material, and break history determined the likelihood of failure for force main segments, which were not physically assessed due to concerns about removing and repairing force main segments.

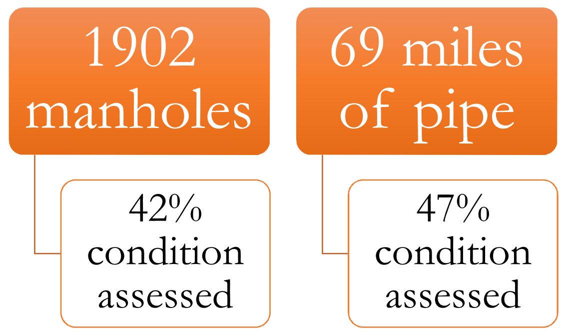

Figure 2 : Portion of Sewer System Assessed

It was also observed that:

- Manhole infrastructure exhibits age-appropriate wear with an average structural rating of approximately 1.75 and average O&M rating of 1.96. Structural manhole defects were predominately related to brickwork. O&M manhole issues were driven by deposits, roots, obstructions, and infiltration.

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[1] The percent of pipes assessed is based on the March 2017 data deliverable from the city and their corresponding GIS pipe lengths.
[2] Traverse City Owned pipes as defined in the provided April 2017 Geodatabase (*SSGravityMain* Layer) were used for analysis.

- Sewer infrastructure has an average structural rating 1.82 and average O&M rating of 1.98. The predominant structural defects as observed in the wastewater system are cracks or fractures and pipe failures; the most common O&M defects in the surveyed system are soil/dirt/rock deposits and roots.
- The infrastructure will continue to degrade over time, for example, even though the average condition of the manhole infrastructure is between a score of 1 (minimal wear and good working) and 2 (moderate wear but still functional) per the 2016 assessment data, a small percent of the infrastructure has a condition rating of 5; this percentage will grow over time.

Criticality and Risk

The investigation leading to the identification of critical sewer infrastructure involved the determination of business risk, which is identified as the combination of the probability of the infrastructure failing as well as the consequence of its failure as shown in Figure 3.

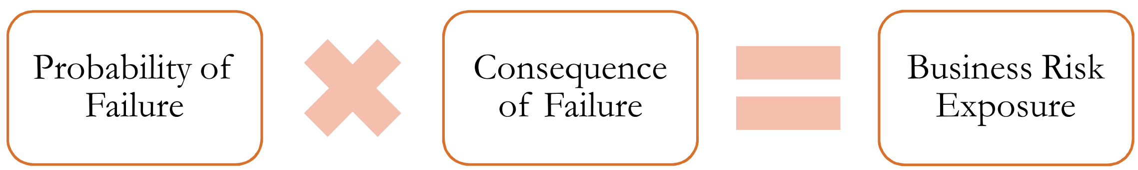

Figure 3 : Risk Equation

The probability of failure is related to the physical condition of an asset. The consequence of failure focuses on the economic losses and impacts to society due to an asset's failure. The following factors were combined to determine the consequence of failure for manholes, sanitary sewer and force mains:

- Network Position – the sum of upstream sewers discharging to a structure
- Diameter/Size – the relative size of the asset with respect to the rest of the system
- Restoration Type/Accessibility – refers to the cost to restore the surface above the asset and if traffic control is needed
- Environment – proximity to sensitive environmental features like Boardman River, Kid's Creek, Grand Traverse Bay, etc.
- Critical Users – important system users (Munson Hospital)

For pumping station assets, probability of failure was based on the condition and the consequence of failure was determined by the effect of an individual asset failure on system operations.

Level of Service

The City, in line with its mission statement outlined earlier, adopted level of service criteria's, which it plans on using as guidelines to manage the sanitary sewer system. These level of service criteria's are summarized in Table 1.

Table 1: Summary of Level of Service Criteria

Key Service Criteria	Performance Indicator	Target Level of Service
Asset Condition Assessment	PACP & MACP Inspections per Year*	• MACP inspect a minimum of 380 manholes per year, approximately 20% of the system • PACP inspect a minimum of 14 miles of sewer per year, approximately 20 % of the system
Meter Updates and Radio Reads	Replace existing meters with the new sensus meters and install radio reads for higher accuracy of reads.	**
Regulatory Compliance	Compliance with MDEQ Sanitary Sewer Overflow (SSO) Policy and the Clean Water Act	Continue to comply with the MDEQ SSO policy and The Clean Water Act
Service Delivery and Customer Communication	Utilize Lucity Software to aid in utility management and promote customer communication, increase effort to reduce number of sewer calls and response time	Respond to customer complaints and requests within one hour
O&M Optimization	Regular cleaning and maintenance of the collection system	Clean and maintain 20% of the system per year

* Pipe Assessment Certification Program (PACP), to assess sanitary sewer condition
  Manhole Assessment Certification Program (MACP), to assess manhole condition

** City to review and provide input. Information pulled from City's 2016-2017 Annual Budget Report.

Revenue Structure and Capital Improvement Plan

The condition assessment helped identify capital improvements that will allow the City to operate at its maximum potential. Additional long-term operations and maintenance strategies will provide the means to maintain a sound structural condition into perpetuity, including:

- Regularly-scheduled sewer, manhole, and pump station inspection
- Repair and rehabilitation to address structural problems resulting from aging infrastructure
- Upgrades to the City's wastewater treatment facilities, many of which have aged beyond their useful service lives

As communities like Traverse City have developed and aged, the buried infrastructure is deteriorating. Unless the City begins to systematically repair, rehabilitate, and/or replace these aging components, City residents and businesses will experience a decreased level of service. The increased level of investment is significant, and will require increased revenues.

Although the City currently has an annual budget of approximately $6 million for its wastewater collection and treatment system, the recommendations in this Asset Management Plan would result in a new annual budget of approximately $9 million. The primary reasons for this increase are:

1. Increased investment in sewer/manhole rehabilitation, repair, and/or replacement for the City's aging infrastructure.

2. Systematic replacement of older force mains, which have aged well beyond their typical service lives.

3. Additional investment at the Wastewater Treatment Plant, with multiple projects to be identified in the upcoming Facility Plan.

4. Upgrades to pump stations that will require higher flow capacities to serve growing areas.

5. Targeted replacement of undersized sanitary sewers, as identified in this report.

6. Increased attention to sewer/manhole inspections and ongoing updates to this Asset Management Plan.

The City Treasurer has reviewed the proposed level of investment for the collection system, pump stations, and the WWTP and has provided the following recommendations for rate increases to address the increased investment need:

- 2017-2018 Budget Year: Increase the base rate from $36.00 per the first 600 cubic feet to $37.00 per the first 600 cubic feet, and increase the next tier from $42.00 per 1,000 cubic feet to $43.00 per 1,000 cubic feet.

- 2018-2019 Budget Year: Increase the base rate from $37.00 per the first 600 cubic feet to $47.00 per the first 600 cubic feet, and increase the next tier from $43.00 per 1,000 cubic feet to $53.00 per 1,000 cubic feet

The recommended rate increases for the 2018-2019 Budget year are relatively large, and should be revisited as the WWTP Facility Plan is developed. Depending on the speed at which the City is able to mobilize the increased investment in the collection and treatment systems, the rate increases may be adjusted or delayed to subsequent years.

See Appendix H for a comprehensive table of proposed investments during the next ten years. This table combines the recommendations from this Asset Management Plan with the cost projections from CH2M on the pumping and treatment facilities they manage.

I. Introduction

In December 2013, the Traverse City applied for and received a Stormwater, Asset Management, and Wastewater (SAW) grant from the Michigan Department of Environmental Quality (MDEQ) (which required a City matching contribution) in order to develop an Asset Management Program or Plan (AMP) for the City's wastewater system. This report summarizes the progress and findings of that program.

The International Infrastructure Management Manual defines the goal of an asset management program as meeting a required level of service in the most cost-effective way through the creation, acquisition, operation, maintenance, rehabilitation, and disposal of assets to provide for present and future customers. Such a program entails several components, which are detailed in this report, along with the means by which the City addressed these components.

A. Mission Statement

The purpose of the City's asset management program is summarized by the following mission statement:

Enhance the safety, health, and quality of life for the people of Traverse City through the effective management and maintenance of its wastewater infrastructure.

B. Team

The team leaders listed in Figure 4 are committed to the asset management mission statement and were instrumental in the progress made and findings outlined in this report. Further questions on the City's asset management program can be directed to these team members.

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Christine Black
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John Travis
- Asset Management Technician
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- 231.922.4900 ext 127

Figure 4 : Asset Management Team

II. Inventory and Condition Assessment

An asset inventory is a list of the city's assets and their attributes, e.g. unique identifier, location, size, material, etc. This inventory resides in the City Geographic Information System (GIS) and is also connected to the City's Computerized Maintenance and Management System (CMMS) program which houses infrastructure condition inspection information as well as work orders associated with individual assets, such as manholes, and sewer pipes. The City is continuing to edit and update the attributes of the inventory using both as-built data as well as observations in the field while performing maintenance and condition assessment.

The condition assessment of the existing infrastructure was designed to survey a representative portion of the system. Assessing every asset in the system would be cost-prohibitive, time consuming, and unnecessary to determine the overall system condition for the purposes of this project. Therefore, a method was used to physically evaluate a representative sample of the system in order to better understand the overall condition of the entire system. Throughout the AMP, condition is shown as a percent of the total. Because the inspected sample was representative of the system, the results can represent the entire system. The procedure for identifying the appropriate infrastructure to sample was preceded by the following analyses:

The City's GIS framework was enhanced as part of this effort, making it easier for the City to store critical data for the location, size, material, and condition of each wastewater asset.

- Characteristics of the System: An age, material, and size distribution of the infrastructure was identified.
- Determination of Sampling Size: Statistical science was incorporated into the analysis in order to approximate the size of the sample so that the results would yield a margin of error no greater than 5%.
- Random Selection of Sample: Once system characteristics were assessed as well as sampling size, pockets of wastewater sewer and manhole infrastructure to be condition assessed were selected randomly in an effort to obtain unbiased condition data that would still be practical to collect.

A. NASSCO Rating System

The National Association of Sewer Service Companies (NASSCO) is a not-for-profit organization setting the industry standard for the rehabilitation of underground utilities. NASSCO's Manhole Assessment Certification Program (MACP) and Pipeline Assessment Certification Program (PACP) standardize identification of the type and severity of defects found in manholes and pipelines. The MACP and PACP processes rate the overall, structural, and operations and maintenance (O&M) condition of the assets using a well-established and universal defect coding system. MACP and PACP use the same process with some minor adjustments to length-dependent defects since manholes are usually not as deep as sewer pipes are long. The results are in the industry standard format used by most municipalities and infrastructure assessment professionals.

The wastewater collection system was sampled to get a reliable assessment of the overall structural condition of the entire system. See Appendix A for illustrations of the City's wastewater system.

Individual defects were assigned a grade from one through five, with five being the most serious, based on the type and severity of the defect. These grades are predefined by NASSCO in their defect coding system. Because there were often multiple defects per asset, their associated grades were totaled and combined to generate several metrics that are representative of the condition of each pipe segment. An explanation of the metrics are included in Figure 5. The metrics are categorized as: Structural, Operation and Maintenance (O&M), and Overall. Structural condition is affected by defects like cracks, fractures, and surface or lining damage. O&M condition is affected by defects like soil/dirt/rock deposits, roots, infiltration, and obstructions. Overall condition metrics combine both Structural and O&M defects. Appendix A contains maps to illustrate the condition of the assets inspected as part of this AMP.

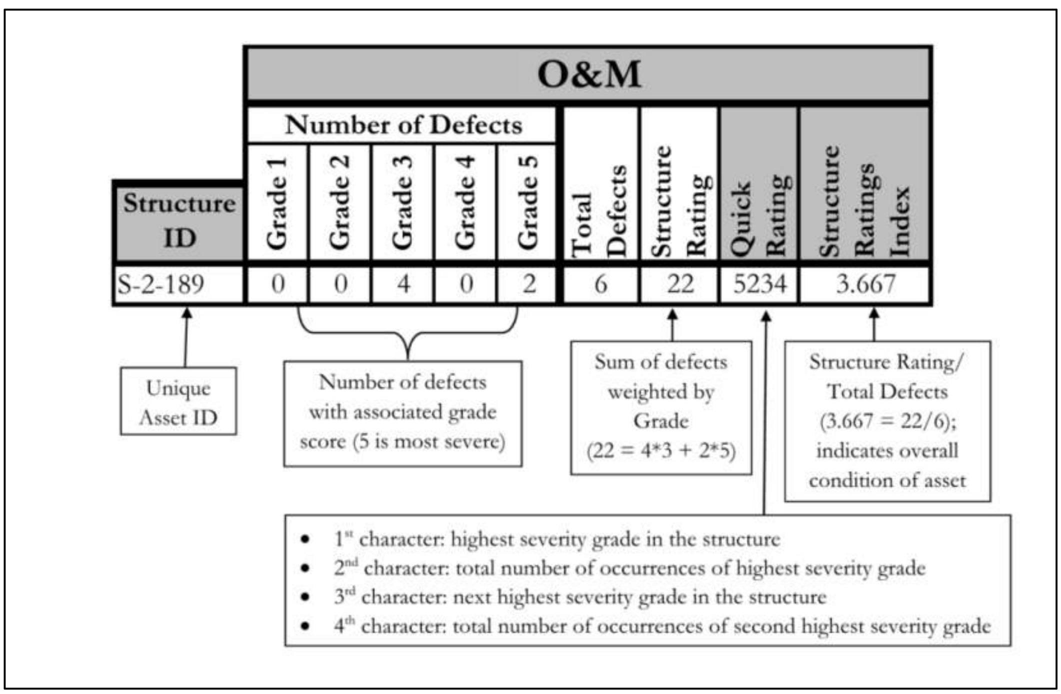


Figure 5: NASSCO Metrics

The Ratings Index indicates the general condition of each inspected asset. The Ratings Indices range from zero through five with zero being the best condition as shown in Table 2.

Table 2: Condition Rating Index

Ratings Index	Asset Condition
0	New or like new
1	Minimal wear and good working condition
2	Moderate wear but still functional
3	Failure unlikely in near future
4	Failure likely in the foreseeable future
5	Marginal functionality with failure imminent

*MACP and PACP Scores

B. Manholes

There are approximately 1,902 manhole structures in the City's wastewater collection system, as listed in the GIS. As part of the SAW effort, a detailed condition assessment was performed on about 807 manholes, or 42% of the total inventory. Figure 6 shows a distribution of the manhole infrastructure based on infrastructure age. The average age of the manholes in the system is nearly 57 years with approximately 66% of the system installed between 1930 and 1960.

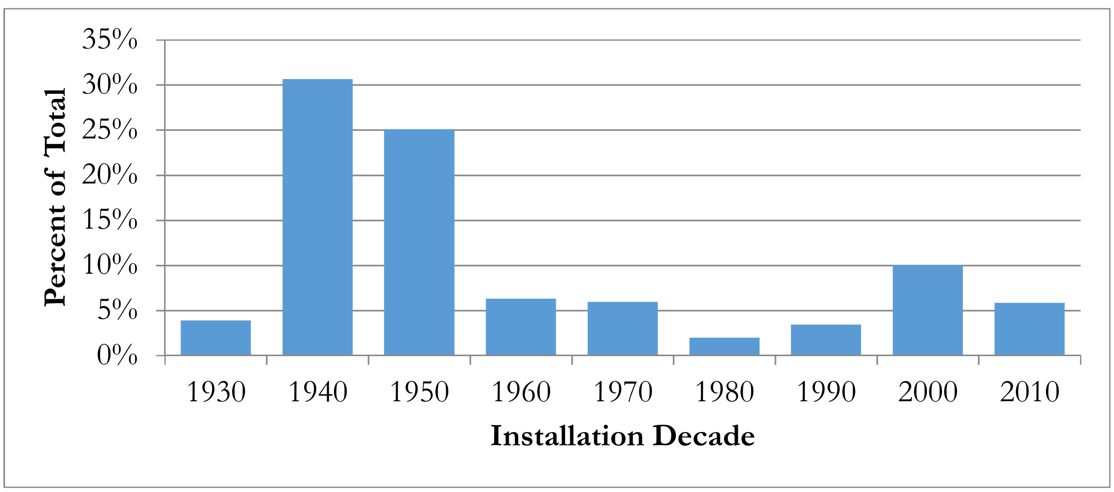


Figure 6: Distribution of Wastewater Manholes Based on Installation Decade

Figure 7 and Figure 8 summarize the average O&M and structural ratings of the surveyed manholes. Overall, the City infrastructure exhibits moderate wear with an average structural rating of approximately 1.75 and average O&M rating of 1.96. Figure 9 summarizes the distribution of MACP condition scores, by decade of installation, for the inspected manholes. This information was utilized in developing a structural deterioration curve for the City's manhole assets. In general, older manholes are in worse structural condition.

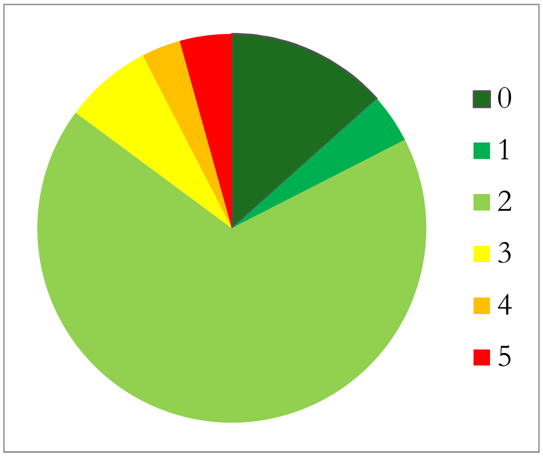


Figure 7: Wastewater Manhole O&M Ratings

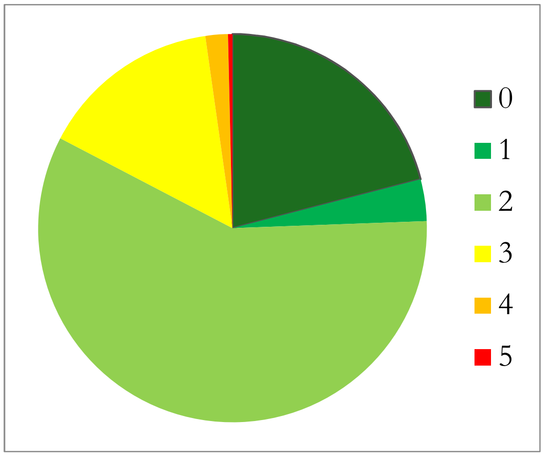


Figure 8: Wastewater Manhole Structural Ratings

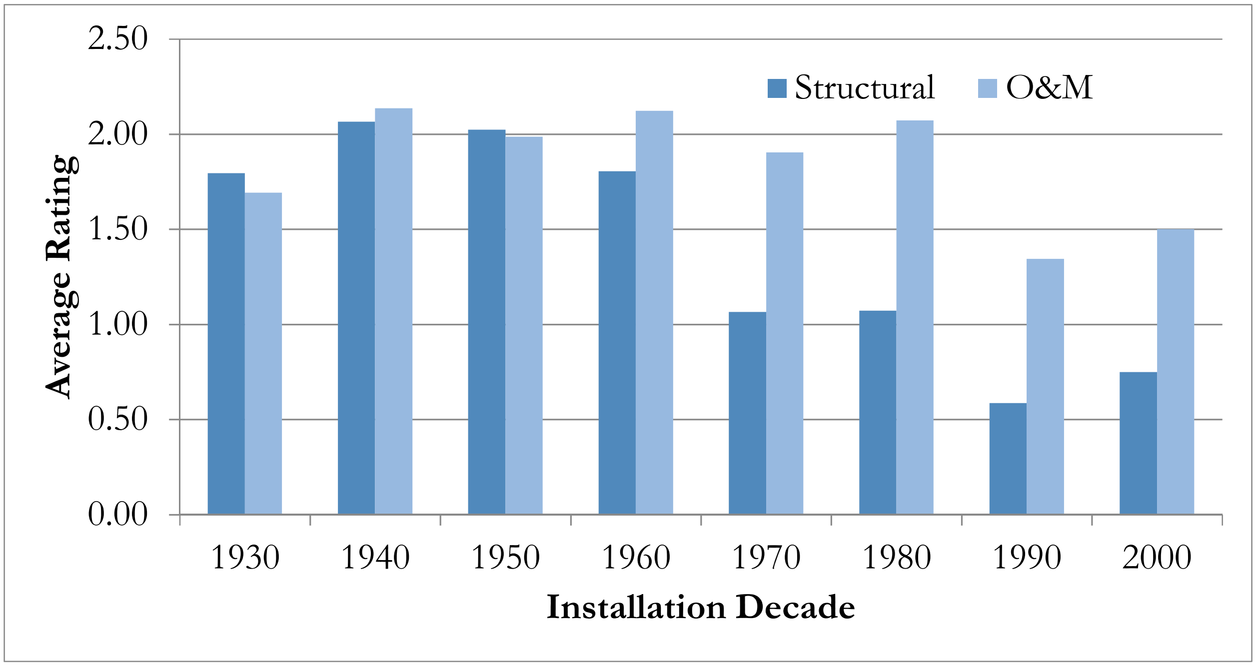


Figure 9: Average Wastewater Manhole Condition Ratings Indices by Installation Decade

* Some asset condition data (for components newer than 1993) were available from previous City inspections that were performed separate from the SAW Grant effort.

Figure 10 and Figure 11 provide additional details of the distribution of scores in each decade. Based on the inspection results, manholes that were installed in 1970's appear to be in the worst structural condition of the inspected manholes, while manholes installed in 1940's appear to be in the worst O&M condition of the inspected manholes. While a rating of 5 suggests imminent failure, a structural rating of 4 is defined as failure likely in the foreseeable future. Figure 10 below shows that pipes installed in the 1930's had the highest occurrences of a structural rating of 4.

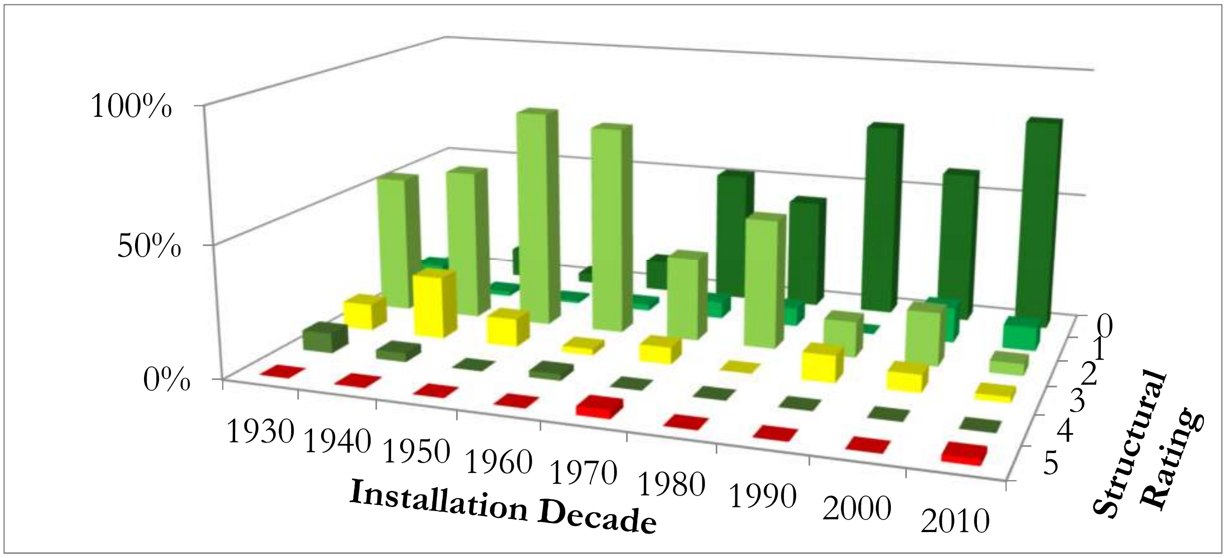


Figure 10: Wastewater Manhole Structural Ratings Indices by Decade

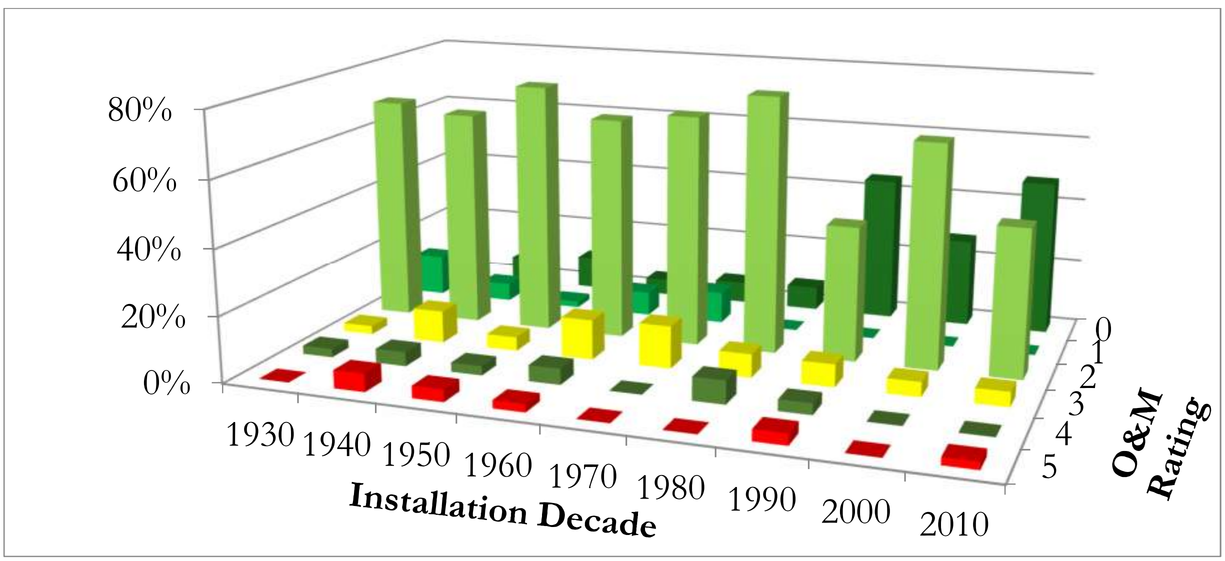


Figure 11: Wastewater Manhole O&M Ratings Indices by Decade

* Some asset condition data (for components newer than 1993) were available from previous City inspections that were performed separate from the SAW Grant effort.

A frequency analysis, represented in Figure 12, indicates the most common defects in the system. Overall, the following additional condition observations were made for the City's manholes:

- Structural manhole defects were predominately related to brickwork. Brickwork defects are assigned when displaced brick, missing brick, and missing mortar are identified in the manhole.
- O&M manhole issues were predominantly driven by deposits, roots, obstructions and infiltration. Infiltration is induced by cracks or fractures in the manhole, which provide inlets for rainwater and soil to infiltrate into the manholes. Deposits occur when soil and other debris build up in a structure without regular cleaning/flushing. Roots enter a manhole through defects such as cracks.

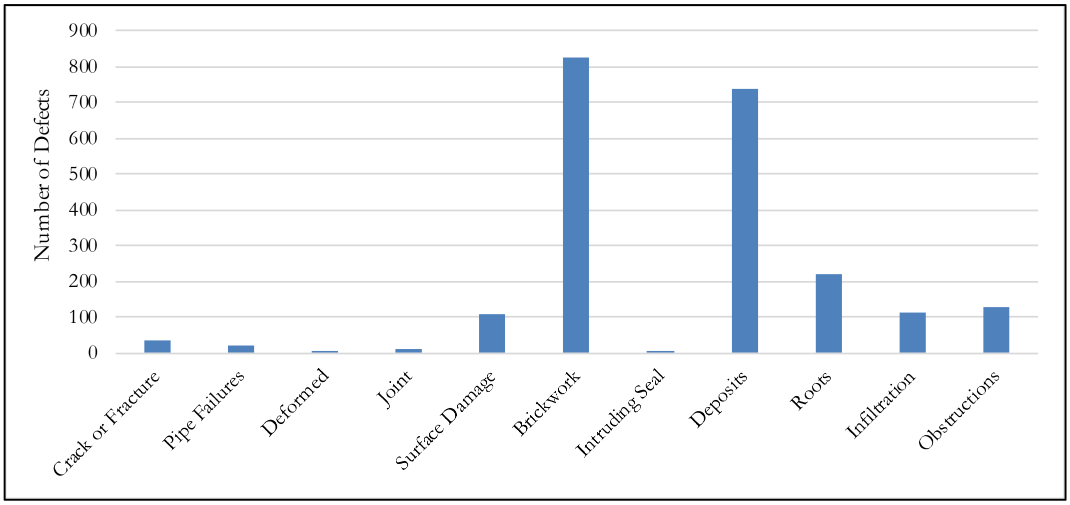


Figure 12: Manhole Defects

C. Sanitary Sewer

There are approximately 81 miles of sanitary sewer pipe in the City's wastewater collection system, as listed in the GIS; however, as stated in the Executive Summary, only 69 miles of sewer were used for the data analysis, as that was the quantity identified as Traverse City-owned assets in the GIS geodatabase received in April 2017. As the City continues to develop and refine its wastewater geodatabase, the sewer ownership attributes should be standardized so that City-owned assets can be grouped together in one ownership class.

The average age of the system is 59 years with nearly 70% of the system installed between 1930 and 1960. Figure 13, Figure 14, and Figure 15 summarize the sanitary sewer collection system inventory in terms of age, diameter, and material. The majority of the system consists of clay and vitrified clay pipe.

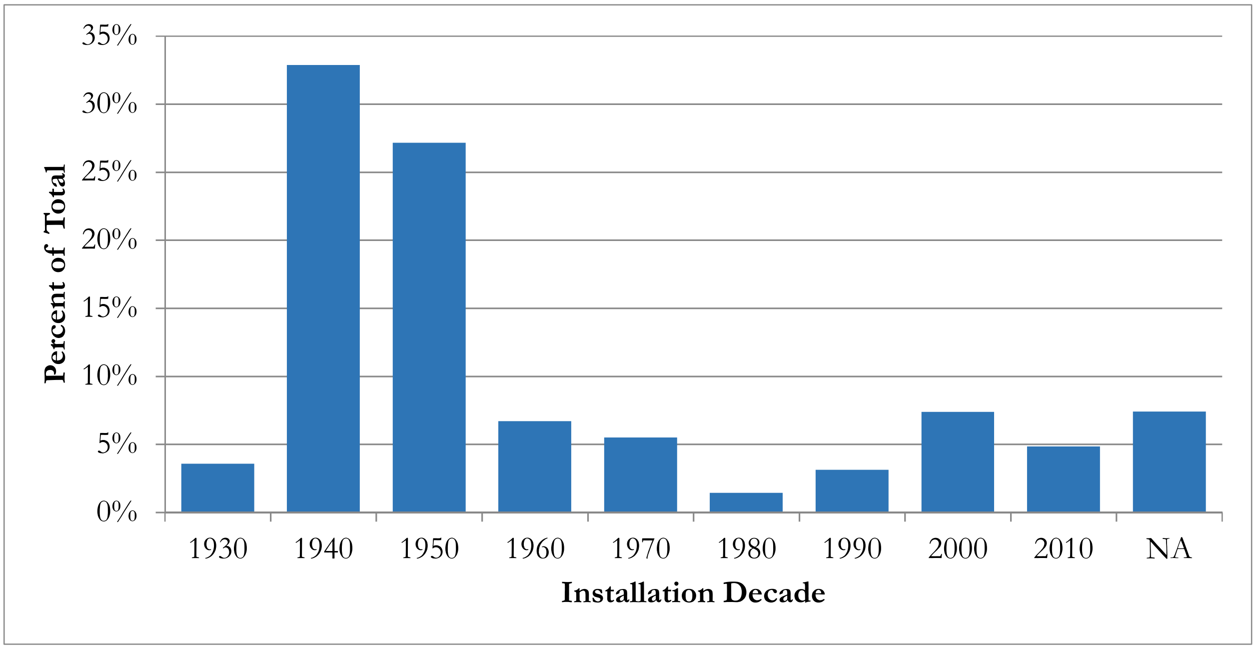


Figure 13: Wastewater Sewer Installation Inventory

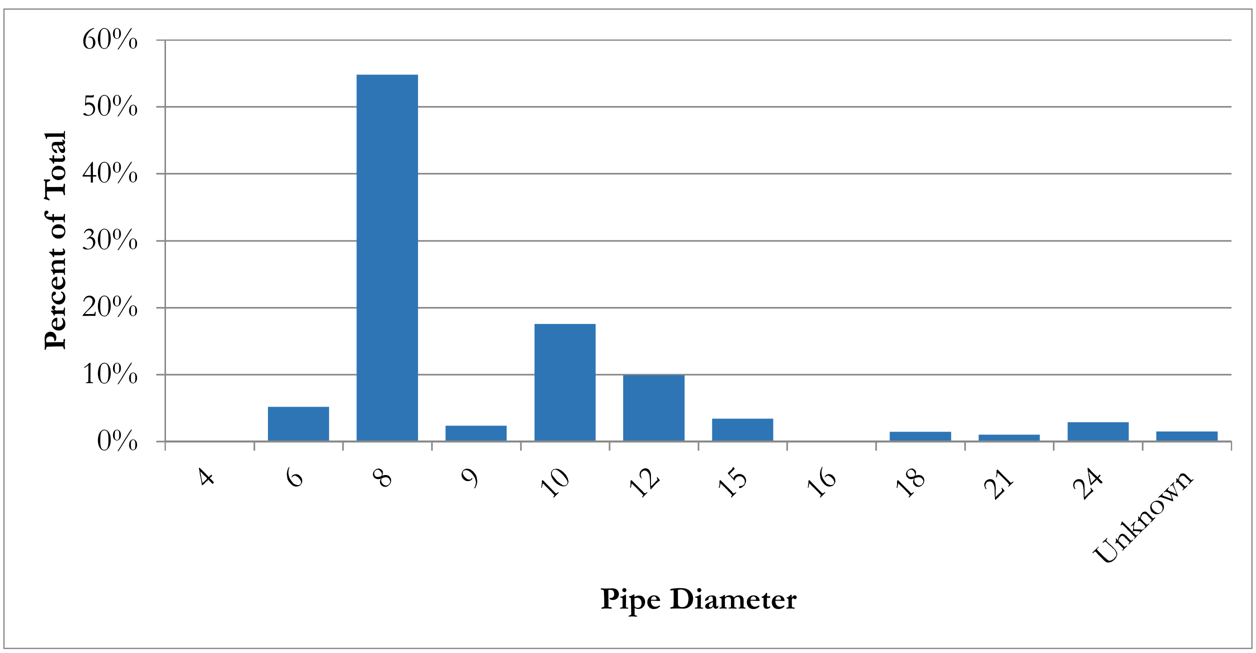


Figure 14: Wastewater Sewer Diameter Inventory

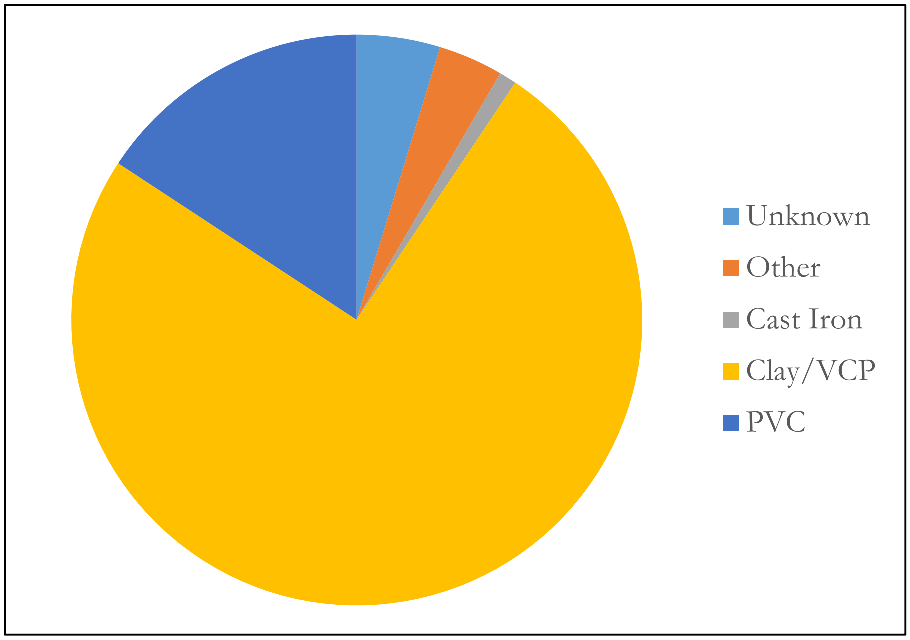


Figure 15: Wastewater Sewer Material Inventory

As part of the SAW effort, a condition assessment was performed on approximately 32 miles of pipe, or about 47% of the system. The inspected portion of the system had an average Overall (structural and O&M) rating of 2.04, indicating that the majority of the system is in good condition. The average structural rating is 1.82, and the overall O&M rating being 1.98. Figure 16 and Figure 17 show a breakdown of Overall PACP Ratings.

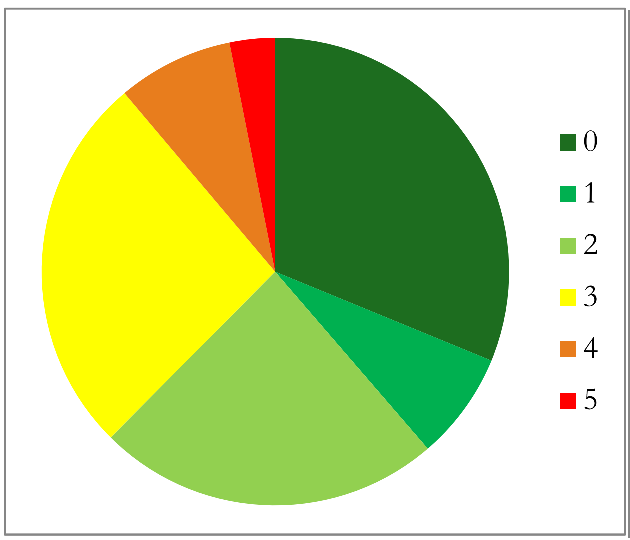


Figure 16: Wastewater Sewer Structural Ratings

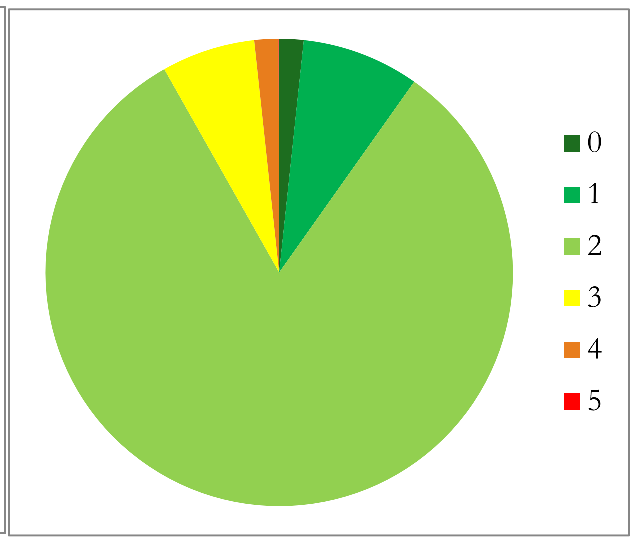


Figure 17: Wastewater Sewer O&M Ratings

Figure 18 shows a breakdown of the average wastewater sewer condition indices by installation decade.

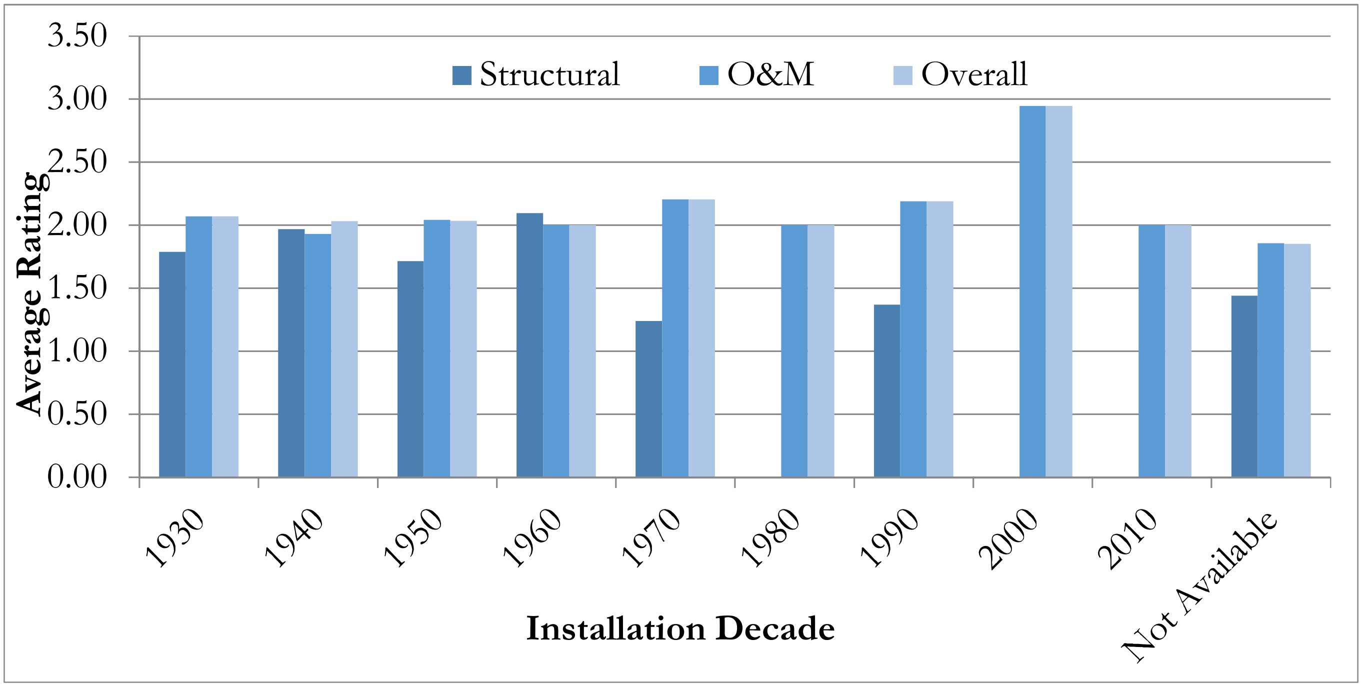


Figure 18: Average Wastewater Sewer Condition Rating Indices by Installation Decade

* Some asset condition data (for components newer than 1993) were available from previous City inspections that were performed separate from the SAW Grant effort.

Figure 19 and Figure 20 provide additional details of the distribution of scores in each decade. Based on the inspected pipes, pipes that were installed in 1960's appear to have the highest occurrences of a rating of 5. None of the inspected pipes returned an O&M rating of 5. In general, based on the structural ratings, pipes installed in 1970's and prior appear to be the worst off, structurally.

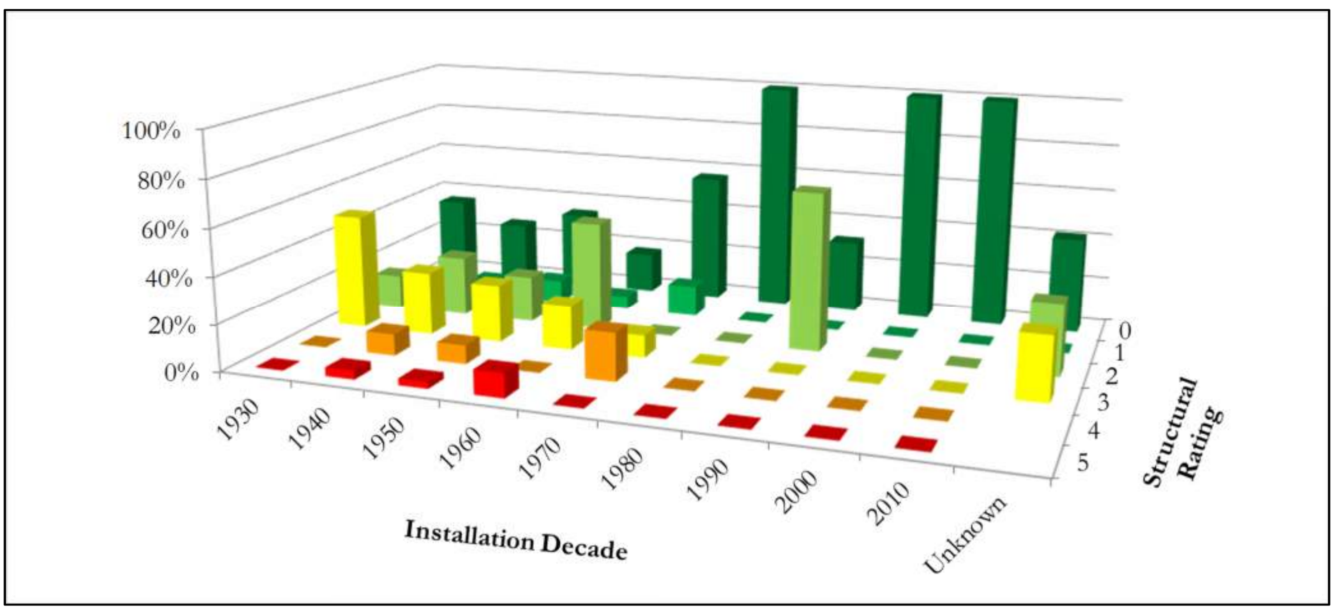


Figure 19: Breakdown of Wastewater Sewer Pipe Structural Scores by Decade

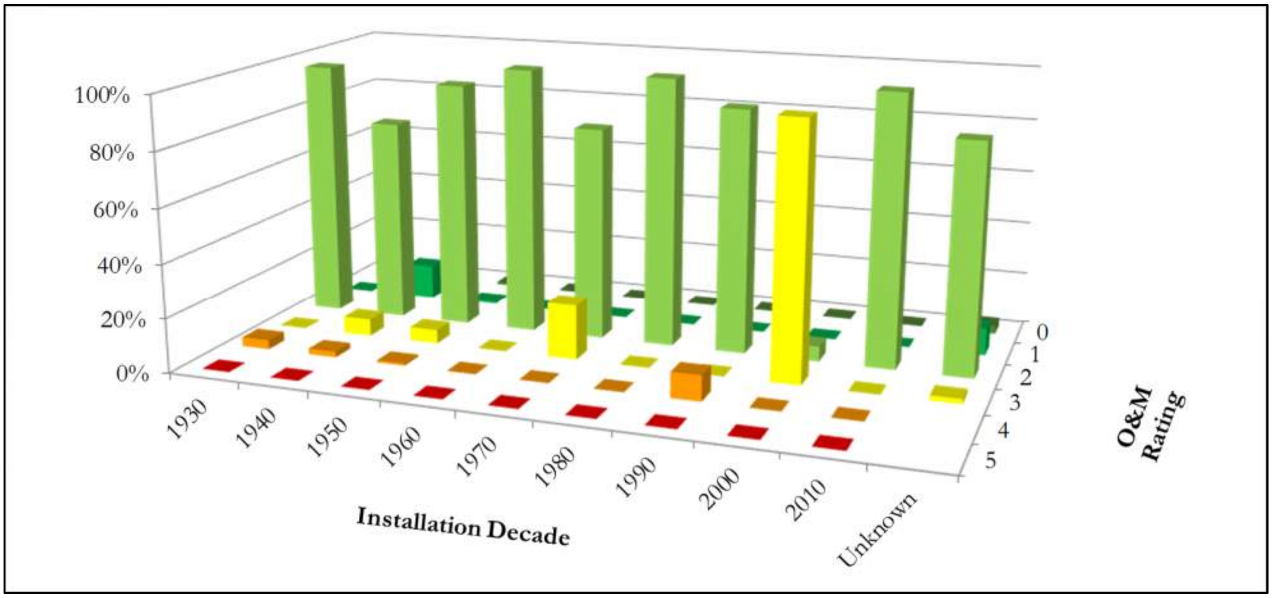


Figure 20: Breakdown of Wastewater Sewer Pipe O&M Scores by Decade

* Some asset condition data (for components newer than 1993) were available from previous City inspections that were performed separate from the SAW Grant effort.

Within the inspected portion of the sewer system, approximately 7 miles of pipe had one or more structural defects of grade 4 or 5 and is deemed to be in need of rehabilitation in order for the sewer to achieve its intended function. This reflects approximately 31% of the inspected system. Extrapolating this to the entire wastewater collection system yields roughly 21 miles of sanitary sewer pipe that is likely in need of rehabilitation. Details on the system extrapolation are available in Table 3.

Table 3: Highest Rated Sewer System Structural Defects Extrapolation

Highest Rated Defect	Inspected Length (mi)	Extrapolation to System (mi)	Percent of Total
0	6.7	21.5	31%
1	1.2	3.8	6%
2	3.1	10.1	15%
3	3.8	12.1	18%
4	2.6	8.3	12%
5	4.1	13.1	19%

Table 4 summarizes the highest rated structural defect by diameter for the inspected system. It appears that the majority of the 7 miles of pipe that had one or more structural defects of grade 4 or 5, are 12-inch in diameter.

Table 4: Highest Rated Sewer System Structural Defects by Diameter

Diameter (in)	0	1	2	3	4	5	Total
6	1918	696	1923	1283	1236	6368	13423
8	11471	2824	3758	3640	1744	5282	28720
9	1765	87	880	709	1831	1152	6424
10	5744	1387	2618	3130	1123	2434	16435
12	6858	175	4435	4022	3803	5565	24859
15	4116	452	1463	2693	2266	456	11445
18	1405	--	--	1091	502	250	3247
21	864	362	525	1475	--	--	3227
24	1171	286	940	1861	1069	17	5343
Total (ft)	35310	6269	16544	19907	13577	21529	113122
Total (mi)	7	1	3	4	3	4	21

The most predominant structural defects as observed in the sanitary system are cracks or fractures and pipe failures; the most common O&M defects in the surveyed system are soil/dirt/rock deposits and roots. Figure 21 depicts the type and number of defects reported in the inspected portion of the wastewater collection system.

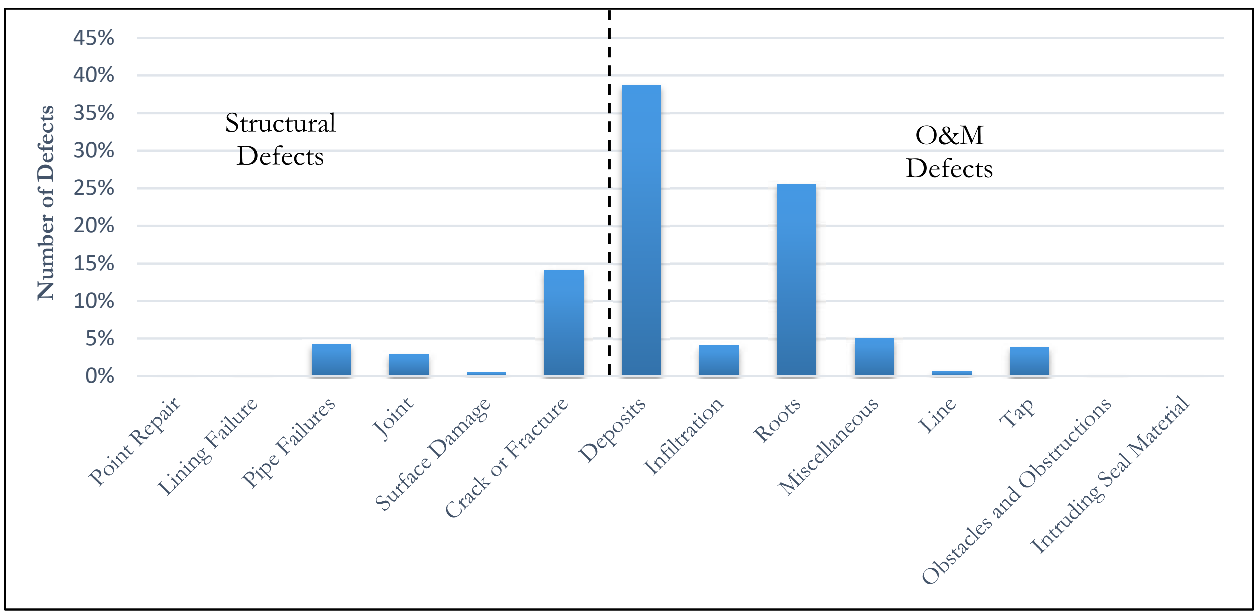


Figure 21: Wastewater Sewer Defects

D. Force Mains

There are approximately 4.7 miles of public force mains in the City's wastewater collection system. An inventory of the force mains was created using existing GIS and record drawings. A technical memorandum summarizing the force mains and their assessment is presented in Appendix C.

Assessing the condition of a force main is costly and often requires destructive or disruptive testing methods, thus no force mains were physically assessed as part of this AMP. However, the installation year, material type, history of breaks, associated pump stations, and location of the force mains were used as a proxy for condition. The CoF (1-5) was based on the associated pump station firm capacity and the location of the force main to roads, railroads, surface water, drinking water wells, other force mains, historic districts, and residential or commercial parcels. The PoF (1-5) was based on the force mains material, installation year, expected asset life, history of repair, crossing of a river or stream and number of junctions. A BRE (1-25) for each segment of force main was then calculated using the CoF and PoF.

Approximately 2.7 miles, or 60%, of the Traverse City's public force mains returned high PoF ratings indicating failure is likely in the foreseeable future or there is marginal functionality with failure being imminent. Table 5 summarizes these force mains ratings and their associated lengths.

Table 5: Prioritized Force Mains

Force Main Associated Pump Station	CoF	PoF	Maximum Segment BRE	Length (feet)
Front Street*	4.2	4.0	16.8	3,109
Coast Guard	3.0	4.2	14.3	7,316
Birchwood	3.1	4.0	13.6	2,583
WWTP	2.9	4.0	13.2	134
Bay	2.9	4.0	13.1	1,126

Includes 558 feet of force main that is also connected to the WWTP Pump Station

E. Pump Stations

There are nine pumping stations in Traverse City's collection system. The assets associated with each station were inventoried and evaluated for condition and criticality. The major components inventoried within each station include but are not limited to pumps, check/control valves, motors, level control systems, backup power, structure, wet well, valve vault, and telemetry. Details of the pump station assessment are available in Appendix D.

The current condition of the pump stations assets was assigned based on judgement of and experienced facility design engineers. The condition ratings range from 1 to 5 with 1 being the best condition as shown in Table 6. The assets PoF was calculated based on the assets percentage of remaining useful life. Together, the assets CoF and PoF was used to determine the assets BRE.

Table 6: Pump Station Asset Probability of Failure

Ratings Index	Asset Condition
1	Excellent, appears new
2	Good, appropriate wear
3	Average, minor life cycle altering defects
4	Poor, significant wear but functional
5	Very poor, failure of intended function

Based on the inspections, Traverse City's pump stations are well maintained. Many assets are functioning past the manufacturer specified useful life. Table 7 below summarizes the pump stations approximate install year and the main issues encountered during inspection.

Table 7: Pump Station Issues

Station	Approx. Install Year	Issue
Riverine	1983	• Pumps, motors and check valves are nearing the end of the expected service life and should be monitored closely. • Heavy grease load at this station can adversely affect the pumps and check valves.
Coast Guard	1995	• Both submersible pumps are near the end of their expected service life. Although they are functioning, they should be closely monitored. • The chart recorder is not in service.
Hull Park	2001	• In 2015 it appeared that the pump was not properly seated causing recirculation in the wet well.
Clinch Park	2003	• No adverse comments.
Bay Street	1994	• Both submersible pumps are near the end of their expected service life. Although they are functioning, they should be closely monitored.
Birchwood	2002	• No adverse comments.
Front St	1930/1996	• Pumps need to be frequently unclogged due to rags and other debris. The result is high maintenance costs. In the future when the pumps need to be replaced, consider dry pit submersible pumps that have better solids handling ability.

A more detailed document describing the data collection and inventory, field investigations and findings, annual capital reserves and CIP, and recommendations for Traverse City's pumping stations is included in Appendix D.

III. Deterioration Forecasting

Forecasting of infrastructure deterioration was based on the system inventory, infrastructure age, historic data, and currently observed condition information. In general terms, the forecasting process included the following steps:

- Structural Deterioration Over Time:
  Infrastructure age and condition information was used to assess structural deterioration of the infrastructure. O&M deterioration is not forecasted, as this tends to be more random in nature and requires more detailed historic maintenance data. The deterioration information was converted to infrastructure structural deterioration curves that provided insights as to the anticipated infrastructure remaining life as well as rate of deterioration.
- Analysis of Entire System:
  The condition information collected through the sampling procedure outlined earlier yielded a structural condition rating distribution for the sampled infrastructure based on its age, size, and material. This information was projected out (extrapolated) to the rest of the system (the infrastructure which was not directly condition assessed) and the system as a whole was allowed to deteriorate over time within a deterioration forecast model.

Deterioration forecasting helps us determine what percentage of the City's assets must be rehabilitated each year in order to avoid unnecessary failures and more expensive emergency repairs.

The results of the forecasting process yielded information that was used to calculate the need for future investment in operation and maintenance of the wastewater infrastructure, which will be required for system components that are aging beyond their useful service lives.

Figure 22 shows the approximated structural deterioration curve for the City's wastewater infrastructure. The current average rating of the City's wastewater infrastructure is 1.82 and as suggested by the curve below, with an average system rating of 1.82, the system has approximately 42% of remaining useful life before reaching a rating of 5 (failure). In addition, the rate of deterioration of the existing infrastructure is likely going to increase, highlighting the importance of field inspection in the upcoming years.

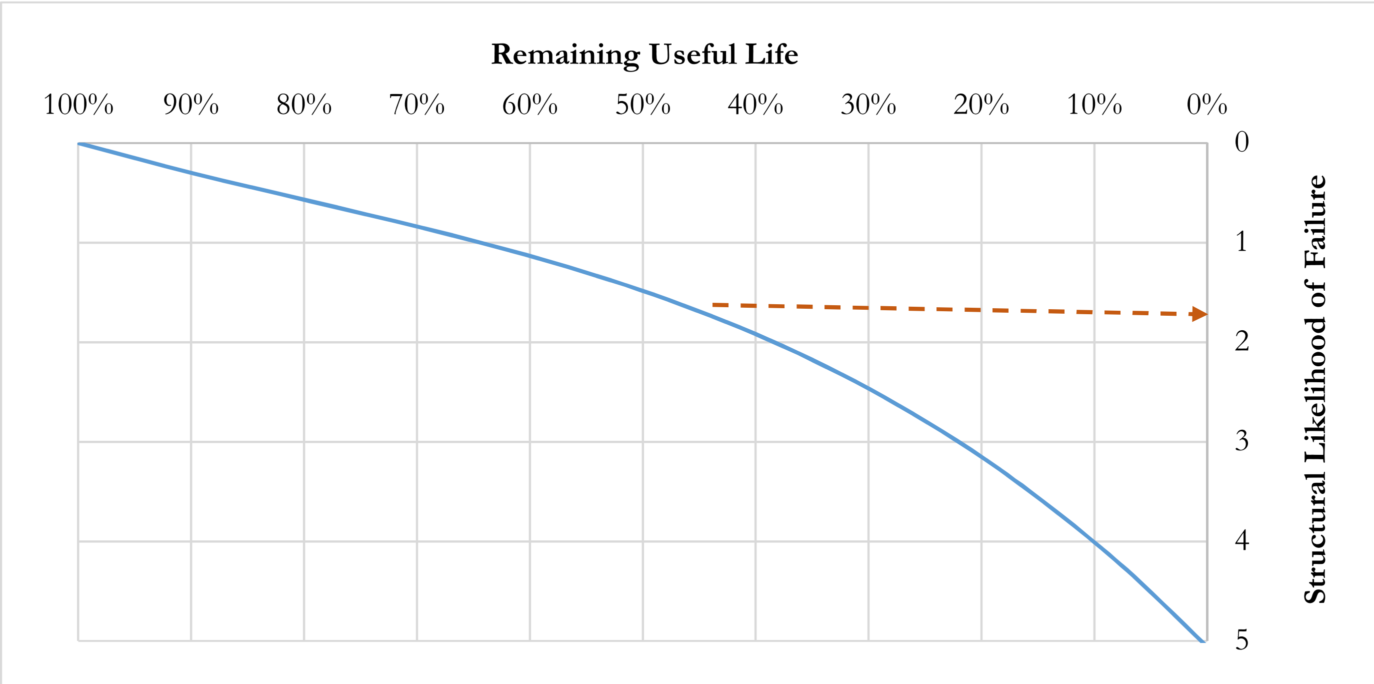


Figure 22: System Deterioration

The longevity of Traverse City's wastewater infrastructure was evaluated by combining data on average structural condition, remaining useful life, rehabilitation costs, and deterioration. Under the current funding structure, many assets are projected to fail as shown in Figure 23. This is indicted by the increasing percentage of red (PACP scores of 5) in the system. Deferred maintenance results in higher legacy costs when emergency repairs become necessary. In Figure 23 and Figure 24, both start with the currently-observed structural condition on the left side of the graph, with a deterioration rate that adjusts each component of the system based on typical annual deterioration for each asset. Traverse City's wastewater system is rapidly aging with some pipes and manholes installed as early as 1930.

With the proposed dedicated funding, Traverse City will be able to proactively maintain and rehabilitate the system, and improve their current level of service as shown in Figure 24.

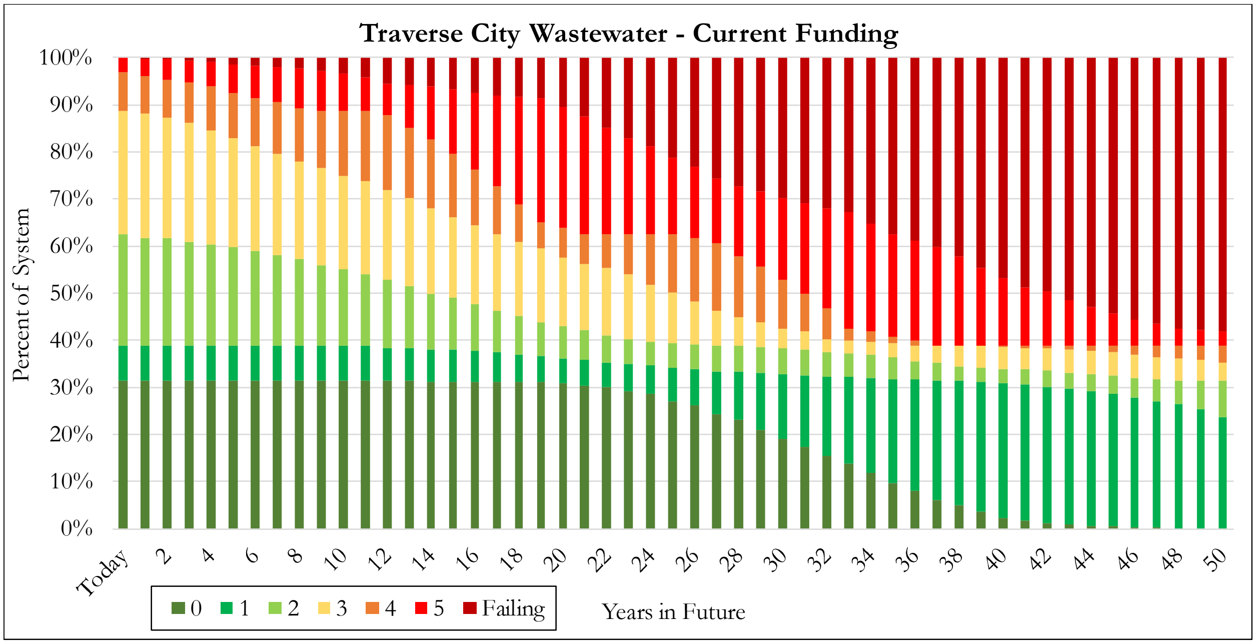


Figure 23: System Deterioration Under Current Funding Level

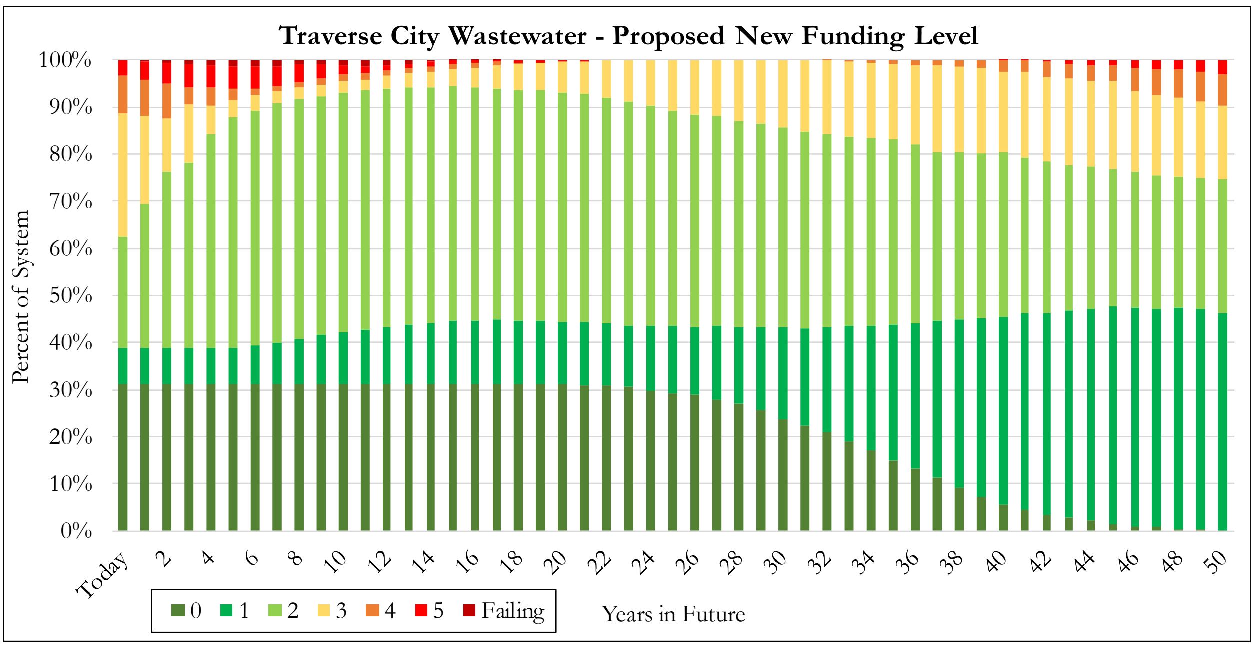


Figure 24: System Deterioration Under Proposed Funding Level

IV. Hydrologic and Hydraulic Modeling

As part of this AMP, the City wanted to assess and evaluate inflow and infiltration (I/I) concerns within the wastewater collection system. Appendix E contains the detailed results from the Antecedent Moisture Model (AMM) method to estimate peak flow rates, hydraulic modeling to evaluate conditions during peak flow rates, and a comparison of modeled peak flows to lift station capacities.

A. Metering

Nine (9) temporary sewer flow meters and one rain gauge were installed for a period of five months, from April - August 2015. The flow meters were used for many facets of this project: as a clue to suggest areas for future condition assessment, as a tool to create and calibrate the hydrologic and hydraulic models to assess the system capacity, as an indicator of current system function, and to help capture the amount of I/I in the system.

B. Antecedent Moisture Model

An AMM allows for development of a continuous hydrologic model of the system accounting for the variation in antecedent moisture conditions. Recent rainfall and soil moisture conditions significantly affect the system response to wet weather events. Two models were built utilizing flow metering and rain data. Other metered districts had wet weather flow responses that were too low to develop a reliable hydrologic model. Ten-year frequency flows were obtained from the AM Models for Meter District 3 and the WWTP. A ten-year frequency flow represents the amount of flow with a 10% chance of being exceeded in any given year. This is the MDEQ standard for evaluating sanitary sewer flow capacities.

Traverse City's Meter District 3 and the WWTP were benchmarked against over 100 other mid-western sewersheds. Benchmarking allows a direct comparison between sewer systems to quantify how tight or leaky the Traverse City system is relative to other systems. Based on this comparison, there is a wide range of wetness due to leaks observed in the City's system. As shown in Figure 25, Traverse Meter District 3 has a Peak I/I Flow per 1,000 acres on the high end of the spectrum and the Traverse City WWTP is on the low end of the spectrum. The antecedent moisture modeling highlighted that Traverse Meter District 3 has excess flow where wet weather flow removal may be especially advantageous.

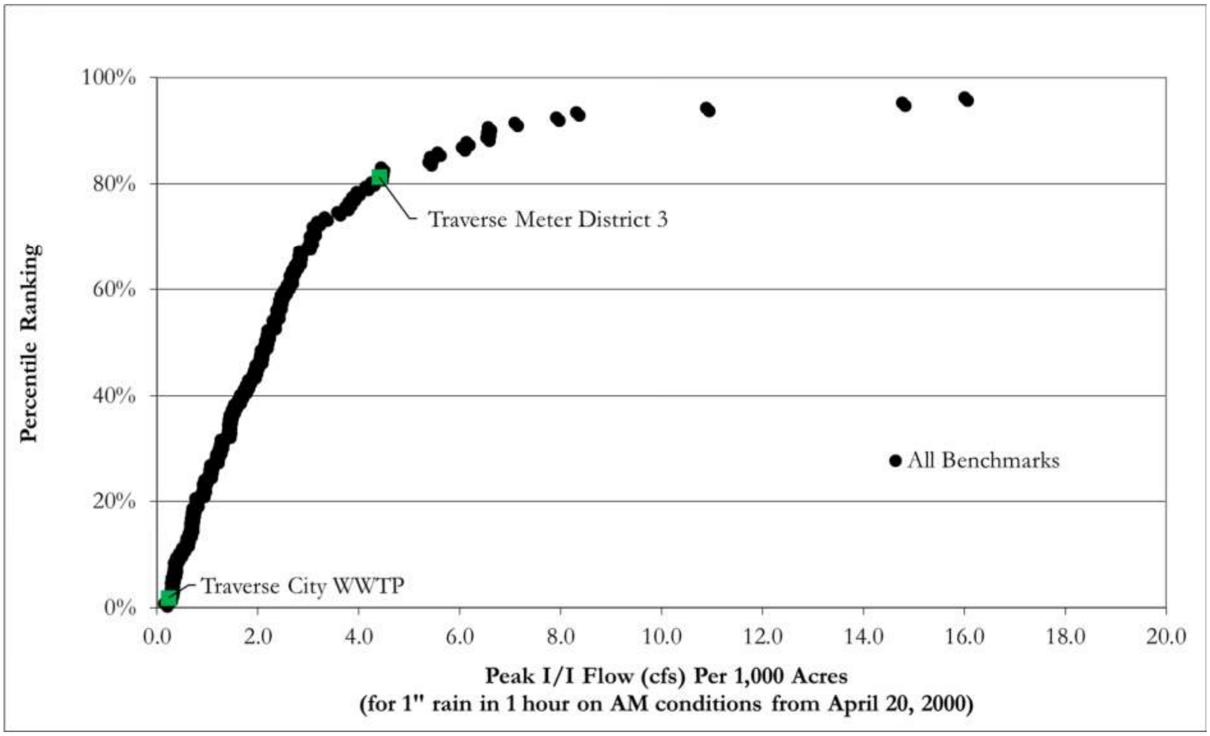


Figure 25: Benchmarked Meter District Wetness

C. Hydraulic Numeric Model

A hydraulic model was created using EPA-SWMM and Traverse City's exiting GIS data, LIDAR data, and additional information supplied by the City. The major trunks of the collection system that run east and west through downtown Traverse City were the focus of the hydraulic model, as these sewers convey the majority of flow in the City's collection system.

The model represents how the system functions, and is calibrated to real storms and the flow response in the sewer system. Using peak flow rates established with Ten State Standards, peaking factors, and results from the AMM, the EPA SWMM model was used to simulate hydraulic conditions during peak flows. The model demonstrated that the main trunk handling flows from the east side of the city has sufficient capacity to handle peak flows with no surcharging or sanitary sewer overflows (SSOs), while the main trunk handling flows on the west side of the city showed significant surcharging.

A more detailed document summarizing the hydrologic and hydraulic modeling completed as part of the SAW grant is included in Appendix E.

D. Recommendations

The recommendations for system upgrades resulting from the modeling study are shown in Table 8, below.

Table 8: Modeling Recommendations

	Task	Estimated Cost	Time Frame
1	Upgrade WWTP flow meter to one capable of recording flows up to 16-18 cfs.	$10,000	Year 1-2
2	Conduct Sanitary Sewer Evaluation Survey (SSES) with smoke testing in Meter District 3 to locate and remove inflow sources.	$30,000	Year 1-2
3	Conduct basement surveys along western trunk to identify allowable surcharging levels.	$12,000	Year 1-2
4	Clean and televise siphons. Based on the televising, plan for rehabilitation (regular cleaning) or replacement of siphon(s)	$25,000	Year 1-2
5	Perform additional metering in District 3 to evaluate new wet weather flows. Re-evaluate the recommended upgrades based on new flows.	$30,000	Year 3-5
6	Plan funding for recommended system upgrades.	-	Year 6-7
7	Perform recommended upgrades to the system. Current recommendations are to upgrade the 355 feet of 12-inch diameter sewer main along South Oak Street to 24-inch sewer, 695 feet of 21-inch diameter pipe downstream of the Oak Street Siphon to 30-inch, and 2,910 feet of 24-inch diameter pipe downstream of the Boardman River Siphon upgraded to 30-inch.	$2,705,000*	Year 8-10
8	Install larger capacity pumps (and, if necessary, force mains) for Bay and Woodmere during scheduled pump replacements	N/A**	During scheduled replacements

**Upgrade recommendations may change with completion of recommended surveys and metering. Construction method to be determined during preliminary design. Cost estimate assumes significant regulatory and geotechnical issues*

***Pump station upgrades are not included in this cost estimate, as they will occur as part of ongoing pump station operations and planned pump replacements as components age out. Pump station replacement costs and future force main rehabilitation and replacement costs are covered in separate technical memoranda.*

V. Level of Service

The City identified what are referred to as level of service measures that can be used to understand staff and resource priorities. Table 9 summarizes these measures for the City's asset management program.

Table 9: Level of Service Criteria, Performance Indicator, and Level

Key Service Criteria	Performance Indicator	Target Level of Service
Asset Condition Assessment	PACP & MACP Inspections Per Year*	• MACP inspect a minimum of 380 manholes per year, approximately 20% of the System • PACP inspect a minimum of 14 miles of sewer per year, approximately 20 % of the system
Meter Updates and Radio Reads	Replace existing meters with the new Sensus meters and install radio reads for higher accuracy of reads.	**
Regulatory Compliance	Compliance with MDEQ Sanitary Sewer Overflow (SSO) Policy and The Clean Water Act	Comply with the MDEQ SSO policy and The Clean Water Act
Service Delivery and Customer Communication	Utilize Lucity Software to Aide in Utility Management and Promote Customer Communication, Increase effort to reduce number of sewer calls	Respond to customer complaints and requests efficiently
O&M Optimization	Regular Cleaning and Maintenance of the Collection System	Clean and maintain 20% of the system per year

* Pipe Assessment Certification Program (PACP), to assess sanitary sewer condition
Manhole Assessment Certification Program (MACP), to assess manhole condition

** City to review and provide input. Information pulled from City's 2016-2017 Annual Budget Report.

VI. Critical Assets

Determining the assets most critical to system operation allows a community to manage risk, support Capital Improvement Plans (CIP), and efficiently allocate O&M funds. The two key factors used to determine criticality are Probability of Failure (PoF) and Consequence of Failure (CoF). PoF and CoF are multiplied to determine the Business Risk Exposure (BRE) as shown in Figure 26, below. Details and maps are available in Appendices F and H.

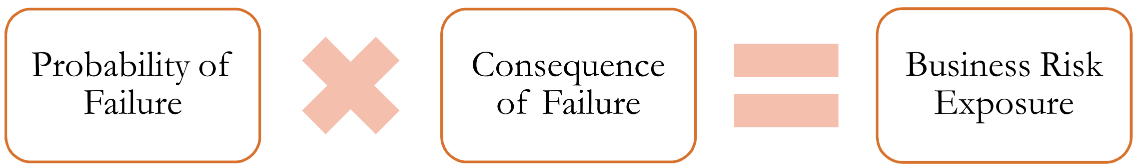


Figure 26: BRE Equation

PoF considers the physical condition or age of an asset and is often based on the Structural MACP or PACP Index Rating. If an asset was not inspected, remaining useful life can be used a proxy for condition. A standardized rating of one through five is assigned to each asset with a score of five indicating worst condition as shown in Table 10.

Table 10: Probability of Failure

Score	Description
1	Improbable
2	Remote, unlikely but possible
3	Possible
4	Probable, likely
5	Imminent, likely in near future

CoF encourages a focus on social, environmental, and economic cost impacts. The economic CoF encompasses the impacts of direct and indirect economic losses to the affected organization and third parties due to asset failure. The social consequence represents the impact of society due to asset failure and the environmental consequence of failure considers the impact to ecological conditions occurring as a result of asset failure.

The factors were rated on a one through five scale for each asset. If one factor is deemed more important, the weighting can be skewed to give that factor more influence. The final CoF incorporating all the factors is described in Table 11. Details in how the factors were scaled is available in Appendix F.

The following factors were combined to determine the final CoF:

- Relative Network Position – the sum of upstream sewers discharging to a structure
- Diameter/Size – the relative size of the asset with respect to the rest of the system
- Restoration Type/Accessibility – refers to the cost to restore the surface above the asset and if traffic control is needed
- Environment – proximity to sensitive environmental features like Boardman River, Kid's Creek, Grand Traverse Bay, etc.
- Critical Users – important system users (Munson Hospital)

Table 11: Consequence of Failure

Score	Description
1	Negligible, minor loss of function
2	Minimal or marginal
3	Noticeable, may suspend some operations
4	Critical, temporarily suspends operations
5	Catastrophic disruption

A CIP should incorporate BRE and institutional knowledge, as shown in the flow chart in Figure 28. Institutional knowledge can reveal known problem areas or areas already designated for upcoming projects. Assets are given high, medium, or low priority based on their BRE as shown in Figure 27. An additional measure confirms that any assets with an MACP or PACP Structural rating of five or with defects likely to cause failure in the near future are automatically given high priority status. Uninspected assets nearing the end of their useful life should be inspected and assessed before potentially unnecessary rehabilitation or replacement funding is allocated. These assets should be given medium priority.

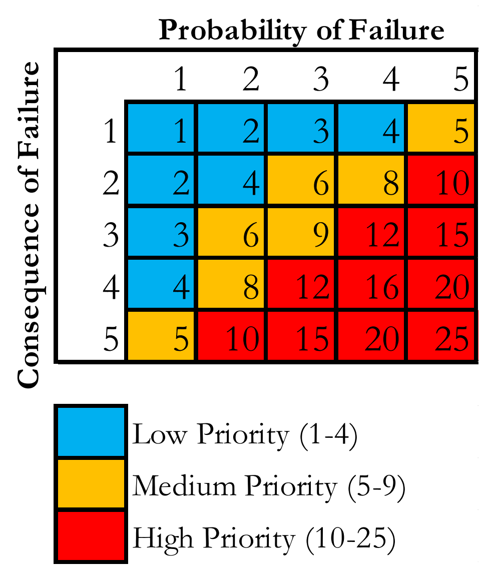


Figure 27 : BRE Matrix

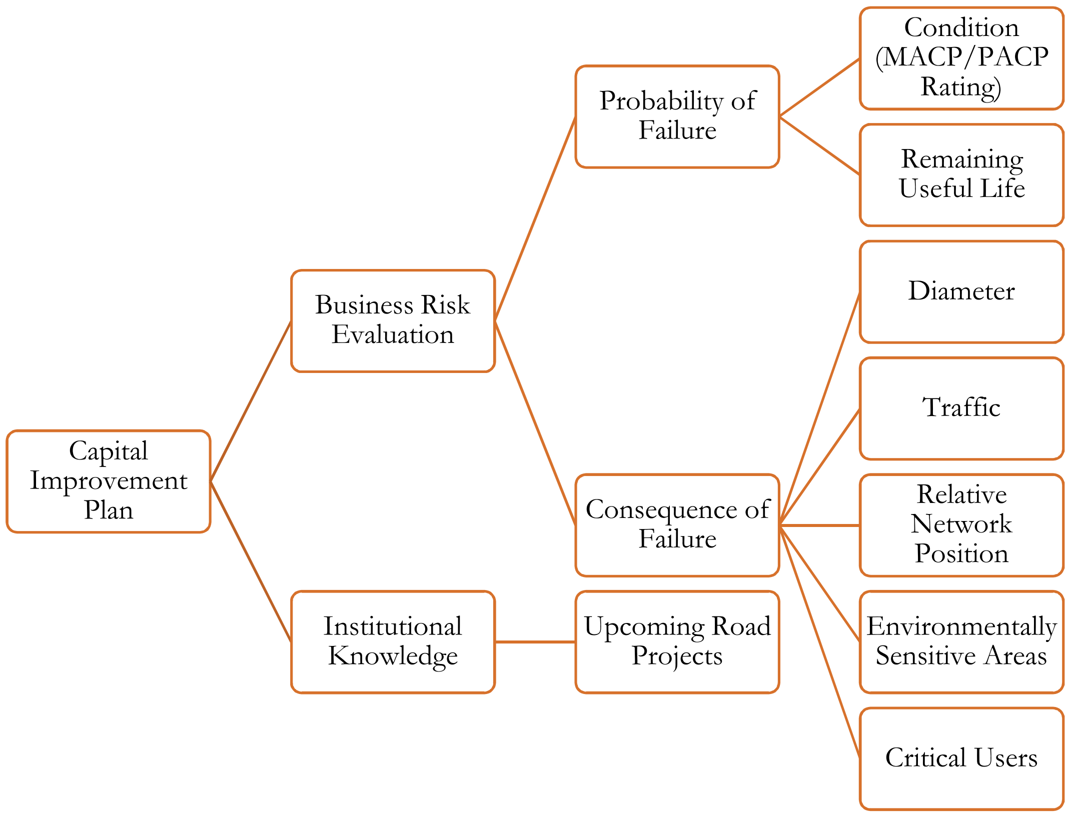


Figure 28: CIP and Risk Flow Chart

A more detailed document describing Traverse City's business risk exposure is included in Appendix F.

VII. Revenue Analysis

The condition assessment helped identify capital improvements that will allow the City to operate at its maximum potential. Additional long-term operations and maintenance strategies will provide the means to maintain a sound structural condition into perpetuity. The City Treasurer has reviewed the proposed level of investment for the collection system, pump stations, and the WWTP and has provided recommendations for rate increases to address the increased investment need. The rate recommendations are listed in the Executive Summary.

A summary table for all recommended investments over the next 10 years is included in Appendix H. This table includes costs identified in this Asset Management Plan as well as pumping/treatment facility costs as identified by CH2M. Appendix G includes CH2M's WWTP CIP and O&M Strategies.

Further refinement to the long-term revenue needs will be necessary when CH2M completes their Facility Plan process, which is expected to commence later in 2017.

A. Capital Improvement Plan

A Capital Improvement Plan (CIP) is a core component of an AMP and an essential planning tool that allows for a community to properly plan for high cost, non-recurring projects. A CIP should detail capital needs related to future/upcoming regulations, major asset replacements, system expansions, system consolidation or regionalization, and improved technology.

Traverse City's Capital Improvement Plan for its collection system is detailed in Appendix F and for its overall wastewater system is detailed in Appendix H. The Capital Improvement Plans will aide in identifying, prioritizing, and implementing capital projects within the City's wastewater collection system during the next 3-5 years.

B. O&M Strategies

Operation and Maintenance (O&M) strategies are an important component of an AMP. By having O&M strategies in-place, such as cleaning and inspecting assets, communicates can properly budget their funds while maintaining their assets.

O&M strategies directly tie into Traverse City's Level of Service (LOS) criteria. Below details the City's O&M strategies developed as part of this AMP.

- <u>Pipes:</u>
  There are approximately 69-miles of pipe in the Traverse City's sanitary system. This O&M strategy will focus on cleaning and inspecting approximately 20% of the systems pipes per year. Table 12 summarizes the estimated cleaning and inspection costs used to calculate the annual O&M cost.

Table 12: Estimated Cleaning and Inspection Costs for Pipes

Diameter (inches)	Cleaning Cost per Foot	Inspection Cost per Foot
4	$ 1.25	$1.08
6	$ 1.25	$1.08
8	$ 1.85	$1.08
9	$ 1.91	$1.09
11	$ 1.98	$1.10
12	$ 2.07	$1.11
15	$ 2.28	$1.22
16	$ 2.43	$1.23
18	$ 2.58	$1.24
21	$ 2.03	$2.30
24	$ 2.70	$2.30
Unknown	$ 2.03	$1.35

* The cleaning and inspection costs are estimated costs and reflective of public bid lists.

Using the cleaning and inspection costs detailed in Table 12 above, the annual O&M costs for pipes would be approximately $230,000 for 14-miles of pipe.

- Manholes:
  There are approximately 1902 manholes in Traverse City's wastewater system. This O&M strategy will focus on inspecting 20% of the systems manholes per year. The table below summarizes the estimate cost for manhole inspection, which was used to calculate the annual O&M cost

Table 13 : Estimated Manhole Inspection Costs

Manhole	Inspection Cost per Manhole
1	$ 100.00

Using the manhole O&M costs detailed in Table 13 above, the annual costs for manholes would be approximately $38,000, for 380 manholes.

Regular cleaning and maintenance of the collection system is necessary to prevent backups due to clogged or structurally-failing sewers. A "televise first" strategy is recommended when cleaning and televising sewers to optimize cleaning budgets. This is done by televising sewers ***before*** jetting/cleaning, and only cleaning when necessary. Based on our experience, most sanitary sewers are self-cleaning. We recommend that the City inspect and clean sanitary sewer collection systems on an "80/20" schedule. This schedule involves cleaning 80% of the system every 20 years and the most critical or high maintenance 20% of the system every five years. The 20% of the system to be cleaned more frequently will be determined through the televising process and will generally consist of those sewers that are identified as those that are not self-cleaning. ***<u>The baseline Level of Service for O&M purposes was a systematic wastewater televising (inspection) program and an annual repair and rehabilitation program to maintain an average structural condition equal to that observed in 2016.</u>***

VIII. On-Going Data Management

A fully utilized AMP will improve the City's wastewater system for the City's future generations. Figure 29 shows that a healthy data management process is an ongoing cycle. The City's new asset management plan has essentially completed one cycle of the data management process. Even though that initial cycle is complete, it is essential that the City continue to collect data. Appendix B explains the lay out of the first cycle conducted by OHM. This data management process will aid in the tracking and use of data to cost-effectively manage the City's wastewater system.

1. **Inventory**

   The City should continue to populate and complete missing or incorrect data in each asset's attributes. When assets are repaired or replaced and new assets are added, the BRE value can be updated. The City should assign new unique Facility IDs to new assets in accordance with their current naming convention.

2. **Inspection Plan**

   Only a portion of the system was condition-assessed in the creation of this AMP, but it will be important to perform ongoing condition assessments of the rest of the system. Eventually you will come back to assets and assess them again. The AMP recommended an initial rate of condition assessment. The City should develop a plan to inspect assets at this rate. Whether the City performs the inspections internally or utilizes the help of a contractor, the City should specify a data format that will integrate with their existing GIS and CMMS software.

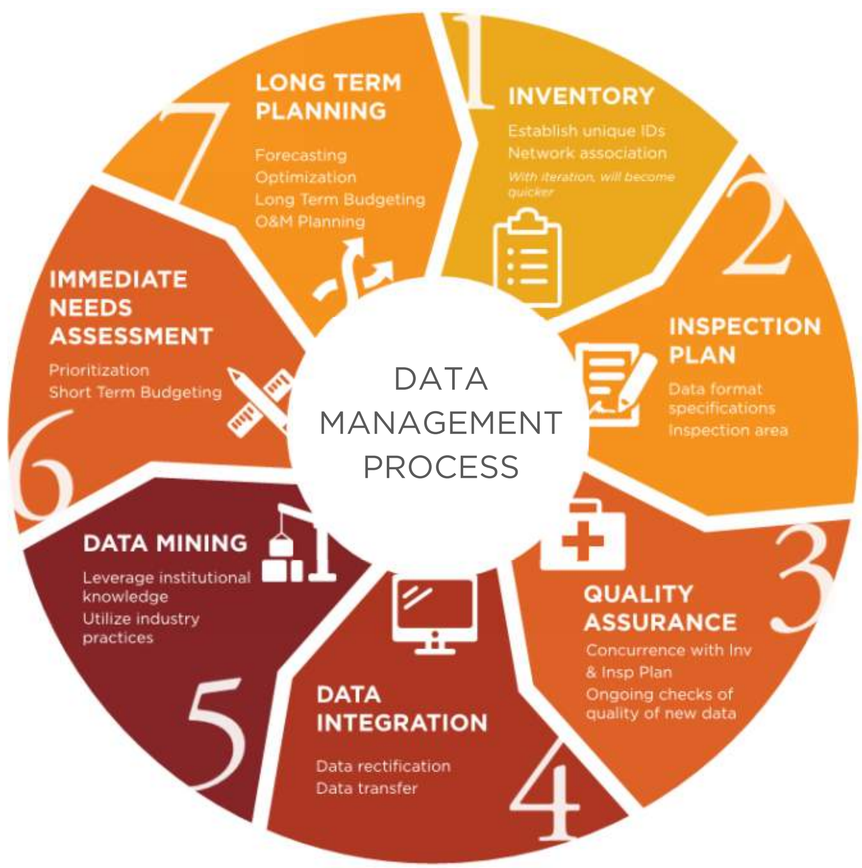


Figure 29: Data Management Process Diagram

3. **Quality Assurance**

   Data from the condition assessments will need to be checked for quality, either by the City or OHM Advisors' staff. The Quality Assurance process should occur throughout the Inventory and Inspection Plan steps, especially while condition assessment is taking place to ensure that the data is of satisfactory quality and in the correct format.

4. **Data Integration**

   After data is checked for quality, it will need to be integrated into the City's existing systems (e.g. GIS and Lucity). Significant data rectification and preparation work may need to be performed so that the collected information will transfer into the City's systems seamlessly. The amount of effort required will depend on the accuracy and format of the inspection data, as well as the status of the existing system database.

5. **Data Mining**

   Once the data is in the City's systems, OHM Advisors can perform data mining or train Traverse City staff on data mining. OHM Advisors analyzes the data to draw valuable insight from the incoming data. These insights include trends in pipes of certain material, size, age, and location.

6. **Immediate Needs Assessment**

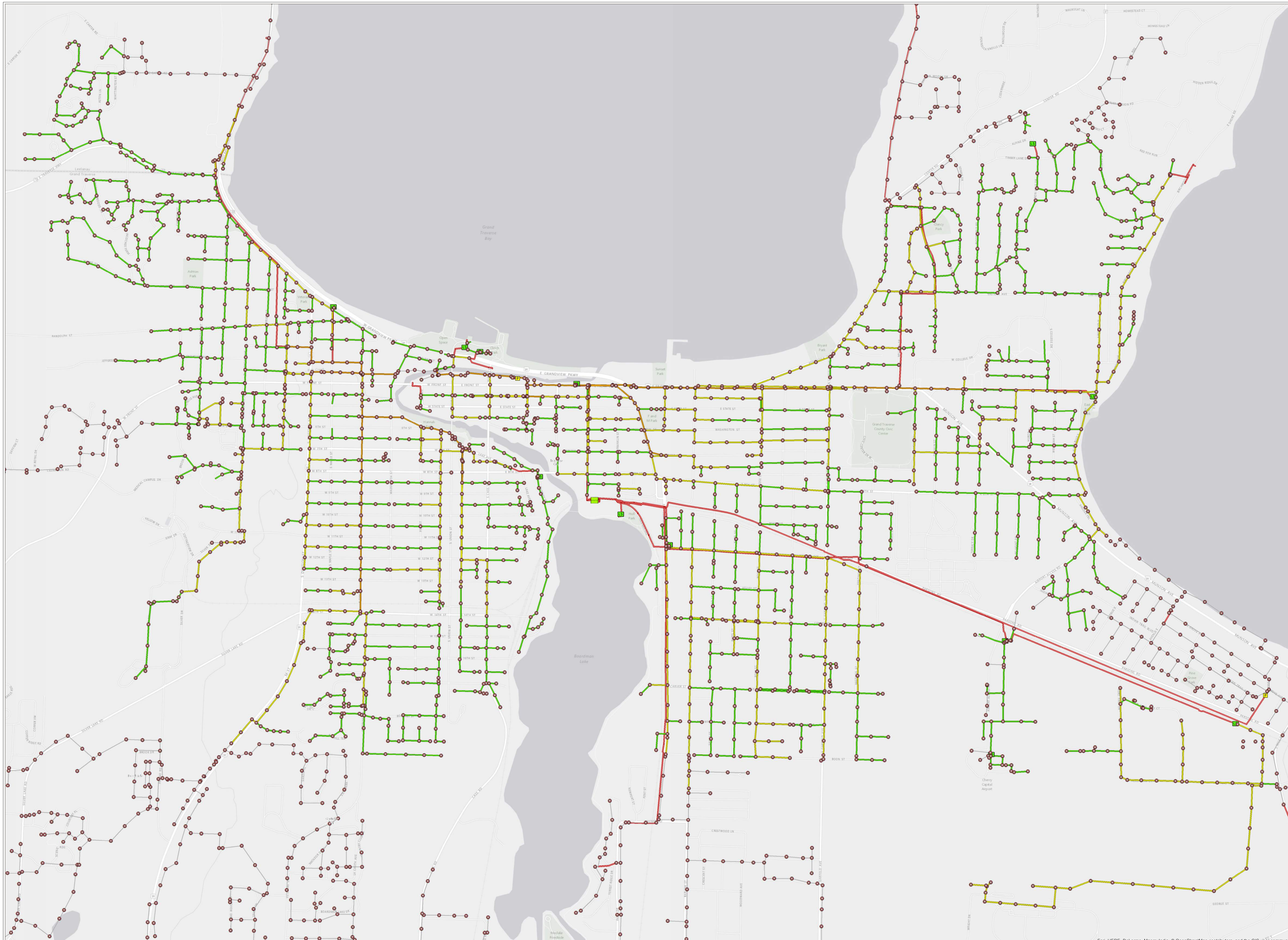
   Use the inspection results to repair/replace assets that are failing and are in need of immediate attention, such as collapsing pipes or other imminent concerns.

7. **Long Term Planning**

   When a new batch of data is added, the City should check to see if the long term plan still aligns with the results of the updated system deterioration forecasting and O&M and budget optimizations. Long term budgeting and O&M planning should be updated as needed.

If these steps for a data management program are followed and continuously repeated and improved, the City will be well on its way to leveraging their asset management plan into a truly sustainable and cost-effective infrastructure management program.

Appendix A: Condition Maps



Wastewater SAW

Overall System

Traverse City, MI

Figure A-1

N
W E
S

0 800 1,600 2,400
Feet
1" = 800'

Sanitary Sewer Manholes
LS Lift Station
P Pump Station
Treatment Plan

Sewer Gravity Mains
Unknown

Diameter
4" - 8"
9" - 15"
16" - 24"
Sewer Pressurized Mains

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: May 30, 2017

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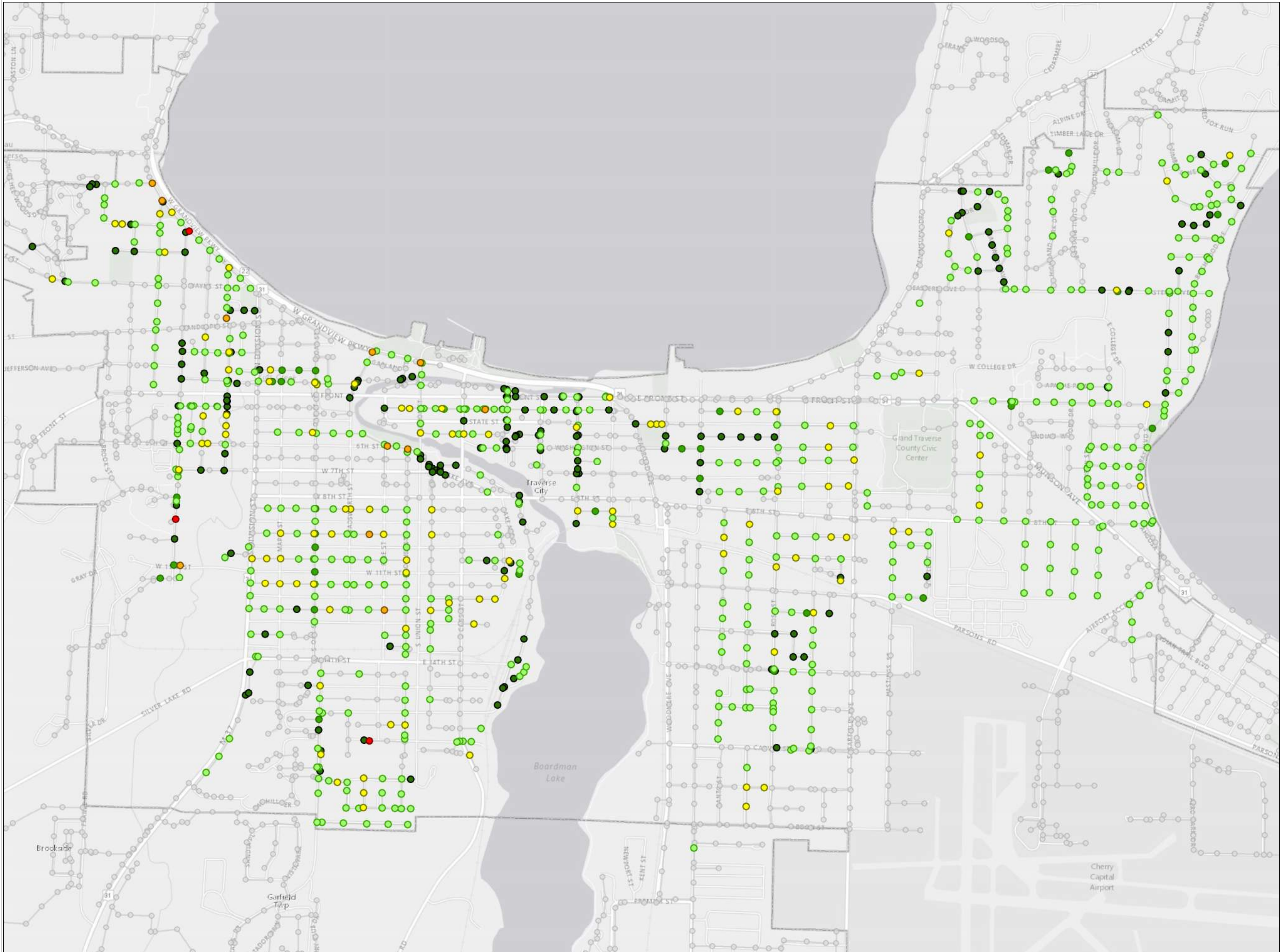

Traverse City SAW
MACP Structural Index Ratings

Traverse City, MI

Figure A- 2

Sanitary Sewer Manholes

Structural Manhole Ratings Index

- 0 - 0.5
- 0.5 - 1.5
- 1.5 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 5
- No Associated Rating
- Sewer Gravity Mains
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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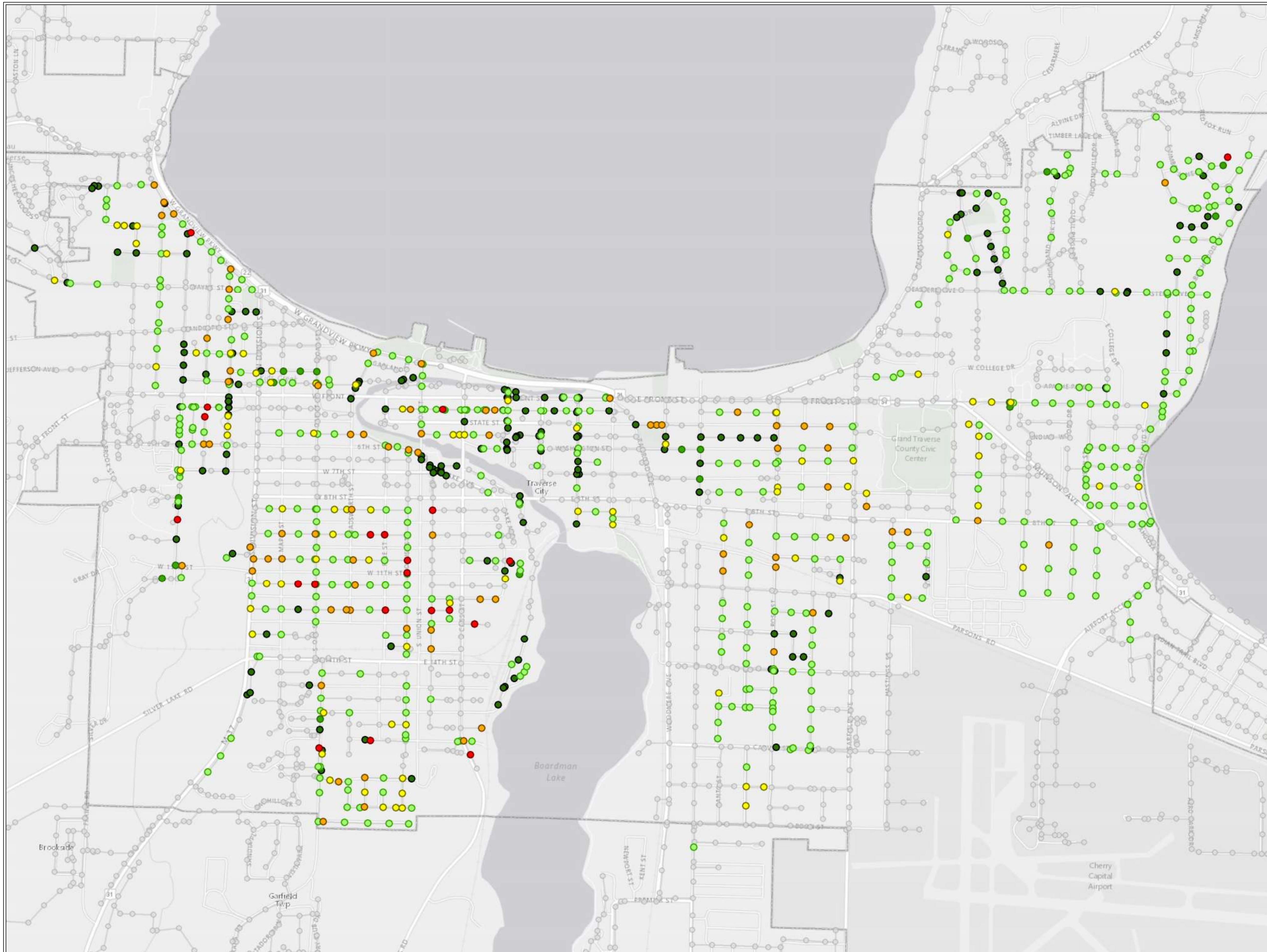
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170427 Traverse City Wastewater MACP and PACP Figs\Figure A-1 MACP Structural Index Ratings.mxd



Traverse City SAW
MACP Highest Rated Structural Defects

Traverse City, MI

Figure A- 3

Sanitary Sewer Manholes

Structural Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Rating
- Sewer Gravity Mains
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

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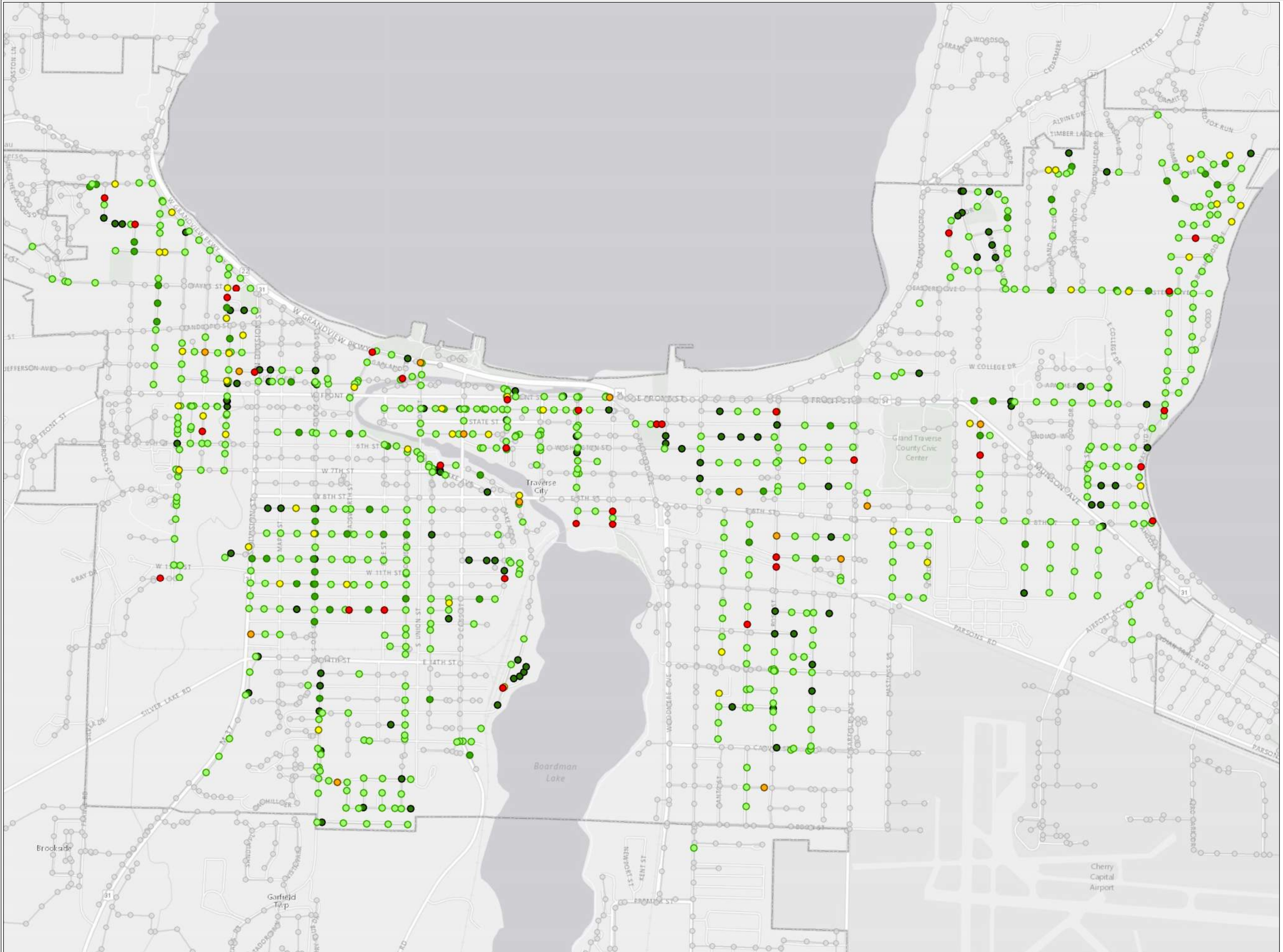

Traverse City SAW

MACP O&M Index Ratings

Traverse City, MI

Figure A- 4

Sanitary Sewer Manholes

O&M Index Ratings

- 0 - 0.5
- 0.5 - 1.5
- 1.5 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 5
- No Associated Rating
- Sewer Gravity Mains
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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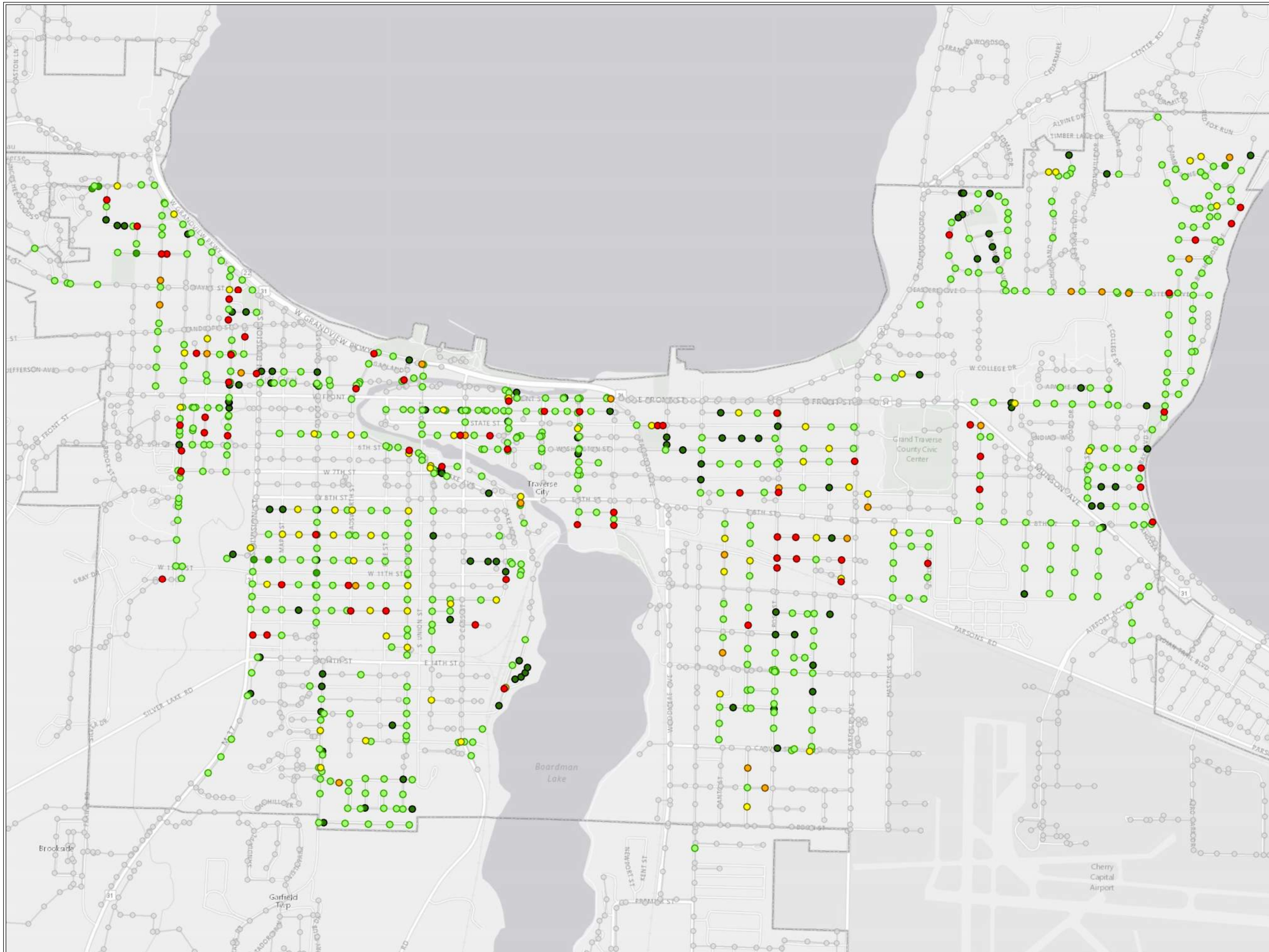

Traverse City SAW

MACP Highest Rated O&M Defects

Traverse City, MI

Figure A- 5

Sanitary Sewer Manholes

O&M Highest Rated Defects

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Rating
- Sewer Gravity Mains
- Traverse City

0 1,600 3,200

Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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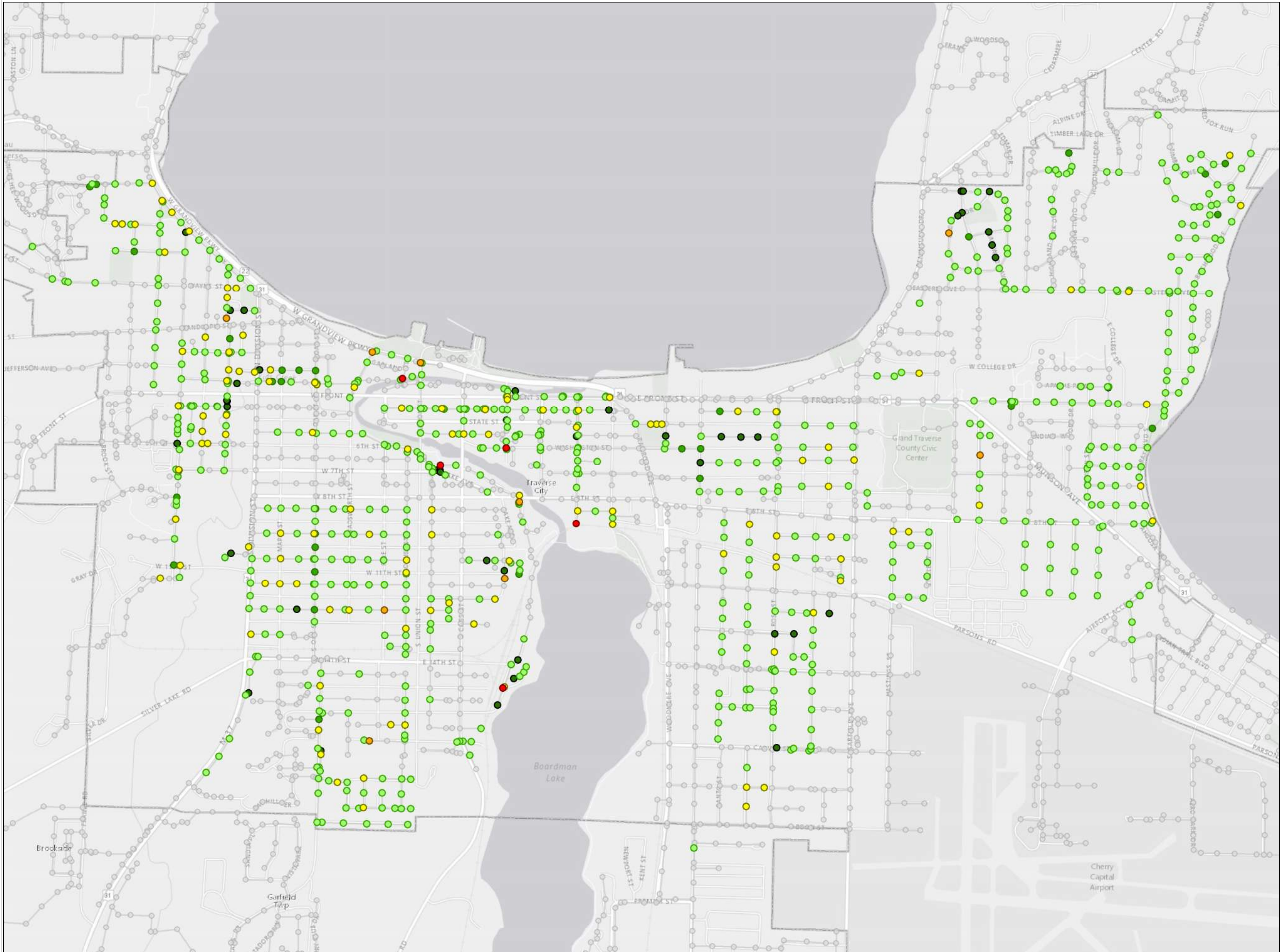
Traverse City SAW

MACP Overall Index Ratings

Traverse City, MI

Figure A- 6



Sanitary Sewer Manholes

Overall Structure Ratings Index

- 0 - 0.5
- 0.5 - 1.5
- 1.5 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 5
- No Associated Rating
- Sewer Gravity Mains
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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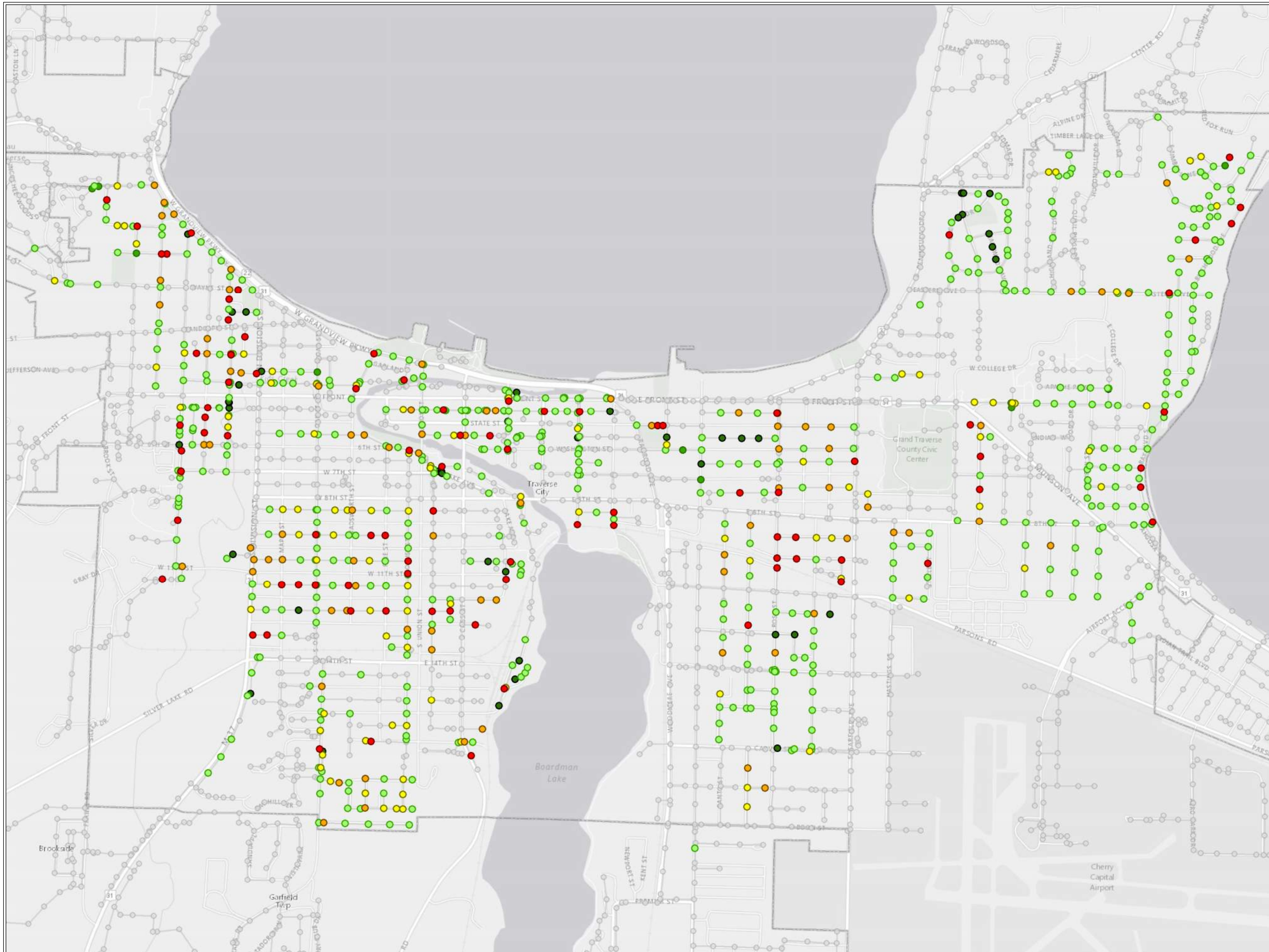
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170427 Traverse City Wastewater MACP and PACP Figs\Figure A-5 MACP Overall Index Ratings.mxd



Traverse City SAW

MACP Highest Rated Overall Defects

Traverse City, MI

Figure A- 7

Sanitary Sewer Manholes

Overall Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Rating
- Sewer Gravity Mains
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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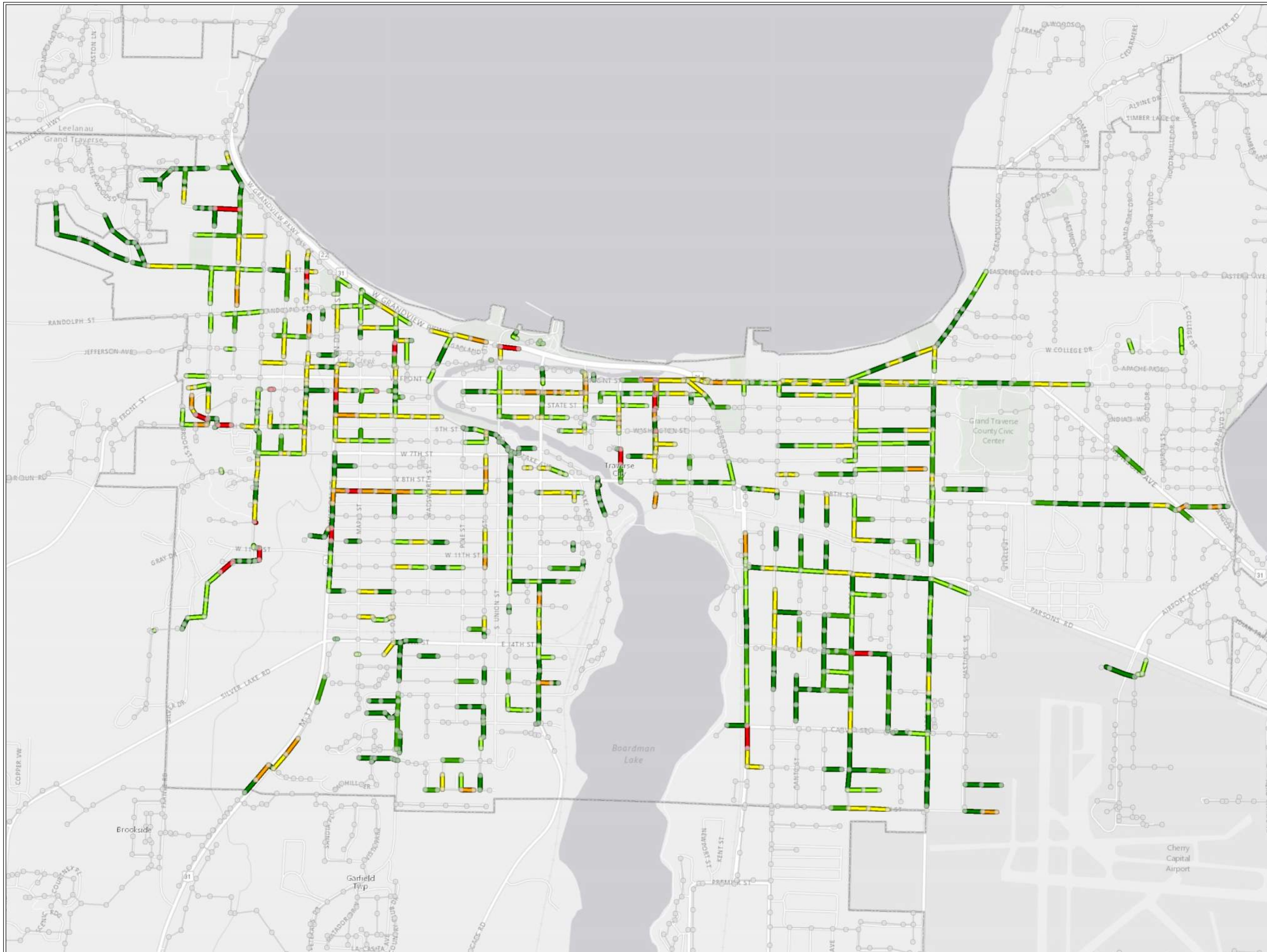
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170427 Traverse City Wastewater MACP and PACP Figs\Figure A-6 MACP Highest Rated Overall Defects.mxd



Traverse City SAW

PACP Structural Index Ratings

Traverse City, MI

Figure A- 8

Sanitary Sewer Manholes

Sewer Gravity Mains

Structural Pipe Ratings Index

- 0 - 0.5
- 0.5 - 1.5
- 1.5 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 5
- No Associated Value
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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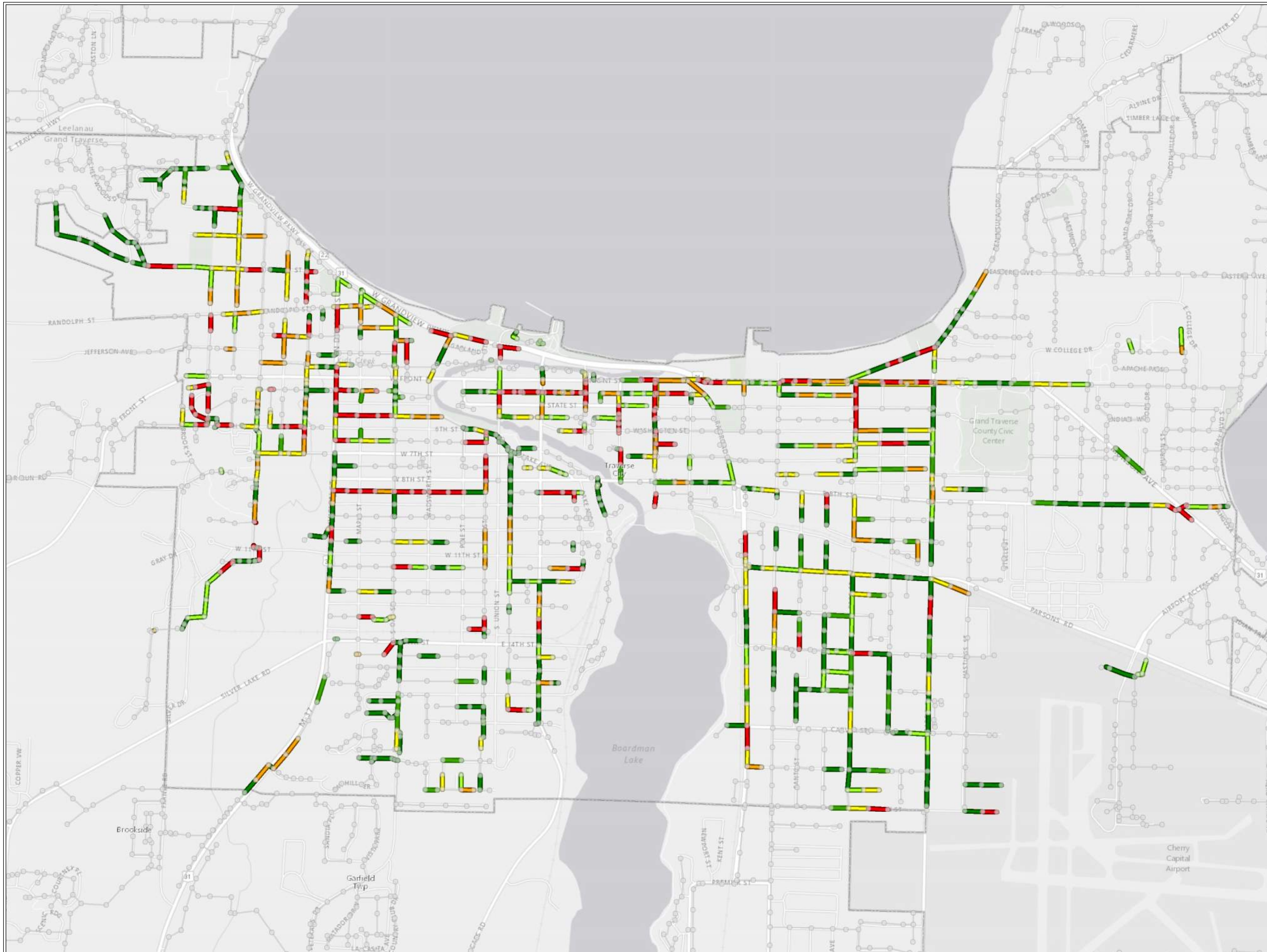

Traverse City SAW

PACP Highest Rated Structural Defects

Traverse City, MI

Figure A- 9

Sanitary Sewer Manholes

Sewer Gravity Mains

Structural Highest Rated Defect

0
1
2
3
4
5
No Associated Value
Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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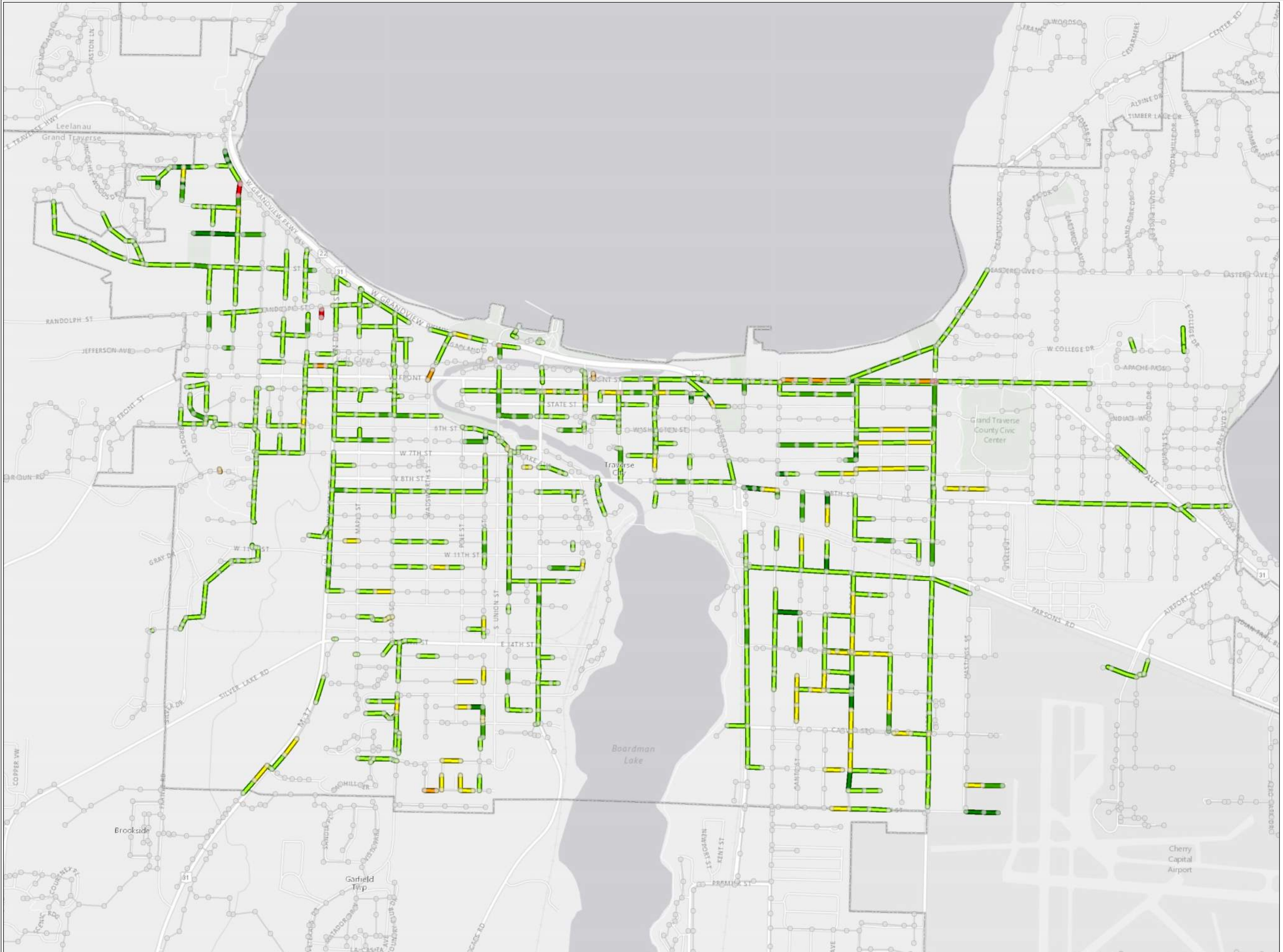
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170427 Traverse City Wastewater MACP and PACP Figs\Figure A-8 PACP Highest Rated Structural Defects.mxd



Traverse City SAW

PACP O&M Index Ratings

Traverse City, MI

Figure A- 10

Sanitary Sewer Manholes

Sewer Gravity Mains

O&M Pipe Ratings Index

- 0 - 0.5
- 0.5 - 1.5
- 1.5 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 5
- No Associated Value
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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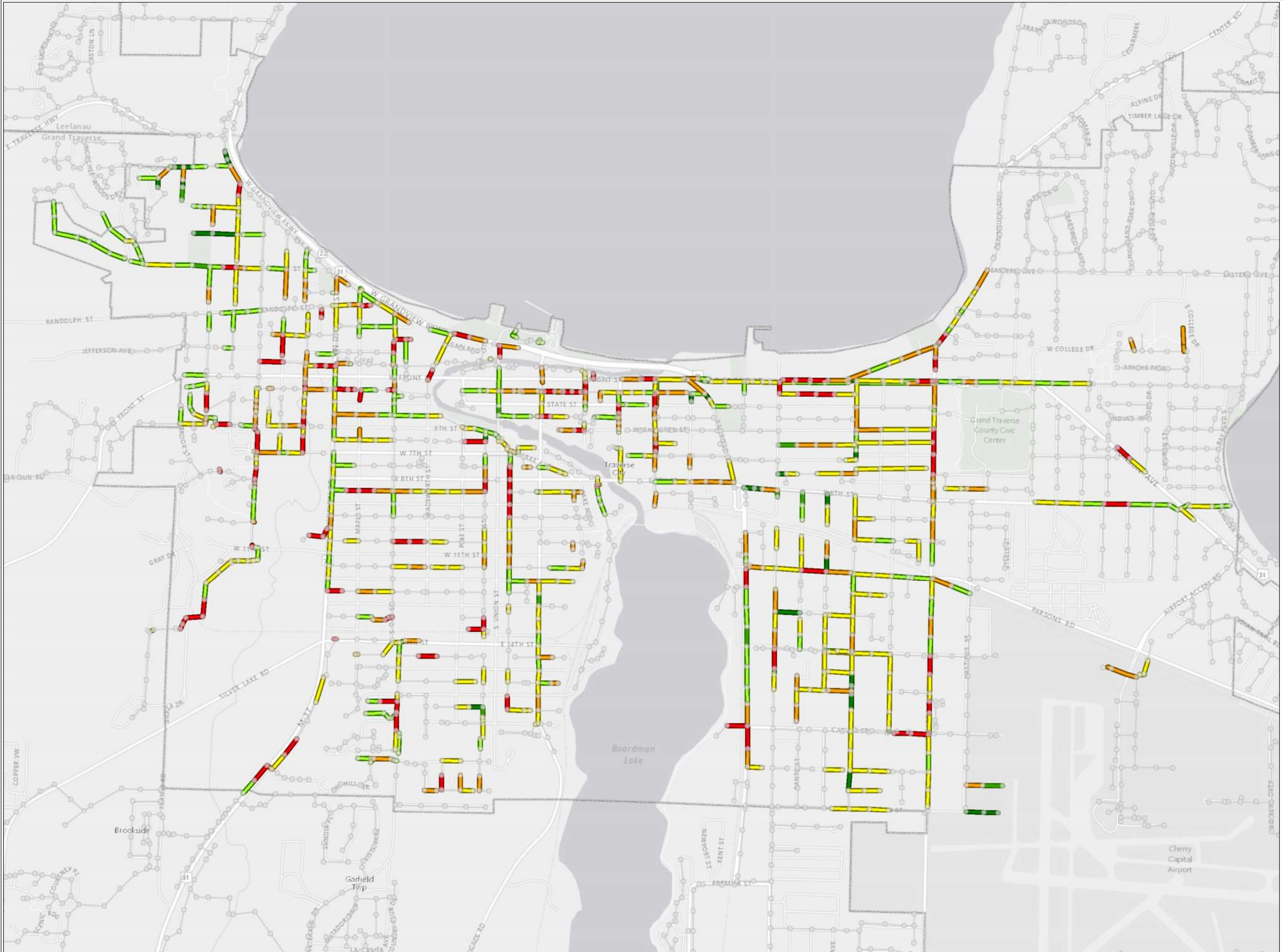
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170427 Traverse City Wastewater MACP and PACP Figs\Figure A-9 PACP O&M Index Ratings.mxd



Traverse City SAW

PACP Highest Rated O&M Defects

Traverse City, MI

Figure A- 11

Sanitary Sewer Manholes

Sewer Gravity Mains

O&M Highest Rated Defect

0
1
2
3
4
5
No Associated Value
Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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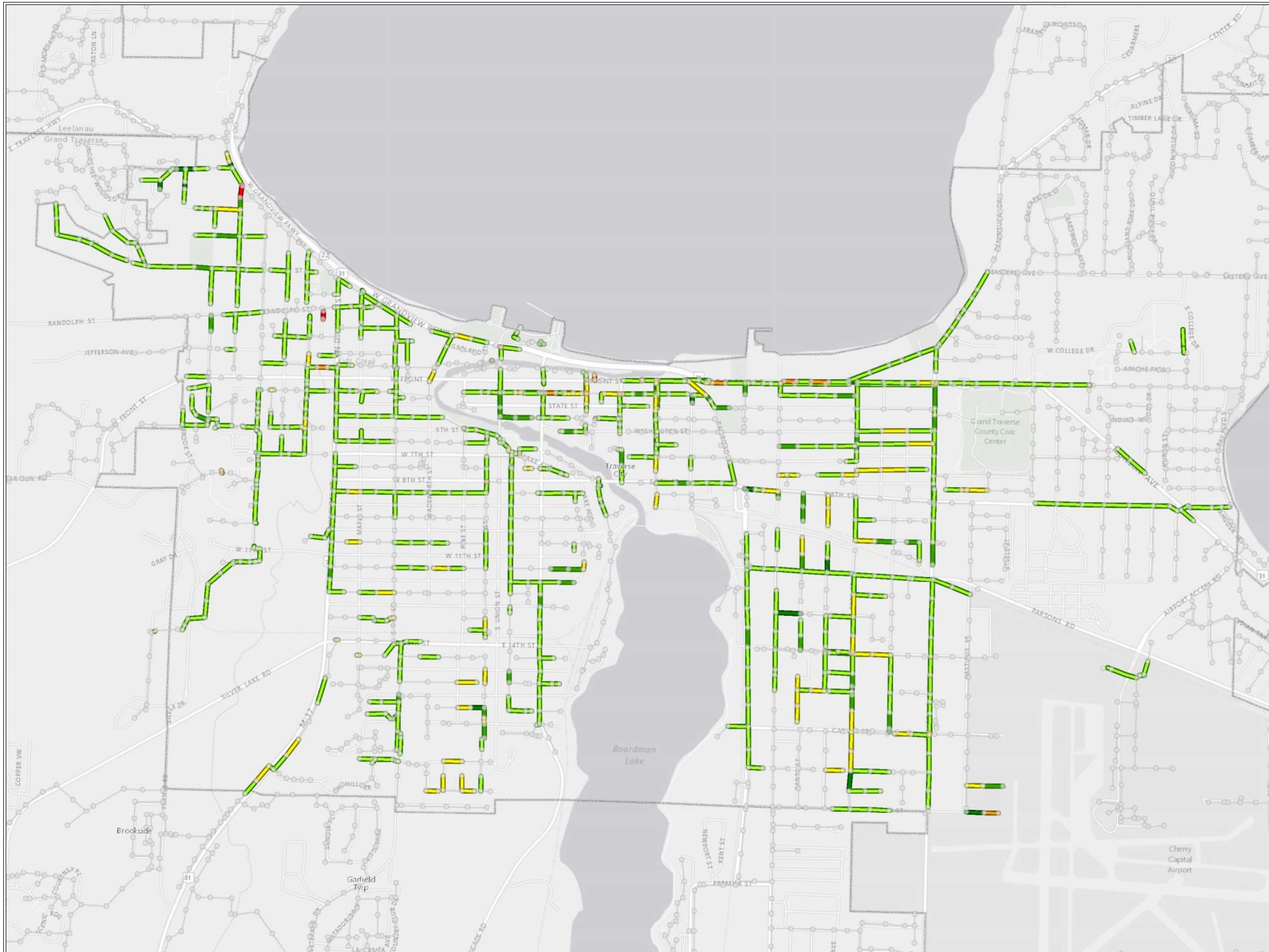
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170427 Traverse City Wastewater MACP and PACP Figs\Figure A-10 PACP Highest Rated O&M Defects.mxd



Traverse City SAW

PACP Overall Index Ratings

Traverse City, MI

Figure A- 12

Sanitary Sewer Manholes

Sewer Gravity Mains

Overall Pipe Ratings Index

- 0 - 0.5
- 0.5 - 1.5
- 1.5 - 2.5
- 2.5 - 3.5
- 3.5 - 4.5
- 4.5 - 5
- No Associated Value
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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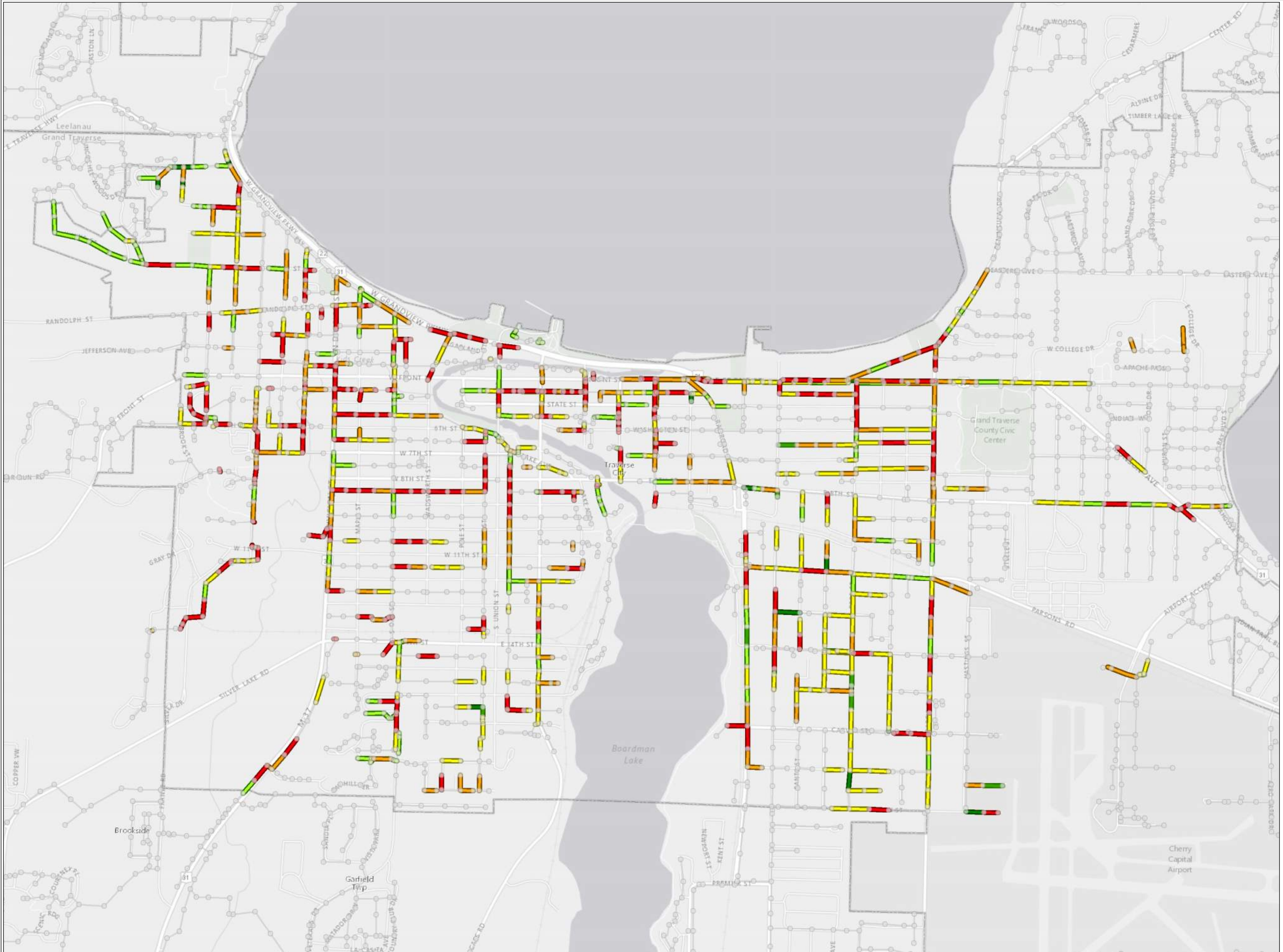
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170427 Traverse City Wastewater MACP and PACP Figs\Figure A-11 PACP Overall Index Ratings.mxd



Traverse City SAW

PACP Highest Rated Overall Defects

Traverse City, MI

Figure A- 13

Sanitary Sewer Manholes

Sewer Gravity Mains

Overall Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Traverse City

0 | 1,600 | 3,200
Feet

1" = 1,600'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: April 27, 2017

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Appendix B: Data Management and Editing

Appendix B: Data Management and Editing

Traverse City's wastewater asset inventory resides in the City's Geographic Information System (GIS) and is also connected to the City's Computerized Maintenance and Management System (CMMS) program which houses infrastructure condition inspection information as well as work orders associated with individual assets. The City is continuing to edit and update the attributes of the inventory. This document lays out edits made by the City and OHM Advisors during the completion of the Asset Management Plan (AMP).

A. Introduction

At the onset of this project, GIS was the repository for all of the City's digitally available asset data. The City shared the wastewater GIS database with OHM Advisors in early 2015. That database and a few subsequent updates served as the references for OHM throughout the course of the project. A screenshot of the database's most recent contents can be seen in Figure B-1.

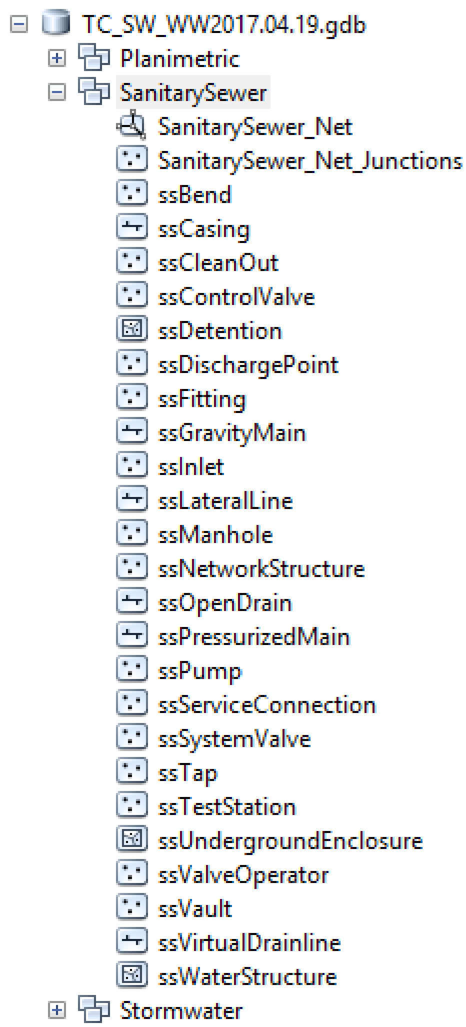


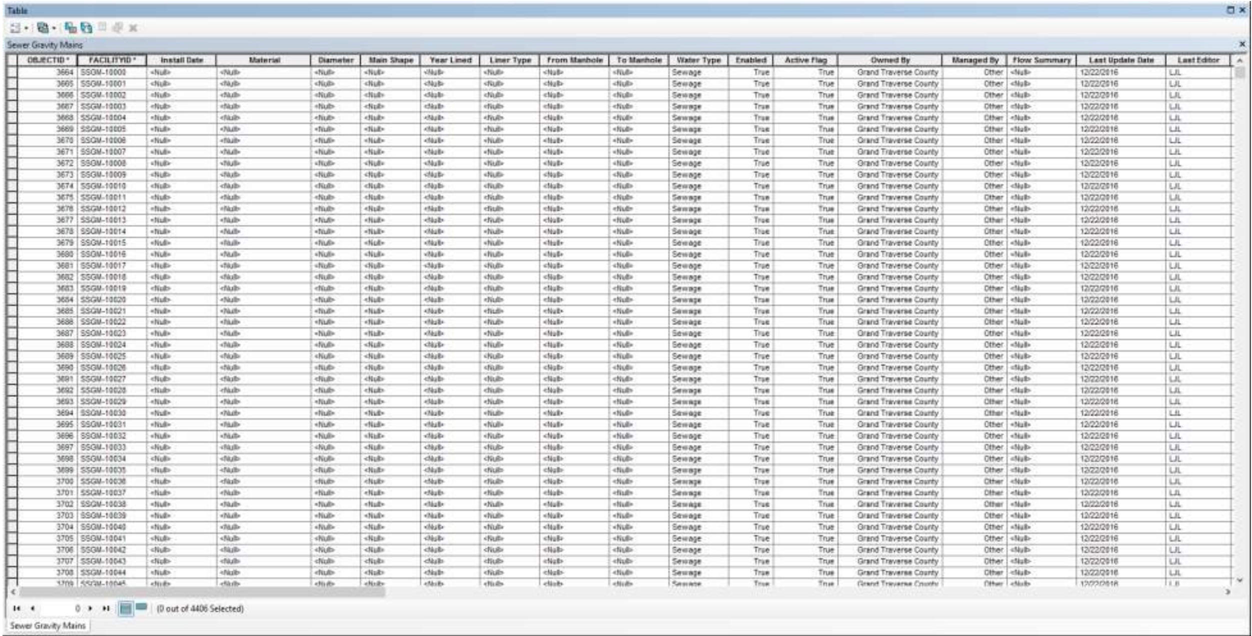
Figure B-1: Wastewater Geodatabase Contents

The City is maintaining the working database, which is constantly receiving updates and changes, some of which will be discussed later in this document. Although the work is ongoing, each asset has its own unique identifier and will be the key to incorporating all of the data collected during this project regardless of method, tool, or software used.

The City used a portion of the SAW grant funds to purchase and implement an asset management software called Lucity. CMMS software like Lucity is intended for integrating the types of data being collected with an existing GIS inventory. Lucity provides an efficient, user-friendly data management and work order platform that will benefit the City's wastewater system moving forward; especially if the City implements a funding source for the wastewater system that allows for systematic inspections, repairs, and rehabilitation.

B. Static Data vs. Dynamic Data

There are two types of data being collected during the inspections: Static and Dynamic. Dynamic data is any piece of information expected to continuously change over the lifespan of a particular asset like a condition rating. Information that isn't expected to change throughout the lifetime of an asset is considered to be static data. Just as the data types are different, the way each is stored should be different as well. Having two software applications as the City does in ArcGIS and Lucity, allows the data to be stored separately, yet remain connected. As long as the link is established between the two programs via the unique asset identifier, both datasets can be viewed from either program. Static data such as the upstream and downstream structures of a pipe, manhole wall material, spatial location, or invert elevations are best stored in a place that allows the data to be edited, exported, and manipulated to create maps or online modules. A GIS geodatabase is the perfect place to store this information, especially since a lot of the City's asset information already exists there. All of the static data can be kept in the attribute tables for each feature class such as manholes, pipes, etc. and only need to be changed if the asset undergoes a major change or replacement. An example of an attribute table for wastewater gravity mains is available in Figure B-2.



Table

Sewer Gravity Mains

OBJECTID *	FACILITYID *	Install Date	Material	Diameter	Main Shape	Year Lined	Liner Type	From Manhole	To Manhole	Water Type	Enabled	Active Flag	Owned By	Managed By	Flow Summary	Last Update Date	Last Editor
3664	SSGM-10000	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3665	SSGM-10001	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3666	SSGM-10002	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3667	SSGM-10003	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3668	SSGM-10004	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3669	SSGM-10005	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3670	SSGM-10006	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3671	SSGM-10007	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3672	SSGM-10008	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3673	SSGM-10009	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3674	SSGM-10010	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3675	SSGM-10011	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3676	SSGM-10012	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3677	SSGM-10013	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3678	SSGM-10014	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3679	SSGM-10015	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3680	SSGM-10016	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3681	SSGM-10017	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3682	SSGM-10018	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3683	SSGM-10019	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3684	SSGM-10020	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3685	SSGM-10021	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3686	SSGM-10022	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3687	SSGM-10023	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3688	SSGM-10024	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3689	SSGM-10025	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3690	SSGM-10026	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3691	SSGM-10027	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3692	SSGM-10028	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3693	SSGM-10029	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3694	SSGM-10030	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3695	SSGM-10031	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3696	SSGM-10032	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3697	SSGM-10033	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3698	SSGM-10034	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3699	SSGM-10035	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3700	SSGM-10036	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3701	SSGM-10037	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3702	SSGM-10038	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3703	SSGM-10039	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3704	SSGM-10040	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3705	SSGM-10041	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3706	SSGM-10042	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3707	SSGM-10043	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3708	SSGM-10044	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL
3709	SSGM-10045	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	Sewage	True	True	Grand Traverse County	Other	<Null>	12/22/2016	LJL

(0 out of 4406 Selected)

Sewer Gravity Mains

Figure B-2: Wastewater Gravity Main Attribute Table

Dynamic data can be effectively stored in Lucity, which allows multiple instances of the same piece of information to be kept for each asset. For example, condition ratings change over time. The condition of the asset is constantly changing and will typically yield a different rating each time it is inspected. In addition, the ratings are typically only valid for a short amount of time (most experts believe three to five years is appropriate) compared to the life of the asset. Therefore, the most recent rating is often the most important, but previous ratings can provide valuable information on an asset's history and deterioration rate. For example, the more ratings that exist for a particular asset over the course of its lifespan, the more accurate the deterioration forecast or remaining useful life estimation will be. By keeping dynamic data in a separate asset management software such as Lucity, the user has the flexibility to only show one or the most recent value in the ArcGIS program, while still having access to that particular asset's entire history of values in the asset management database.

C. Manhole Data

OHM Advisors performed manhole inspections in accordance with NASSCO's Manhole Assessment Certification Program (MACP). Due to NASSCO's Level 1 inspection being too basic and their Level 2 inspection being extremely detailed, OHM performed a hybrid Level 1.5 or 1+ inspection on 807 manholes. This hybrid level inspection contains all of the Level 1 data fields, some of the Level 2 data fields that OHM believes to be most important, defect coding, as well as an interior video of the manhole. Because the manhole inspection data was finalized prior to the City's shift to Lucity for the dynamic data storage, the information was delivered to the City on December 1, 2016 in a Microsoft Excel document named "Final Manhole Inspection Tables_WW.xlsx." This table can also can be found on the external hard drive associated with the wastewater AMP. This file contains all of the manhole inspection information in a tabular format that is linked to the inspection videos and consistent with the rest of the condition data deliverables.

D. Sewer Data

Terra Contracting Services was hired to perform pipe inspections in accordance with NASSCO's Pipeline Assessment Certification Program (PACP). Terra inspected 25.4 miles of sewer, which is approximately 30% of the City's collection system. Terra provided the City with the inspection videos, reports, and two database files named "TRAVERSE CITY.mdb" (delivered to the City and shared with OHM shortly after) and "Traverse City.mdb" delivered directly to OHM on February 20, 2017. City staff also performed pipe inspections in accordance with NASSCO's Pipeline Assessment Certification Program (PACP) on 7.8 miles of sewer. This dataset was delivered to OHM on November 9, 2016.

OHM Advisors compiled the data from all database files and returned the finished product in an Excel file with multiple tables. This format provides the flexibility to integrate the data into Lucity and use the data for subsequent reporting and analysis. The Excel file contained the following five different tables:

1. "Inspection Data" – Table containing all of the header information, which would be considered the static data component of the inspection
2. "Media Links" – Table showing which media files pertain to which feature in GIS
3. "Structure Defect List" – Complete list of defects and their associated information
4. "Ratings" – NASSCO ratings table based on the defect coding
5. "Rehab Recommendation Summary" –Table containing all of the recommended rehabilitation that was identified during the review of the inspection videos

The sample final table file was sent to the City on September 12, 2016 and approved on November 21, 2016.

Several pipe inspections discovered discrepancies with the existing GIS mapping, such as buried manholes that needed to be added to the manhole features class or pipe segments that needed to be split at a structure connected to, but not located at the endpoint of the line segment. OHM Advisors provided the City with a list of the discrepancies and suggested corresponding GIS edits. The list became a working document between the City and OHM Advisors to track the collaboration and updates. All of the discrepancies were addressed and compiled into a final table. This final table documents all of the suggested changes, notes between OHM Advisors and the City, and geodatabase edits that were completed by the City. It is named "Final GIS Discrepancy List from Wastewater PACP Data.xlsx" and can be found on the external hard drive.

Upon completion of the edits, the PACP data fields were updated and compiled into the final data table format previously mentioned. This Excel file is named "Final Sewer Inspection Tables_WW.xlsx" and can be found on the external hard drive.

The external hard drive is a separate deliverable and will be submitted to the City on or before May 31, 2017.

E. Criticality Factors

The criticality factors were created using the "20160223_Storm_WatseWater.gdb" geodatabase. A new attribute field was created for each criticality factor, which was populated for all manhole and pipe segment features. Please refer to Appendix D for further details on factors and how the criticality matrix was developed. This table was not intended to be a working database. Instead, it is deliverable that will allow the City to join these new fields with their current working database based on the unique asset identifier. Once the new fields have been joined to the City's working database, they can be edited easily in the future as the condition of the assets change over time. The individual consequence of failure factors used to calculate the ratings will also delivered to the City on the external hard drive, so the City can re-evaluate risk as more inspections and rehabilitation projects are completed in the future.

F. Future Data Management Recommendations

The asset management plan is intended to be a working "document" that must be continuously edited to incorporate new information and update existing data. The deliverables produced during the SAW Grant project only pertain to a portion of the City's wastewater system, so the datasets are just the foundation of an ongoing effort to enhance the asset management plan. In addition, some of the data that was compiled during the project will need to be replaced with more current data as time goes on. For example, attribute fields such as condition ratings or risk factors will need to be adjusted in the event of any new inspections or changes to an asset's properties in the future.

Continued field data collection and database update efforts are crucial to an effective AMP.

Appendix C: Force Main Inventory and Assessment Technical Memorandum

Appendix C: Force Main Inventory and Assessment Technical Memorandum

A. Introduction

This memorandum summarizes the collection and assessment of data for the 4.7 miles of force main in Traverse City's wastewater conveyance system. The locations of these are shown in Figure C-A-1 in Appendix C-A. A force main's probability of failure was determined from age, pipe material, break history, presence of stream crossings, and number of junctions. Criticality was determined by associated pump station capacity, roadway traffic ratings, close proximity surface water, railroad crossings, close proximity drinking water wells, presence of redundant force mains, presence of historical districts, and the number of residential or commercial properties along the force main. A copy of the proposed methodology that was originally provided to Traverse City to describe these criticality ratings is provided in Appendix C-B. The rating scale and several other details have since been modified to better fit Traverse City's needs. The goal of this process is to provide an estimate of the needed annual reserves and capital improvement costs for force main maintenance and replacement.

B. Data Collection and Inventory

The 4.7 miles of force main that are maintained by Traverse City are shown in Figure C-A-1 in Appendix C-A. An inventory of the force mains was created using the existing GIS, record drawings, and operator input. Force mains were subdivided into shorter segments and inventoried separately when split by fittings or valves, for diameter changes, for material changes, and at major force main junction points. Segmentation allowed the risk potentials along the entire force main to be identified in more detail and helps prioritize areas of greater concern for future inspections. A unique facility identifier (ID) was assigned to each segment to link criticality ratings back to the existing GIS. Information collected for each segment is summarized in Table C-C-1 in Appendix C-C. Force main segments of an unknown material type or diameter were assumed to have the same properties as adjoining segments. Those with an unknown installation year were assumed to be installed at the same time as the associated pump station.

Assessing the condition of a force main is costly and often requires destructive or disruptive testing methods. In most cases bypass pumping would be required to prevent interruptions in flows and keep the system operating during testing. For these reasons, it was elected to forgo a condition assessment and use available information on each segment's expected useful life, history of repairs, presence of a stream or river crossing, and number of junctions as a surrogate for condition ratings.

A Probability of Failure (POF) rating predicts the likelihood of an asset to fail. Table C-1 provides a description of the POF score. The score was determined by taking a weighted average of several POF factors that were rated using the same scale. Remaining useful life was the highest weighted factor. As a force main deteriorates, and the remaining useful life decreases, the POF increases. Observations of the deterioration of sewer conduits suggest that deterioration in a new sewer starts slowly and occurs more rapidly as defects accumulate, thus fitting the shape of an exponential curve. The properties of a deterioration curve are unique to each system. However, with little information on the force main conditions in Traverse City to help fit the curve, a general exponential relationship was assumed by an experienced facilities design engineer. This relationship is characterized in Table C-2 and Figure C-1. As additional information on how the system is aging becomes available this curve should be updated. The history of repairs, presence of a stream crossing, and the number of additional junctions at the end of a force main segment are also assigned a 1 to 5 rating and are factored in the POF. A description of their individual ratings is provided in Table C-C-3 in Appendix C-C and rational for each item is further explained in the criticality document in Appendix C-D.

Table C-1: Probability of Failure Descriptions

Score	Description
1	Improbable
2	Remote, unlikely but possible
3	Possible
4	Probable, likely
5	Imminent, likely in near future

Table C-2: Probability of Failure Rating Compared to Force Main Remaining Useful Life

Remaining Useful Life	Probability of Failure
14%	4.0
22%	3.5
32%	3.0
43%	2.5
57%	2.0
75%	1.5
100%	1.0

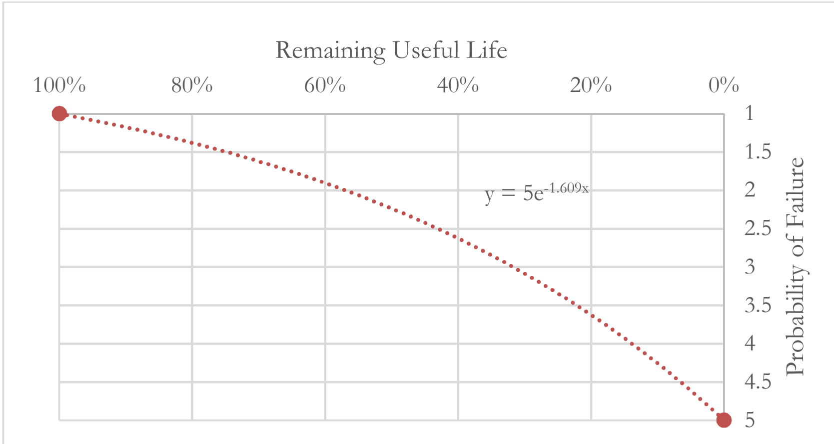


Figure C-1: Probability of Failure for Force Mains

The Consequence of Failure (COF) rating describes the effect of an individual asset's failure on system operations. This value corresponds to the descriptions in Table C-3. COF was determined by taking the weighted average of the following COF factors: the associated pump station capacity, roadway traffic ratings, proximity to surface water, railroad crossings, proximity to groundwater wells, presence of redundant force mains, presence of historical districts, and the number of residential or commercial properties along the force main segment. Each factor was assigned a 1 to 5 value with the higher values being used in conditions where failure of the force main would have a more catastrophic result. Table C-C-2 in Appendix C-C includes a breakdown of each factor, it's weighting, and how it is rated. Additional details for each factor are presented in the criticality methodology document in Appendix C-D.

Table C-3: Consequence of Failure

Score	Effect
1	Negligible, minor loss of function
2	Minimal or marginal disruption of operations
3	Noticeable, may suspend some operations
4	Critical, temporarily suspends operations
5	Catastrophic disruption

Traverse City expressed a desire for the POF to have greater significance than the COF when determining criticality. For this reason, a weighted average was calculated for the two factors with POF worth two-thirds of the average and COF worth the remaining one-third. The resulting average was squared to create the correct scale for the Business Risk Exposure (BRE) score. The BRE is used to determine the criticality of an asset to system operation and is helpful for prioritizing limited funding. BRE ranges from 1-25. Generally, assets with a BRE less than 8 are considered non-critical and greater than 16 are considered critical. Assets with higher BRE scores are more likely to need immediate attention. Assets with a lower BRE have longer remaining useful lives or a smaller consequence of failure, but still need to be maintained.

C. Force Main Assessment

Traverse City's force mains appear to be functioning as intended. Only five breaks have been recorded in the past 16 years. One of these breaks was a result of damage during construction while the remaining four were shear breaks. No single force main has had more than two recorded breaks.

Approximately 2.7 miles of force main has exceeded its material's expected useful life. Several of these force mains are more critical to the system and have been noted in Table C-4, along with the reasons for their BRE score. The life expectancy of ductile iron and cast iron force mains is 60-75 years. Some newer materials such as HDPE and PVC will last closer to 100 years. As the force mains continue to age, the risk of breaks and failures increases. It is recommended that force mains which are at or exceeding their maximum life expectancy be replaced as soon as possible to avoid a failure. The cost of force main replacement makes it difficult to replace all the aging force mains at the same time and so a recommended replacement schedule has been provided that spreads these out over the next fifteen years. Segments have been grouped by the upstream pump station and the most critical segments have been incorporated into the proposed 5-year Capital Improvement Plan budget.

Table C-4: High Business Risk Exposure Force Mains

Force Main Pump Station	BRE Explanation	Maximum Segment BRE	Length (feet)
Front Street and connection to WWTP	The 85-year-old cast iron and ductile iron force main has exceeded its expected life. There are no redundant force mains between the pump station and its connection to the WWTP. It is connected to a high capacity pump station and is located near some higher traffic roads and close to the Boardman River.	16.8	3,109
Coast Guard	Some 73-year-old ductile iron and cast iron segments between the Coast Guard Pump Station and Woodmere have exceeded their expected life. There have been two repairs, these segments are near a high traffic road, and they cross a railroad.	14.3	7,316
Birchwood	The 60-year-old cast iron force main is at the end of its expected life. It is connected to a decent capacity pump station, there is no redundant force main, and it is near multiple residential properties.	13.6	2,583
WWTP	The force mains that connect individual pump station force mains to the WWTP appear to be 85 years old and past or near their expected life depending on material. These force mains handle several pump stations and are higher capacity, have a few segments with no redundancy, and have many junctions.	13.2	134
Bay	This 85-year-old cast iron force main has exceeded its expected life. There is no redundancy, and it is near surface water and multiple commercial and residential properties.	13.1	1,126

D. Annual Capital Reserves and Capital Improvement Plan

This analysis provides an overview of the cost projections to manage Traverse City's force mains. The useful life of a force main is typically greater than 50 years. Capital assets with useful lives greater than 20 years are not funded annually by a replacement fund. The capital costs are substantial and should have some additional funding sources which may include bonds or other established accounts. Cost estimates are based on 2016 dollars. These values do not account for inflation.

Current technologies provide trenchless restoration options for force mains as an alternative to direct replacement. Costs for using one of these restoration options, a cured-in-place pipe (CIPP) lining system, were compared to the costs for a complete replacement. The cost comparison showed that for some of the smaller diameter force mains CIPP could provide a cheaper option, but for 10-inch diameter and greater the savings were no longer significant and in some cases more expensive. Based on these cost considerations, all estimated costs for force mains 10-inches in diameter or greater were for the complete replacement of the force main. All smaller diameter force main costs are for CIPP, with the exclusion of 2-inch force mains which are too small for CIPP and must also be replaced.

Table 5 includes capital costs for force mains summed over the next 15 years. The critical force mains from Table C-4 that have exceeded their expected life are spread throughout this period order of their BRE rating. It may also be practical to consider prioritizing force mains that that are no longer appropriately sized. Figure C-2 graphically displays the annual capital cost for these replacements. A detailed list of these assets and any additional ones expected to fail over the next five years is available in Appendix C-D.

Table C-5: Annual Cash Reserves for Replacement and Repair

Force Main Pump Station	Capital Fund														
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Bay	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$180,084	$0
Birchwood	$0	$0	$0	$0	$0	$0	$0	$568,278	$0	$0	$0	$0	$0	$0	$0
Coast Guard	$0	$0	$0	$0	$1,172,593	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Front Street	$0	$607,834	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Front Street – WWTP	$0	$148,531	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
WWTP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$32,051	$0	$0	$0	$0
Grand Total	**$0**	**$756,365**	**$0**	**$0**	**$1,172,593**	**$0**	**$0**	**$568,278**	**$0**	**$0**	**$32,051**	**$0**	**$0**	**$180,084**	**$0**

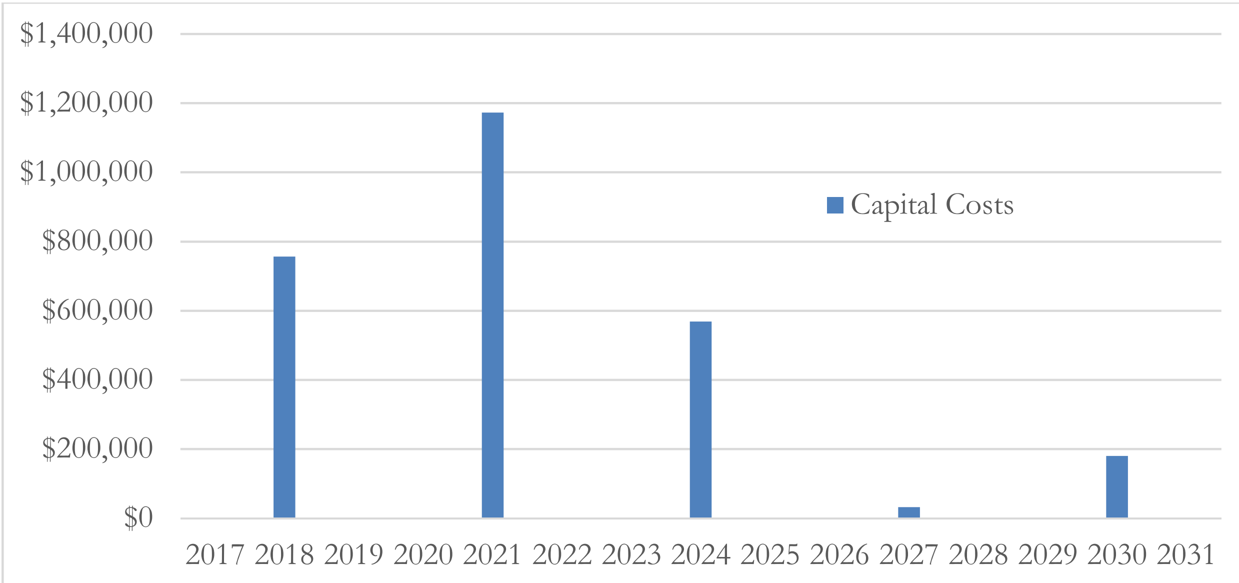


Figure C-2: Funding Necessary over Time at Recommended Replacement Years

In Figure C-3, costs were averaged over time to show typical annual expenses. All costs from the next five years were summed and divided by five to get an expected annual expense over those years. This provides a visualization of expected costs over time. The result is a capital cost of approximately $385,791 annually between 2017 and 2021 for a total of roughly $1,928,957. The following five years (2022-2026) decrease to an annual cost of $113,656 for a five year total of roughly $568,278. The last five years (2027-2031) continue to decrease with an annual cost of $42,427 and a total cost of $212,135.

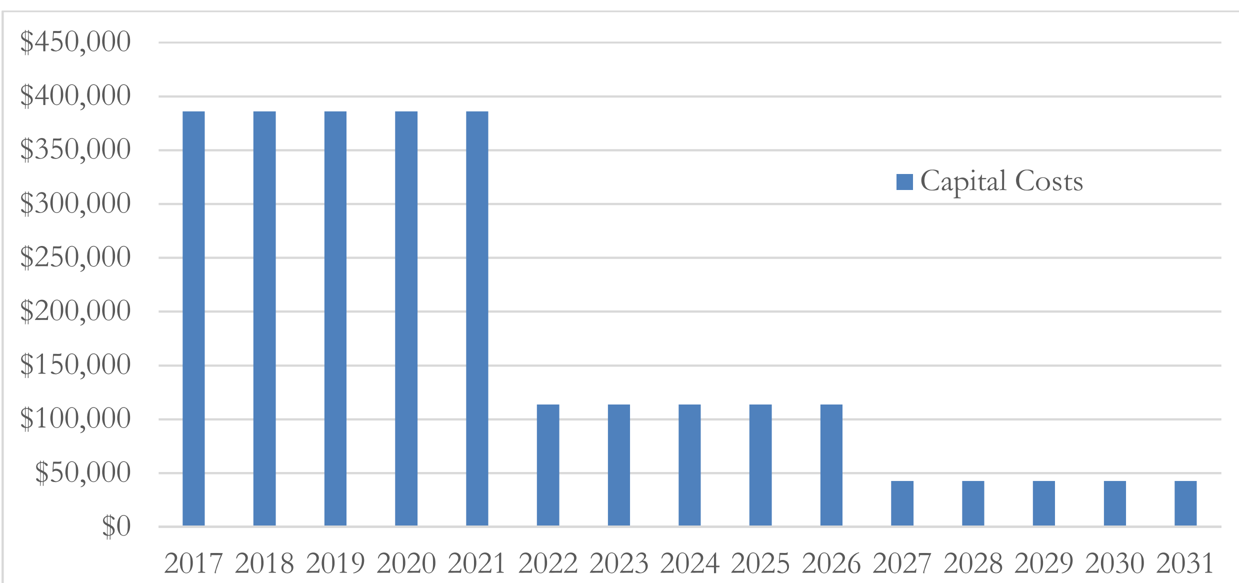


Figure C-3: Funding Spread Out Over Time for Recommended Replacements

E. Recommendations

The information gathered during the inventory and assessment will be compiled into an easily accessible and updatable database. The data presented in this memorandum provide an overview of the cost projections with the understanding that a combination of funding sources will be the best solution to manage Traverse City's force main assets. Future iterations will be documented with final agreed upon plan and funding mechanisms presented to the MDEQ in the rate analysis and Asset Management Plan (AMP).

Future work will include a comprehensive capital improvement plan for the system. A holistic approach to future improvements will incorporate results from assessments of the rest of the conveyance and treatment system.

In any AMP, it is vital to actively assess system components. As force mains age and are replaced, their probability of failure and system criticality change. These changes should be reflected in planning. As repairs and replacements occur it is recommended that the opportunity be taken to perform physical pipe inspections. Condition information from these inspections should be incorporated into an updated AMP.

Appendix C-A – Map of Traverse City's Force Mains

Traverse City

Figure C-A-1. Force Main Locations

Legend

- Lift Station
- Pump Station
- Force Mains Maintained by Others
- Traverse City Owned Force Mains
- Sanitary Gravity Main
- Railroads

0 1,500 3,000
Feet

1" = 1,500'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 HARN StatePlane Michigan North FIPS 2111 Feet Intl

Map Published: June 5, 2017

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Appendix C-B – Original Proposed Assessment Methodology

PROPOSED METHODOLOGY – FM CRITICALITY ANALYSIS

To complete a conditional assessment and establish priorities for force main inspection and maintenance, TRAVERSE CITY proposes to perform a criticality analysis of their force main. A criticality analysis is a form of risk analysis that assigns priorities to individual force main segments for field inspection. Criticality scores are calculated values that use criteria to estimate, i.e., score, the likelihood (i.e. probability) of failure and consequence (i.e. impact) of failure for a given force main segment.

Prior to conducting the criticality analysis, TRAVERSE CITY will subdivide each force main into shorter segments (segmentation). The vertical and horizontal alignment of a force main, the environmental conditions that a force main travels through and the physical characteristics of the force main, are not typically uniform along its entire length. For example, a segment of force main that crosses a creek as a submerged section of pipe (or as an aerial crossing) represents a higher risk (i.e. criticality) condition than a segment of the same force main that travels along a 30-ft dedicated sewer utility easement. The primary purpose of segmentation is to disaggregate a force main into smaller, more discrete segments that can be scored differently to better reflect the different risk potential along the entire force main alignment.

TRAVERSE CITY will segment the force main system into multiple segments, and each segment will be assigned a unique asset ID number for use with TRAVERSE CITY's GIS system. The criteria used to perform the segmentation process are as follows:

1) Changes in force main diameter
2) Changes in force main material
3) Locations of force main junction points (e.g. tee fittings)
4) Intersections with mainline valves
5) 2,500 linear feet or less per segment

Weighting Factors

Recognizing that each criterion is not of equal importance in determining criticality, weighting factors are used to prioritize the degree of importance. A higher weighting factor indicates that the criterion is of greater importance in the decision-making process. For both likelihood of failure and consequence of failure criteria, weighting factors will be applied to the raw scores to arrive at a weighted score for each criterion.

TRAVERSE CITY expressed a desire to place more importance on likelihood of failure criteria. For the initial criticality analysis, therefore, likelihood of failure scores will be weighted with a factor ranging from 5 to 10, and consequence of failure scores will be weighted with a factor ranging from 1 to 6. By applying greater overall weighting to likelihood of failure criteria, the criticality analysis resulted in a prioritization that places a greater emphasis on identifying force main segments with a higher likelihood, or probability, of failure. While consequence of failure is also recognized as important, the objective of this approach is to identify the force main segments that represent the highest likelihood of failure so that corrective action can be implemented prior to a failure event occurring.

Likelihood of Failure Criteria

Likelihood of failure scores are intended to represent the probability that a force main will fail based on the environmental conditions of where the force main is located and the physical characteristics of the force main. Likelihood of failure criteria typically include age, material of construction, soil type where the force main is buried, flow and pressure on the force main, work order history for the force main, and actual pipe condition (as observed and recorded through field inspections). Following is a brief description of the likelihood of failure criteria used by TRAVERSE CITY for the criticality analysis.

Pipe Material: Pipe material is a critical factor in determining the most typical failure modes for a given force main segment. Most ferrous and cement-based force main failures are attributed to corrosion (internal or external), and most PVC and other plastic pipe force main failures are attributed to improper installation.

Age of Material: All pipe materials age and deteriorate over time due to abrasive, structural and mechanical forces, and corrosive agents. All pipelines, therefore, have a finite useful service life, but that service life is extremely difficult to predict because of the multitude of variables impacting it. 50 years is generally accepted as a reasonable design service life for a pressure pipeline.

Stream/river Crossings: Force main segments that cross streams or rivers represent a special concern for TRAVERSE CITY given the potential for accelerated rates of corrosion in the coastal environment and a history of failures at such locations. Deterioration of these pipe segments can be severe for ferrous and cement-based pipe materials, especially those segments that are exposed to such conditions over an extended period of time.

Number of Force Main Junctions (Taps): For the purposes of this analysis, a force main tap was defined as the location at which one force main is connected or joined to another force main by means of a structural or mechanical modification to the receiving force main segment. The location of the structural or mechanical modification is assumed to be a potential point of failure. Each segment may have 0, 1 or 2 taps associated with it. This criterion was scored based on the number of taps present on a force main segment.

Consequence of Failure Criteria

Consequence of failure scores are intended to represent the degree of impact of a force main failure on the service area located in close proximity to the force main. Consequence of failure criteria typically consider direct impacts, such as loss of service and cost for repair and cleanup, health and environmental impacts, such as public health risks and environmental resource impacts, and socioeconomic impacts, such as transportation and business disruptions (Thomson). Following is a brief description of the consequence of failure criteria used by TRAVERSE CITY for the criticality analysis.

Quantity of Flow: This criterion is based on the potential quantity of flow discharged to the environment as a result of a force main segment failure. Average daily flow rates for each pumping station in the system was provided by TRAVERSE CITY and incorporated into the criticality analysis.

Surface Waters: This criterion is based on potential impacts to surface waters as a result of a force main segment failure. Force main segments located in closest proximity to surface waters were scored higher (greater consequence of failure) than force main segments located farthest from surface waters.

Groundwater Wells: This criterion is based on the potential impacts to public and private groundwater wells in the event of a force main segment failure. Force main segments located in closest proximity to groundwater wells are scored higher (greater consequence of failure) than force main segments located farthest from groundwater wells.

High Quality Water and Outstanding Resource Water (HQW-ORW) Management Zones: This criterion is based on the potential impacts to high quality waters or outstanding resource waters as a result of a force main segment failure. Force main segments located in closest proximity to high quality waters or outstanding resource waters were scored higher (greater consequence of failure) than force main segments located farthest from high quality waters or outstanding resource waters.

TRANSPORTATION SYSTEMS: This criterion is based on the potential impacts to transportation systems in the event of a force main segment failure. This criterion was scored based on the number and type of transportation systems crossed by a force main segment.

PRESENCE OR ABSENCE OF REDUNDANT FORCE MAIN: This criterion is based on the presence or absence of a redundant force main in the event of a force main segment failure. Force main segments without a redundant force main were scored higher than force segments with a redundant force main.

CULTURAL RESOURCE IMPACTS: This criterion is based on the potential impacts to cultural resources in the event of a force main segment failure. Force main segments that crossed historic districts were scored higher than force main segments that did not cross historic districts.

RESIDENTIAL IMPACTS: This criterion is based on the potential impacts to residents in the event of a force main segment failure. This criterion was scored based on the estimated number of residential parcels located within an anticipated construction repair corridor for each force main segment.

COMMERCIAL IMPACTS: This criterion is based on the potential impacts to commerce in the event of a force main segment failure. This criterion was scored based on the estimated number of commercial parcels located within an anticipated construction repair corridor for each force main segment.

The above Forcemain Condition Assessment methods were modified from the original Abstract Paper identified below:

CRITICALITY ANALYSIS AND INSPECTION METHODS FOR FORCE MAIN CONDITION ASSESSMENT

Authors: Ray Cox [1], Kelly Derr [2], Jim Perotti [2], Clayton Glatt [2] ***(1 – Highfill Infrastructure Engineering, 2 – Brown & Caldwell)***

REFERENCES: Thomson, James C., et al. *Inspection Guidelines for Wastewater Force Mains*. Water Environment Research Foundation (WERF). IWA Publishing: London, UK, 2010. WERF Publication 04-CTS- 6URa.

Appendix C-C – Assessment and Inventory

Legend for Table C-C-1 by Column Number Heading:

1: Unique Asset ID
2: Associated Pump Station
3: Force Main Material Type
4: Force Main Diameter (Inches)
5: Force Main Segment Length (Feet)
6: Installation Year
7: Expected Asset Life (Years): Based on typical material life
8: Remaining Life Based on Installation Date (Years):
    [8] = [7] – (Evaluation Year – [6])
9: Percent Remaining Useful Life
    [9] = ([8] / [7]) * 100
10: Consequence of Failure: Assigned based on the criticality factors in Table B-2
11: Probability of Failure: Assigned based on the criticality factors in Table B-3
12: Business Risk Exposure
    $[12] = ((1/3)*[10] + (2/3)*[11])^2$
13: Replacement Year
    [13] = Current Evaluation Year + [8]
14: 2016 Replacement Cost: Assigned based on the judgement of experienced engineer
15: 2016 Value Assuming Linear Depreciation: Assumes depreciation based on asset's total predicted life [15] = [9] * [14]
16: CIPP vs Replacement: Shows whether replacement cost is based on a full replacement of the force main or CIPP.

Appendix C-C, Table C-C-1 Force Main Inventory and Assessment

Evaluation Year: 2016

								Risk Weighting:	33.3%	66.7%					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Asset ID	**Associated Pump Station**	**Material**	**Diameter (Inches)**	**Length (Feet)**	**Installation Year**	**Expected Asset Life (Years)**	**Remaining Life Based on Install Date (Years)**	**Percent Remaining Useful Life**	**Consequence of Failure (1-5)**	**Probability of Failure (1-5)**	**Business Risk Exposure (1-25)**	**Replacement Year**	**2016 Replacement Cost**	**2016 Value Assuming Linear Depreciation**	**CIPP vs Replacement**
SSFM-32	Riverine	PVC	12	681	1982	90	56	62%	3.2	1.8	5.1	2072	$136,106	$84,688	Replacement
SSFM-153	Riverine	PVC	12	9	1982	90	56	62%	2.9	1.8	4.6	2072	$1,798	$1,119	Replacement
SSFM-10	Bay	CI	8	1126	1931	60	-25	0%	2.9	4.0	13.1	1991	$180,084	$0	CIPP
SSFM-148	Front Street	CI	16	973	1931	60	-25	0%	4.2	4.0	16.4	1991	$233,558	$0	Replacement
SSFM-150	Front Street	CI	16	1559	1931	60	-25	0%	4.0	4.2	16.8	1991	$374,275	$0	Replacement
SSFM-251	Front Street - WWTP	CI	16	3	**1931**	60	-25	0%	3.5	4.2	15.6	1991	$695	$0	Replacement
SSFM-252	Front Street - WWTP	DI	16	2	**1931**	70	-15	0%	3.5	4.2	15.6	2001	$480	$0	Replacement
SSFM-282	Front Street - WWTP	DI	**18**	57	**1931**	70	-15	0%	2.7	4.0	12.7	2001	$14,315	$0	Replacement
SSFM-261	Front Street - WWTP	DI	18	195	**1931**	70	-15	0%	2.9	4.0	13.2	2001	$48,750	$0	Replacement
SSFM-250	Front Street - WWTP	CI	16	16	**1931**	60	-25	0%	2.9	4.2	14.0	1991	$3,885	$0	Replacement
SSFM-281	Front Street - WWTP	DI	**24**	41	**1931**	70	-15	0%	2.7	4.0	12.7	2001	$11,470	$0	Replacement
SSFM-259	Front Street - WWTP	DI	24	150	**1931**	70	-15	0%	2.8	4.0	13.0	2001	$41,941	$0	Replacement
SSFM-280	Front Street - WWTP	DI	**16**	112	**1931**	70	-15	0%	2.8	4.2	13.8	2001	$26,996	$0	Replacement
SSFM-289	Hull	PVC	4	47	**2001**	90	75	83%	1.9	1.2	2.1	2091	$3,723	$3,102	CIPP
SSFM-291	Hull	PVC	4	50	**2001**	90	75	83%	1.9	1.2	2.1	2091	$4,000	$3,333	CIPP
SSFM-287	Hull	HDPE	2	222	**2001**	100	85	85%	1.8	1.2	2.0	2101	$5,319	$4,522	Replacement
SSFM-286	Hull	PVC	2	2	**2001**	90	75	83%	1.6	1.4	2.1	2091	$48	$40	Replacement
SSFM-202	Woodmere	DI	6	12	**1992**	70	46	66%	1.8	1.6	2.7	2062	$1,408	$925	CIPP
SSFM-189	Woodmere	DI	6	34	**1992**	70	46	66%	1.8	1.6	2.7	2062	$4,028	$2,647	CIPP
SSFM-188	Woodmere	DI	6	42	**1992**	70	46	66%	1.8	1.6	2.7	2062	$5,028	$3,304	CIPP
SSFM-203	Woodmere	DI	6	12	**1992**	70	46	66%	1.8	1.6	2.7	2062	$1,416	$931	CIPP
SSFM-182	Woodmere	PVC	**6**	1	**1992**	90	66	73%	1.8	1.6	2.7	2082	$120	$88	CIPP
SSFM-185	Woodmere	PVC	**6**	2	**1992**	90	66	73%	1.8	1.6	2.7	2082	$180	$132	CIPP
SSFM-179	Woodmere	DI	6	4	**1992**	70	46	66%	2.4	1.6	3.4	2062	$420	$276	CIPP
SSFM-180	Woodmere	DI	6	4	**1992**	70	46	66%	2.4	1.6	3.4	2062	$420	$276	CIPP
SSFM-181	Woodmere	DI	6	4	**1992**	70	46	66%	2.4	1.7	3.8	2062	$420	$276	CIPP
SSFM-171	Woodmere	DI	8	14	**1992**	70	46	66%	2.4	1.6	3.4	2062	$2,240	$1,472	CIPP
SSFM-169	Woodmere	DI	8	2	1992	70	46	66%	2.4	1.7	3.8	2062	$320	$210	CIPP
SSFM-167	Woodmere	**CI**	8	4	**1992**	60	36	60%	1.6	1.8	3.1	2052	$640	$384	CIPP
SSFM-176	Woodmere	CI	8	3	**1992**	60	36	60%	1.6	1.7	2.7	2052	$400	$240	CIPP
SSFM-166	Woodmere	**CI**	8	18	**1992**	60	36	60%	2.6	2.0	4.9	2052	$2,880	$1,728	CIPP
SSFM-192	Woodmere	DI	14	669	**1992**	70	46	66%	2.7	1.9	4.6	2062	$147,100	$96,666	Replacement
SSFM-231	Woodmere	CI	10	372	1992	60	36	60%	2.4	1.8	4.1	2052	$67,775	$40,665	Replacement
SSFM-18	Woodmere	CI	10	655	1992	60	36	60%	2.4	1.7	3.7	2052	$119,208	$71,525	Replacement
SSFM-4	Woodmere+Coast Guard + Hull	PVC	**16**	341	**1992**	90	66	73%	2.9	1.7	4.5	2082	$81,840	$60,016	Replacement
SSFM-284	Woodmere+Coast Guard + Hull	DI	**16**	96	**1992**	70	46	66%	2.3	1.6	3.2	2062	$23,016	$15,125	Replacement
SSFM-276	Woodmere+Coast Guard + Hull	DI	16	21	**1992**	70	46	66%	2.3	1.7	3.7	2062	$5,016	$3,296	Replacement
SSFM-277	Woodmere+Coast Guard + Hull	DI	16	24	**1992**	70	46	66%	2.3	1.6	3.2	2062	$5,664	$3,722	Replacement
SSFM-295	Coast Guard	DI	8	58	1996	70	50	71%	2.4	1.4	3.1	2066	$9,280	$6,629	CIPP
SSFM-24	Coast Guard	CI	8	4090	1943	60	-13	0%	2.9	4.0	13.1	2003	$654,369	$0	CIPP
SSFM-23	Coast Guard	**CI**	8	3175	1943	60	-13	0%	3.0	4.2	14.3	2003	$507,956	$0	CIPP
SSFM-198	Coast Guard	DI	12	51	**1943**	70	-3	0%	2.7	4.0	12.6	2013	$10,267	$0	Replacement
SSFM-196	Coast Guard	DI	12	499	1996	70	50	71%	3.2	1.6	4.5	2066	$99,824	$71,303	Replacement
SSFM-199	Coast Guard	DI	12	2	1996	70	50	71%	2.6	1.6	3.8	2066	$374	$267	Replacement
SSFM-207	Coast Guard	DI	12	5	1996	70	50	71%	2.8	1.4	3.5	2066	$980	$700	Replacement

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Asset ID	Associated Pump Station	Material	Diameter (Inches)	Length (Feet)	Installation Year	Expected Asset Life (Years)	Remaining Life Based on Install Date (Years)	Percent Remaining Useful Life	Consequence of Failure (1-5)	Probability of Failure (1-5)	Business Risk Exposure (1-25)	Replacement Year	2016 Replacement Cost	2016 Value Assuming Linear Depreciation	CIPP vs Replacement
SSFM-208	Coast Guard	DI	12	5	1996	70	50	71%	2.8	1.4	3.5	2066	$980	$700	Replacement
SSFM-211	Coast Guard	DI	12	471	1996	70	50	71%	2.8	1.4	3.5	2066	$94,135	$67,239	Replacement
SSFM-214	Coast Guard	DI	12	5	1996	70	50	71%	2.5	1.4	3.2	2066	$980	$700	Replacement
SSFM-215	Coast Guard	DI	12	5	1996	70	50	71%	2.5	1.4	3.2	2066	$1,000	$714	Replacement
SSFM-216	Coast Guard	DI	12	517	1996	70	50	71%	2.5	1.6	3.6	2066	$103,331	$73,808	Replacement
SSFM-220	Coast Guard+Hull	DI	12	4	1996	70	50	71%	2.8	1.4	3.6	2066	$800	$571	Replacement
SSFM-218	Coast Guard+Hull	PVC	**12**	1	1996	90	70	78%	2.8	1.5	3.7	2086	$200	$156	Replacement
SSFM-151	TBA	AC	12	16	1970	80	34	43%	3.2	2.1	6.2	2050	$3,300	$1,402	Replacement
SSFM-28	TBA	AC	12	4834	1970	80	34	43%	2.9	2.2	6.0	2050	$966,889	$410,928	Replacement
SSFM-154	Birchwood	CI	14	26	**1956**	60	0	0%	2.9	4.0	13.2	2016	$5,720	$0	Replacement
SSFM-30	Birchwood	CI	14	2557	1956	60	0	0%	3.1	4.0	13.6	2016	$562,558	$0	Replacement
SSFM-122	Clinch Park	DI	4	1	2002	70	56	80%	1.9	1.5	2.6	2072	$81	$65	CIPP
SSFM-123	Clinch Park	DI	4	1	2002	70	56	80%	1.9	1.3	2.2	2072	$79	$63	CIPP
SSFM-124	Clinch Park	DI	4	3	2002	70	56	80%	1.9	1.3	2.2	2072	$222	$177	CIPP
SSFM-127	Clinch Park	DI	4	2	2002	70	56	80%	1.9	1.5	2.6	2072	$132	$106	CIPP
SSFM-125	Clinch Park	DI	4	1	2002	70	56	80%	1.9	1.5	2.6	2072	$78	$63	CIPP
SSFM-126	Clinch Park	DI	4	3	2002	70	56	80%	1.9	1.3	2.2	2072	$220	$176	CIPP
SSFM-128	Clinch Park	DI	4	2	2002	70	56	80%	1.9	1.5	2.6	2072	$164	$131	CIPP
SSFM-129	Clinch Park	DI	4	1	2002	70	56	80%	1.9	1.5	2.6	2072	$60	$48	CIPP
SSFM-130	Clinch Park	DI	4	1	2002	70	56	80%	1.9	1.5	2.6	2072	$108	$86	CIPP
SSFM-120	Clinch Park	DI	4	7	2002	70	56	80%	1.8	1.6	2.8	2072	$592	$474	CIPP
SSFM-121	Clinch Park	PVC	**4**	7	2002	90	76	84%	1.8	1.4	2.3	2092	$522	$441	CIPP
SSFM-119	Clinch Park	DI	4	3	2002	70	56	80%	1.8	1.5	2.5	2072	$200	$160	CIPP
SSFM-118	Clinch Park	PVC	**4**	171	2002	90	76	84%	2.4	1.2	2.6	2092	$13,707	$11,575	CIPP
SSFM-117	Clinch Park	DI	4	149	2002	70	56	80%	2.5	1.3	2.9	2072	$11,930	$9,544	CIPP
SSFM-131	Clinch Park Area	PVC	2	42	2002	90	76	84%	2.2	1.4	2.7	2092	$1,004	$848	Replacement
SSFM-132	Clinch Park Area	PVC	2	19	2002	90	76	84%	2.2	1.5	3.1	2092	$458	$387	Replacement
SSFM-155	Coast Guard-Woodmere Bypass	**DI**	10	69	**1992**	70	46	66%	2.6	1.6	3.6	2062	$12,573	$8,262	Replacement
SSFM-161	Coast Guard-Woodmere Bypass	**CI**	6	5	**1992**	60	36	60%	2.0	1.8	3.6	2052	$599	$359	CIPP
SSFM-162	Coast Guard-Woodmere Bypass	**CI**	6	8	**1992**	60	36	60%	2.0	1.7	3.2	2052	$953	$572	CIPP
SSFM-163	Coast Guard-Woodmere Bypass	**CI**	6	3	**1992**	60	36	60%	2.0	1.8	3.6	2052	$359	$215	CIPP
SSFM-156	Coast Guard-Woodmere Bypass	CI	10	3	**1992**	60	36	60%	2.0	1.7	3.2	2052	$546	$328	Replacement
SSFM-157	Coast Guard-Woodmere Bypass	CI	10	3	**1992**	60	36	60%	2.0	1.7	3.2	2052	$546	$328	Replacement
SSFM-158	Coast Guard-Woodmere Bypass	**CI**	10	2	**1992**	60	36	60%	2.0	1.8	3.6	2052	$364	$218	Replacement
SSFM-160	Coast Guard-Woodmere Bypass	CI	10	2	**1992**	60	36	60%	2.0	1.8	3.6	2052	$364	$218	Replacement
SSFM-164	Coast Guard-Woodmere Bypass	CI	10	9	**1992**	60	36	60%	2.6	1.8	4.4	2052	$1,638	$983	Replacement
SSFM-201	Coast Guard - Cleanout Branch	DI	12	40	1996	70	50	71%	1.8	1.4	2.4	2066	$8,000	$5,714	Replacement
SSFM-200	Coast Guard - Cleanout Branch	DI	**12**	2	1996	70	50	71%	1.8	1.6	2.8	2066	$353	$252	Replacement
SSFM-271	WWTP	DI	16	26	**1931**	70	-15	0%	2.5	4.2	13.0	2001	$6,240	$0	Replacement
SSFM-263	WWTP	PVC	**16**	32	**1931**	90	5	6%	2.9	3.8	12.5	2021	$7,680	$427	Replacement
SSFM-283	WWTP	DI	**16**	44	**1931**	70	-15	0%	2.9	4.0	13.2	2001	$10,451	$0	Replacement
SSFM-270	WWTP	PVC	**16**	27	**1931**	90	5	6%	2.3	3.8	11.1	2021	$6,480	$360	Replacement
SSFM-273	WWTP	PVC	**16**	5	**1931**	90	5	6%	2.3	3.8	11.1	2021	$1,200	$67	Replacement

*Items in bold were unknown and assumed based on available information.

Legend for Table C-C-2 by Column Number Heading:

1: Unique Asset ID
2: Associated Pump Station
3: Force Main Diameter (Inches)
4: Force Main Segment Length (Feet)
5: Pump Station Firm Capacity (gpm): Upstream pump station capacity
6: Road ADT Value: Highest annual average daily traffic count for the streets that the force main segment travels under
7: Railroad Crossings: Labeled N if no crossings occurred and Y if a force main crossed under a railroad.
8: Distance to Closest High Quality Surface Water (feet): Surface waters around Traverse City include the Boardman River, Boardman Lake, and Grand Traverse Bay.
9: Distance to Closest Drinking Water Well (feet): Determined using DEQ Wellogic information
10. Redundant Force Main: Y if a flows can be routed around this segment using another force main, N if no bypass force main is present.
11. Crosses Historic District: Y if the force main travels through a historic district, N if not
12. Number of Residential Parcels: Number of residential parcels within the anticipated construction repair zone for the force main
13. Number of Commercial Parcels: Number of commercial parcels within the anticipated construction repair zone for the force main
14: Quantity of Flow Rating (1-5): Assigned a rating based on [5] and below table

Rating Scale	Pump Station Capacity Description
5	GPM>=1,500
4	500<=GPM<1,500
3	250<=GPM<500
2	100<=GPM<250
1	GPM<100

15: High Quality Surface Water Rating (1-5): Assigned a rating based on [8] and below table

Rating Scale	Surface Water Description
5	0-50 feet from surface water
4	51-100 feet from surface water
3	101- 200 feet from surface water
2	201- 300 feet from surface water
1	Over 300 feet from surface water

16: Groundwater Wells Rating (1-5): Assigned a rating based on [9] and below table

Rating Scale	Groundwater Wells Descriptions
5	0-100 feet from well
4	101-200 feet from well
3	201-500 feet from well
2	501-1,000 feet from well
1	Greater than 1,000 feet from well

17: Transportation Systems Rating (1-5): Assigned a rating based on [6], [7], and below table

Rating Scale	Transportation Description
5	Railroad Crossed
4	ADT >= 15,000
3	5,000 <= ADT < 15,000
2	0 < ADT < 5,000
1	Unrated/Pervious Surface

18: Redundant Force Main Rating (1-5): Assigned a rating based on [10] and below table

Rating Scale	Redundant Force Main Description
5	No redundant force main
1	Redundant force main present

19: Cultural Impact Rating (1-5): Assigned a rating based on [11] and below table

Rating Scale	Cultural Impact Description
5	Within historic district
1	Not within historic district

20: Residential Impact Rating (1-5): Assigned a rating based on [12] and below table

Rating Scale	Residential Impact Description
5	Over 20 Parcels
4	11-20 Parcels
3	4-10 Parcels
2	1-3 Parcels
1	0 Parcels

21: Commercial Impact Rating (1-5): Assigned a rating based on [13] and below table

Rating Scale	Commercial Impact Description
5	Over 10 Parcels
4	6-10 Parcels
3	3-5 Parcels
2	1-2 Parcels
1	0 Parcels

22: Consequence of Failure: Weighted average of columns [14]-[21]

Appendix C-C, Table C-C-2 Force Main Criticality Factors

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
												COF Factor Weights:	40.0%	10.0%	10.0%	10.0%	15.0%	5.0%	5.0%	5.0%	100.0%
Asset ID	Associated Pump Station	Diameter (Inches)	Length (Feet)	Pump Station Firm Capacity (gpm)	Road ADT Value	Railroad Crossing (Y or N)	Closest High Quality Surface Water (feet)	Distance to Closest Drinking Water Well (feet)	Redundent Force Main (Y or N)	Crosses Historic Districts (Y or N)	Number of Residential Parcels	Number of Commercial Parcels	Quantity of Flow Rating (1-5)	High Quality Surface Water Rating (1-5)	Groundwater Wells Rating (1-5)	Transportation Systems Rating (1-5)	Redundant Force Main Rating (1-5)	Cultural Impact Rating (1-5)	Residential Impact Rating (1-5)	Commercial Impact Rating (1-5)	Consequence of Failure (1-5)
SSFM-32	Riverine	12	681	350	24054	N	130	379	N	N	2	2	3	3	3	4	5	1	2	2	3.2
SSFM-153	Riverine	12	9	350	0	N	120	370	N	N	0	1	3	3	3	1	5	1	1	2	2.9
SSFM-10	Bay	8	1126	430	928	N	155	3000	N	N	5	1	3	3	1	2	5	1	3	2	2.9
SSFM-148	Front Street	16	973	3600	24054	N	30	741	N	N	1	4	5	5	2	4	5	1	2	3	4.2
SSFM-150	Front Street	16	1559	3600	7868	Y	231	580	N	N	1	4	5	2	2	5	5	1	2	3	4.0
SSFM-251	Front Street - WWTP	16	3	3600	0	N	195	780	N	N	0	0	5	3	2	1	5	1	1	1	3.5
SSFM-252	Front Street - WWTP	16	2	3600	0	N	195	780	N	N	0	0	5	3	2	1	5	1	1	1	3.5
SSFM-282	Front Street - WWTP	**18**	57	3600	0	N	325	875	Y	N	0	0	5	1	2	1	1	1	1	1	2.7
SSFM-261	Front Street - WWTP	18	195	3600	0	N	195	775	Y	N	0	0	5	3	2	1	1	1	1	1	2.9
SSFM-250	Front Street - WWTP	16	16	3600	0	N	195	780	Y	N	0	0	5	3	2	1	1	1	1	1	2.9
SSFM-281	WWTP	**24**	41	3600	0	N	325	875	Y	N	0	0	5	1	2	1	1	1	1	1	2.7
SSFM-259	Front Street - WWTP	24	150	3600	0	N	213	790	Y	N	0	0	5	2	2	1	1	1	1	1	2.8
SSFM-280	Front Street - WWTP	**16**	112	3600	0	N	213	785	Y	N	0	0	5	2	2	1	1	1	1	1	2.8
SSFM-289	Hull	4	47	**30**	0	N	65	1450	N	N	0	0	1	4	1	1	5	1	1	1	1.9
SSFM-291	Hull	4	50	**30**	0	N	55	1450	N	N	0	0	1	4	1	1	5	1	1	1	1.9
SSFM-287	Hull	2	222	60	0	N	105	1350	N	N	0	0	1	3	1	1	5	1	1	1	1.8
SSFM-286	Hull	2	2	60	0	N	320	1350	N	N	0	0	1	1	1	1	5	1	1	1	1.6
SSFM-202	Woodmere	6	12	450	0	N	370	2545	Y	N	0	0	3	1	1	1	1	1	1	1	1.8
SSFM-189	Woodmere	6	34	450	0	N	418	2583	Y	N	0	0	3	1	1	1	1	1	1	1	1.8
SSFM-188	Woodmere	6	42	450	0	N	350	2535	Y	N	0	0	3	1	1	1	1	1	1	1	1.8
SSFM-203	Woodmere	6	12	450	0	N	370	2545	Y	N	0	0	3	1	1	1	1	1	1	1	1.8
SSFM-182	Woodmere	**6**	1	450	0	N	370	2535	Y	N	0	0	3	1	1	1	1	1	1	1	1.8
SSFM-185	Woodmere	**6**	2	450	0	N	350	2535	Y	N	0	0	3	1	1	1	1	1	1	1	1.8
SSFM-179	Woodmere	6	4	450	0	N	340	2540	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-180	Woodmere	6	4	450	0	N	340	2540	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-181	Woodmere	6	4	450	0	N	340	2540	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-171	Woodmere	8	14	450	0	N	340	2530	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-169	Woodmere	8	2	450	0	N	340	2530	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-167	Woodmere	8	4	0	0	N	340	2530	N	N	0	0	1	1	1	1	5	1	1	1	1.6
SSFM-176	Woodmere	8	3	0	0	N	340	2530	N	N	0	0	1	1	1	1	5	1	1	1	1.6
SSFM-166	Woodmere	8	18	450	13247	N	330	2510	N	N	0	0	3	1	1	3	5	1	1	1	2.6
SSFM-192	Woodmere	14	669	450	13247	N	330	2225	N	N	0	1	3	1	1	3	5	1	1	2	2.7
SSFM-231	Woodmere	10	372	450	0	N	380	1230	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-18	Woodmere	10	655	450	0	N	441	1589	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-4	Woodmere+Coast Guard + Hull	**16**	341	975	0	N	350	950	N	N	0	0	4	1	2	1	5	1	1	1	2.9
SSFM-284	Woodmere+Coast Guard + Hull	**16**	96	975	0	N	315	875	Y	N	0	0	4	1	2	1	1	1	1	1	2.3
SSFM-276	Woodmere+Coast Guard + Hull	16	21	975	0	N	370	935	Y	N	0	0	4	1	2	1	1	1	1	1	2.3
SSFM-277	Woodmere+Coast Guard + Hull	16	24	975	0	N	345	970	Y	N	0	0	4	1	2	1	1	1	1	1	2.3
SSFM-295	Coast Guard	8	58	465	0	N	3000	1420	N	N	0	0	3	1	1	1	5	1	1	1	2.4
SSFM-24	Coast Guard	8	4090	465	11967	Y	2840	1445	N	N	2	0	3	1	1	5	5	1	2	1	2.9
SSFM-23	Coast Guard	8	3175	465	26039	N	330	2590	N	N	25	5	3	1	1	4	5	1	5	3	3.0

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Asset ID	**Associated Pump Station**	**Diameter (Inches)**	**Length (Feet)**	**Pump Station Firm Capacity (gpm)**	**Road ADT Value**	**Railroad Crossing (Y or N)**	**Closest High Quality Surface Water (feet)**	**Distance to Closest Drinking Water Well (feet)**	**Redundent Force Main (Y or N)**	**Crosses Historic Districts (Y or N)**	**Number of Residential Parcels**	**Number of Commercial Parcels**	**Quantity of Flow Rating (1-5)**	**High Quality Surface Water Rating (1-5)**	**Groundwater Wells Rating (1-5)**	**Transportation Systems Rating (1-5)**	**Redundant Force Main Rating (1-5)**	**Cultural Impact Rating (1-5)**	**Residential Impact Rating (1-5)**	**Commercial Impact Rating (1-5)**	**Consequence of Failure (1-5)**
SSFM-198	Coast Guard	12	51	465	13247	N	325	2555	N	N	0	1	3	1	1	3	5	1	1	2	2.7
SSFM-196	Coast Guard	12	499	465	13247	Y	75	2135	N	N	0	2	3	4	1	5	5	1	1	2	3.2
SSFM-199	Coast Guard	12	2	465	13247	N	303	2566	N	N	0	0	3	1	1	3	5	1	1	1	2.6
SSFM-207	Coast Guard	12	5	465	0	N	75	2140	N	N	0	1	3	4	1	1	5	1	1	2	2.8
SSFM-208	Coast Guard	12	5	465	0	N	75	2135	N	N	0	1	3	4	1	1	5	1	1	2	2.8
SSFM-211	Coast Guard	12	471	465	0	N	75	1730	N	N	0	1	3	4	1	1	5	1	1	2	2.8
SSFM-214	Coast Guard	12	5	465	0	N	265	1735	N	N	0	0	3	2	1	1	5	1	1	1	2.5
SSFM-215	Coast Guard	12	5	465	0	N	265	1730	N	N	0	0	3	2	1	1	5	1	1	1	2.5
SSFM-216	Coast Guard	12	517	465	0	N	265	1235	N	N	0	0	3	2	1	1	5	1	1	1	2.5
SSFM-220	Coast Guard+Hull	12	4	525	0	N	380	1235	N	N	0	0	4	1	1	1	5	1	1	1	2.8
SSFM-218	Coast Guard+Hull	**12**	1	525	0	N	380	1235	N	N	0	0	4	1	1	1	5	1	1	1	2.8
SSFM-151	TBA	12	16	700	0	Y	1825	3960	N	N	0	0	4	1	1	5	5	1	1	1	3.2
SSFM-28	TBA	12	4834	700	3339	N	1825	1420	N	N	0	0	4	1	1	2	5	1	1	1	2.9
SSFM-154	Birchwood	14	26	800	0	N	295	4055	N	N	0	0	4	2	1	1	5	1	1	1	2.9
SSFM-30	Birchwood	14	2557	800	1244	N	310	4000	N	N	19	0	4	1	1	2	5	1	4	1	3.1
SSFM-122	Clinch Park	4	1	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-123	Clinch Park	4	1	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-124	Clinch Park	4	3	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-127	Clinch Park	4	2	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-125	Clinch Park	4	1	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-126	Clinch Park	4	3	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-128	Clinch Park	4	2	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-129	Clinch Park	4	1	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-130	Clinch Park	4	1	175	0	N	90	3110	Y	Y	0	0	2	4	1	1	1	5	1	1	1.9
SSFM-120	Clinch Park	4	7	175	0	N	140	3105	Y	Y	0	0	2	3	1	1	1	5	1	1	1.8
SSFM-121	Clinch Park	**4**	7	175	0	N	140	3105	Y	Y	0	0	2	3	1	1	1	5	1	1	1.8
SSFM-119	Clinch Park	4	3	175	0	N	155	3105	Y	Y	0	0	2	3	1	1	1	5	1	1	1.8
SSFM-118	Clinch Park	**4**	171	175	0	N	155	3105	N	Y	0	0	2	3	1	1	5	5	1	1	2.4
SSFM-117	Clinch Park	4	149	175	6883	N	210	3110	N	Y	0	0	2	2	1	3	5	5	1	1	2.5
SSFM-131	Clinch Park Area	2	42	**15**	0	N	5	3150	N	Y	0	0	1	5	1	1	5	5	1	1	2.2
SSFM-132	Clinch Park Area	2	19	**15**	0	N	0	3170	N	Y	0	0	1	5	1	1	5	5	1	1	2.2
SSFM-155	Coast Guard-Woodmere Bypass	10	69	465	13247	N	325	2515	N	N	0	0	3	1	1	3	5	1	1	1	2.6
SSFM-161	Coast Guard-Woodmere Bypass	6	5	465	13247	N	330	2530	Y	N	0	0	3	1	1	3	1	1	1	1	2.0
SSFM-162	Coast Guard-Woodmere Bypass	6	8	465	13247	N	330	2530	Y	N	0	0	3	1	1	3	1	1	1	1	2.0
SSFM-163	Coast Guard-Woodmere Bypass	6	3	465	13247	N	330	2530	Y	N	0	0	3	1	1	3	1	1	1	1	2.0
SSFM-156	Coast Guard-Woodmere Bypass	10	3	465	13247	N	330	2530	Y	N	0	0	3	1	1	3	1	1	1	1	2.0
SSFM-157	Coast Guard-Woodmere Bypass	10	3	465	13247	N	330	2530	Y	N	0	0	3	1	1	3	1	1	1	1	2.0
SSFM-158	Coast Guard-Woodmere Bypass	10	2	465	13247	N	330	2530	Y	N	0	0	3	1	1	3	1	1	1	1	2.0
SSFM-160	Coast Guard-Woodmere Bypass	10	2	465	13247	N	330	2530	Y	N	0	0	3	1	1	3	1	1	1	1	2.0
SSFM-164	Coast Guard-Woodmere Bypass	10	9	465	13247	N	330	2510	N	N	0	0	3	1	1	3	5	1	1	1	2.6
SSFM-201	Coast Guard - Cleanout Branch	12	40	0	13247	N	325	2560	N	N	0	0	1	1	1	3	5	1	1	1	1.8
SSFM-200	Coast Guard - Cleanout Branch	**12**	2	0	13247	N	325	2560	N	N	0	0	1	1	1	3	5	1	1	1	1.8
SSFM-271	WWTP	16	26	**450**	0	N	360	920	N	N	0	0	3	1	2	1	5	1	1	1	2.5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Asset ID	**Associated Pump Station**	**Diameter (Inches)**	**Length (Feet)**	**Pump Station Firm Capacity (gpm)**	**Road ADT Value**	**Railroad Crossing (Y or N)**	**Closest High Quality Surface Water (feet)**	**Distance to Closest Drinking Water Well (feet)**	**Redundent Force Main (Y or N)**	**Crosses Historic Districts (Y or N)**	**Number of Residential Parcels**	**Number of Commercial Parcels**	**Quantity of Flow Rating (1-5)**	**High Quality Surface Water Rating (1-5)**	**Groundwater Wells Rating (1-5)**	**Transportation Systems Rating (1-5)**	**Redundant Force Main Rating (1-5)**	**Cultural Impact Rating (1-5)**	**Residential Impact Rating (1-5)**	**Commercial Impact Rating (1-5)**	**Consequence of Failure (1-5)**
SSFM-263	WWTP	**16**	32	**915**	0	N	340	895	N	N	0	0	4	1	2	1	5	1	1	1	2.9
SSFM-283	WWTP	**16**	44	**915**	0	N	315	875	N	N	0	0	4	1	2	1	5	1	1	1	2.9
SSFM-270	WWTP	**16**	27	975	0	N	400	930	Y	N	0	0	4	1	2	1	1	1	1	1	2.3
SSFM-273	WWTP	**16**	5	975	0	N	400	950	Y	N	0	0	4	1	2	1	1	1	1	1	2.3

*Items in bold were unknown and assumed based on available information.

Legend for Table C-C-3 by Column Number Heading:

1: Unique Asset ID
2: Associated Pump Station
3: Force Main Material Type
4: Force Main Diameter (Inches)
5: Force Main Segment Length (Feet)
6: Installation Year
7: Expected Asset Life (Years): Based on typical material life
8: Remaining Life Based on Installation Date (Years):
[8] = [7] – (Evaluation Year – [6])
9: Percent Remaining Useful Life
[9] = ([8] / [7]) * 100
10: History of Repairs: Number of repairs that have been needed
11: Stream or River Crossing: Y if force main crosses under a stream or river, N if not.
12: Number of Junctions: Number of additional force main connections at the upstream and downstream end of the force main.
13: Age Rating (1-5): Assigned a rating based on [9] and the estimated exponential relationship between the remaining life and probability of failure as shown in Figure 1 and Table 2
14: Repair Rating (1-5): Assigned a rating based on [10] and below table

Rating Scale	Repair History Descriptions
5	>= 4 Repairs
4	3 Repairs
3	2 Repairs
2	1 Repair
1	0 Repairs

15: Stream Crossing Rating (1-5): Assigned a rating based on [11] and below table

Rating Scale	Stream Crossing Description
5	Stream or river crossing
1	No crossing

16: Junction Rating (1-5): Assigned a rating based on [12] and below table

Rating Scale	Junction Descriptions
5	2 Junctions
3	1 Junction
1	0 Junctions

17: Probability of Failure: Weighted average of columns [13] to [16] the four consequence ratings.

Appendix C, Table C-C-3 Force Main Probability of Failure

Evaluation Year: 2016

POF Factor Weights: 75.0% | 8.3% | 8.3% | 8.3%

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Asset ID	Associated Pump Station	Material	Diameter (Inches)	Length (Feet)	Installation Year	Expected Asset Life (Years)	Remaining Life Based on Installation	Percent Remaining Useful Life	History of Repairs	Stream or River Crossing (Y or N)	Number of Junctions	Age Rating (1-5)	Repair Rating (1-5)	Stream Crossing Rating (1-5)	Junction Rating (1-5)	Probability of Failure (1-5)
SSFM-32	Riverine	PVC	12	681	1982	90	56	62%		N	1	1.8	1	1	3	1.8
SSFM-153	Riverine	PVC	12	9	1982	90	56	62%		N	1	1.8	1	1	3	1.8
SSFM-10	Bay	CI	8	1126	1931	60	-25	0%		N	0	5.0	1	1	1	4.0
SSFM-148	Front Street	CI	16	973	1931	60	-25	0%		N	0	5.0	1	1	1	4.0
SSFM-150	Front Street	CI	16	1559	1931	60	-25	0%		N	1	5.0	1	1	3	4.2
SSFM-251	Front Street - WWTP	CI	16	3	**1931**	60	-25	0%		N	1	5.0	1	1	3	4.2
SSFM-252	Front Street - WWTP	DI	16	2	**1931**	70	-15	0%		N	1	5.0	1	1	3	4.2
SSFM-282	Front Street - WWTP	DI	**18**	57	**1931**	70	-15	0%		N	0	5.0	1	1	1	4.0
SSFM-261	Front Street - WWTP	DI	18	195	**1931**	70	-15	0%		N	0	5.0	1	1	1	4.0
SSFM-250	Front Street - WWTP	CI	16	16	**1931**	60	-25	0%		N	1	5.0	1	1	3	4.2
SSFM-281	Front Street - WWTP	DI	**24**	41	**1931**	70	-15	0%		N	0	5.0	1	1	1	4.0
SSFM-259	Front Street - WWTP	DI	24	150	**1931**	70	-15	0%		N	0	5.0	1	1	1	4.0
SSFM-280	Front Street - WWTP	DI	**16**	112	**1931**	70	-15	0%		N	1	5.0	1	1	3	4.2
SSFM-289	Hull	PVC	4	47	**2001**	90	75	83%		N	0	1.3	1	1	1	1.2
SSFM-291	Hull	PVC	4	50	**2001**	90	75	83%		N	0	1.3	1	1	1	1.2
SSFM-287	Hull	HDPE	2	222	**2001**	100	85	85%		N	0	1.3	1	1	1	1.2
SSFM-286	Hull	PVC	2	2	**2001**	90	75	83%		N	1	1.3	1	1	3	1.4
SSFM-202	Woodmere	DI	6	12	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-189	Woodmere	DI	6	34	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-188	Woodmere	DI	6	42	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-203	Woodmere	DI	6	12	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-182	Woodmere	PVC	**6**	1	**1992**	90	66	73%		N	1	1.5	1	1	3	1.6
SSFM-185	Woodmere	PVC	**6**	2	**1992**	90	66	73%		N	1	1.5	1	1	3	1.6
SSFM-179	Woodmere	DI	6	4	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-180	Woodmere	DI	6	4	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-181	Woodmere	DI	6	4	**1992**	70	46	66%		N	1	1.7	1	1	3	1.7
SSFM-171	Woodmere	DI	8	14	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-169	Woodmere	DI	8	2	1992	70	46	66%		N	1	1.7	1	1	3	1.7
SSFM-167	Woodmere	**CI**	8	4	**1992**	60	36	60%		N	1	1.9	1	1	3	1.8
SSFM-176	Woodmere	CI	8	3	**1992**	60	36	60%		N	0	1.9	1	1	1	1.7
SSFM-166	Woodmere	**CI**	8	18	**1992**	60	36	60%		N	2	1.9	1	1	5	2.0
SSFM-192	Woodmere	DI	14	669	**1992**	70	46	66%	2	N	1	1.7	3	1	3	1.9
SSFM-231	Woodmere	CI	10	372	1992	60	36	60%		N	1	1.9	1	1	3	1.8
SSFM-18	Woodmere	CI	10	655	1992	60	36	60%		N	0	1.9	1	1	1	1.7
SSFM-4	Woodmere+Coast Guard + Hull	PVC	**16**	341	**1992**	90	66	73%		N	2	1.5	1	1	5	1.7
SSFM-284	Woodmere+Coast Guard + Hull	DI	**16**	96	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Asset ID	**Associated Pump Station**	**Material**	**Diameter (Inches)**	**Length (Feet)**	**Installation Year**	**Expected Asset Life (Years)**	**Remaining Life Based on Installation**	**Percent Remaining Useful Life**	**History of Repairs**	**Stream or River Crossing (Y or N)**	**Number of Junctions**	**Age Rating (1-5)**	**Repair Rating (1-5)**	**Stream Crossing Rating (1-5)**	**Junction Rating (1-5)**	**Probability of Failure (1-5)**
SSFM-276	Woodmere+Coast Guard + Hull	DI	16	21	**1992**	70	46	66%		N	1	1.7	1	1	3	1.7
SSFM-277	Woodmere+Coast Guard + Hull	DI	16	24	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-295	Coast Guard	DI	8	58	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-24	Coast Guard	CI	8	4090	1943	60	-13	0%		N	0	5.0	1	1	1	4.0
SSFM-23	Coast Guard	**CI**	8	3175	1943	60	-13	0%	2	N	0	5.0	3	1	1	4.2
SSFM-198	Coast Guard	DI	12	51	**1943**	70	-3	0%		N	0	5.0	1	1	1	4.0
SSFM-196	Coast Guard	DI	12	499	1996	70	50	71%		N	1	1.6	1	1	3	1.6
SSFM-199	Coast Guard	DI	12	2	1996	70	50	71%		N	1	1.6	1	1	3	1.6
SSFM-207	Coast Guard	DI	12	5	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-208	Coast Guard	DI	12	5	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-211	Coast Guard	DI	12	471	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-214	Coast Guard	DI	12	5	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-215	Coast Guard	DI	12	5	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-216	Coast Guard	DI	12	517	1996	70	50	71%		N	1	1.6	1	1	3	1.6
SSFM-220	Coast Guard+Hull	DI	12	4	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-218	Coast Guard+Hull	PVC	**12**	1	1996	90	70	78%		N	1	1.4	1	1	3	1.5
SSFM-151	TBA	AC	12	16	1970	80	34	43%		N	0	2.5	1	1	1	2.1
SSFM-28	TBA	AC	12	4834	1970	80	34	43%	1	N	0	2.5	2	1	1	2.2
SSFM-154	Birchwood	CI	14	26	**1956**	60	0	0%		N	0	5.0	1	1	1	4.0
SSFM-30	Birchwood	CI	14	2557	1956	60	0	0%		N	0	5.0	1	1	1	4.0
SSFM-122	Clinch Park	DI	4	1	2002	70	56	80%		N	1	1.4	1	1	3	1.5
SSFM-123	Clinch Park	DI	4	1	2002	70	56	80%		N	0	1.4	1	1	1	1.3
SSFM-124	Clinch Park	DI	4	3	2002	70	56	80%		N	0	1.4	1	1	1	1.3
SSFM-127	Clinch Park	DI	4	2	2002	70	56	80%		N	1	1.4	1	1	3	1.5
SSFM-125	Clinch Park	DI	4	1	2002	70	56	80%		N	1	1.4	1	1	3	1.5
SSFM-126	Clinch Park	DI	4	3	2002	70	56	80%		N	0	1.4	1	1	1	1.3
SSFM-128	Clinch Park	DI	4	2	2002	70	56	80%		N	1	1.4	1	1	3	1.5
SSFM-129	Clinch Park	DI	4	1	2002	70	56	80%		N	1	1.4	1	1	3	1.5
SSFM-130	Clinch Park	DI	4	1	2002	70	56	80%		N	1	1.4	1	1	3	1.5
SSFM-120	Clinch Park	DI	4	7	2002	70	56	80%		N	2	1.4	1	1	5	1.6
SSFM-121	Clinch Park	PVC	**4**	7	2002	90	76	84%		N	1	1.3	1	1	3	1.4
SSFM-119	Clinch Park	DI	4	3	2002	70	56	80%		N	1	1.4	1	1	3	1.5
SSFM-118	Clinch Park	PVC	**4**	171	2002	90	76	84%		N	0	1.3	1	1	1	1.2
SSFM-117	Clinch Park	DI	4	149	2002	70	56	80%		N	0	1.4	1	1	1	1.3
SSFM-131	Clinch Park Area	PVC	2	42	2002	90	76	84%		N	1	1.3	1	1	3	1.4
SSFM-132	Clinch Park Area	PVC	2	19	2002	90	76	84%		Y	0	1.3	1	5	1	1.5
SSFM-155	Coast Guard-Woodmere Bypass	**DI**	10	69	**1992**	70	46	66%		N	0	1.7	1	1	1	1.6
SSFM-161	Coast Guard-Woodmere Bypass	**CI**	6	5	**1992**	60	36	60%		N	1	1.9	1	1	3	1.8
SSFM-162	Coast Guard-Woodmere Bypass	**CI**	6	8	**1992**	60	36	60%		N	0	1.9	1	1	1	1.7
SSFM-163	Coast Guard-Woodmere Bypass	**CI**	6	3	**1992**	60	36	60%		N	1	1.9	1	1	3	1.8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Asset ID	**Associated Pump Station**	**Material**	**Diameter (Inches)**	**Length (Feet)**	**Installation Year**	**Expected Asset Life (Years)**	**Remaining Life Based on Installation**	**Percent Remaining Useful Life**	**History of Repairs**	**Stream or River Crossing (Y or N)**	**Number of Junctions**	**Age Rating (1-5)**	**Repair Rating (1-5)**	**Stream Crossing Rating (1-5)**	**Junction Rating (1-5)**	**Probability of Failure (1-5)**
SSFM-156	Coast Guard-Woodmere Bypass	CI	10	3	**1992**	60	36	60%		N	0	1.9	1	1	1	1.7
SSFM-157	Coast Guard-Woodmere Bypass	CI	10	3	**1992**	60	36	60%		N	0	1.9	1	1	1	1.7
SSFM-158	Coast Guard-Woodmere Bypass	**CI**	10	2	**1992**	60	36	60%		N	1	1.9	1	1	3	1.8
SSFM-160	Coast Guard-Woodmere Bypass	CI	10	2	**1992**	60	36	60%		N	1	1.9	1	1	3	1.8
SSFM-164	Coast Guard-Woodmere Bypass	CI	10	9	**1992**	60	36	60%		N	1	1.9	1	1	3	1.8
SSFM-201	Coast Guard - Cleanout Branch	DI	12	40	1996	70	50	71%		N	0	1.6	1	1	1	1.4
SSFM-200	Coast Guard - Cleanout Branch	DI	**12**	2	1996	70	50	71%		N	1	1.6	1	1	3	1.6
SSFM-271	WWTP	DI	16	26	**1931**	70	-15	0%		N	1	5.0	1	1	3	4.2
SSFM-263	WWTP	PVC	**16**	32	**1931**	90	5	6%		N	1	4.6	1	1	3	3.8
SSFM-283	WWTP	DI	**16**	44	**1931**	70	-15	0%		N	0	5.0	1	1	1	4.0
SSFM-270	WWTP	PVC	**16**	27	**1931**	90	5	6%		N	1	4.6	1	1	3	3.8
SSFM-273	WWTP	PVC	**16**	5	**1931**	90	5	6%		N	1	4.6	1	1	3	3.8

*Items in bold were unknown and assumed based on available information.

Appendix C-D– 5-Year Asset Replacement Recommendations

Appendix C-D: 5-Year Asset Replacement Recommendations

Year	Max Segment BRE	Station and Location	Original Replacement Year Based on Material and Install Date	Asset	Length (ft)	Replacement Cost	Funding Source OM&R	Funding Source CIP
2017	No Replacements							
						Annual Total	**$0**	**$0**
2018	16.8	Front Street	1991	Force Main	2533	$607,834		X
	15.6	Front Street - WWTP	1991	Force Main	19	$4,579		X
	14.3	Front Street - WWTP	2001	Force Main	557	$143,951		X
						Annual Total	**$0**	**$756,364**
2019	No Replacements							
						Annual Total	**$0**	**$0**
2020	No Replacements							
						Annual Total	**$0**	**$0**
2021	14.3	Coast Guard	2003	Force Main	7265	$1,162,326		X
	12.6	Coast Guard	2013	Force Main	51	$10,267		X
						Annual Total	**$0**	**$1,172,593**

Appendix D: Pump Station Inventory and Assessment Technical Memorandum

Appendix D: Pump Station Inventory and Assessment Technical Memorandum

A. Introduction

This memorandum summarizes the collection and assessment of data for nine pumping stations in Traverse City's sanitary collection system. These stations are shown in the map in Appendix D-A. The assets associated with each station were inventoried and evaluated for condition and criticality. The goal of this process is to provide an estimate of the needed annual reserves for asset maintenance and replacement. An analysis of the annual reserves for replacement are also included with a criticality based Capital Improvement Plan.

B. Data Collection and Inventory

The nine pumping stations in Traverse City's collection system are shown on the map in Appendix D-A. The major components inventoried within each station include but are not limited to pumps, check/control valves, motors, level control systems, backup power, structure, wet well, valve vault, and telemetry. The detailed asset inventory was collected through field visits, operator input, suppliers' input, and other sources. Each asset's information, including name, category, location, installation date, typical useful life, redundancy, and an estimated cost to replace, was collected and compiled into the spreadsheet shown in Appendix D-B.

The current condition was assigned based on the judgement of experienced facility design engineers. The condition rating range from 1 to 5 with 1 being the best condition as shown in Table D-1.

Table D-1: Condition Ratings

Ratings Index	Asset Condition
1	Excellent, appears new
2	Good, appropriate wear
3	Average, minor life cycle altering defects
4	Poor, significant wear but functional
5	Very poor, failure of intended function

Asset types or categories (i.e. pumps, valves, electrical components, etc.) have expected useful life numbers based on manufacturer experiences that can predict when an asset is likely to stop functioning. However, each asset has a unique useful life number based on the current condition and the age of an individual asset. The determination of the unique useful life number for each asset was modified considering current condition, age, and the judgement of experienced facility design engineers.

A Probability of Failure (POF) value was determined based on the percentage of remaining useful life. The POF predicts the likelihood of an asset to fail. The POF for each asset was determined using the chart and the trend line shown in Tables D-2, D-3 and D-4 and Figures D-1 and 2. Different trend lines were developed for the mechanical and electrical components and the structural components. Structural components like wet wells or valve vaults are less likely to fail since they have much longer useful lives and are often repaired instead of replaced. Generally, impending structural failure is visually apparent and can be addressed in a timely manner.

Table D-2: Probability of Failure

Score	Description
1	Improbable
2	Remote, unlikely but possible
3	Possible
4	Probable, likely
5	Imminent, likely in near future

Table D-3: Probability of Failure for Mechanical and Electrical Assets

Remaining Useful Life	Probability of Failure
10%	5
15%	4
25%	3
40%	2
50%	1.5
70%	1

Table D-4: Probability of Failure for Structural Assets

Remaining Useful Life	Probability of Failure
10%	4
18%	3.5
25%	3
35%	2.5
45%	2
70%	1

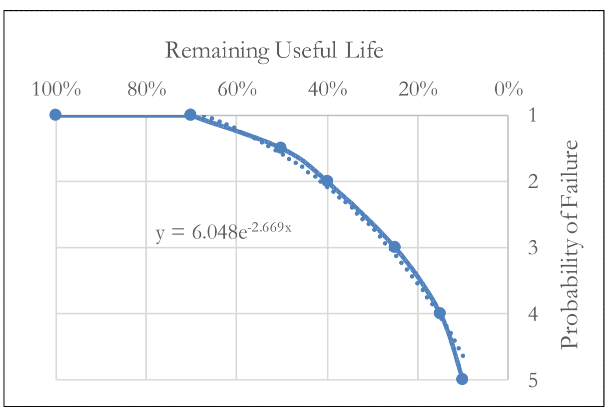


Figure D-1: Probability of Failure for Structural Assets

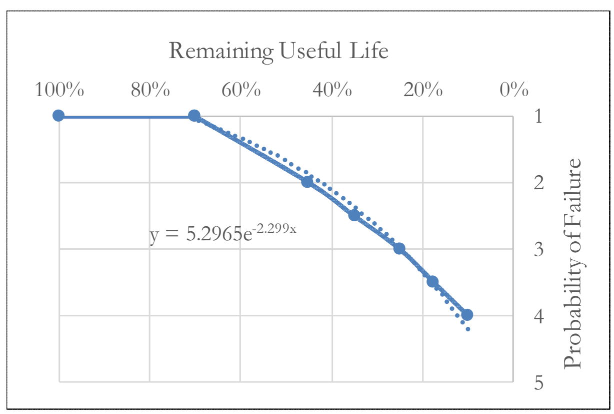


Figure D-2: Probability of Failure for Mechanical and Electrical Assets

The Consequence of Failure (COF) determines the effect of an individual asset failure on system operations. Each value was determined by an experienced engineer corresponding to the descriptions in Table D-5.

Table D-5: Consequence of Failure

Score	Effect
1	Negligible, minor loss of function
2	Minimal or marginal
3	Noticeable, may suspend some operations
4	Critical, temporarily suspends operations
5	Catastrophic disruption

The Consequence of Failure and Probability of Failure are multiplied to determine a Business Risk Exposure (BRE). The BRE is used to determine the criticality of an asset to system operation and is helpful for prioritizing limited funding. BRE ranges from 1-25. Generally, assets with BRE less than 8 are considered non-critical and greater than 16 are considered critical. Assets with higher BRE scores are more likely to need immediate attention. Assets with lower BRE have longer remaining useful lives but still need to be maintained.

C. Field Investigative Findings and Issues

Traverse City's pump stations are very well maintained. Many assets are functioning past the manufacturer specified useful life. The system is likely incurring higher annual maintenance and repair costs to forestall greater capital costs in the future.

There are several stations with critical assets likely to fail in the near future. These are noted in Table D-6, along with any other notable comments from inventory. A detailed list of the assets expected to fail over the next five years is available in Appendix D-C.

Table D-6: Pumping Station Issues

Facility ID	Station	Structure Type	Approx. Install Year	Issue
SSNS-6	Riverine	Lift Station	1983	• Pumps, motors and check valves are nearing the end of the expected service life and should be monitored closely. • Heavy grease load at this station can adversely affect the pumps and check valves.
SSNS-10	Coast Guard	Lift Station	1995	• Both submersible pumps are near the end of their expected service life. Although they are functioning, they should be closely monitored. • The chart recorder is not in service.
SSNS-18	Hull Park	Lift Station	2001	• In 2015 it appeared that the pump was not properly seated causing recirculation in the wet well.
SSNS-4	Clinch Park	Lift Station	2003	• No adverse comments.
SSNS-2	Bay Street	Lift Station	1994	• Both submersible pumps are near the end of their expected service life. Although they are functioning, they should be closely monitored.
SSNS-7	Birchwood	Lift Station	2002	• No adverse comments.
SSNS-16	Front St	Lift Station	1930/1996	• Pumps need to be frequently unclogged due to rags and other debris. The result is high maintenance costs. In the future when the pumps need to be replaced, consider dry pit submersible pumps that have better solids handling ability.

D. Annual Capital Reserves and Capital Improvement Plan

This analysis provides an overview of the cost projections with the anticipation that a combination of funding sources will be the best solution to manage Traverse City's pumping station assets. The breakdown considers the annual cash reserves to set aside annually to replace assets with Expected Asset Lives of 20 years or less. It also considers the total capital costs to replace assets with Expected Asset Lives greater than 20 years. The annual reserve needed is based on the assets' replacement cost divided by the Expected Asset Life. The total capital cost is that of replacing the asset at the year of failure. If an asset is expected to be replaced using cash reserves, a replacement fund should be incorporated into revenue requirement calculations. Capital assets with Expected Asset Lives greater than 20 years are not funded annually by a replacement fund and are not incorporated into the revenue requirement. The capital costs are substantial and should have some additional funding sources which may include bonds or other established accounts. The values used are based on 2015 dollars and do not include inflation. It is anticipated that Traverse City will need to review and revise the projected repair and replacement schedule to ensure that resulting revenue requirements are reasonable.

Table D-7 includes both the cash reserves set aside in a replacement fund and capital costs summed over the next five years and by station. As the pump stations age, it may be useful to consider replacing several assets at one station at once. In many instances, a number of assets in one station are expected to fail around the same time. It may also be practical to consider prioritizing stations that are more critical to the system or those with capacity issues. The issues listed for the pump stations in Table D-6 provide a manageable starting point for improvement necessary in the next five years. A detailed list of the assets expected to fail over the next five years is available in Appendix D-C.

The annual cash reserves that should be set aside for replacement and repair of existing assets over the next 5 years is shown in Table D-7 by station. The replacement costs for each asset at each station are divided by the manufacturer predicted lifetime of the asset to calculate the replacement funds to be set aside annually in an OM&R account. Taking into account the ages of current assets with Expected Asset Lifetimes of 20 years or less, Traverse City's OM&R fund should already contain approximately $140,000 for upcoming replacements at the City's pumping stations.

Table D-7: Annual Cash Reserves for Replacement and Repair

Station	Annual Replacement	Capital Fund					
		2016	2017	2018	2019	2020	2021
Bay Street	$2,450	$0	$0	$0	$15,000	$0	$0
Birchwood	$500	$0	$0	$0	$0	$0	$0
Clinch Park	$1,000	$0	$0	$0	$0	$0	$0
Coast Guard	$2,700	$0	$0	$0	$0	$15,000	$0
Front St	$1,300	$0	$0	$0	$0	$0	$45,000
Hull Park	$230	$0	$0	$0	$0	$0	$0
Riverine	$250	$0	$0	$39,400	$0	$0	$0
TBA	$250	$0	$36,000	$15,000	$0	$4,000	$0
Woodmere	$450	$8,500	$0	$0	$0	$34,500	$0
Grand Total	**$9,130**	**$8,500**	**$36,000**	**$54,400**	**$15,000**	**$53,500**	**$45,000**

In Figure D-3, the cash reserves necessary for replacement are compared to the capital cost for replacement at failure year. The capital cost spikes are due to estimated failures at the indicated year.

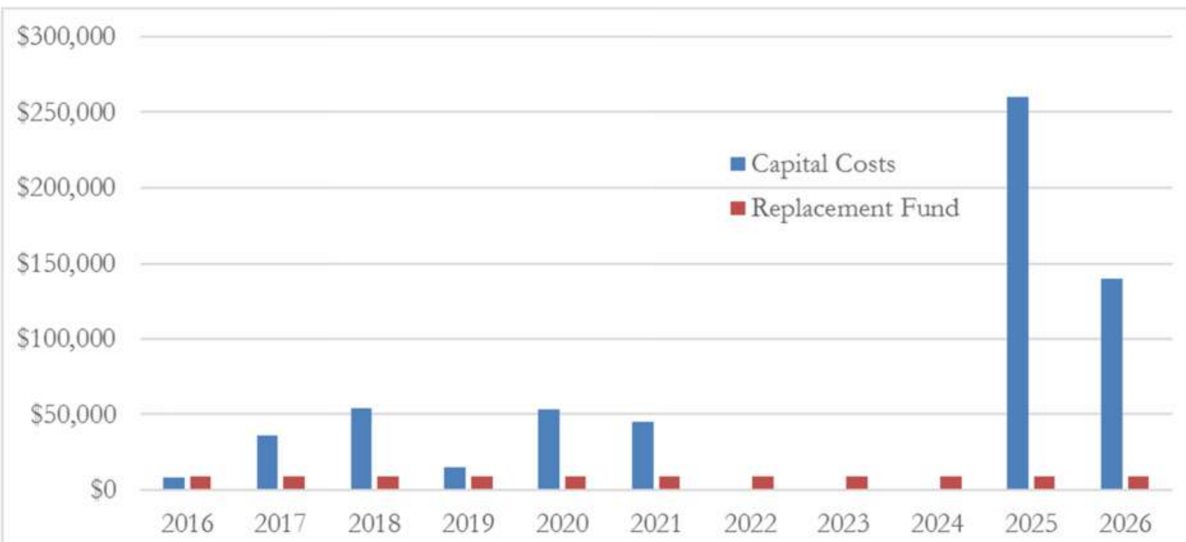


Figure D-3: Funding Necessary over Time

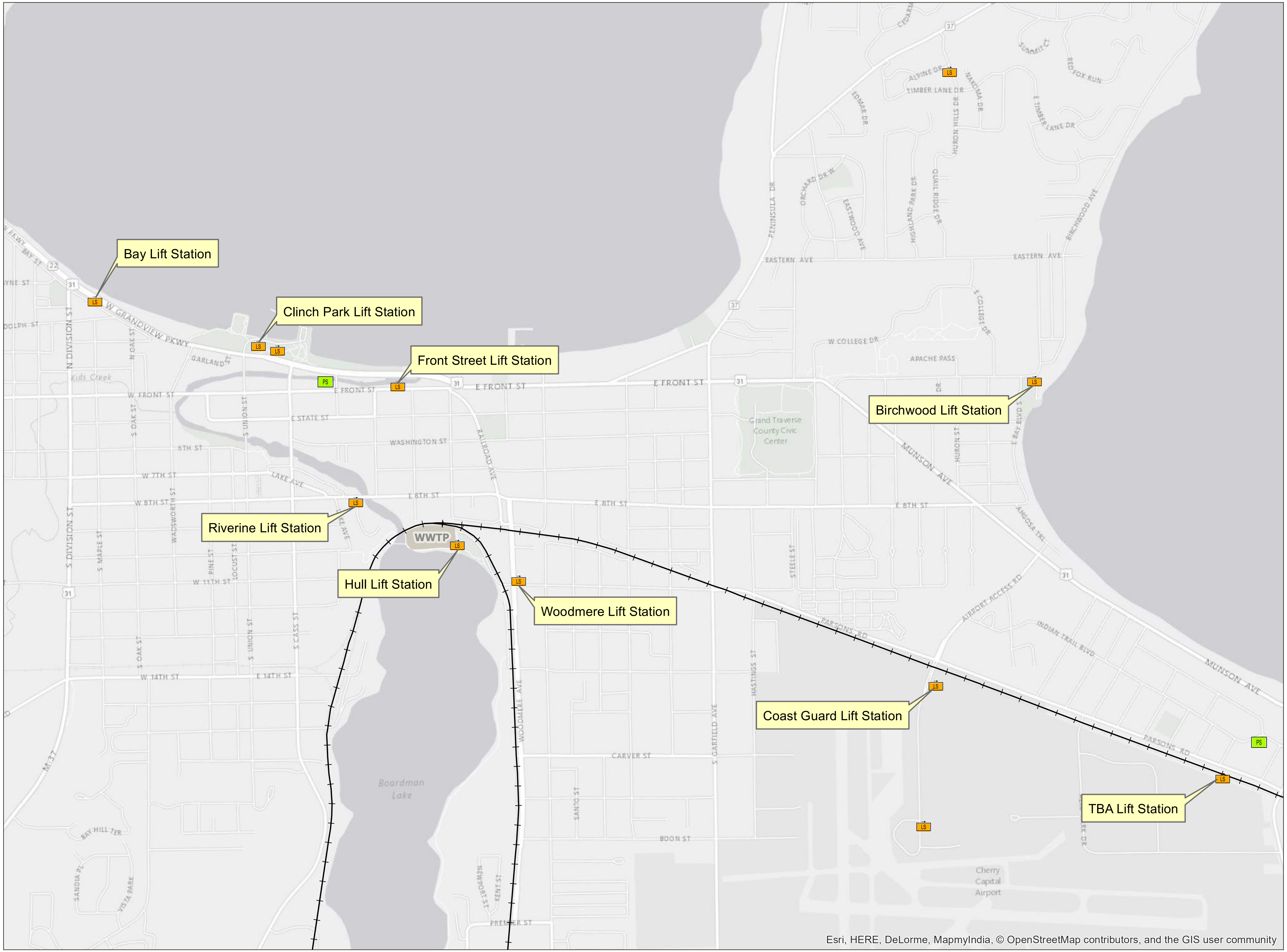
E. Recommendations

The multitudes of information gathered during the inventory and assessment will be compiled into a GIS geodatabase. The data presented in this memorandum provide an overview of the cost projections with the understanding that some combination of funding sources will be the best solution to manage Traverse City's pumping station assets. Future iterations will be documented with final agreed upon plan and funding mechanisms presented to the MDEQ in the rate analysis and Asset Management Plan. This section of the report will be expanded to reflect the final decisions.

Future work will include a comprehensive capital improvement plan for the system. A holistic approach to future improvements will incorporate results from assessments of the rest of the collection and treatment system.

In any AMP, it is vital to actively assess your system. As the pump station assets age and are replaced, their probability of failure and system criticality change. These changes should be reflected in planning.

Appendix D-A: Map of Traverse City's Lift Stations



Traverse City

Figure D-A-1. Lift Station Locations

Legend

- Lift Station
- Pump Station
- Railroads

0 1,500 3,000
Feet

1" = 1,500'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 HARN StatePlane Michigan North FIPS 2111 Feet Intl

Map Published: June 5, 2017

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Appendix D-B: Assessment and Inventory Table

Legend by Column Number Heading:

1: Unique Asset ID

2: Pump Station

3: Asset Type

4: Description of Asset

5: Installation Year

6: Expected Asset Life (Year): Based on manufacturer specifications

7: Remaining Life Based on Installation Date (Years):

    7 = 5 + 6 – Current Evaluation Year

8: Condition: Assigned based on the judgement of experienced facility design engineer

9: Predicted Remaining Life Based on Condition (Years): Assigned based on the judgement of experienced facility design engineer

10: Asset Life Based on Install Date and Predicted Life (Years):

    10 = Current Evaluation Year + 9 – 5

11: Percent Remaining Useful Life

    11 = (9 / 10) * 100%

12: Consequence of Failure: Assigned based on the judgement of experienced facility design engineer

13: Probability of Failure: Empirically based on Remaining Useful Life

    13 = function of 11

14: Business Risk Exposure

    14 = 12 * 13

15: Replacement Year

    15 = Current Evaluation Year + 9

16: 2015 Replacement Cost: Assigned based on the judgement of experienced facility design engineer

17: 2015 Value Assuming Linear Depreciation: Assumes depreciation based on asset's total predicted life

    17 = 11 * 16

18: Annual Replacement Cost When Predicted Life < 20 Years: If an asset has a total predicted life of less than 20 years, it should be funded from a dedicated replacement fund on an annual basis

    18 = 16 / 10 if 16 < 20 years

19: Funding Source: CIP for assets with useful life > 20 years assumes no dedicated saving annually for asset replacement vs OM&R for assets with useful life < 20 years assumes a dedicated replacement fund on an annual basis

Asset ID	Station	Asset	Description	Installation Year	Expected Asset Life (Years)	Remaining Life Based on Installation Date (Years)	Condition	Predicted Remaining Life Based on Condition (Years)	Asset Life Based on Install Date and Predicted Life (Years)	Percent Remaining Useful Life	Consequence of Failure	Probability of Failure	Business Risk Exposure	Replacement Year	2015 Replacement Cost	2015 Value Assuming Linear Depreciation	Annual Replacement Cost When Predicted Life < 20 Years	Funding Source
	TBA	Pump #1	Dry Pit Vertical	1969	30	-16	4	2	48	4%	3	5.0	15.0	2017	$18,000	$750	$0	CIP
	TBA	Pump #2	Dry Pit Vertical	1969	30	-16	4	2	48	4%	3	5.0	15.0	2017	$18,000	$750	$0	CIP
	TBA	Check/Control Valve #1	Swing Check 6"	1969	35	-11	3	5	51	10%	3	4.7	14.0	2020	$2,000	$196	$0	CIP
	TBA	Check/Control Valve #2	Swing Check 6"	1969	35	-11	3	5	51	10%	3	4.7	14.0	2020	$2,000	$196	$0	CIP
	TBA	Motor #1	Dry pit ODP	1969	30	-16	3	2	48	4%	3	5.0	15.0	2017	$0	$0	$0	CIP
	TBA	Motor #2	Dry pit ODP	2012	30	27	3	27	30	90%	3	1.0	3.0	2042	$0	$0	$0	CIP
	TBA	Control Panel		1969	25	-21	4	3	49	6%	4	5.0	20.0	2018	$15,000	$918	$0	CIP
	TBA	Level Control System	Floats	1969	10	-36	3	5	51	10%	4	4.7	18.6	2020	$500	$49	$50	OM&R
	TBA	Telemetry	Sensiphone autodialer	1969	20	-26	2	5	51	10%	2	4.7	9.3	2020	$4,000	$392	$200	OM&R
	TBA	Dry Well	Steel Can	1969	70	24	4	10	56	18%	4	3.5	14.1	2025	$20,000	$3,571	$0	CIP
	TBA	Wet Well	large wet well with cat walk	1969	70	24	3	24	70	34%	4	2.4	9.6	2039	$15,000	$5,143	$0	CIP
	Riverine	Pump #1	Dry Pit Vertical	1983	30	-2	3	3	35	9%	3	4.8	14.4	2018	$11,000	$943	$0	CIP
	Riverine	Pump #2	Dry Pit Vertical	1983	30	-2	3	3	35	9%	3	4.8	14.4	2018	$11,000	$943	$0	CIP
	Riverine	Check/Control Valve #1	Swing Check 4"	1983	35	3	3	3	35	9%	3	4.8	14.4	2018	$1,200	$103	$0	CIP
	Riverine	Check/Control Valve #2	Swing Check 4"	1983	35	3	3	3	35	9%	3	4.8	14.4	2018	$1,200	$103	$0	CIP
	Riverine	Motor #1	Dry pit	1983	30	-2	3	3	35	9%	3	4.8	14.4	2018	$0	$0	$0	CIP
	Riverine	Motor #2	Dry pit	1983	30	-2	3	3	35	9%	3	4.8	14.4	2018	$0	$0	$0	CIP
	Riverine	Control Panel		1983	25	-7	3	3	35	9%	4	4.8	19.2	2018	$15,000	$1,286	$0	CIP
	Riverine	Level Control System	Floats	1983	10	-22	2	5	37	14%	3	4.2	12.7	2020	$500	$68	$50	OM&R
	Riverine	Backup Floats	Floats	1983	10	-22	2	5	37	14%	3	4.2	12.7	2020	$500	$68	$50	OM&R
	Riverine	Telemetry	Sensiphone autodialer	1983	20	-12	2	5	37	14%	2	4.2	8.4	2020	$3,000	$405	$150	OM&R
	Riverine	Dry Well	Steel Can	1983	70	38	2	38	70	54%	4	1.5	6.1	2053	$20,000	$10,857	$0	CIP
	Riverine	Wet Well	8'diameter	1983	70	38	2	38	70	54%	4	1.4	5.7	2053	$15,000	$8,143	$0	CIP
	Coast Guard	Pump #1	Submersible	1995	20	0	3	5	25	20%	3	3.5	10.6	2020	$18,000	$3,600	$900	OM&R
	Coast Guard	Pump #2	Submersible	1995	20	0	3	5	25	20%	3	3.5	10.6	2020	$18,000	$3,600	$900	OM&R
	Coast Guard	Check/Control Valve #1	Swing Check 6"	1995	35	15	3	15	35	43%	3	1.9	5.8	2030	$2,000	$857	$0	CIP
	Coast Guard	Check/Control Valve #2	Swing Check 6"	1995	35	15	3	15	35	43%	3	1.9	5.8	2030	$2,000	$857	$0	CIP
	Coast Guard	Control Panel		1995	25	5	3	5	25	20%	4	3.5	14.2	2020	$15,000	$3,000	$0	CIP
	Coast Guard	Level Control System	Milltronics sonic	1995	20	0	2	5	25	20%	3	3.5	10.6	2020	$4,000	$800	$200	OM&R
	Coast Guard	Flow Meter	F & P Magmeter	1995	20	0	4	0	20	0%	1	5.0	5.0	2015	$10,000	$0	$500	OM&R
	Coast Guard	Telemetry	Sensiphone autodialer	1995	20	0	2	5	25	20%	3	3.5	10.6	2020	$4,000	$800	$200	OM&R
	Coast Guard	Structure	Brick & block building	1995	70	50	2	50	70	71%	4	1.0	4.0	2065	$15,000	$10,714	$0	CIP
	Coast Guard	Wet Well	concrete, 10' Dia Precast	1995	70	50	3	50	70	71%	4	1.0	4.0	2065	$15,000	$10,714	$0	CIP
	Coast Guard	Valve Vault	Concrete	1995	70	50	3	50	70	71%	4	1.0	4.0	2065	$6,000	$4,286	$0	CIP
	Hull Park	Pump #1	Grinder	2013	20	18	2	18	20	90%	3	1.0	3.0	2033	$3,600	$3,240	$180	OM&R
	Hull Park	Control Panel		2001	25	11	2	11	25	44%	3	1.9	5.6	2026	$15,000	$6,600	$0	CIP
	Hull Park	Level Control System	Floats	2001	10	-4	2	5	19	26%	3	3.0	9.0	2020	$500	$132	$50	OM&R
	Hull Park	Wet Well	3' FRP	2001	70	56	2	56	70	80%	3	1.0	3.0	2071	$4,000	$3,200	$0	CIP

Asset ID	Station	Asset	Description	Installation Year	Expected Asset Life (Years)	Remaining Life Based on Installation Date (Years)	Condition	Predicted Remaining Life Based on Condition (Years)	Asset Life Based on Install Date and Predicted Life (Years)	Percent Remaining Useful Life	Consequence of Failure	Probability of Failure	Business Risk Exposure	Replacement Year	2015 Replacement Cost	2015 Value Assuming Linear Depreciation	Annual Replacement Cost When Predicted Life < 20 Years	Funding Source
	Clinch Park	Pump #1	Submersible	2003	20	8	3	8	20	40%	3	2.1	6.2	2023	$7,500	$3,000	$375	OM&R
	Clinch Park	Pump #2	Submersible	2013	20	18	2	18	20	90%	3	1.0	3.0	2033	$7,500	$6,750	$375	OM&R
	Clinch Park	Check/Control Valve #1	Swing Check 4"	2003	35	23	3	23	35	66%	3	1.0	3.1	2038	$1,200	$789	$0	CIP
	Clinch Park	Check/Control Valve #2	Swing Check 4"	2003	35	23	3	23	35	66%	3	1.0	3.1	2038	$1,200	$789	$0	CIP
	Clinch Park	Control Panel		2003	25	13	3	13	25	52%	4	1.5	6.0	2028	$15,000	$7,800	$0	CIP
	Clinch Park	Level Control System	Floats	2003	10	-2	2	5	17	29%	3	2.8	8.3	2020	$500	$147	$50	OM&R
	Clinch Park	Backup Floats		2003	10	-2	2	5	17	29%	3	2.8	8.3	2020	$500	$147	$50	OM&R
	Clinch Park	Telemetry	Sensiphone autodialer	2003	20	8	3	8	20	40%	2	2.1	4.2	2023	$3,000	$1,200	$150	OM&R
	Clinch Park	Wet Well	concrete, 6' Dia Precast	2003	70	58	2	58	70	83%	4	1.0	4.0	2073	$15,000	$12,429	$0	CIP
	Clinch Park	Valve Vault	Concrete	2003	70	58	2	58	70	83%	4	1.0	4.0	2073	$6,000	$4,971	$0	CIP
	Bay Street	Pump #1	Submersible	1994	20	-1	3	3	24	13%	2	4.3	8.7	2018	$11,000	$1,375	$550	OM&R
	Bay Street	Pump #2	Submersible	1994	20	-1	3	3	24	13%	2	4.3	8.7	2018	$11,000	$1,375	$550	OM&R
	Bay Street	Check/Control Valve #1	Swing Check 6"	1994	35	14	3	14	35	40%	2	2.1	4.2	2029	$2,000	$800	$0	CIP
	Bay Street	Check/Control Valve #2	Swing Check 6"	1994	35	14	3	14	35	40%	2	2.1	4.2	2029	$2,000	$800	$0	CIP
	Bay Street	Control Panel		1994	25	4	2	4	25	16%	2	3.9	7.9	2019	$15,000	$2,400	$0	CIP
	Bay Street	Level Control System	Milltronics sonic	1994	20	-1	2	5	26	19%	3	3.6	10.9	2020	$4,000	$769	$200	OM&R
	Bay Street	Telemetry	Sensiphone dialer	1994	20	-1	2	5	26	19%	2	3.6	7.2	2020	$4,000	$769	$200	OM&R
	Bay Street	Backup Floats		1994	10	-11	3	5	26	19%	4	3.6	14.5	2020	$500	$96	$50	OM&R
	Bay Street	Flow Meter	F & P Magmeter	1994	20	-1	4	1	22	5%	1	5.0	5.0	2016	$10,000	$455	$500	OM&R
	Bay Street	Structure	Brick & glazed block building	1994	70	49	2	49	70	70%	4	1.1	4.2	2064	$15,000	$10,500	$0	CIP
	Bay Street	Wet Well	concrete, 8' Dia Precast	1994	70	49	2	49	70	70%	4	1.1	4.2	2064	$15,000	$10,500	$0	CIP
	Bay Street	Other	Mixer	2014	10	9	3	9	10	90%	2	1.0	2.0	2024	$4,000	$3,600	$400	OM&R
	Bay Street	Valve Vault	Concrete	1994	70	49	2	49	70	70%	2	1.1	2.1	2064	$6,000	$4,200	$0	CIP
	Woodmere	Pump #1	Dry Pit Submersible	1994	25	4	4	1	22	5%	3	5.0	15.0	2016	$8,500	$386	$0	CIP
	Woodmere	Pump #2	Dry Pit Submersible	1994	25	4	3	5	26	19%	3	3.6	10.9	2020	$8,500	$1,635	$0	CIP
	Woodmere	Check/Control Valve #1	Swing Check 6"	2011	35	31	2	31	35	89%	3	1.0	3.0	2046	$2,000	$1,771	$0	CIP
	Woodmere	Check/Control Valve #2	Swing Check 6"	2011	35	31	2	31	35	89%	3	1.0	3.0	2046	$2,000	$1,771	$0	CIP
	Woodmere	Control Panel		1994	25	4	2	5	26	19%	4	3.6	14.5	2020	$15,000	$2,885	$0	CIP
	Woodmere	Level Control System	Milltronics sonic	1994	20	-1	2	5	26	19%	3	3.6	10.9	2020	$4,000	$769	$200	OM&R
	Woodmere	Backup Floats		1994	10	-11	3	5	26	19%	3	3.6	10.9	2020	$500	$96	$50	OM&R
	Woodmere	Telemetry	Sensiphone autodialer	1994	20	-1	3	5	26	19%	2	3.6	7.2	2020	$4,000	$769	$200	OM&R
	Woodmere	Flow Meter	E & H Magmeter	1994	25	4	3	5	26	19%	1	3.6	3.6	2020	$11,000	$2,115	$0	CIP
	Woodmere	Structure	Brick & block building	1994	70	49	2	49	70	70%	4	1.1	4.2	2064	$15,000	$10,500	$0	CIP
	Woodmere	Wet Well	6'x8' Concrete	1994	70	49	2	49	70	70%	4	1.1	4.2	2064	$15,000	$10,500	$0	CIP
	Woodmere	Valve Vault	Concrete	1994	70	49	2	49	70	70%	4	1.1	4.2	2064	$6,000	$4,200	$0	CIP
	Woodmere	Dry Well	8'x8'	1994	70	49	2	49	70	70%	4	1.1	4.2	2064	$6,000	$4,200	$0	CIP
	Birchwood	Pump #1	Dry Pit Submersible	2002	30	17	2	17	30	57%	3	1.3	4.0	2032	$18,000	$10,200	$0	CIP
	Birchwood	Pump #2	Dry Pit Submersible	2002	30	17	2	17	30	57%	3	1.3	4.0	2032	$18,000	$10,200	$0	CIP
	Birchwood	Check/Control Valve #1	Swing Check 8"	2002	35	22	2	22	35	63%	3	1.1	3.4	2037	$3,000	$1,886	$0	CIP
	Birchwood	Check/Control Valve #2	Swing Check 8"	2002	35	22	2	22	35	63%	3	1.1	3.4	2037	$3,000	$1,886	$0	CIP
	Birchwood	Control Panel		2002	25	12	2	12	25	48%	4	1.7	6.7	2027	$15,000	$7,200	$0	CIP
	Birchwood	Level Control System	Milltronics sonic	2002	20	7	3	7	20	35%	3	2.4	7.1	2022	$4,000	$1,400	$200	OM&R
	Birchwood	Backup Floats		2002	10	-3	3	2	15	13%	3	4.2	12.7	2017	$500	$67	$50	OM&R
	Birchwood	Telemetry	Sensiphone autodialer	2002	20	7	2	7	20	35%	2	2.4	4.8	2022	$5,000	$1,750	$250	OM&R
	Birchwood	Backup Power	Generator on site	2002	30	17	2	17	30	57%	3	1.3	4.0	2032	$38,000	$21,533	$0	CIP
	Birchwood	Structure	Concrete & Brick	2002	70	57	2	57	70	81%	4	1.0	4.0	2072	$20,000	$16,286	$0	CIP
	Birchwood	Wet Well	4'x13' Concrete	2002	70	57	2	57	70	81%	4	1.0	4.0	2072	$15,000	$12,214	$0	CIP
	Birchwood	Pump & Valve Vault	Concrete	2002	70	57	2	57	70	81%	4	1.0	4.0	2072	$6,000	$4,886	$0	CIP

Asset ID	Station	Asset	Description	Installation Year	Expected Asset Life (Years)	Remaining Life Based on Installation Date (Years)	Condition	Predicted Remaining Life Based on Condition (Years)	Asset Life Based on Install Date and Predicted Life (Years)	Percent Remaining Useful Life	Consequence of Failure	Probability of Failure	Business Risk Exposure	Replacement Year	2015 Replacement Cost	2015 Value Assuming Linear Depreciation	Annual Replacement Cost When Predicted Life < 20 Years	Funding Source
	Front St	Pump #2	Dry Pit Vertical	1996	30	11	3	10	29	34%	2	2.4	4.8	2025	$80,000	$27,586	$0	CIP
	Front St	Pump #3	Dry Pit Vertical	1996	30	11	3	10	29	34%	2	2.4	4.8	2025	$80,000	$27,586	$0	CIP
	Front St	Pump #4	Dry Pit Vertical	1996	30	11	3	10	29	34%	2	2.4	4.8	2025	$80,000	$27,586	$0	CIP
	Front St	Check/Control Valve #2	Swing Check 12"	1996	35	16	3	16	35	46%	2	1.8	3.6	2031	$7,000	$3,200	$0	CIP
	Front St	Check/Control Valve #3	Swing Check 12"	1996	35	16	3	16	35	46%	2	1.8	3.6	2031	$7,000	$3,200	$0	CIP
	Front St	Check/Control Valve #4	Swing Check 12"	1996	35	16	3	16	35	46%	2	1.8	3.6	2031	$7,000	$3,200	$0	CIP
	Front St	Motor #2	Dry Pit	1996	30	11	2	10	29	34%	2	2.4	4.8	2025	$0	$0	$0	CIP
	Front St	Motor #3	Dry Pit	1996	30	11	3	10	29	34%	2	2.4	4.8	2025	$0	$0	$0	CIP
	Front St	Motor #4	Dry Pit	1996	30	11	3	10	29	34%	2	2.4	4.8	2025	$0	$0	$0	CIP
	Front St	Control Panel #2	VFD	1996	25	6	3	6	25	24%	2	3.2	6.4	2021	$15,000	$3,600	$0	CIP
	Front St	Control Panel #3	VFD	1996	25	6	3	6	25	24%	2	3.2	6.4	2021	$15,000	$3,600	$0	CIP
	Front St	Control Panel #4	VFD	1996	25	6	3	6	25	24%	2	3.2	6.4	2021	$15,000	$3,600	$0	CIP
	Front St	Level Control System	Milltronics sonic	1996	20	1	3	5	24	21%	3	3.5	10.4	2020	$4,000	$833	$200	OM&R
	Front St	Backup Floats	Floats	1996	10	-9	3	2	21	10%	3	4.7	14.1	2017	$1,000	$95	$100	OM&R
	Front St	SCADA Panel	Wireless link 2 2 PLC 5	1996	20	1	3	5	24	21%	3	3.5	10.4	2020	$20,000	$4,167	$1,000	OM&R
	Front St	Backup Power	Generator on site	1996	30	11	3	11	30	37%	4	2.3	9.1	2026	$125,000	$45,833	$0	CIP
	Front St	Structure	37'x22', Brick, stone	1930	70	-15	3	25	110	23%	4	3.1	12.6	2040	$80,000	$18,182	$0	CIP
	Front St	Wet Well	37'x6'	1930	70	-15	3	25	110	23%	4	3.1	12.6	2040	$30,000	$6,818	$0	CIP

Appendix D-C: 5-Year Asset Replacement Recommendations

Appendix D-C: 5-Year Asset Replacement Recommendations

Year	Asset ID	Station	Asset	Business Risk	Replacement Cost	Funding Source	
						OM&R	CIP
2015	0	Coast Guard	Flow Meter	5	10000	X	
					Annual Total	**$10,000**	**$0**
2016	0	Bay Street	Flow Meter	5	10000	X	
	0	Woodmere	Pump #1	15	8500		X
					Annual Total	**$10,000**	**$8,500**
2017	0	Birchwood	Backup Floats	13	500	X	
	0	Front St	Backup Floats	14	1000	X	
	0	TBA	Pump #1	15	18000		X
	0	TBA	Pump #2	15	18000		X
	0	TBA	Motor #1	15	0		X
					Annual Total	**$1,500**	**$36,000**
2018	0	Bay Street	Pump #1	9	11000	X	
	0	Bay Street	Pump #2	9	11000	X	
	0	Riverine	Pump #1	14	11000		X
	0	Riverine	Pump #2	14	11000		X
	0	Riverine	Check/Control Valve #1	14	1200		X
	0	Riverine	Check/Control Valve #2	14	1200		X
	0	Riverine	Motor #1	14	0		X
	0	Riverine	Motor #2	14	0		X
	0	Riverine	Control Panel	19	15000		X
	0	TBA	Control Panel	20	15000		X
					Annual Total	**$22,000**	**$54,400**
2019	0	Bay Street	Control Panel	8	15000		X
					Annual Total	**$0**	**$15,000**
2020	0	Bay Street	Level Control System	11	4000	X	
	0	Bay Street	Telemetry	7	4000	X	
	0	Bay Street	Backup Floats	14	500	X	
	0	Clinch Park	Level Control System	8	500	X	
	0	Clinch Park	Backup Floats	8	500	X	
	0	Coast Guard	Pump #1	11	18000	X	
	0	Coast Guard	Pump #2	11	18000	X	
	0	Coast Guard	Control Panel	14	15000		X
	0	Coast Guard	Level Control System	11	4000	X	
	0	Coast Guard	Telemetry	11	4000	X	
	0	Front St	Level Control System	10	4000	X	
	0	Front St	SCADA Panel	10	20000	X	
	0	Hull Park	Level Control System	9	500	X	
	0	Riverine	Level Control System	13	500	X	
	0	Riverine	Backup Floats	13	500	X	
	0	Riverine	Telemetry	8	3000	X	
	0	TBA	Check/Control Valve #1	14	2000		X
	0	TBA	Check/Control Valve #2	14	2000		X
	0	TBA	Level Control System	19	500	X	

Appendix D-C: 5-Year Asset Replacement Recommendations

Year	Asset ID	Station	Asset	Business Risk	Replacement Cost	Funding Source	
						OM&R	CIP
	0	TBA	Telemetry	9	4000	X	
	0	Woodmere	Pump #2	11	8500		X
	0	Woodmere	Control Panel	14	15000		X
	0	Woodmere	Level Control System	11	4000	X	
	0	Woodmere	Backup Floats	11	500	X	
	0	Woodmere	Telemetry	7	4000	X	
	0	Woodmere	Flow Meter	4	11000		X
					Annual Total	**$95,000**	**$53,500**
2021	0	Front St	Control Panel #2	6	15000		X
	0	Front St	Control Panel #3	6	15000		X
	0	Front St	Control Panel #4	6	15000		X
					Annual Total	**$0**	**$45,000**

Appendix E: Hydrologic and Hydraulic Technical Memorandum

Appendix E: Hydrologic and Hydraulic Technical Memorandum

A. Introduction

Using SAW Grant Program Assistance, Traverse City retained OHM Advisors to assess infiltration and inflow concerns within the Traverse City wastewater system. To address these concerns, OHM worked with Martin Control Services (MCS) to install 8 temporary flow meters and one rain gauge for the duration of 6 months during 2015. Flows were recorded from these meters, as well as the permanent Wastewater Treatment Plant (WWTP) flow meter, under varying antecedent moisture conditions and used to determine a wet weather response for the development of hydrologic modeling parameters. These parameters were applied to a hydraulic model of the system's main trunks and used to evaluate the current system.

This memorandum summarizes the results from the Antecedent Moisture Model (AMM) method to estimate peak flow rates, hydraulic modeling to evaluate conditions during peak flow rates, and a comparison of modeled peak flows to lift station capacities.

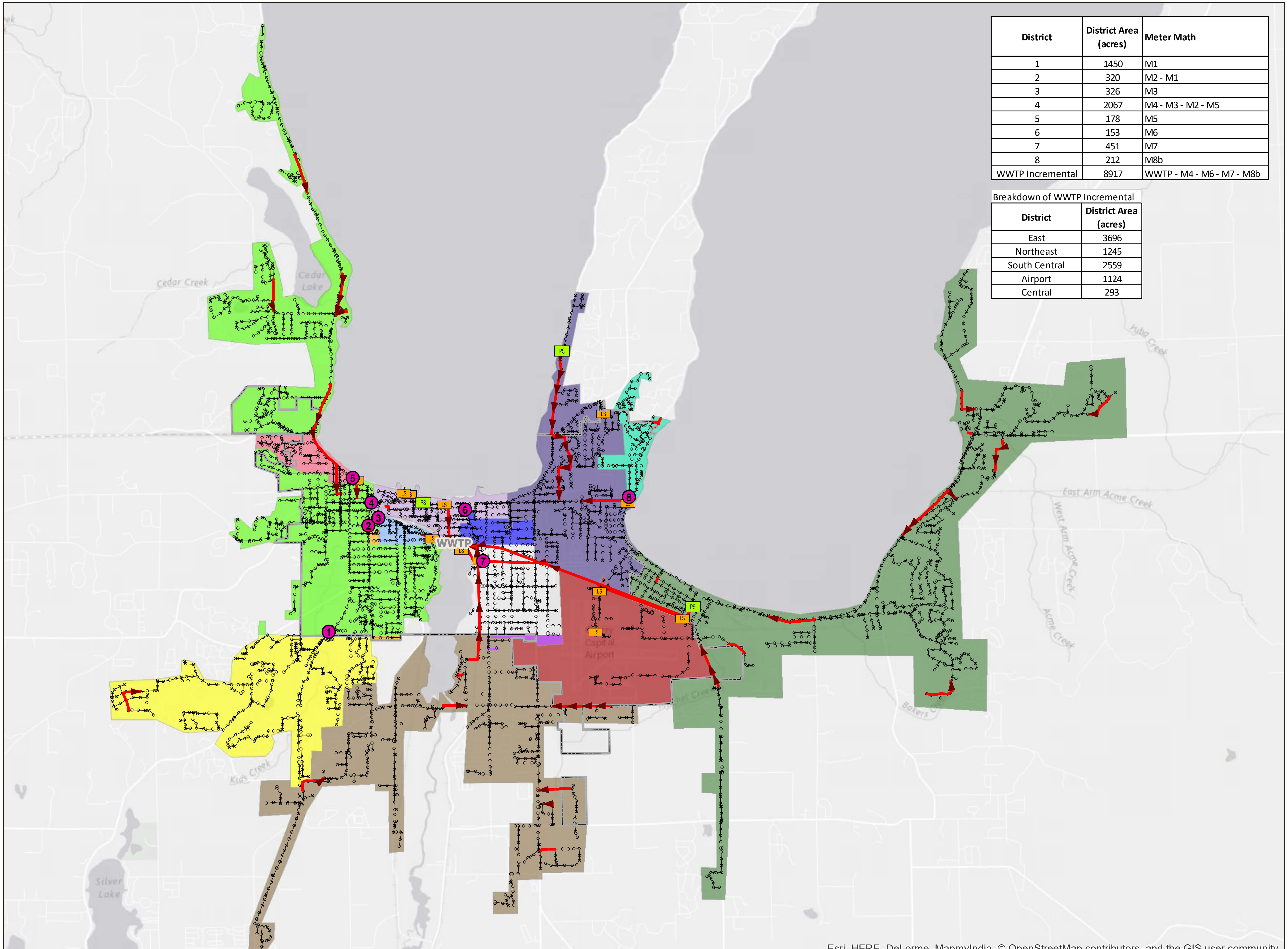
Most of the system showed little to no discernable wet weather response, indicating that wet weather flows are not generally a significant issue within this system. The one exception was Meter District 3 (Figure E-1), where increased peak flows in response to wet weather conditions were observed and an AMM was developed. Benchmarking data suggests that the capture coefficient (percentage of rainfall that enters the collection system) for these storm events is fairly low compared to other sanitary sewer systems, however the effect on peak flows is fairly high with a peaking factor in the top 80th percentile of benchmarked systems. A model for the WWTP was also completed to verify the overall wet weather response of the system, including the incremental areas downstream of the temporary meters. The WWTP also had a low wet weather response, making it one of the driest systems OHM has ever observed. The AMM model was applied at these two locations for the following uses:

- Meter District 3
    - This model was developed for Meter District 3, which had the greatest wet weather response. This area is to the west of Boardman Lake and enters the main trunk just upstream of Meter 4. Results were used to determine peak flows for the meter district and in benchmarking comparisons to other systems.

- WWTP
    - This model was developed to measure the wet weather flow response of the entire Traverse City System. Results were used in benchmarking comparisons to other systems and to determine the flow rate during peak flows.

For the Traverse City flow analysis, the calibrated models from the two analysis points were used to determine the 10-year frequency peak wet weather flows. The 10-year frequency flow is critical in Michigan, as the 2002 SSO Policy (MDEQ) makes a specific reference to collection systems being designed so as to overflow less than once in ten years; in other words, systems should be designed to safely convey the 10-year recurrence interval flow rate.

The remaining districts were evaluated using a peaking factor determined from the Ten State Standards formula for peak design flows. It was found that the Ten State Standards formula resulted in a higher (more conservative) peak hour flow when the incremental WWTP districts were summed than the 10-year flow predicted by the WWTP AMM model. This confirmed that the use of Ten State Standards would not cause an under prediction of peak flows within the model. For Meter District 3, the 10-year frequency peak flow was greater than the Ten State Standards peak design flow and so the 10-year frequency flow was used. Hydraulic conditions during these peak hour flows were evaluated using an EPA SWMM hydraulic model and lift station capacities were compared to expected inflows. Any deficiencies within the system are summarized and recommendations provided.



District	District Area (acres)	Meter Math
1	1450	M1
2	320	M2 - M1
3	326	M3
4	2067	M4 - M3 - M2 - M5
5	178	M5
6	153	M6
7	451	M7
8	212	M8b
WWTP Incremental	8917	WWTP - M4 - M6 - M7 - M8b

Breakdown of WWTP Incremental

District	District Area (acres)
East	3696
Northeast	1245
South Central	2559
Airport	1124
Central	293

Traverse City
Figure E-1. Meter Districts

Legend

- 2015 Meter Locations
- Lift Station
- Pump Station
- Force Main
- Sanitary Gravity Main
- Traverse City Boundary
- Manhole

Meter Districts

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- East
- Northeast
- South Central
- Airport
- Central

0 5,200 10,400
Feet

1" = 5200'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 HARN StatePlane Michigan North FIPS 2111 Feet Intl

Map Published: May 23, 2017

OHM

B. Background

1. <u>Purpose and Scope</u>

1. *Temporary Flow Metering*: The purpose of this task was to install temporary flow meters near existing pump stations and other key locations within the Traverse City collection system to capture local sewer flow response during both dry and wet weather conditions. Once the data were gathered, meter math was conducted for each meter district to obtain incremental flows and identify locations of higher inflow/infiltration.
2. *Develop hydrologic model for selected metered districts*. The purpose of using the AMM was to create a continuous hydrologic model that predicts the effects of a wet weather response. The model is calibrated to optimize the accuracy of fit to the observed conditions. Only meter districts which showed sufficient inflow/infiltration responses were modeled.
3. *Develop hydraulic model of the collection system's trunk*. The purpose of this task was to evaluate the hydrologic responses and hydraulic performance of the wastewater collection system, noting any specific problems related to elevated base flows, wet weather flows, and hydraulic deficiencies under peak flow conditions. This analysis focused on the City's larger-diameter sewer systems, primarily downstream of key sewersheds and pump stations.
4. *Transition the hydraulic model files to City staff and provide training*. The model was created with EPA SWMM version 5.1 which is available as a free download from the EPA's website. This task will be completed following the submittal of this memo and will ensure that staff have an understanding of the model structure and capabilities.

C. Hydrology

1. <u>Antecedent Moisture Model (AMM)</u>

This study utilizes the AMM, which is a continuous hydrologic model that can accurately account for antecedent moisture and its effect on sanitary sewer wet weather response over continually varying climate conditions. Antecedent moisture is a term that describes the relative wetness or dryness of a sewershed. The AMM takes into consideration the ground's moisture and more accurately predicts the sewershed response to base groundwater flow and rainfall dependent inflow and infiltration over an extended period of time using rainfall and air temperature data.

2. <u>Development of Antecedent Moisture Model</u>

AMMs were developed for Meter District 3 and the WWTP. Other metered districts had wet weather flow responses that were too low to develop a reliable hydrologic model. The metering data for the other districts was necessary to determine that inflow and infiltration during wet weather was not a major concern. With the meter data successfully demonstrating that they were in good shape, Meter District 3 and the WWTP could be focused on.

Once the meter and rain data were formatted and filtered, meter math was conducted for each meter district in order to isolate the contributing sewersheds for each meter. The meter districts are shown in Figure E-1 with the meter math used to determine the flows from each district.

Long term hourly rainfall data used for the AMM frequency analysis were obtained for the period of 1958-2013 through the National Oceanic and Atmospheric Administration's (NOAA) website from COOP: 208246. This station is located within 2.3 miles of the Wastewater Treatment Plant. Daily temperature data for the same time period were obtained from the Cherry Capital Airport Weather Station (WMO: 726387).

3. Calibration

Six months (March 27 – September 4, 2015) of meter data were used to build and calibrate the AMM. To calibrate the models, the diurnal flow pattern was filtered out and specific storms were defined. The daily diurnal flow pattern was filtered so that the resulting observed flow signal only contained inflow and infiltration (I/I). The storms that were chosen were based on the total event rainfall. These storms each have a minimum of 0.5 inches of total rainfall and generally consist of uniform rainfall distribution. The storm events used in this analysis are listed in Table E-1. Only the May 24 – 25th storm exceed the 24-hour 1-year storm event rainfall (2.0 inches) as defined by NOAA's Atlas 14 Precipitation Frequency Estimates.

Table E-1: Summary of Model Storms -- 2015 Temporary Monitoring Period

Storm Events	Total Rainfall (in)
4/9/2015*	1.1
5/24/2015	2.1
8/2/2015	1.3
8/18/2015	1.0

** The 4/9/2015 storm event was not used for Meter District 3 AMM model calibration due to changing diurnal patters that prohibited proper filtering of the diurnal flows.*

Calibration adjustments were made based on the model flow fitting the observed meter flow data as accurately as possible.

4. Accuracy of Fit

To quantify the percent error of peak flows and volumes for each storm, accuracy of fit plots were created. These plots are illustrated in Appendix E-A. For each storm, the total errors for peak flow and volume were calculated as well as the net error of each. Net error is the average of all the errors and allows positive and negative values. Total error is the average of the absolute value of the errors. The goal of this study was to reach a net error close to 0 percent and a total error less than 20 percent. The summary of the calculated net and total errors is listed in Table E-2. Negative values indicate that the AMM under-predicts and positive values indicate that the AMM over-predicts the observed flows.

Table E-2 Summary of Net and Total Error for Each AMM Model

	Net Peak Error	Total Peak Error	Net Volume Error	Total Volume Error
Meter District 3	-3.7%	3.7%	23.0%	23.0%
WWTP	-1.0%	12.8%	1.5%	3.6%

Due to issues with the flow meter data from Meter 3, only one storm was used for accuracy of fit analysis for Meter District 3. The May 24th storm was the largest storm and was used for this purpose. The total errors indicate that the AMM predicted peak flows and peak volumes to within 13% of observed values for the WWTP and 23% of observed values for Meter District 3. Net errors indicate that the AMM for the WWTP was not biased towards over- or under-prediction of flows or volumes while the AMM for Meter District 3 tended to over-predict volumes. Because of high variability in the Meter 3 data and unusual storm event responses, the model was purposefully kept more conservative in volume predictions.

5. Validation

It is preferable to verify a model's performance against storm events not used in the calibration. In this case there were insufficient suitable storms to perform this validation. For most districts, there was no discernable wet weather response in the flow metering data, and the Ten State Standards formula combined with average flows from metering was used to establish peak flows.

6. Frequency Analyses

A frequency analysis was performed for each model to determine the expected 10- and 25-year frequency peak flows. The calibrated AMMs were used in conjunction with temperature and precipitation data from the period of 1958 to 2013 to estimate annual peak flows. The Log Pearson Type III methodology was then used to determine the design 10-year and 25-year peak flows listed in Table E-3. The plots also include the 95% confidence interval and are illustrated in Appendix E-B.

Table E-3 Summary of Peak Flows

Model	10-year (cfs)	25-year (cfs)
Meter District 3	3.4	4.1
WWTP	12.7	14.1

7. Benchmarking

In order to adequately characterize Traverse City's wastewater collection system, the modeled wet weather response was compared to those of other Midwest U.S. collection systems. OHM Advisors has, through similar analyses, developed a benchmarking tool that allows for comparisons to 56 other metered sewer districts in the Midwest U.S.

The peak flows and capture coefficients predicted from the AMMs for a 1-inch, 1-hour event are presented in Table E-4 along with a typical Midwest collection system for comparison. Figure E-2 and E-3 provide a graphical comparison of the peak flow and capture coefficients at the WWTP and Meter District 3 compared to other Midwest collection systems. These figures reveal that Traverse City's collection system as a whole has less inflow and infiltration than any other system that OHM Advisors has modeled. Meter District 3 has high peak flows with a lower capture coefficient, suggesting that inflows are creating high peak flows and little infiltration is occurring causing a smaller volume of the storm to be captured. This may indicate the presence of directly connected stormwater sources in this district, which may be cost effective to locate and remove.

Table E-4 Peak Flow (cfs per 1,000 acres) and Capture Coefficient (%)

Model	Peak Flow (cfs per 1,000 acres)	Peak Flow Benchmark Ranking	Capture Coefficient (%)	Capture Coefficient Benchmark Ranking
Meter District 3	4.4	82.5%	1.2%	10.5%
WWTP	0.2	0%	0.1%	0%
Typical Midwest System	2.0	50%	2.6%	50%

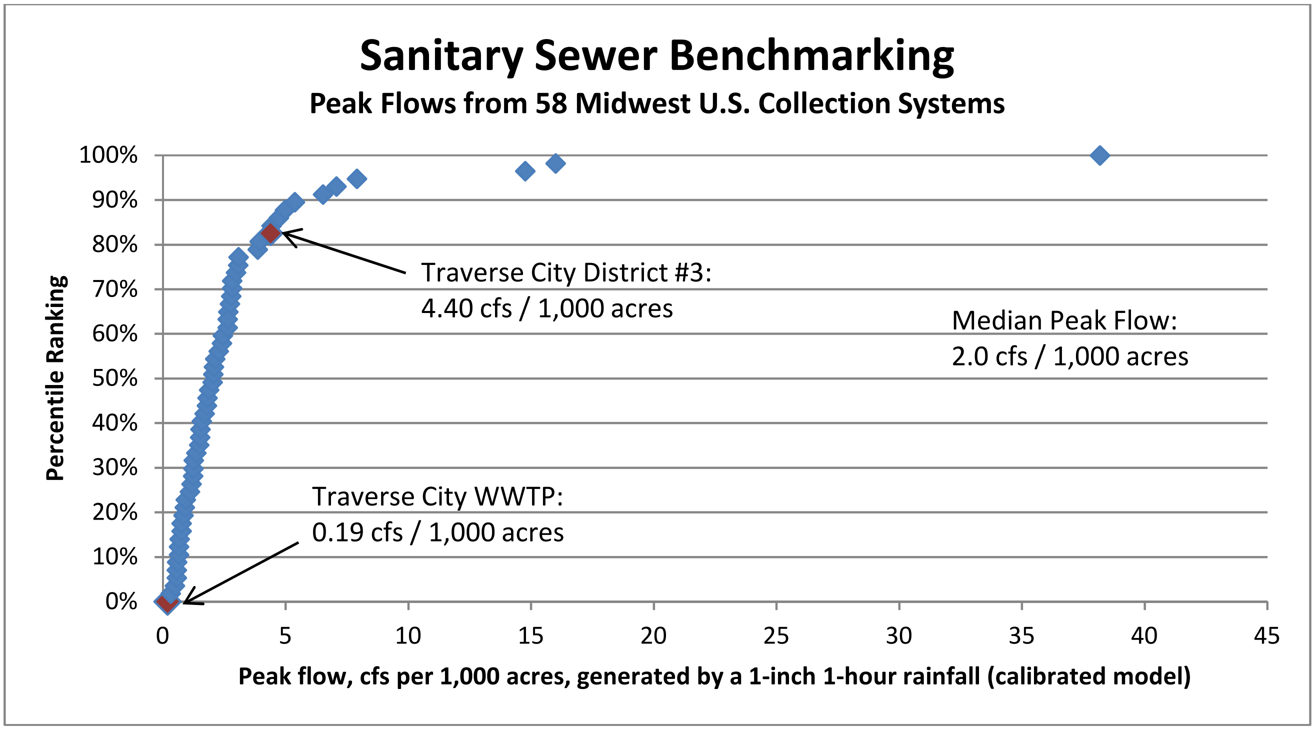


Figure E-2: Peak Flows from 58 Typical Midwest U.S. Collection Systems

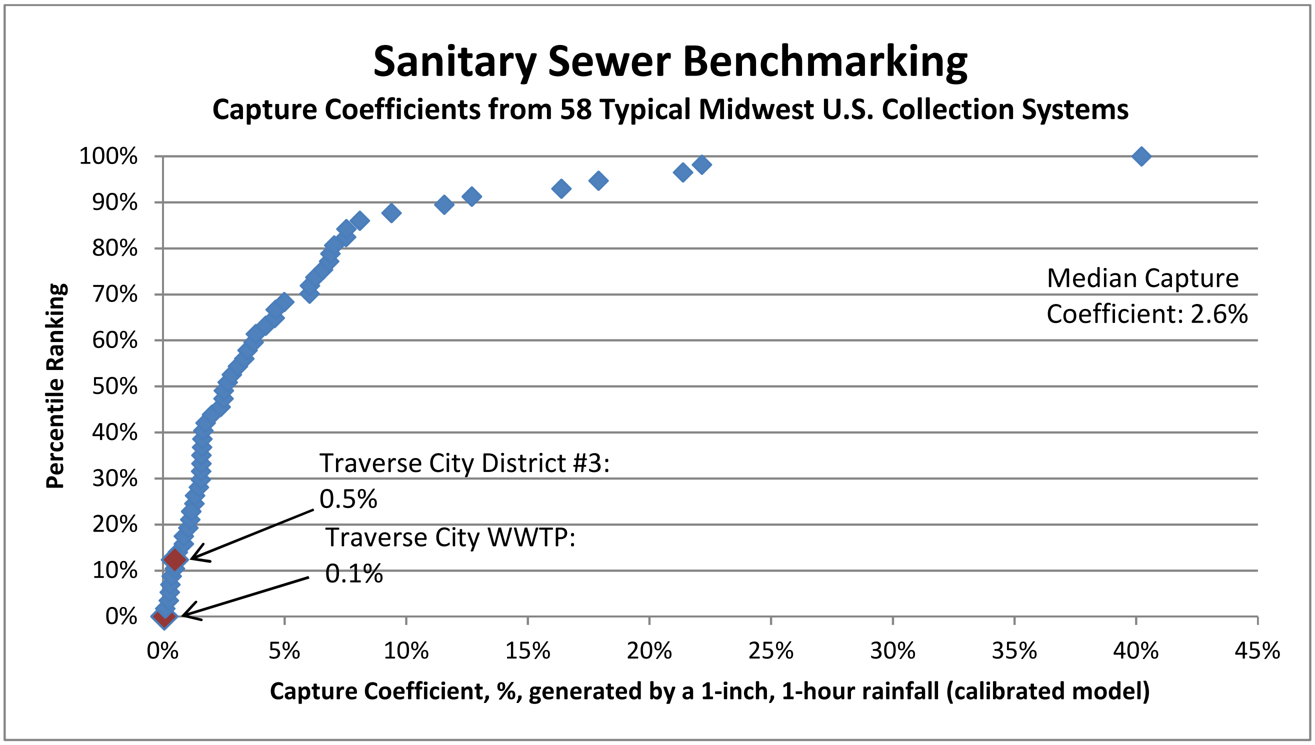


Figure E-3: Capture Coefficients from 58 Typical Midwest U.S. Collection Systems

8. Lake Michigan Level

Due to Traverse City's location on a bay of Lake Michigan, it is very possible that lake levels could be a driving factor in groundwater infiltration. Lake level data alongside monthly WWTP flows was provided by the City and is included in Appendix E-D. The monthly flows make it difficult to extract historical diurnal patterns and differentiate between changes in flows from groundwater and flows from other sources. More recent lake level data was also obtained from the US Army Corps of Engineers. As shown in Figure E-4, lake levels during the meter data collection were above average. Elevated lake levels continued into 2016. Groundwater levels and infiltration of groundwater into pipes as a result of these levels is taken into account in the base flow when calibrating the AMMs. A complete analysis of lake levels was outside the scope of this study and it is uncertain how lake levels will behave in the future.

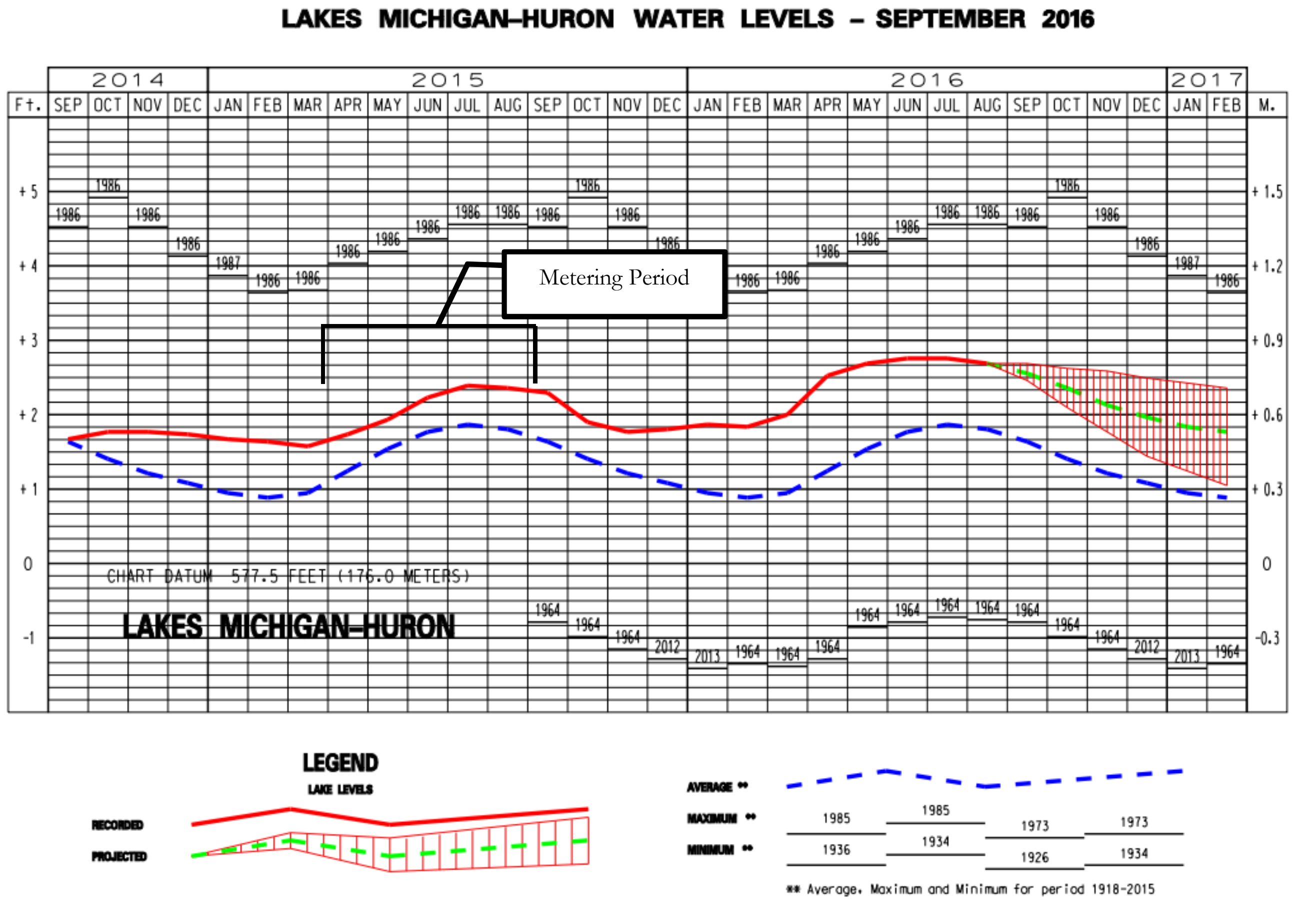


Figure E-4: Lake Michigan and Huron water levels and predictions from US Army Corps of Engineers

D. Hydraulic Model

1. Development of Hydraulic Model

A hydraulic model was created using EPA-SWMM and Traverse City's existing GIS data. LIDAR data was used where GIS data did not provide manhole rim elevations. Traverse City supplied additional information for the siphon located at Front and Oak Street and the siphon under Kids Creek. The major trunks of the collection system that ran east and west through downtown Traverse City were the focus of the hydraulic model, as these sewers convey the majority of flow in the City's collection system. Flows from the west side of the city were modeled starting at Meter 2 (South Oak Street between 6th and 7th street), following the main trunk north on South Oak until intersecting with the 18-inch and 21-inch sewers just north of West Front Street, and then east under the Boardman River until it reached the

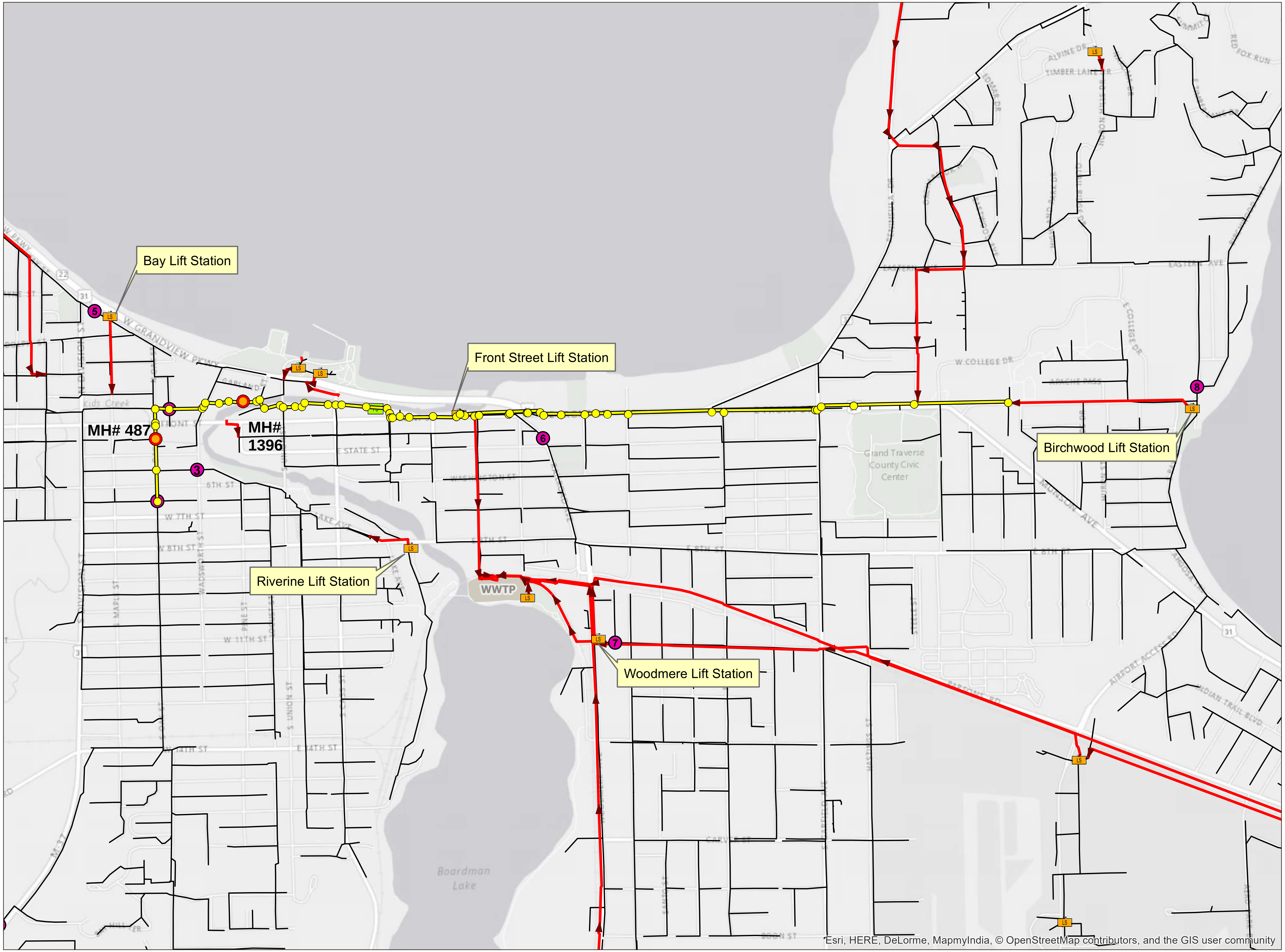
Front Street lift station. Flows for the east side of the city were modeled starting at the downstream end of the Birchwood force main and traveling west along East Front Street until also converging at the Front Street lift station. The modeled sections of the system are illustrated in Figure E-5.

The Ten State Standards design peaking factors for peak hourly flows were used in conjunction with average flows from meter data to estimate peak flows for all districts except Meter District 3, which demonstrated higher wet weather responses. Population information for the peaking factor calculations was determined for each area using ESRI's GIS-based U.S. Census Bureau 2010 Census Information. The modeled peak flows, summarized in Table E-5, were compared to the peak flows obtained from 2015 metering data and the 10-year peak flows from the AMM for Meter District 3 and the WWTP. The highest predicated peak flow from each method was used in the model to increase confidence that the EPA SWMM model would not under predict flows within Traverse City and to surpass the minimum 10-year flow event requirement for this model.

Table E-5 Summary of Peak Flows

<table>
<tr><th>Meter District</th><th>2015 observed peak flow (cfs)</th><th>AMM 10-year peak flow (cfs)</th><th>Ten State Standards peak flow (cfs)</th><th>Peak flow used in model (cfs)</th><th>Manhole at which modeled flows were added</th></tr>
<tr><td>1</td><td>1.3</td><td></td><td rowspan="2">4.4</td><td rowspan="2">4.4</td><td rowspan="2">333</td></tr>
<tr><td>2</td><td>1.4</td><td></td></tr>
<tr><td>3</td><td>2.4</td><td>3.4</td><td>1.6</td><td>3.4</td><td>481</td></tr>
<tr><td>4</td><td>1.1</td><td></td><td rowspan="2">3.0</td><td rowspan="2">3.0</td><td rowspan="2">211</td></tr>
<tr><td>5</td><td>0.7</td><td></td></tr>
<tr><td>6</td><td>0.4</td><td></td><td>0.4</td><td>0.4</td><td>1496</td></tr>
<tr><td>7</td><td>1.2</td><td></td><td>1.4</td><td>1.4</td><td>WWTP</td></tr>
<tr><td>8</td><td>0.4</td><td></td><td>0.7</td><td>0.7</td><td>1452</td></tr>
<tr><td>East</td><td rowspan="5">not metered</td><td></td><td>1.0</td><td>1.0</td><td>WWTP</td></tr>
<tr><td>Northeast</td><td></td><td>0.8</td><td>0.8</td><td>1452 (42%)
1470 (34%)
880 (17%)
1458 (7%)</td></tr>
<tr><td>South Central</td><td></td><td>1.0</td><td>1.0</td><td>WWTP</td></tr>
<tr><td>Airport</td><td></td><td>0.01</td><td>0.01</td><td>WWTP</td></tr>
<tr><td>Central</td><td></td><td>0.3</td><td>0.3</td><td>1499 (60%)
1399 (40%)</td></tr>
<tr><td>WWTP</td><td>9.0</td><td>12.7</td><td>14.6</td><td>16.4</td><td></td></tr>
</table>

Peak flows were added to the hydraulic model at the manholes downstream of the temporary meters where a district's flow entered a modeled trunk. The manholes where flows were introduced are listed in Table E-5 and correspond to the manhole numbers in the GIS provided by Traverse City. In some cases, flows from multiple districts entered the modeled trunk at the same manhole and the peak flows were summed. Districts with manholes along the modeled trunk that weren't directly metered had their flows split between multiple manholes with flows proportional to the upstream acreage for that individual manhole. In this situation the percentage of the district's total peak flow added to each manhole is also shown in Table E-5. Lastly, four of the districts never contributed to flows in the modeled trunks. These are considered only as additional flows to the WWTP and are not present in the hydraulic model.



Traverse City

Figure E-5. Modeled Sanitary Trunk

Legend

- 2015 Meter Locations
- Lift Station
- Pump Station
- Force Main
- Sanitary Gravity Main
- Modeled Manholes
- Modeled SSO at Manhole
- Modeled Trunk

0 1,300 2,600
Feet

1" = 1,300'

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 HARN StatePlane Michigan North FIPS 2111 Feet Intl

Map Published: May 23, 2017

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P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\Figure E-5 Modeled San Mains.mxd

E. Evaluation of System Deficiencies

1. Hydraulic Model – Anticipated problem areas

Using peak flow rates established with Ten State Standards peaking factors and results from the AMM, the EPA SWMM model was used to simulate hydraulic conditions during peak flows. The model demonstrated that the main trunk handling flows from the east side of the city has sufficient capacity to handle peak flows with no surcharging or sanitary sewer overflows (SSOs). On the other hand, the main trunk handling flows on the west side of the city showed significant surcharging with a model-predicted SSO at MH #487 on South Oak Street. This manhole is called out in Figure E-5 and is the location of a pipe diameter change from 24-inch upstream to 12-inch downstream. This pipeline diameter decrease precedes a double barreled siphon with a 12-inch and 10-inch line. Profile views from the model for the east and the west side are presented in Appendix E-C Figures E-C.1. and E-C.2.

The model was then run with the 335 feet of 12-inch diameter pipe near the Oak Street Siphon upgraded to a 24-inch diameter pipe. This removed the most significant restriction within the main trunk on the west side and was used to determine the success improvements would have on the system hydraulics. Surcharging was significantly reduced with this upgrade. The predicted SSO at MH#487 was removed, however the problem moved downstream and a SSO was predicted at a low elevation manhole just upstream of the Boardman River Siphon (MH#1389). Figure E-C.3. shows the new profile view for the west side of the city and Figure E-5 depicts the location of this new SSO.

To address the new SSO at manhole #1389, the 2,910 ft of 24-inch diameter pipe downstream of the Boardman River siphon was upgraded to 30-inch diameter pipe. This removed the predicted SSO and surcharging was eliminated with the exception of a 695 foot section of 21-inch diameter pipe directly downstream of the Oak Street Siphon. Figure E-C.4 shows these upgrades. A further upgrade of this section of 21-inch diameter pipe to 30-inch eliminated the remaining surcharging. The profile of the system with all recommended upgrades is shown in Figure E-C.5.

The last scenario evaluated was a reduction in peak hour flows from Meter District 3. Peak flows could likely be reduced by removing infiltration and inflow sources through a Sanitary Sewer Evaluation Survey (SSES). The peak flow used for this model was determined using the Ten State Standards peaking factor calculation. As shown in Table E-5, this would be a reduction in Meter District 3 peak flows from 3.4 cfs to 1.6 cfs. This scenario does not require any pipe size upgrades and would address the model-predicted SSOs. However, significant surcharging would still be present along most of the western trunk under this scenario. A profile view from this scenario is presented in Figure E-C.6. A reduction in peak flows of this magnitude from source removal is not guaranteed and therefore use of other upgrades is recommended in conjunction with source removal.

2. <u>Flow Meter Limits at WWTP</u>

During the September 5, 2014 rain event in Traverse City, the peak flow at the WWTP could not be accurately established because the flow meter maxed out at 9.5 cfs causing a flat line (Figure E-6). Maxing out of the meter was seen in several other locations in the 2013-2015 5-minute interval data for the WWTP. To accurately record peak flows at the WWTP the flow meter should be upgraded to one that can record higher maximum flows. Given our prediction of design-event peak flows exceeding 12 cfs, the flow capacity of the WWTP influent meter should at a minimum exceed this flow.

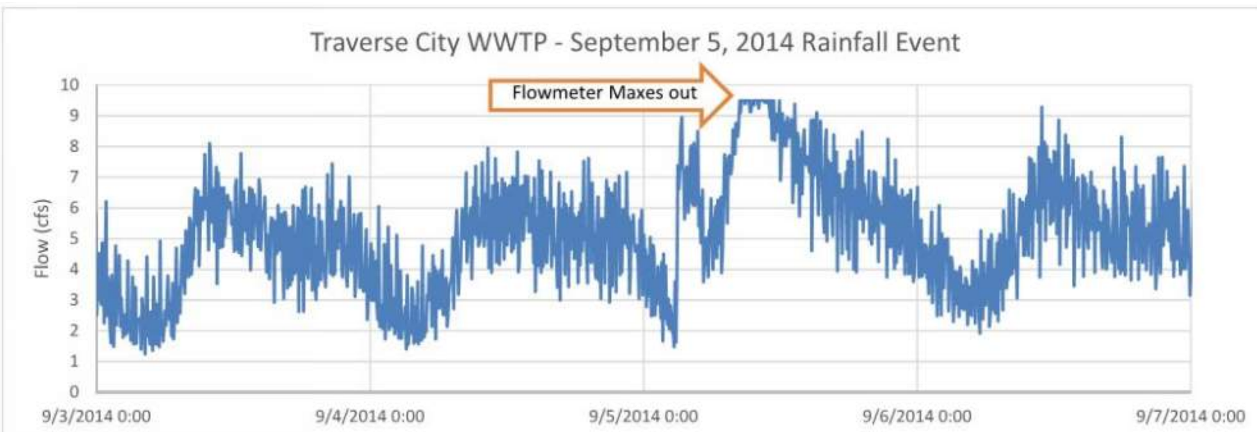


Figure E-6: Flows recorded at WWTP during the September 5, 2014 storm event

3. <u>Lift Station Evaluation</u>

The capacities of major lift stations within Traverse City were compared to expected inflows from the peak flow model. Only lift stations that were associated with the calculated peak flows were evaluated. This caused the Clinch Park and Hall lift stations to be excluded Predicted flows were proportionally scaled based on acreage if only part of a meter district contributed to lift station flows. A summary of lift station capacities and expected peak flows is presented in Table E-6. Several lift stations were identified as having firm capacities below the estimated peak flows.

Although we are not recommending immediate pump replacement, the City should consider upgrading the firm capacities to match the modeled peak flows in Table E-6 when the existing pumps reach the end of their respective useful lives. In some cases, this may require more substantial facility improvements, including force main replacement.

Table E-6 Lift Station Capacities and Peak Flows

Lift Station	Firm Capacity (gpm)	1997 Pump Test Capacity (gpm)	Upstream Area	Modeled Peak Flow (gpm)
Riverine	350	-	Meter District 3 (45 ac)	180
Bay	430	560	Meter District 5	516
Front Street	6200	6200	Total Modeled Flows	5198
Birchwood	800	-	Meter District 8	314
Woodmere	450	670	Meter District 7 + South Central (100 ac)	646
Coast Guard	400	535	Airport Meter District (454 ac)	18*
TBA	700	760	Airport Meter District (670 ac)	27*

Capacities in red are exceeded by modeled peak flow.

**These peak flows are associated with unmetered districts where flows were distributed based on residential populations. Flows are transported directly to the WWTP and not part of the modeled collection system trunks. They are likely higher than indicated because of flows from non-residential sources.*

F. Evaluation of Alternatives and Recommendations

Flow meter information for the WWTP does not accurately capture actual peak flows due to a maximum measurement capacity of 9.5 cfs. It is recommended that the flow meter at the WWTP be upgraded to one that is capable of measuring flows up to 16-18 cfs. This accommodates the projected design-event flows and provides additional flexibility for future growth in the collection system.

Lift Station pump capacities at Bay and Woodmere were insufficient for the modeled peak hour flows. When pumps at these stations need to be replaced due to pump/motor equipment condition, larger capacity pumps should be considered.

During the estimated peak hour flows, surcharging and SSOs are predicted in the hydraulic model for the main collection system trunk on the west side of the city. To correct these concerns, it is recommended that the following upgrades be completed if flows can't be reduced:

- 335 feet of 12-inch diameter pipe along South Oak Street upgraded to 24-inch
- 695 feet of 21-inch diameter pipe downstream of the Oak Street Siphon upgraded to 30-inch
- 2,910 feet of 24-inch diameter pipe downstream of the Boardman River Siphon upgraded to 30-inch

The conditions of the pipes at these recommended upgrade locations were reviewed when recent CCTV inspections were available. The 12-inch diameter pipe on South Oak Street upstream of the inverted siphon was in relatively good condition but could not be fully inspected because of high water levels caused by the siphon. The 12-inch pipe directly downstream of the siphon had some longitudinal cracks, suggesting an upgrade of the pipe in this location would also be structurally beneficial. Most of the remaining locations were lined less than 15 years ago and were not inspected. Those that were inspected were in good shape structurally with a few O&M concerns from the presence of deposits and high water marks. The relative good shape of the system supports actions to reduce flows before proceeding with upgrades.

Meter District 3 was identified as one of the main sources of increased wet weather flows. AMM results and benchmarking information suggest that inflows are the most prevalent flow source in District 3 and infiltration is minimal. Removal of these inflow sources will serve to further reduce peak flows and surcharging in the system and may reduce the amount of recommended upgrades. It is suggested that a SSES that includes smoke testing should be conducted in this district to locate possible direct connections (i.e. roof drains, footing drains, etc.) before the above upgrades are performed.

In addition to the SSES, it is recommended that basement surveys are conducted along the western trunk. These surveys would provide information on the degree of surcharging that could be present without causing basement flooding and help prioritize pipeline upgrades. Following these surveys, an additional flowmeter study should be conducted for District 3 to determine the extent that wet weather flows were eliminated. Based on the results, it can be re-evaluated which pipeline upgrades are required. A recommended schedule and estimated costs for completing these activities is below.

Table E-7 Summary of Recommended Actions and Estimated Costs

	Task	Estimated Cost	Time Frame
1	Upgrade WWTP flow meter to one capable of recording flows up to 16-18 cfs.	$10,000	Year 1-2
2	Conduct Sanitary Sewer Evaluation Survey (SSES) with smoke testing in Meter District 3 to locate and remove inflow sources.	$30,000	Year 1-2
3	Conduct basement surveys along western trunk to identify allowable surcharging levels.	$12,000	Year 1-2
4	Clean and televise siphons. Based on the televising, plan for rehabilitation (regular cleaning) or replacement of siphon(s)	$25,000	Year 1-2
5	Perform additional metering in District 3 to evaluate new wet weather flows. Re-evaluate the recommended upgrades based on new flows.	$30,000	Year 3-5
6	Plan funding for recommended system upgrades.	-	Year 6-7
7	Perform recommended upgrades to the system. Current recommendations are to upgrade the 355 feet of 12-inch diameter sewer main along South Oak Street to 24-inch sewer, 695 feet of 21-inch diameter pipe downstream of the Oak Street Siphon to 30-inch, and 2,910 feet of 24-inch diameter pipe downstream of the Boardman River Siphon upgraded to 30-inch.	$2,705,000*	Year 8-10
8	Install larger capacity pumps (and, if necessary, force mains) for Bay and Woodmere during scheduled pump replacements	N/A**	During scheduled replacements

**Upgrade recommendations may change with completion of recommended surveys and metering. Construction method to be determined during preliminary design. Cost estimate assumes significant regulatory and geotechnical issues*

***Pump station upgrades are not included in this cost estimate, as they will occur as part of ongoing pump station operations and planned pump replacements as components age out. Pump station replacement costs and future force main rehabilitation and replacement costs are covered in separate technical memoranda.*

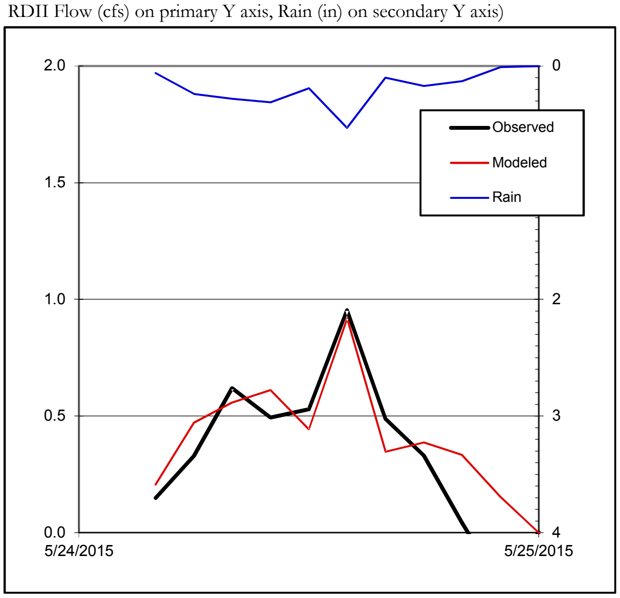
Appendix E-A: AMM Accuracy of Fit Figures

Traverse City Sanitary Sewer Wet Weather Evaluation Project - Antecedent Moisture Model - Accuracy of Fit Analysis
Meter District #3 -2015

Storm	Rain (in)	Observed Peak (cfs)	Model Peak (cfs)	Peak Flow Error (%)	Observed Vol (1000's cf)	Model Vol (1000's cf)	Volume Error (%)	Notes
05/24/15	2.05	0.95	0.92	-3.7%	13	17	23.0%	
08/02/15	1.32							
08/18/15	1.04	**Storms removed from the analysis due to issues with the data.**						

Net Average Error	-3.7%		23.0%
Total Average Error	3.7%		23.0%

RDII Flow (cfs) on primary Y axis, Rain (in) on secondary Y axis)



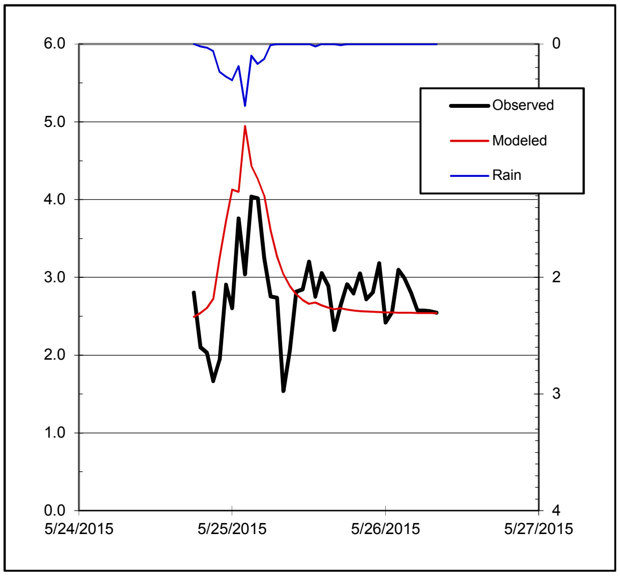
Traverse City Sanitary Sewer Wet Weather Evaluation Project - Antecedent Moisture Model - Accuracy of Fit Analysis

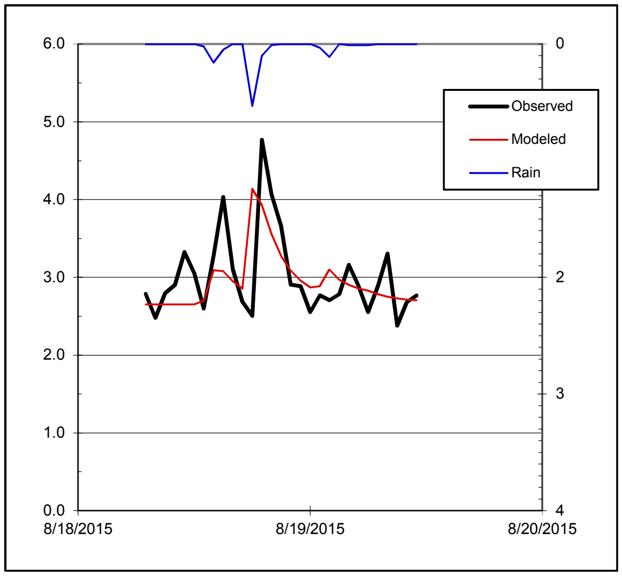
Meters-WWTP - 2015

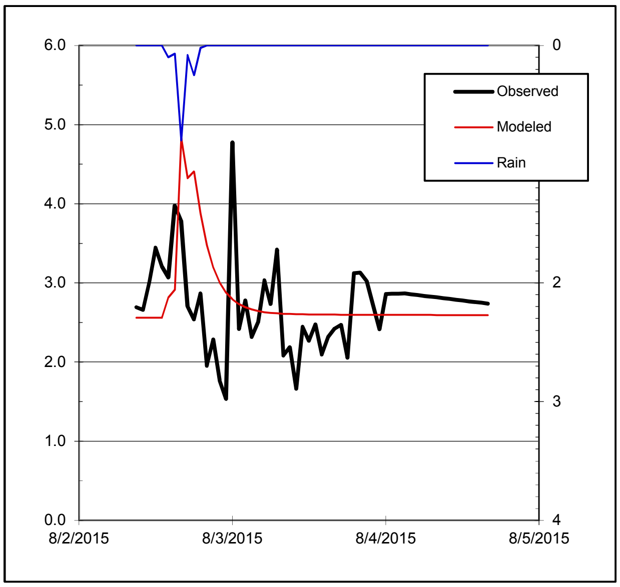
Storm	Rain (in)	Observed Peak (cfs)	Model Peak (cfs)	Peak Flow Error (%)	Observed Vol (1000's cf)	Model Vol (1000's cf)	Volume Error (%)	Notes
05/24/15	2.1	4.04	4.95	22.5%	394	425	7.9%	
08/18/15	1.04	4.77	4.14	-13.2%	324	318	-1.8%	
08/02/15	1.32	4.78	4.83	1.2%	557	569	2.2%	
04/09/15	1.05	3.92	3.36	-14.5%	294	287	-2.3%	

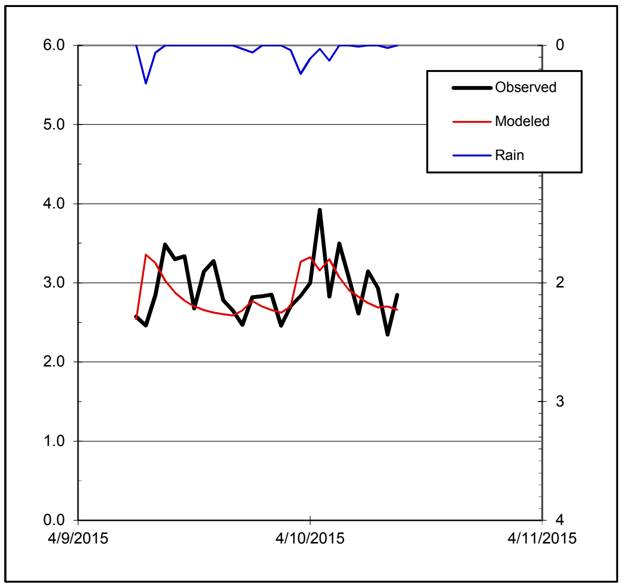
Net Average Error	-1.0%		1.5%
Total Average Error	12.8%		3.6%

RDII Flow (cfs) on primary Y axis, Rain (in) on secondary Y axis)

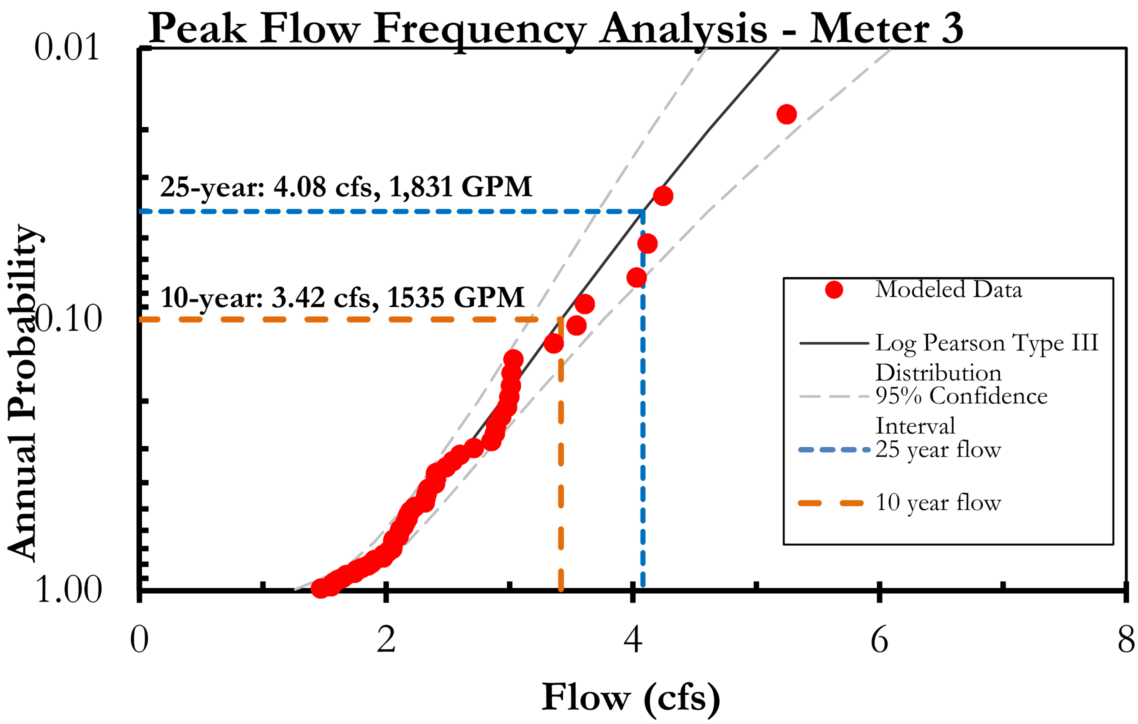




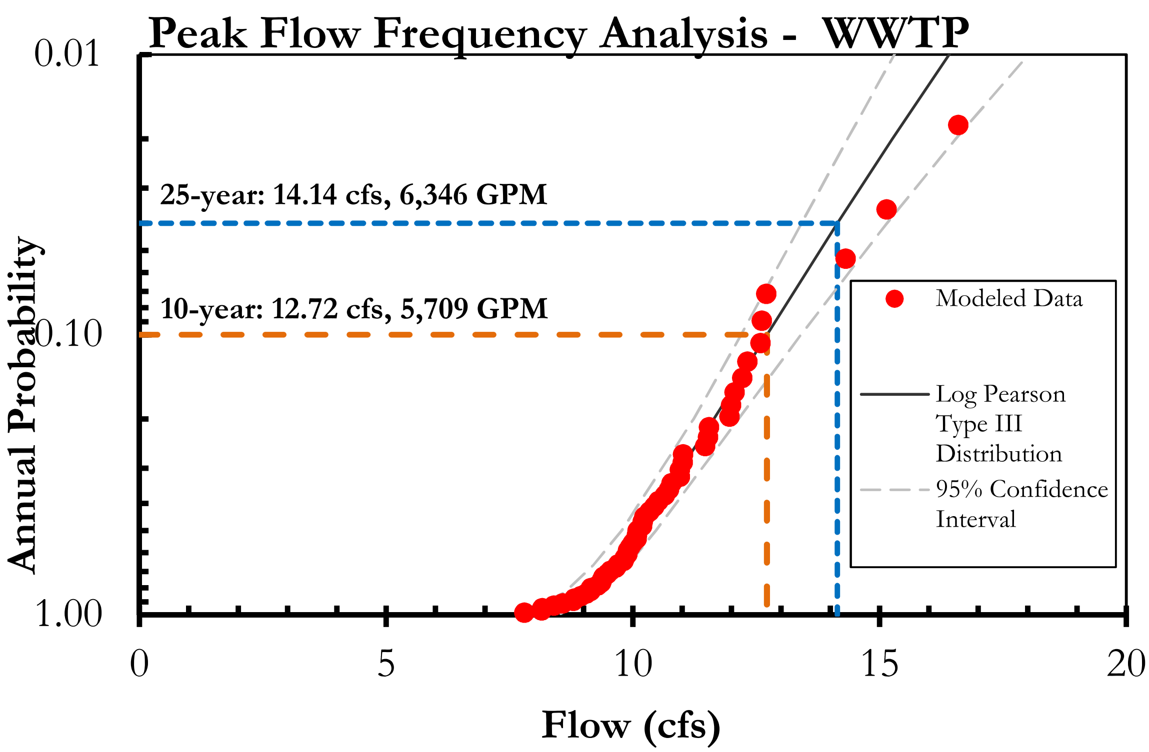




Appendix E-B: AMM Frequency Analysis Figures



Peak Flow Frequency Analysis - Meter 3
0.01
0.10
1.00
Annual Probability
25-year: 4.08 cfs, 1,831 GPM
10-year: 3.42 cfs, 1535 GPM
Modeled Data
Log Pearson Type III Distribution
95% Confidence Interval
25 year flow
10 year flow
0
2
4
6
8
Flow (cfs)



Peak Flow Frequency Analysis - WWTP
0.01
0.10
1.00
Annual Probability
25-year: 14.14 cfs, 6,346 GPM
10-year: 12.72 cfs, 5,709 GPM
Modeled Data
Log Pearson Type III Distribution
95% Confidence Interval
0
5
10
15
20
Flow (cfs)

Appendix E-C: SWMM Model Profiles

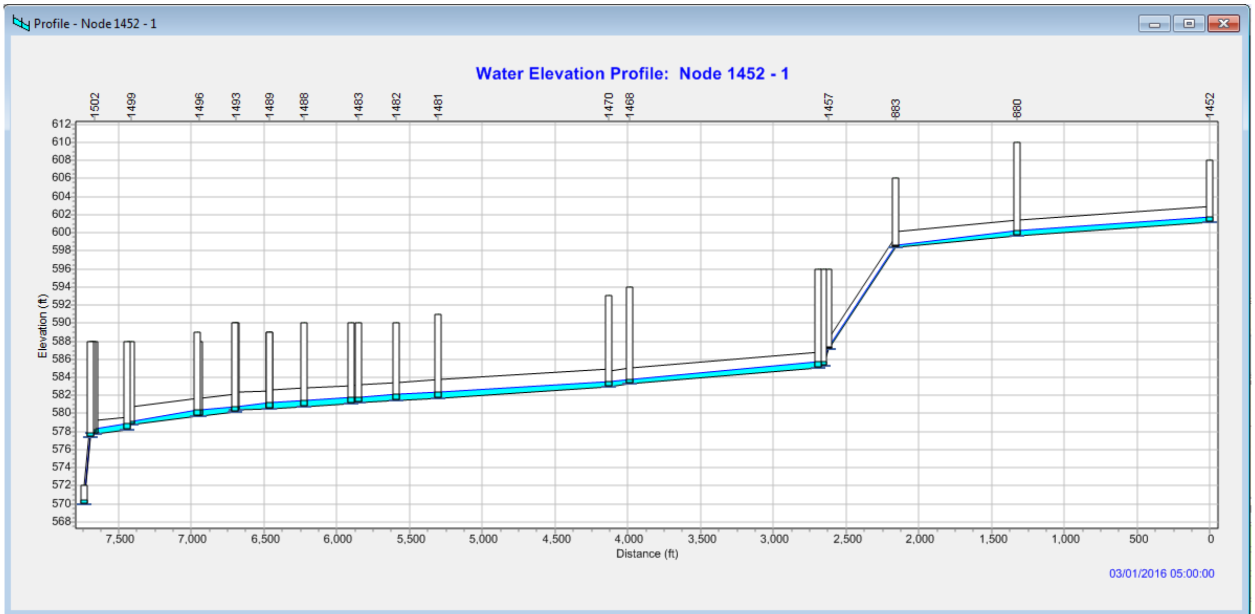


Figure E-C-1: East side during peak hourly flows
No SSOs or surcharging

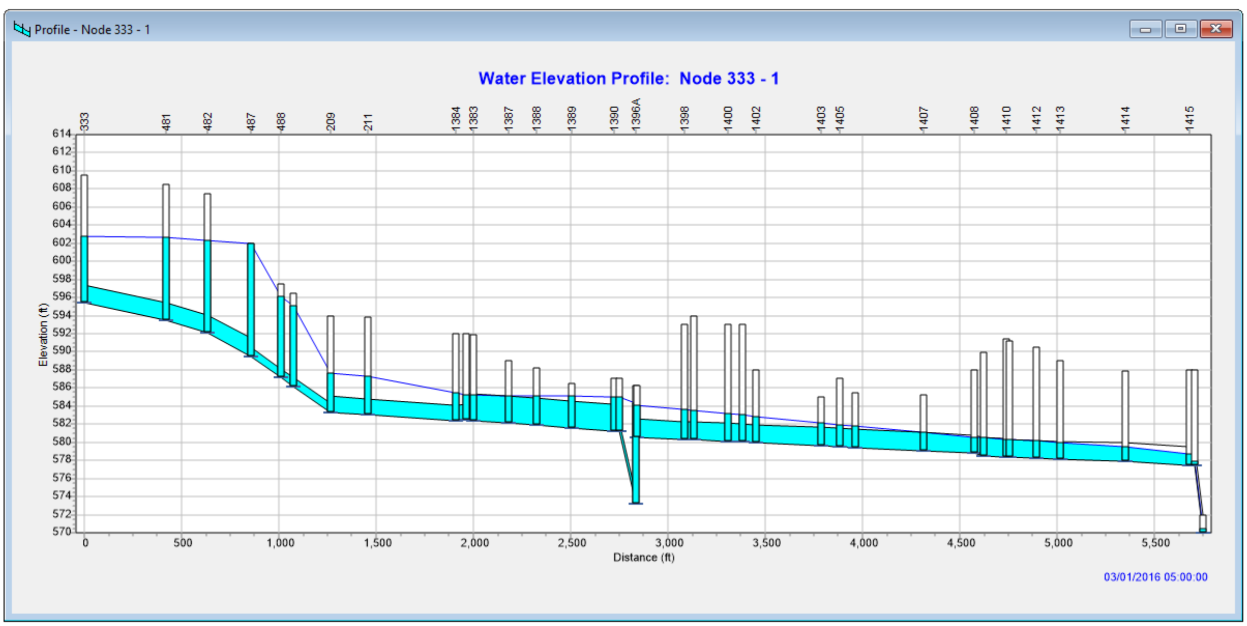


Figure E-C-2: West side during peak hourly flows
Surcharging along line and SSO occurs at MH#487

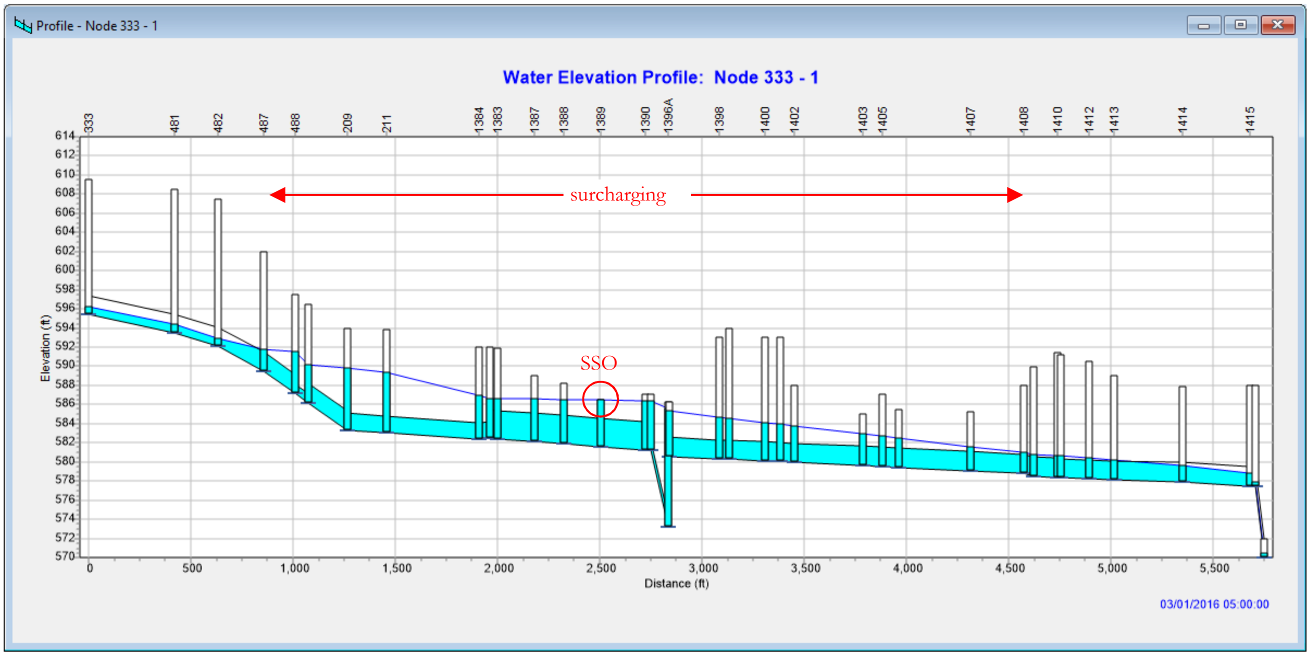


Figure E-C-3: West side during peak hourly flows with 12" lengths upgraded to 24"
Reduced surcharging upstream, increased surcharging downstream, and SSO now at MH#1389

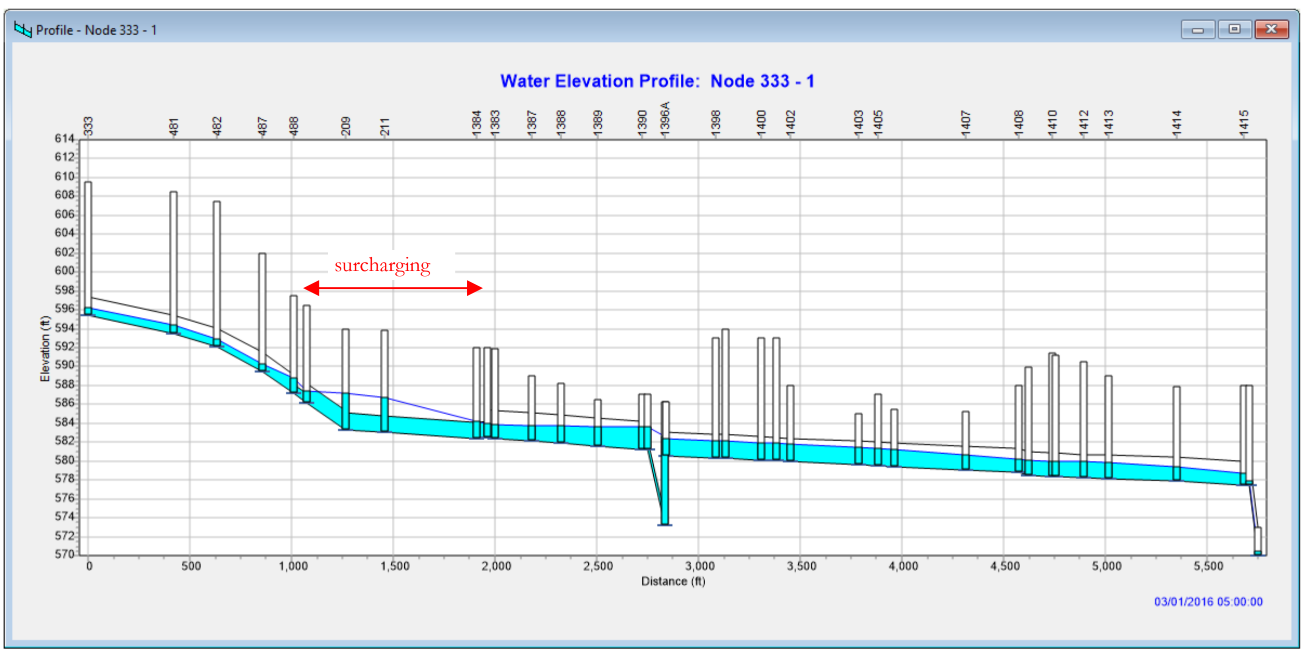


Figure E-C-4: West side during peak hourly flows with all 12" lengths upgraded to 24" and 24" downstream of Boardman Siphon upgraded to 30"
SSO removed and surcharging greatly reduced

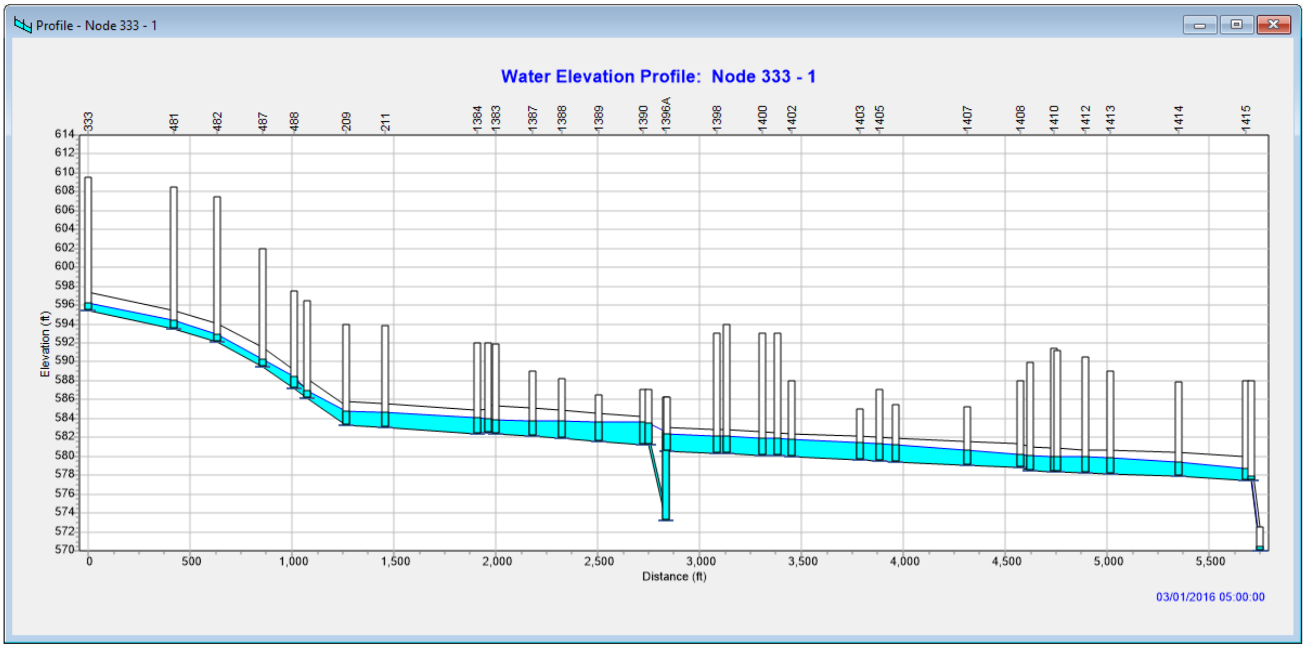


Figure E-C-5: West side during peak hourly flows with all 12" lengths upgraded to 24", all 24" downstream of Boardman Siphon upgraded to 30", and all 21" upgraded to 30"
No SSOs and no surcharging present

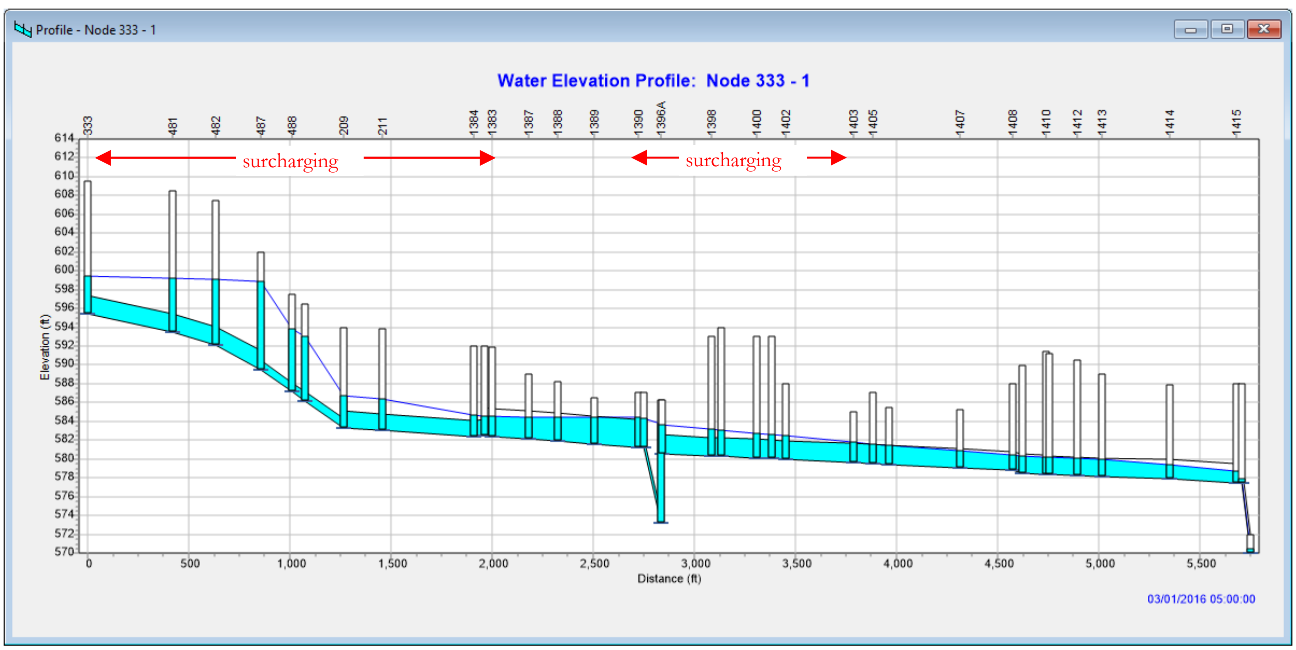


Figure E-C-6: West side during peak hourly flows reduced flows from Meter District 3
Significant surcharging, no SSO

Appendix E-D: Historic WWTP Flows and Lake Levels


Monthly Flow Data
Inches - MGDx10
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Jul-87 Nov-87 Mar-88 Jul-88 Nov-88 Mar-89 Jul-89 Nov-89 Mar-90 Jul-90 Nov-90 Mar-91 Jul-91 Nov-91 Mar-92 Jul-92 Nov-92 Mar-93 Jul-93 Nov-93 Mar-94 Jul-94 Nov-94 Mar-95 Jul-95 Nov-95 Mar-96 Jul-96 Nov-96 Mar-97 Jul-97 Nov-97 Mar-98 Jul-98 Nov-98 Mar-99 Jul-99 Nov-99 Mar-00
Date
Precip
Plant Flow
City Flow
12.9
11.0 90%
CAPACITY @ 15.5 MGd. MONTH
(60% CAPACITY)
PROJECTED FLOW 10.4 MGD - MONTH
PROJECTED FLOW 8.6 MGD - MONTH


Lake Levels
Elevation
582
580
578
576
Jul-87 Nov-87 Mar-88 Jul-88 Nov-88 Mar-89 Jul-89 Nov-89 Mar-90 Jul-90 Nov-90 Mar-91 Jul-91 Nov-91 Mar-92 Jul-92 Nov-92 Mar-93 Jul-93 Nov-93 Mar-94 Jul-94 Nov-94 Mar-95 Jul-95 Nov-95 Mar-96 Jul-96 Nov-96 Mar-97 Jul-97 Nov-97 Mar-98 Jul-98 Nov-98 Mar-99 Jul-99 Nov-99 Mar-00
Lake Levels
Date

Appendix F: Collection System Criticality and Capital Improvement Plan

Appendix F: Collection System Criticality and Capital Improvement

A. Criticality

Determining the assets most critical to system operation allows a community to manage risk, support Capital Improvement Plans (CIP), and efficiently allocate O&M funds. The two key factors used to determine criticality are Probability of Failure (PoF) and Consequence of Failure (CoF). PoF and CoF are multiplied to determine the Business Risk Exposure (BRE). Figure F-A-1 illustrates Traverse City's PoF for its assessed collection systems assets and Figure F-A-2 illustrates Traverse City's CoF for its collection systems assets.

PoF considers the physical condition or age of an asset and is often based on the Structural MACP or PACP Index Rating. If an asset was not inspected, predicted remaining useful life can be used as a proxy for condition. A standardized rating of one through five is assigned to each asset with a score of five being the worst condition as shown in Table F-1.

Table F-1: Probability of Failure

Score	Description
1	Improbable
2	Remote, unlikely but possible
3	Possible
4	Probable, likely
5	Imminent, likely in near future

CoF focuses on social, environmental, and economic cost impacts for a community. The economic CoF encompasses the impacts of direct and indirect economic losses to the affected organization and third parties due to asset failure (NASSCO, 2015). The social consequence represents the impact of society due to asset failure, and the environmental consequence of failure considers the impact to ecological conditions occurring as a result of asset failure (NASSCO, 2015). Each type of community impact is measure with individual CoF factors as indicated in Table F-2. The following CoF factors are combined to determine the final CoF: Network Position, Diameter of Pipe, Location of Pipe, Proximity to Sensitive Environment Features, and Top Users.

Table F-2: Consequence of Failure

Score	Description
1	Negligible, minor loss of function
2	Minimal or marginal
3	Noticeable, may suspend some operations
4	Critical, temporarily suspends operations
5	Catastrophic disruption

Table F-3: Consequence of Failure Community Impacts

CoF Community Impact	Weighting for CoF	CoF Factors
Social	25%	Location of Pipe; Diameter; Network Position; Top Users
Environmental	25%	Proximity to Sensitive Environment Features
Economic	50%	Location of Pipe; Diameter

The factors are rated on a one through five scale for each asset. Each CoF factor (Network Position, Diameter, Location, Proximity to Sensitive Environment, and Top Users) is weighted equally to calculate the CoF for each type of community impact as shown in Table F-3. The final CoF is then computed by taking a weighted average of the CoF Community Impacts as depicted in Figure F-1. The economic impacts are considered 50% of the final CoF score with social and environmental impacts each worth 25%. The final CoF score maintains a one through five scale as described in Table F-2. If one factor is deemed more important, the weighting can be skewed to give that factor more influence. The factors and their rating scales are described in the following section.

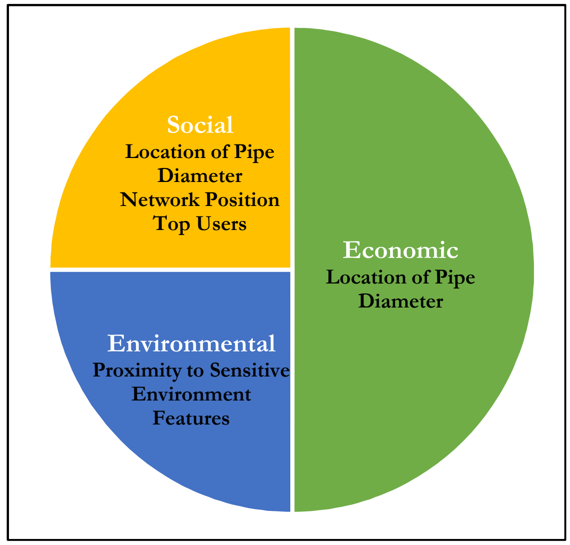


Figure F-1: CoF Community Impacts

<u>Location of Pipe:</u> The Location of Pipe factor analyzes the type of pervious surface that overlays the pipes and the Average Daily Traffic (ADT) score. An ADT score evaluates the frequency of road travel for local roads, highways, collector roads, etc. Pipes that are under pervious surfaces have a lower CoF compared to pipes under impervious locations with heavy traffic. A higher rating is an indication that repairs or replacement will likely result in higher costs due to the impervious conditions and increased disruption of traffic. For each community, the Location of Pipe rankings are scaled to represent the community more accurately.

Table F-4 is an example of the rating scale used for the Location of Pipe factor.

Table F-4: CoF Factor: Location of Pipe

Rating Scale	Description
1	Pervious: Vegetation, one or 2 driveways, small stretches of sidewalk
2	Location of pipe is under an impervious surface and has less than 5,000 vehicles travel over the surface in a day
3	Location of pipe is under an impervious surface and has between 5,000 and 10,000 vehicles travel over the surface in a day
4	Location of pipe is under an impervious surface and has between 15,500 and 10,000 vehicles travel over the surface in a day
5	Location of pipe is under an impervious surface and has 15,500 or more vehicles travel over the surface in a day

Relative Network Position of Pipe: The Relative Network Position factor is the cumulative sum of the number of pipe segments connected (discharging) to the pipe being rated (similar methodology to watershed stream order). The Relative Network Position factor scales how many customers would be affected upstream in the case of a failed pipe. A higher CoF is assigned to pipes that have a higher Relative Network Position since more customers would be affected if a pipe were to fail. Table F-5, below, is a guide to help scale Relative Network Position of Pipe.

Table F-5: CoF Factor: Relative Network Position of Pipe

Rating Scale	Description (# of Customers Impacted)
1	10 or less
2	11 – 30
3	31 – 70
4	71 – 120
5	121 or more

Top Users: Top Users are customers who are significant to the community's well-being. The Top Users factor will add risk to areas that may experience severe difficulties due to a service disruption. A higher rating is assigned to pipes that are closer in linear feet to Top Users such as hospitals, healthcare facilities, schools, or large industrial users with potentially greater health risks. Community input is often requested to help identify additional Top Users for consideration within this category. Table F-6 summarizes the rating scale.

Table F-6: CoF Factor: Top Users

Rating Scale	Description
1	20,000 LF or More
2	15,000 LF – 20,000 LF
3	10,000 LF – 15,000 LF
4	5,000 LF – 10,000 LF
5	Less Than 5,000 LF

Diameter: The Diameter factor considers the diameter of the pipes in the collection system. When large diameter pipes fail they generally cost more to repair, service, and replace. In addition, large diameter pipes generally serve more customers, so they are assigned a higher CoF. Table F-7 summarizes the rating scale.

Table F-7: CoF Factor: Diameter

Rating Scale	Description (pipe diameter)
1	Less than 10 in
2	$\geq$ 10 in - < 15 in
3	$\geq$ 15 in - < 18 in
4	$\geq$ 18 in - < 24 in
5	$\geq$ 24 in

Environmentally Sensitive Features: Environmentally Sensitive Features include railroads, drinking water source areas, and bodies of water such as rivers, creeks. Pipes may be installed within a close distance to environmentally sensitive features, which can make it difficult to access the pipe and may cause significant environmental damage if the pipe fails. A CoF factor for Sensitive Features is based on the distance between a pipe and an environmentally sensitive feature. Table F-8 summarizes the rating scale.

Table F-8: CoF Factor: Sensitive Features

Rating Scale	Description (proximity to sensitive feature)
1	150 LF or more
2	100 – 150 LF
3	75 – 100 LF
4	50 – 75 LF
5	Less than 50 LF

Pavement Surface Evaluation and Rating (PASER) is a rating system for road pavement conditions developed by the University of Wisconsin-Madison Transportation Information Center. The State of Michigan has selected PASER as the statewide standard for pavement condition. Rating one is considered a failing road and requires reconstruction, and ten is considered a road in excellent condition and needs no maintenance. PASER can help prioritize manhole or pipe replacement projects to take place during roadway replacement or reconstruction. The PASER ratings system is shown in Table F-9.

Table F-9: PASER Scale

PASER Rating	Pavement Condition
9-10	Excellent/New
7-8	Good
5-6	Fair
3-4	Poor
1-2	Failed
NA	Data Not Available

B. Business Risk Exposure and Capital Improvement Plan

A Capital Improvement Plan (CIP) is a core component of an Asset Management Plan (AMP) and an essential planning tool that allows for a community to properly plan for high cost, non-recurring projects. A CIP should detail capital needs related to future/upcoming regulations, major asset replacements, system expansions, system consolidation or regionalization, and improved technology.

The City of Traverse City CIP incorporates the Business Risk Exposure (BRE) score as well as institutional knowledge. The BRE is calculated by multiplying the Probability of Failure (PoF) and Consequence of Failure (CoF) for each asset (i.e. for each manhole or sewer segment). The BRE matrix is shown in Figure F-2. The wastewater assets in Traverse City were given high, medium or low priority based on their BRE shown in Figure F-2.

The funding needed to address the CIP projects identified from the inspected pipes is approximately $3,540,300 and from the inspected manholes is approximately $642,230. The City has currently allocated $680,000 per year to gravity sewer rehabilitation and repair and $150,000 per year to manhole rehabilitation and repair.

Consequence of Failure \ Probability of Failure	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Low Priority (1-4)

Medium Priority (5-9)

High Priority (10-25)

Figure F-2: BRE Prioritization Matrix

This CIP includes a detailed project table for an initial three (3) year planning period, with the first projects reflecting those with the highest BRE score which generated rehabilitation recommendations or those occurring near projects with the highest BRE scores. Some projects were manually moved higher on the list if a known street project will occurring in the affected area or if a higher priority project were occurring immediately adjacent to the project (to reduce mobilization costs). The capital projects for each year are provided in Table F-10 through F-15. Each table lists the associated project and associated planning-level costs. The associated projects listed are for high level planning; the City should further evaluate the wastewater infrastructure before beginning the CIP design process.

Priority of the wastewater CIP projects listed below should be revisited if any stormwater projects are occurring within the vicinity of identified rehabilitation areas for wastewater in order to reduce mobilization costs and potential pavement disturbance costs.

Since the City of Traverse City has already gone through the majority of the budget planning process for FY2017/2018, the first year of the proposed CIP begins in FY2018/2019. However, the City may choose to begin implementing high priority projects right away, should budget be available in FY2017/2018.

Table F-10: Capital Improvement Projects for Year 1 (FY2018/2019)

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM -6293	24	60	3	3	9	Grouting	$5,224.57	E. Front St
SSGM -6294	24	5	3	3	9	Cleaning	$33.80	E. Front St
SSGM -6687	8	24	1	5	5	Spot Liner(s), Cleaning	$3,486.42	Wellington St
SSGM -7986	15	161	3	4	12	Cleaning	$760.36	N. Cedar St.
SSGM -7987	15	183	3	6	18	Heavy Cleaning	$1,856.14	N. Cedar St.
SSGM -7988	15	165	3	5	15	Monitor Closely, Heavy Cleaning	$1,674.32	N. Cedar St.
SSGM -7990	18	185	4	5	20	Grouting, Cleaning, Lateral Cutting, Letter to Customer(s)	$12,304.08	N. Division St.
SSGM -8276	12	147	3	5	15	Monitor Closely, Spot Liner(s), Cleaning, Cutting and Grouting	$11,552.41	N. Division St.
SSGM -8277	12	242	2	5	10	Full Liner	$16,348.11	N. Division St.
SSGM -8278	6	221	1	5	5	Monitor Closely, Spot Liner(s), Heavy Cleaning, Cutting and Grouting	$10,921.02	N. Division St.
SSGM -8279	6	125	1	5	5	Heavy Cleaning	$1,011.29	N. Division St.
SSGM -8284	12	216	2	5	10	Spot Liner(s), Cleaning	$6,418.89	N. Division St.
SSGM -8326	15	187	2	5	10	Full Liner, Lateral Cutting	$19,582.31	N. Cedar St.
SSGM -8327	15	218	2	4	8	Grouting	$9,583.91	N. Cedar St.
SSGM -8329	6	349	3	4	12	Heavy Cleaning	$2,829.31	N. Cedar St.
SSGM -8332	15	148	3	5	15	Grouting	$6,501.88	N. Cedar St.
SSGM -8333	15	176	3	5	15	Heavy Cleaning	$1,785.72	N. Cedar St.
SSGM -8336	12	150	3	5	15	Full Liner	$10,148.06	N. Cedar St.
SSGM -8337	12	289	3	5	15	Grouting	$9,737.96	N. Cedar St.
SSGM -8342	6	70	2	5	10	Heavy Cleaning	$566.08	N. Cedar St.
SSGM -8908	24	16	4	5	20	Grouting, Spot Liner(s), Cleaning	$12,288.00	E. Front St
SSGM -8909	24	15	4	4	16	Cleaning	$102.99	E. Front St
SSGM -8910	18	224	4	6	24	Grouting, Full Liner	$41,535.45	E. Front St

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM -8911	18	26	4	6	24	Grouting, Full Liner	$4,870.60	E. Front St
SSGM -8915	24	167	3	5	15	Full Liner	$33,880.15	E. Front St
SSGM -8916	12	123	2	6	12	Full Liner	$8,286.81	E. Front St
SSGM -8917	12	97	2	6	12	Full Liner	$6,522.81	E. Front St
SSGM -8918	12	235	2	6	12	Full Liner, Letter to Customer(s)	$15,894.35	E. Front St
SSGM -8919	24	238	3	4	12	Grouting	$20,922.17	E. Front St
SSGM -8920	24	240	3	4	12	Grouting	$21,030.84	E. Front St
SSGM -8921	24	458	4	4	16	Grouting	$40,210.75	E. Front St
SSGM -8922	12	331	2	4	8	Spot Liner(s), Cleaning	$12,365.80	E. Front St
SSGM -8923	24	322	3	4	12	Grouting	$28,288.06	E. Front St
SSGM -8924	24	49	3	4	12	Cleaning	$331.73	E. Front St
SSGM -8929	24	258	3	3	9	Cleaning	$1,743.49	E. Front St
SSGM -8930	24	290	3	3	9	Cleaning	$1,960.36	E. Front St
SSGM -8932	9	196	1	5	5	Cleaning	$927.31	Barlow St.
SSGM -8933	12	193	2	4	8	Spot Liner(s)	$12,150.00	Hope St.
SSGM -8943	24	527	4	4	16	Spot Liner(s), Cleaning	$46,756.05	E. Front St
SSGM -8944	24	375	3	5	15	Full Liner	$75,875.56	Railroad Ave
SSGM -9006	18	256	2	4	8	Spot Liner(s), Heavy Cleaning	$10,859.85	Wellington St
SSGM -9007	12	268	1	5	5	Full Liner, Cutting and Grouting	$28,012.06	Wellington St
SSGM -9020	8	188	1	5	5	Spot Liner(s), Heavy Cleaning	$8,273.27	Wellington St
SSGM -9021	8	327	1	5	5	Full Liner, Cleaning	$19,217.26	Wellington St
SSGM -9022	6	202	2	5	10	Full Liner	$10,915.42	Wellington St
SSGM -9076	10	221	2	6	12	Full Liner, Heavy Cleaning	$15,205.46	E. Front St
SSGM -9077	24	249	3	3	9	Grouting	$21,810.68	E. Front St
SSGM -9082	10	302	2	6	12	Spot Liner(s), Heavy Cleaning	$6,494.43	E. Front St
SSGM -9085	10	322	2	4	8	Spot Liner(s), Heavy Cleaning, Letter to Customer(s)	$6,662.03	E. Front St

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM -10341	15	180	3	5	15	Grouting	$7,902.67	N. Cedar St.
SSGM -10343	16	17	3	3	9	Cleaning	$89.24	N. Cedar St.
SSGM -10344	16	129	3	3	9	Cleaning	$694.50	N. Cedar St.
SSGM -10345	16	97	3	5	15	Heavy Cleaning	$1,043.25	N. Cedar St.
SSGM -10347	16	13	2	3	6	Cleaning	$71.21	N. Cedar St.
SSGM -10348	15	69	2	4	8	Full Liner	$6,992.47	N. Cedar St.
SSGM -10614	12	156	2	5	10	Full Liner, Heavy Cleaning, Letter to Customer(s)	$11,821.00	Wellington St
SSGM -11660	6	52	3	3	9	Cleaning	$243.81	Wellington St
SSGM -10699	24	134	3	4	12	Cleaning	$907.75	Railroad Ave
						Estimated Total CIP Cost*	**$675,486**	

The estimated total CIP cost for Year 1 is slightly lower than the Gravity Sewer Rehabilitation & Repair annual funding. The difference in cost is made up in the estimated total CIP cost for Year 2. In the fiscal year of 2017/2018, Front Street from N. Division St. to N. Elmwood Ave will be under construction to address water main issues. Wastewater sewer pipes that are along and near this reach have been incorporated into the CIP for the 2018/2019 fiscal year in anticipation that the 2017/2018 road projects will potentially go through 2018.

Table F-11: Capital Improvement Projects for Year 2 (FY2019/2020)

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM -6286	12	414	2	5	10	Full Liner, Lateral Cutting	$28,647.30	Rose St.
SSGM -6287	10	387	2	5	10	Grouting, Spot Liner(s), Heavy Cleaning	$29,784.67	Rose St.
SSGM -6290	12	139	2	5	10	Spot Liner(s), Heavy Cleaning	$11,923.86	Wellington St.
SSGM -6685	10	354	2	5	10	Spot Liner(s), Cutting and Grouting	$18,607.02	Peninsula Dr.
SSGM -8020	10	187	2	5	10	Grouting	$5,049.00	Peninsula Dr.
SSGM -8022	12	304	2	5	10	Spot Liner(s), Letter to Customer(s)	$10,806.75	Peninsula Dr.
SSGM -8024	12	228	2	5	10	Spot Liner(s), Cutting and Grouting	$19,279.61	Peninsula Dr.
SSGM -8026	12	380	2	4	8	Cleaning	$1,794.15	Peninsula Dr.
SSGM -8027	8	208	1	5	5	Heavy Cleaning	$1,684.47	N. Garfield Ave.

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM -8028	8	197	1	5	5	Heavy Cleaning	$1,595.60	N. Garfield Ave.
SSGM -8035	10	160	2	3	6	Grouting	$4,307.70	Peninsula Dr.
SSGM -11631	12	194	2	3	6	Cleaning	$917.14	Peninsula Dr.
SSGM -8045	10	241	2	4	8	Cleaning	$1,137.04	Peninsula Dr.
SSGM -8234	12	288	1	5	5	Spot Liner(s), Cutting and Grouting	$16,206.75	Silver Dr.
SSGM -8238	12	290	2	5	10	Heavy Cleaning	$2,349.74	Silver Dr.
SSGM -8555	12	313	2	4	8	Spot Liner(s), Cutting and Grouting, Letter to Customer(s)	$17,010.22	Barlow St.
SSGM -8556	12	374	2	5	10	Grouting, Full Liner	$37,855.23	Barlow St.
SSGM -8565	10	349	2	3	6	Spot Liner(s)	$4,050.00	Woodmere Ave.
SSGM -8567	10	371	2	4	8	Spot Liner(s), Heavy Cleaning, Letter to Customer(s)	$7,062.41	Woodmere Ave.
SSGM -8568	10	349	2	5	10	Heavy Cleaning	$2,823.69	Carver St.
SSGM -8570	10	394	2	5	10	Remove and Replace, Letter to Customer(s)	$47,892.33	Woodmere Ave.
SSGM -8571	10	307	2	5	10	Heavy Cleaning	$2,490.50	Woodmere Ave.
SSGM -8611	10	313	2	4	8	Cleaning, Letter to Customer(s)	$1,487.53	S. Garfield Ave.
SSGM -8612	10	33	2	4	8	Heavy Cleaning	$264.40	S. Garfield Ave.
SSGM -8618	10	328	2	4	8	Cleaning	$1,551.29	S. Garfield Ave.
SSGM -8619	10	203	2	5	10	Heavy Cleaning, Letter to Customer(s)	$1,647.59	S. Garfield Ave.
SSGM -8626	10	333	3	4	12	Cutting and Grouting, Letter to Customer(s)	$9,908.89	S. Garfield Ave.
SSGM -8627	10	330	3	5	15	Spot Liner(s), Cutting and Grouting, Letter to Customer(s)	$15,426.12	S. Garfield Ave.
SSGM -8678	12	305	2	4	8	Cutting and Grouting	$11,331.96	Barlow St.
SSGM -8684	12	333	2	5	10	Cutting and Grouting	$12,371.97	Barlow St.
SSGM -8840	15	262	2	4	8	Full Liner, Cleaning	$27,795.72	Boardman Ave
SSGM -8975	8	300	2	4	8	Cleaning	$1,419.66	Boardman Ave
SSGM -8976	8	260	2	5	10	Spot Liner(s), Cutting and Grouting, Letter to Customer(s)	$10,128.70	Boardman Ave
SSGM -11635	15	156	2	4	8	Spot Liner(s), Cleaning	$7,487.17	Wellington St.

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM -8988	12	330	2	5	10	Full Liner	$22,270.88	Wellington St.
SSGM -9008	12	205	2	3	6	Cleaning, Letter to Customer(s)	$977.11	Boardman Ave
SSGM -9009	12	181	2	4	8	Cutting and Grouting	$6,735.61	Boardman Ave
SSGM -9010	12	49	2	5	10	Heavy Cleaning	$396.01	Boardman Ave
SSGM -9011	6	203	2	3	6	Spot Liner(s)	$4,050.00	Boardman Ave
SSGM -9014	6	99	2	5	10	Full Liner	$5,334.64	Boardman Ave
SSGM -9017	6	158	2	5	10	Full Liner	$8,520.22	Boardman Ave
SSGM -9018	6	110	2	6	12	Remove and Replace, Full Liner	$19,245.30	Boardman Ave
SSGM -9019	6	50	2	5	10	Full Liner	$2,714.26	Boardman Ave
SSGM -9038	15	262	3	4	12	Cleaning	$1,236.61	E. 8th St.
SSGM -9040	10	66	2	4	8	Cleaning	$310.75	Hannah Ave.
SSGM -9041	8	64	2	4	8	Grouting	$1,517.43	Hannah Ave.
SSGM -9042	8	179	2	3	6	Grouting	$4,228.93	Woodmere Ave.
SSGM -9047	8	376	2	6	12	Full Liner	$20,294.98	Woodmere Ave.
SSGM -9048	15	234	3	4	12	Heavy Cleaning	$2,373.41	Hannah Ave.
SSGM -9051	15	220	3	3	9	Grouting	$9,639.22	Hannah Ave.
SSGM -9059	15	428	2	5	10	Full Liner, Cleaning, Cutting and Grouting	$66,064.43	Hannah Ave.
SSGM -9061	15	416	2	4	8	Spot Liner(s), Letter to Customer(s)	$6,756.75	Hannah Ave.
SSGM -9069	10	327	3	3	9	Cleaning	$1,545.24	S. Garfield Ave.
SSGM -9071	12	342	2	5	10	Spot Liner(s), Heavy Cleaning	$8,169.68	Hannah Ave.
SSGM -9072	12	340	2	4	8	Spot Liner(s)	$5,400.00	Hannah Ave.
SSGM -9084	12	63	2	4	8	Cleaning	$299.93	Peninsula Dr.
SSGM -9093	9	255	1	6	6	Monitor Closely, Spot Liner(s), Cleaning	$5,256.70	E. Front St.
SSGM -9095	9	325	1	5	5	Full Liner	$17,525.75	E. Front St.
SSGM -9097	9	54	1	5	5	Spot Liner(s), Heavy Cleaning	$4,487.40	E. Front St.
SSGM -9100	15	38	2	5	10	Heavy Cleaning	$389.74	E. Front St.

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM -9101	15	228	2	4	8	Spot Liner(s)	$13,500.00	E. Front St.
SSGM -9103	15	230	2	3	6	Spot Liner(s)	$20,250.00	E. Front St.
SSGM -9108	10	437	2	5	10	Cleaning, Letter to Customer(s)	$2,069.38	S. Garfield Ave.
SSGM -9109	10	343	2	5	10	Heavy Cleaning	$2,782.34	S. Garfield Ave.
SSGM -9111	8	137	2	4	8	Heavy Cleaning	$1,107.03	S. Garfield Ave.
SSGM -9112	8	317	2	4	8	Heavy Cleaning	$2,570.87	S. Garfield Ave.
SSGM -9117	8	275	2	3	6	Cleaning	$1,301.33	S. Garfield Ave.
SSGM -9118	8	378	2	4	8	Cutting and Grouting	$9,822.13	S. Garfield Ave.
SSGM -9124	8	422	1	5	5	Spot Liner(s), Heavy Cleaning	$6,791.50	Washington St.
SSGM -9182	21	222	2	4	8	Heavy Cleaning	$2,401.04	E. Front St.
SSGM -9240	8	431	2	5	10	Cutting and Grouting, Letter to Customer(s)	$11,211.98	E. 8th St.
SSGM -9342	8	276	2	3	6	Spot Liner(s)	$3,375.00	E. 8th St.
SSGM -9343	8	158	2	5	10	Monitor Closely, Spot Liner(s)	$3,375.00	E. 8th St.
SSGM -10716	8	121	1	5	5	Heavy Cleaning	$980.79	Silver Dr.
SSGM -11640	10	65	2	3	6	Grouting	$1,751.41	Peninsula Dr.
						Estimated Total CIP Cost*	**$683,127**	

Table F-12: Capital Improvement Projects for Year 3 (FY2020/2021)

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM-6353	12	394	3	3	9	Monitor Closely, Spot Liner(s), Cleaning	$7,260.12	S. Union St.
SSGM-6678	6	176	1	5	5	Heavy Cleaning	$1,426.10	N. Maple St.
SSGM-6705	8	73	2	3	6	Cleaning	$345.71	6th St.
SSGM-6710	8	184	2	5	10	Full Liner, Cleaning	$10,798.76	6th St.
SSGM-6716	12	177	2	4	8	Spot Liner(s), Heavy Cleaning	$6,833.18	Park St.
SSGM-7920	10	231	2	5	10	Grouting	$6,245.92	Bay St.
SSGM-7975	8	356	1	5	5	Spot Liner(s), Cutting and Grouting, Letter to Customer(s)	$12,632.77	N. Spruce St.
SSGM-7982	15	111	2	4	8	Cleaning, Letter to Customer(s)	$529.06	N. Cedar St.

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM-7983	15	229	2	6	12	Full Liner	$23,222.39	N. Cedar St.
SSGM-8010	12	199	3	6	18	Remove and Replace	$30,223.10	S. Union St.
SSGM-8013	10	312	2	5	10	Spot Liner(s)	$4,050.00	W. Grandview Pkwy
SSGM-8014	8	28	2	6	12	Full Liner, Heavy Cleaning	$1,726.50	W. Grandview Pkwy
SSGM-8195	6	109	2	4	8	Spot Liner(s), Cutting and Grouting	$12,949.66	S. Elmwood Ave.
SSGM-8196	6	93	2	4	8	Cutting and Grouting	$2,419.79	S. Elmwood Ave.
SSGM-8198	6	165	2	4	8	Spot Liner(s), Cutting and Grouting, Letter to Customer(s)	$7,670.10	S. Elmwood Ave.
SSGM-8199	8	50	2	5	10	Heavy Cleaning	$405.50	S. Elmwood Ave.
SSGM-8202	12	46	2	3	6	Grouting	$1,558.43	7th St.
SSGM-8204	12	33	2	3	6	Grouting	$1,098.57	S. Elmwood Ave.
SSGM-8206	10	146	2	4	8	Grouting, Spot Liner(s)	$8,004.82	S. Elmwood Ave.
SSGM-8208	10	110	2	3	6	Cleaning	$522.09	S. Madison St.
SSGM-8210	8	233	2	3	6	Grouting	$5,509.03	6th St.
SSGM-8212	8	92	2	4	8	Cutting and Grouting	$2,398.45	S. Madison St.
SSGM-8213	8	222	2	5	10	Full Liner	$11,995.12	Circle Ave.
SSGM-8214	8	137	2	5	10	Spot Liner(s), Cutting and Grouting	$6,932.75	Circle Ave.
SSGM-8215	8	216	2	5	10	Full Liner	$11,658.85	Circle Ave.
SSGM-8217	8	302	2	5	10	Spot Liner(s),Heavy Cleaning	$5,818.40	S. Madison St.
SSGM-8226	10	66	2	3	6	Grouting	$1,769.83	S. Elmwood Ave.
SSGM-8227	10	240	2	3	6	Grouting	$6,492.72	S. Elmwood Ave.
SSGM-8250	18	276	3	4	12	Spot Liner(s)	$8,100.00	N. of 6th St.
SSGM-8251	18	228	3	4	12	Full Liner	$29,207.48	N. of 6th St.

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM-8280	8	117	2	5	10	Cleaning	$554.26	S. Oak St.
SSGM-8282	8	23	1	5	5	Spot Liner(s)	$3,375.00	N. Maple St.
SSGM-8286	6	359	1	6	6	Full Liner, Cleaning	$21,101.76	N. of 6th St.
SSGM-8287	6	361	1	5	5	Full Liner	$19,505.51	N. of 6th St.
SSGM-8288	6	232	1	5	5	Full Liner	$12,503.18	N. of 6th St.
SSGM-8290	12	213	2	5	10	Heavy Cleaning	$1,722.14	S. Division St.
SSGM-8314	12	218	2	5	10	Spot Liner(s), Heavy Cleaning	$7,163.61	S. Division St.
SSGM-8339	12	253	3	3	9	Grouting	$8,538.75	7th St.
SSGM-8341	12	374	2	4	8	Grouting, Letter to Customer(s)	$12,625.30	7th St.
SSGM-8344	6	98	2	5	10	Full Liner	$5,310.57	6th St.
SSGM-8345	6	200	2	4	8	Cutting and Grouting	$5,196.67	6th St.
SSGM-8364	10	56	2	6	12	Heavy Cleaning	$455.82	S. Oak St.
SSGM-8366	10	88	1	5	5	Cleaning	$415.88	S. Oak St.
SSGM-8388	10	136	2	3	6	Cleaning	$643.79	Veterans Dr.
SSGM-8391	10	182	2	6	12	Cutting and Grouting	$5,399.75	Veterans Dr.
SSGM-8397	10	313	2	5	10	Cutting and Grouting	$9,300.02	Veterans Dr.
SSGM-8398	10	319	2	4	8	Cutting and Grouting	$9,474.91	Veterans Dr.
SSGM-8442	12	41	3	5	15	Cleaning	$195.90	W. 14th St.
SSGM-8450	15	348	2	5	10	Heavy Cleaning	$3,522.15	M-37
SSGM-8451	15	322	2	4	8	Cleaning	$1,523.55	M-38
SSGM-8453	15	112	2	4	8	Heavy Cleaning	$1,130.80	M-39
SSGM-8494	6	263	1	6	6	Full Liner	$14,215.98	W. Griffin St.
SSGM-8495	10	197	2	6	12	Full Liner	$11,950.08	Locust St.
SSGM-8521	12	213	2	5	10	Monitor Closely, Spot Liner(s), Cutting and Grouting	$13,296.38	S. Cass St.
SSGM-8719	18	58	3	4	12	Cutting and Grouting	$3,688.51	6th St.
SSGM-8767	12	891	2	5	10	Heavy Cleaning	$7,214.24	E. of Union

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM-8771	15	207	2	3	6	Cleaning	$977.76	E. of Union
SSGM-8778	12	425	2	4	8	Spot Liner(s), Heavy Cleaning	$8,845.36	E. of Union
SSGM-8799	12	192	2	5	10	Spot Liner(s), Letter to Customer(s)	$27,006.75	Locust St.
SSGM-8835	12	119	2	4	8	Spot Liner(s)	$5,400.00	Park St.
SSGM-8841	15	54	3	6	18	Full Liner	$5,468.48	Park St.
SSGM-8844	24	49	4	4	16	Cleaning	$329.80	Park St.
SSGM-8845	9	70	1	5	5	Full Liner, Heavy Cleaning	$4,365.72	Park St.
SSGM-8846	12	59	2	5	10	Spot Liner(s), Heavy Cleaning	$5,874.56	Park St.
SSGM-8847	12	19	2	5	10	Heavy Cleaning	$151.69	Park St.
SSGM-8849	12	182	2	6	12	Full Liner	$12,297.88	Park St.
SSGM-8850	15	172	2	6	12	Full Liner	$17,415.78	Park St.
SSGM-8851	12	334	3	3	9	Spot Liner(s), Cleaning	$12,377.94	Park St.
SSGM-8854	24	95	3	6	18	Heavy Cleaning	$1,286.63	E. Front St.
SSGM-8863	10	180	3	5	15	Heavy Cleaning	$1,457.19	N. Cass St.
SSGM-8874	12	161	2	3	6	Spot Liner(s)	$4,050.00	S. Union St.
SSGM-8875	12	258	2	5	10	Full Liner	$17,390.99	S. Union St.
SSGM-8876	8	190	2	4	8	Cleaning	$895.61	S. Union St.
SSGM-8877	8	53	1	5	5	Full Liner, Cleaning	$16,630.65	S. Union St.
SSGM-8885	9	142	1	5	5	Full Liner	$7,662.79	Park St.
SSGM-8887	12	302	2	5	10	Spot Liner(s), Heavy Cleaning, Letter to Customer(s)	$7,854.42	Park St.
SSGM-9402	8	406	2	5	10	Full Liner, Cutting and Grouting, Letter to Customer(s)	$32,507.96	3rd St.
SSGM-9472	10	68	2	5	10	Grouting	$1,846.78	S. Elmwood Ave.
SSGM-9473	10	204	2	5	10	Grouting	$5,507.42	S. Elmwood Ave.
SSGM-10324	12	51	2	3	6	Grouting	$1,719.37	S. Elmwood Ave.

Facility ID	Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
SSGM-10325	12	32	2	3	6	Grouting	$1,063.22	S. Elmwood Ave.
SSGM-10673	12	68	2	4	8	Spot Liner(s), Cleaning	$16,523.09	N. Cass St.
SSGM-10817	12	119	2	5	10	Heavy Cleaning	$963.90	S. of Lake Ave.
SSGM-11659	12	143	3	3	9	Grouting	$4,830.36	7th St.
SSGM-11648	12	431	2	4	8	Full Liner, Heavy Cleaning	$47,557.13	E. of Union
						Estimated Total CIP Cost*	**$680,089**	

In the fiscal year 2020/21, Griffin Street from Pine St to Locust St will be under construction to address pavement, sanitary, and water main and 10th Street from S. Union St and Lake Ave will be under construction to address pavement, sanitary, and water main. In the fiscal year 2021/22, Fitzhugh Drive from US-31 to Terminus will be under construction to address pavement, sanitary, and water main and E. Eleventh St from S. Union S. to Lake Ave will be under construction to address pavement, sanitary, and water main. Wastewater sewer pipes that are along and near this reach have been incorporated into the CIP for that fiscal year.

Table F-13: Manhole Capital Improvement Projects Year 1 (FY2018/2019)

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-1495	4	4	16	Monitor Closely, Sewer Cleaning/Vactoring, Replace Chimney	$3,307.50
SSM-813	3	5	15	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-475	3	5	15	Sewer Cleaning/Vactoring, Replace Chimney	$3,307.50
SSM-154	3	5	15	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-1628	3	4	12	Sewer Cleaning/Vactoring	$675.00
SSM-474	3	4	12	Monitor Closely, Minor Point Repair	$135.00
SSM-397	3	4	12	Monitor Closely, Minor Point Repair	$135.00
SSM-208	3	4	12	Minor Point Repair, Chimney Liner	$607.50
SSM-824	2	5	10	Monitor Closely, Sewer Cleaning/Vactoring, Root Treatment	$877.50
SSM-355	2	5	10	Monitor Closely, Sewer Cleaning/Vactoring, Replace Chimney, Full Manhole Liner	$7,357.50
SSM-359	2	5	10	Minor Point Repairs, Full Manhole Liner	$4,320.00
SSM-394	2	5	10	Sewer Cleaning/Vactoring, Minor Point Repair, Full Manhole Liner	$4,860.00
SSM-418	2	5	10	Sewer Cleaning/Vactoring, Major Point Repair, Full Manhole Liner	$5,062.50
SSM-400	2	5	10	Minor Point Repair, Cone Liner	$1,215.00
SSM-347	2	5	10	Sewer Cleaning/Vactoring, Major Point Repairs, Full Manhole Liner	$5,400.00

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-345	2	5	10	Sewer Cleaning/Vactoring, Minor Point Repair, Full Manhole Liner	$4,860.00
SSM-167	2	5	10	Replace Chimney, Replace Cone	$6,480.00
SSM-146	2	5	10	Sewer Cleaning/Vactoring, Replace Chimney	$3,307.50
SSM-147	2	5	10	Minor Point Repair, Wall Liner	$3,510.00
SSM-983	2	5	10	Chimney Liner	$472.50
SSM-173	2	5	10	Sewer Cleaning/Vactoring, Minor Point Repair, Root Treatment, Full Manhole Liner	$5,062.50
SSM-185	2	5	10	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-183	2	5	10	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-28	2	5	10	Minor Point Repair, Major Point Repair	$472.50
SSM-1703	2	5	10	Sewer Cleaning/Vactoring	$675.00
SSM-1794	2	5	10	Sewer Cleaning/Vactoring	$675.00
SSM-1627	3	3	9	Sewer Cleaning/Vactoring, Minor Point Repairs	$1,080.00
SSM-1384	3	3	9	Chimney Liner	$472.50
SSM-839	2	4	8	Full Manhole Liner	$4,050.00
SSM-555	2	4	8	Full Manhole Liner	$4,050.00
SSM-553	2	4	8	Sewer Cleaning/Vactoring, Chimney Liner	$1,147.50
SSM-389	2	4	8	Major Point Repair, Full Manhole Liner	$4,387.50
SSM-406	2	4	8	Sewer Cleaning/Vactoring, Minor Point Repair, Full Manhole Liner	$4,860.00
SSM-402	2	4	8	Sewer Cleaning/Vactoring, Minor Point Repair, Chimney Liner	$1,282.50
SSM-344	2	4	8	Minor Point Repair, Full Manhole Liner	$4,185.00
SSM-1522	2	4	8	Full Manhole Liner	$4,050.00
SSM-42	2	4	8	Minor Point Repair, Cone Liner	$1,215.00
SSM-189	2	4	8	Minor Point Repair, Full Manhole Liner	$4,185.00
SSM-21	2	4	8	Minor Point Repair	$135.00
SSM-809	2	3	6	Chimney Liner	$472.50
SSM-820	1	5	5	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-1541	1	5	5	Sewer Cleaning/Vactoring, Major Point Repair, Full Manhole Liner	$5,062.50
SSM-426	1	5	5	Sewer Cleaning/Vactoring, Chimney Liner	$1,147.50
SSM-392	1	5	5	Replace Chimney, Full Manhole Liner	$6,682.50
SSM-1385	1	5	5	Sewer Cleaning/Vactoring	$675.00
SSM-1382	1	5	5	Sewer Cleaning/Vactoring, Replace Chimney	$3,307.50
SSM-38	1	5	5	Sewer Cleaning/Vactoring, Chimney Liner	$1,147.50
SSM-39	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-24	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repair, Full Manhole Liner	$4,860.00
SSM-18	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-14	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring	$675.00

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-1516	1	5	5	Chimney Liner, Cone Liner	$1,552.50
SSM-1757	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repairs	$1,080.00
SSM-1751	1	3	3	Sewer Cleaning/Vactoring	$675.00
				Estimated Total Cost*	**$150,795.00**

The manhole capital projects were selected based on high BRE scores and their vicinity to the Year 1 – 3 sewer pipe capital projects. If a manhole that generated rehab recommendations based on its inspection data was near a sewer pipe capital project, it was evaluated and placed in the proper capital project year even if its BRE score was in the medium to low range in order to reduce disturbance and mobilization costs.

Table F-14: Manhole Capital Improvement Projects Year 2 (FY2019/2020)

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-707	3	5	15	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-718	3	5	15	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-696	2	5	10	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-1552	2	5	10	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-837	2	5	10	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-547	2	5	10	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-647	2	4	8	Monitor Closely, Major Point Repair	$337.50
SSM-1454	2	4	8	Full Manhole Liner	$4,050.00
SSM-1455	2	4	8	Full Manhole Liner	$4,050.00
SSM-863	2	4	8	Reset Frame, Replace Chimney, Full Manhole Liner	$7,222.50
SSM-1235	2	4	8	Minor Point Repair, Chimney Liner	$607.50
SSM-388	2	4	8	Sewer Cleaning/Vactoring, Major Point Repair	$1,012.50
SSM-1654	2	4	8	Chimney Liner	$472.50
SSM-731	2	3	6	Minor Point Repair, Full Manhole Liner	$4,185.00
SSM-645	2	3	6	Full Manhole Liner	$4,050.00
SSM-764	2	3	6	Full Manhole Liner	$4,050.00
SSM-895	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring, Minor Point Repair	$810.00
SSM-601	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-602	1	5	5	Sewer Cleaning/Vactoring, Root Treatment, Chimney Liner	$1,552.50
SSM-606	1	5	5	Sewer Cleaning/Vactoring, Chimney Liner	$1,147.50
SSM-580	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-582	1	5	5	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-583	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring, Minor Point Repair	$810.00

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-588	1	5	5	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-587	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-867	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-1243	1	5	5	Sewer Cleaning/Vactoring, Replace Chimney, Full Manhole Liner	$7,357.50
SSM-771	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repair, Full Manhole Liner	$4,860.00
SSM-772	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-857	1	5	5	Sewer Cleaning/Vactoring, Replace Chimney	$3,307.50
SSM-856	1	5	5	Sewer Cleaning/Vactoring, Major Point Repair, Chimney Liner	$1,485.00
SSM-551	1	5	5	Sewer Cleaning/Vactoring, Major Point Repair, Full Manhole Liner	$5,062.50
SSM-563	1	5	5	Sewer Cleaning/Vactoring	$675.00
SSM-362	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repairs, Replace Chimney, Full Manhole Liner	$7,627.50
SSM-363	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring, Replace Chimney	$3,307.50
SSM-1277	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-266	1	5	5	Monitor Closely, Reset Frame, Cone Liner	$1,822.50
SSM-295	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repair, Chimney Liner, Cone Liner	$2,362.50
SSM-296	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repair	$810.00
SSM-504	1	5	5	Minor Point Repair, Full Manhole Liner	$4,185.00
SSM-505	1	5	5	Sewer Cleaning/Vactoring, Major Point Repair, Chimney Liner	$1,485.00
SSM-312	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring, Reset Frame, Cone Liner	$3,577.50
SSM-321	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repair, Full Manhole Liner	$4,860.00
SSM-1656	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repairs	$945.00
SSM-762	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-1362	1	5	5	Sewer Cleaning/Vactoring	$675.00
SSM-579	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
				Estimated Total Cost*	**$148,568.00**

Table F-15: Manhole Capital Improvement Projects Year 3 (FY2020/2021)

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-1503	3	5	15	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-734	3	5	15	Sewer Cleaning/Vactoring	$675.00
SSM-735	3	5	15	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-1411	4	3	12	Sewer Cleaning/Vactoring	$675.00

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-478	3	4	12	Sewer Cleaning/Vactoring, Minor Point Repair, Chimney Liner	$1,282.50
SSM-479	3	4	12	Monitor Closely, Major Point Repair	$337.50
SSM-461	2	5	10	Minor Point Repair, Major Point Repair, Root Treatment, Full Manhole Liner	$4,725.00
SSM-231	2	5	10	Minor Point Repair, Full Manhole Liner	$4,185.00
SSM-1651	2	5	10	Minor Point Repair	$135.00
SSM-137	2	5	10	Sewer Cleaning/Vactoring, Minor Point Repair	$810.00
SSM-135	2	5	10	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-159	2	5	10	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-1372	2	5	10	Sewer Cleaning/Vactoring, Minor Point Repair, Replace Chimney	$3,442.50
SSM-1375	2	5	10	Sewer Cleaning/Vactoring	$675.00
SSM-536	2	4	8	Minor Point Repairs	$270.00
SSM-1639	2	4	8	Replace Chimney, Full Manhole Liner	$6,480.00
SSM-557	2	4	8	Minor Point Repair, Full Manhole Liner	$4,185.00
SSM-452	2	4	8	Minor Point Repair, Full Manhole Liner	$4,185.00
SSM-249	2	4	8	Minor Point Repair, Major Point Repair, Cone Liner	$1,552.50
SSM-148	2	4	8	Major Point Repair, Full Manhole Liner	$4,387.50
SSM-149	2	4	8	Full Manhole Liner	$4,050.00
SSM-1437	2	4	8	Wall Liner	$3,375.00
SSM-1436	2	4	8	Minor Point Repairs, Full Manhole Liner	$4,320.00
SSM-232	2	3	6	Root Treatment	$202.50
SSM-239	2	3	6	Sewer Cleaning/Vactoring, Chimney Liner, Cone Liner	$2,227.50
SSM-303	2	3	6	Sewer Cleaning/Vactoring, Chimney Liner	$1,147.50
SSM-1646	2	3	6	Minor Point Repair	$135.00
SSM-180	2	3	6	Sewer Cleaning/Vactoring	$675.00
SSM-1085	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repairs, Chimney Liner	$1,417.50
SSM-498	1	5	5	Minor Point Repair, Rebuild Bench, Full Manhole Liner	$4,995.00
SSM-737	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring	$675.00
SSM-105	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-111	1	5	5	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-36	1	5	5	Monitor Closely, Sewer Cleaning/Vactoring, Chimney Liner, Cone Liner	$2,227.50
SSM-1593	1	5	5	Sewer Cleaning/Vactoring, Minor Point Repairs, Root Treatment, Reset Frame	$1,890.00
SSM-102	1	5	5	Sewer Cleaning/Vactoring, Cone Liner	$1,755.00
SSM-219	1	4	4	Monitor Closely, Replace Chimney	$2,632.50
SSM-1343	1	4	4	Minor Point Repair, Chimney Liner, Cone Liner	$1,687.50
SSM-510	1	4	4	Full Manhole Liner	$4,050.00

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
SSM-350	1	4	4	Sewer Cleaning/Vactoring, Major Point Repair, Full Manhole Liner	$5,062.50
SSM-356	1	4	4	Sewer Cleaning/Vactoring, Minor Point Repair, Full Manhole Liner	$4,860.00
SSM-366	1	4	4	Sewer Cleaning/Vactoring, Minor Point Repair, Major Point Repair, Full Manhole Liner	$5,197.50
SSM-11	1	4	4	Sewer Cleaning/Vactoring, Root Treatment, Full Manhole Liner	$4,927.50
SSM-10	1	4	4	Monitor Closely, Cone Liner	$1,080.00
SSM-703	1	3	3	Full Manhole Liner	$4,050.00
SSM-1342	1	3	3	Full Manhole Liner	$4,050.00
SSM-1711	1	3	3	Sewer Cleaning/Vactoring, Minor Point Repairs	$1,080.00
SSM-581	1	3	3	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-367	1	3	3	Full Manhole Liner	$4,050.00
SSM-319	1	3	3	Sewer Cleaning/Vactoring, Full Manhole Liner	$4,725.00
SSM-323	1	3	3	Chimney Liner, Cone Liner	$1,552.50
SSM-324	1	3	3	Minor Point Repair, Chimney Liner	$607.50
SSM-752	1	3	3	Root Treatment, Full Manhole Liner	$4,252.50
				Estimated Total Cost*	**$150,390.00**

Figure F-A-4 shows the capital improvement projects per year for the three year period.

C. Continuing the Asset Management Plan Beyond 2017

As the capital and rehabilitation projects are completed for both the wastewater sewer pipes and manholes, ***the City wastewater geodatabase must be continuously updated*** to reflect the changing conditions. For example, the PoF variable, which indicates structural condition, must be reset after a pipe or manhole is replaced or repaired. This could consist of the PACP structural rating changing from a 5 to a 1 or 2. This can be done using the same data collection methodologies developed during the SAW Grant project. The continuation of the sewer inspection program will allow the City to maintain a current set of structural conditions that can be used to guide the Capital Improvement Planning process every year.

This process is not entirely automated. When the annual CIP table is updated in future years, City staff should evaluate the following manual adjustments:

- Assets with a mid-range BRE should be moved up the list if a proposed roadway project coincides with the asset location.
- If assets with mid-range BREs are immediately adjacent to a high BRE, consider adding the mid-range asset to the CIP, as the adjacency may increase cost efficiencies and avoid an unnecessary re-mobilization.

Appendix F-A: Maps

Figures

Figure F-A-1
Probability of Failure

Traverse City, MI

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: May 18, 2017

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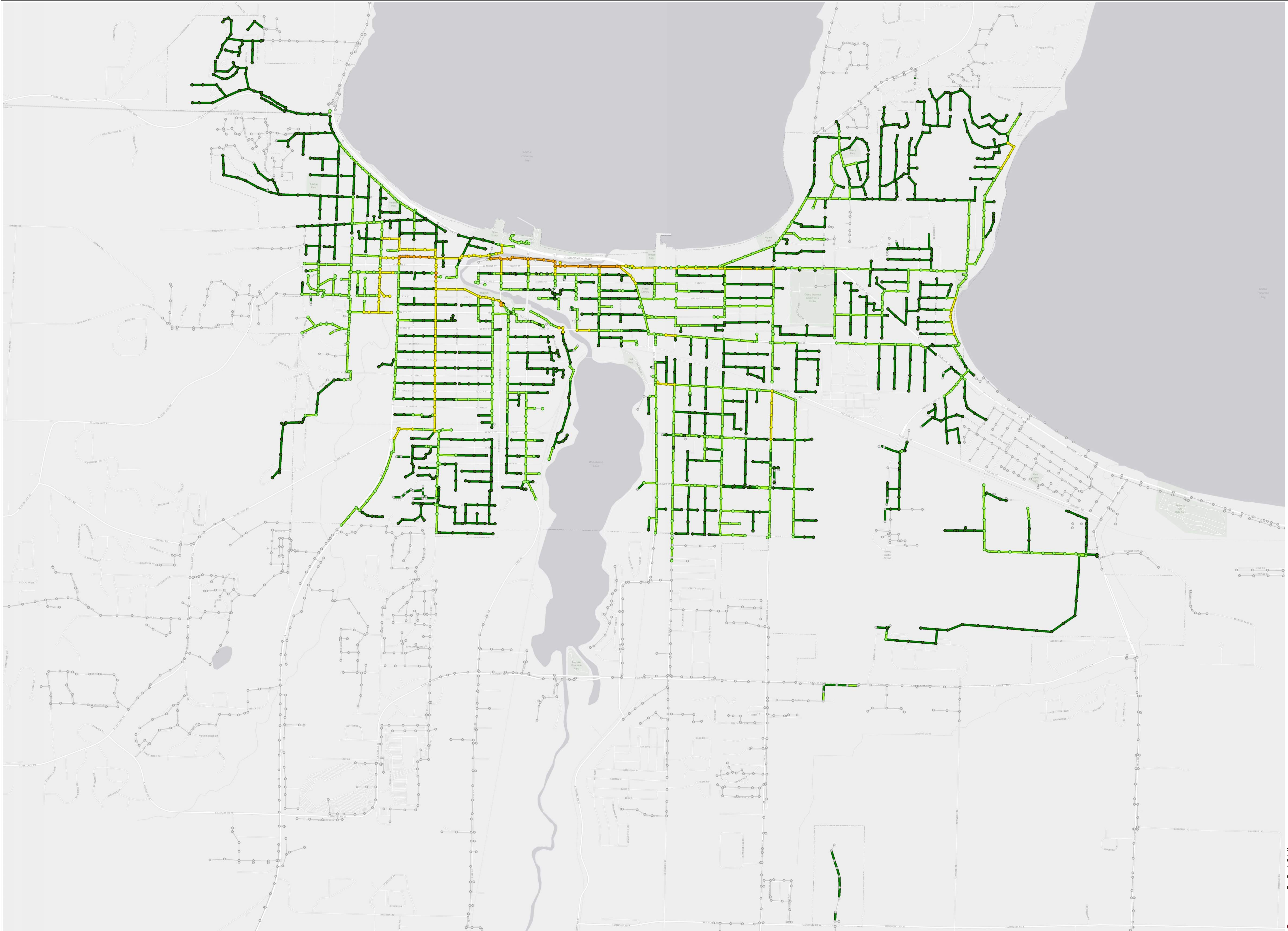

Figure F-A-2
Consequence of Failure

Traverse City, MI

N
W E
S

0 1,100 2,200 3,300
Feet

1" = 1,100'

Sanitary Sewer Manholes

No Associated Value

Consequence of Failure

- 1
- 2
- 3
- 4

Sewer Gravity Mains

No Associated Value

Consequence of Failure

- 1
- 2
- 3
- 4

Traverse City

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

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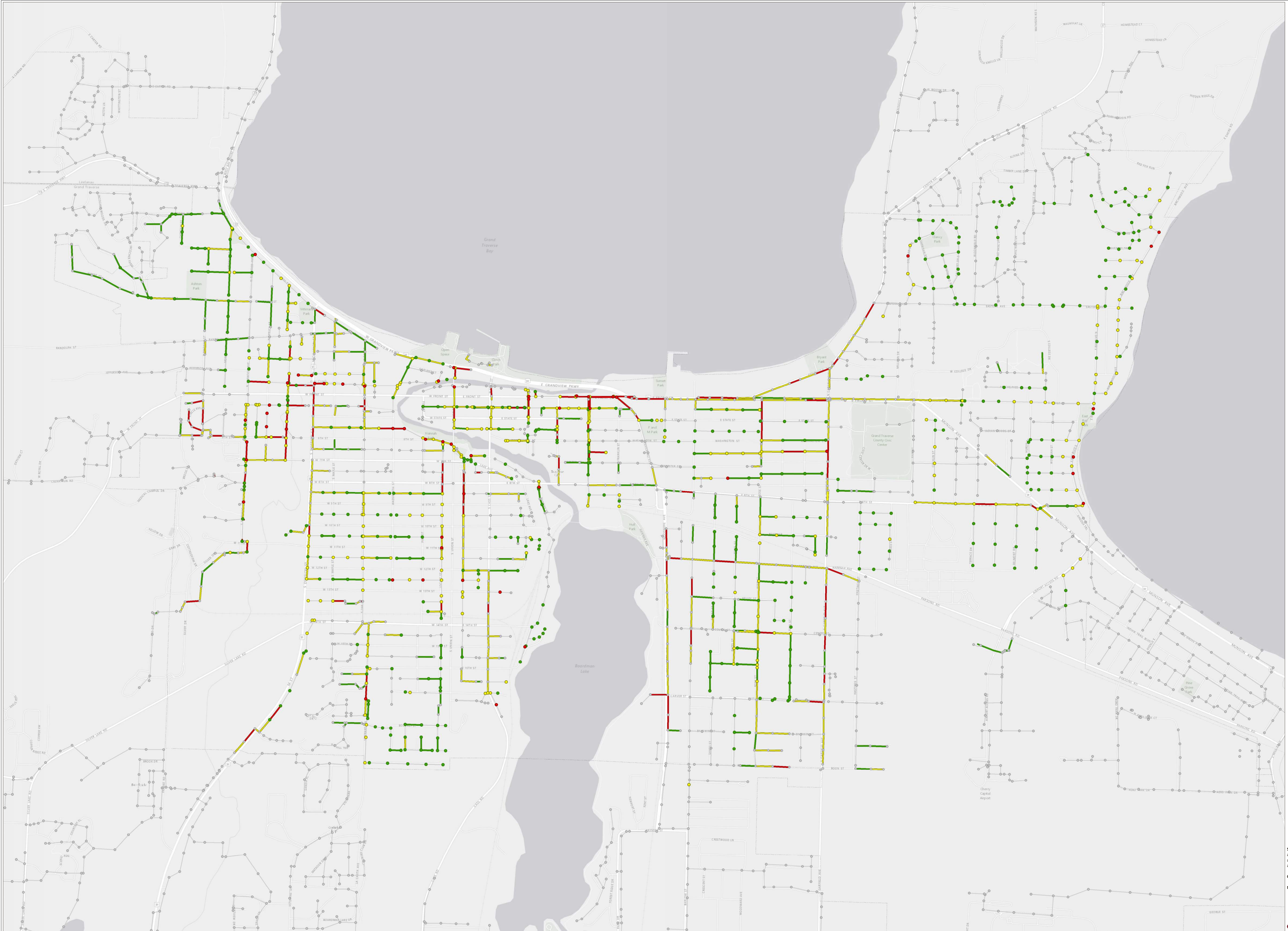

Figure F-A-3
Business Risk

Traverse City, MI

N
W E
S

0 800 1,600 2,400
Feet
1" = 800'

Sanitary Sewer Manholes
- No Associated Value

Business Risk
- Low Priority (1-4)
- Medium Priority (5-9)
- High Priority (10-25)

Sewer Gravity Mains
- No Associated Value

Business Risk
- Low Priority (1-4)
- Medium Priority (5-9)
- High Priority (10-25)
- Traverse City

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: May 18, 2017

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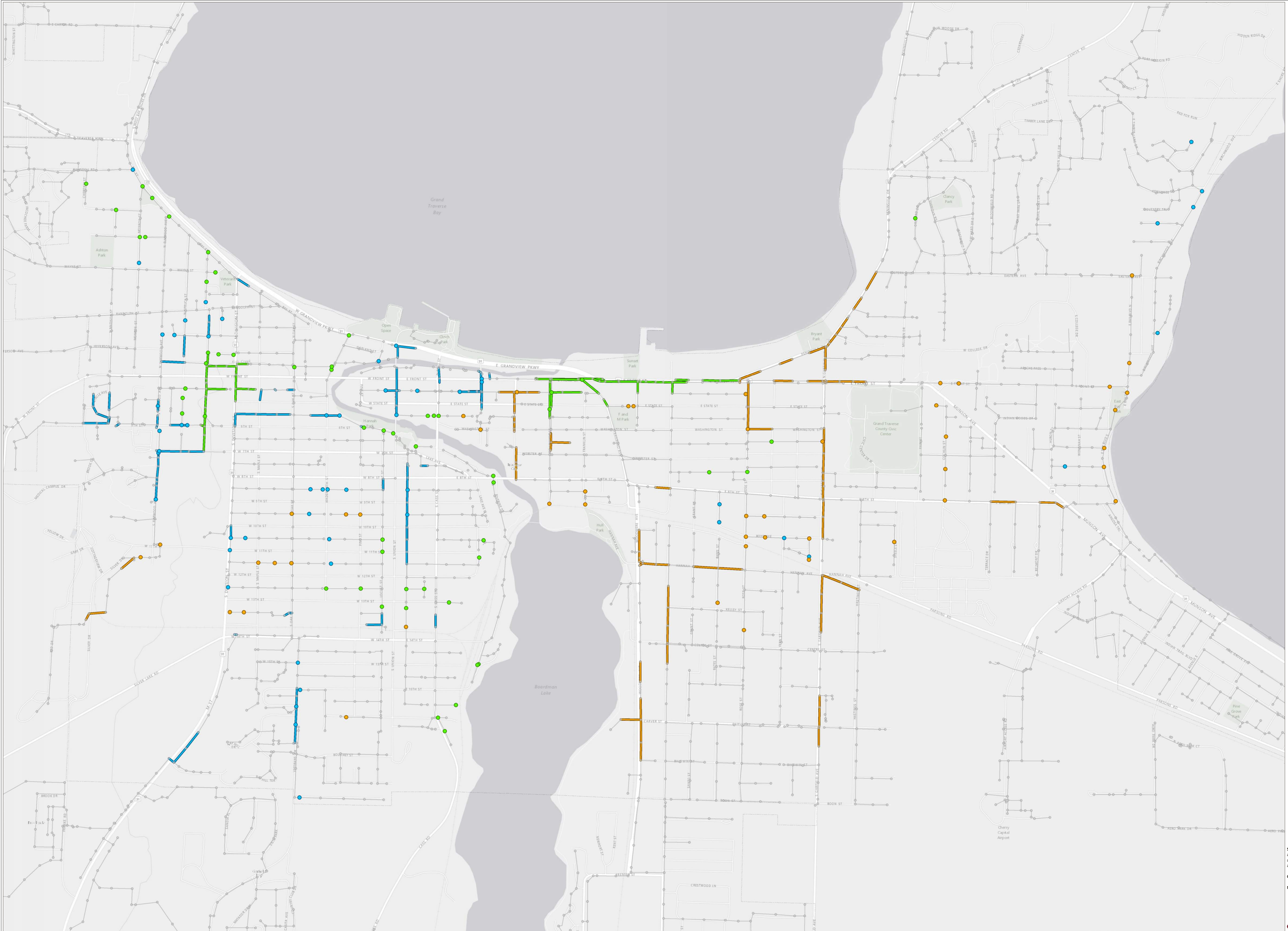
P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170518 Traverse City CIP Maps\20170518 Business Risk.mxd

Figure F-A-4

CIP Yearly Projects

Traverse City, MI



N
W E
S

0 700 1,400 2,100

Feet

1" = 700'

Sanitary Sewer Manholes

CIP Year

- Year 1
- Year 2
- Year 3
- No Associated Year

Sewer Gravity Mains

CIP Year

- Year 1
- Year 2
- Year 3
- No Associated Year
- Traverse City

Source: Data provided by Traverse City. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate spatial location of the mapped features within the Community and all use is strictly at the user's own risk.

Coordinate System: NAD 1983 StatePlane Michigan Central FIPS 2112 Feet Intl

Map Published: May 18, 2017

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P:\1000_1999\1006140012_Traverse City SAW Wastewater_GIS\ArcLayouts\20170505 Traverse City Wastewater CIP.mxd

Appendix G: CH2M WWTP CIP and O&M Strategies

City of Traverse City
Asset Management Plan
Wastewater Plant and Collections System

City of Traverse City
Asset Management Plan
Wastewater Plant and Collections System

Prepared for

City of Traverse City

Date 8/1/2016

Contents

Section Page

Exhibits

Document Revision History

VERSION	AUTHOR	DATE	CHANGES
1.0			

City of Traverse City, Asset Management Plan, Wastewater Plant and Collections System

1.0 Plan Overview

This document lays out a process by which assets required to collect and treat wastewater for residents and businesses serviced by the Traverse City Regional Wastewater Treatment Plant (TCRWWTP) are operated and maintained to reliably meet the service and permit requirements while controlling asset life-cycle cost. This process has become known as Asset Management. The key factors in an Asset Management Plan are;

- Know what you own
- Know the relative criticality of each asset
- Know how long it has been in service
- Know what the current condition of the assets are
- Know what it is currently costing to maintain the assets
- Know what it will cost to replace the assets

The TCRWWTP is supported by three separate teams working together to provide wastewater collection and treatment services in Traverse City and Grand Traverse County. The City of Traverse City operates the portion of the collection system located within the city through the Traverse City Department of Public Services (TCDPS). The portion of the collection system and lift stations located outside the city in Grand Traverse County is operated by Grand Traverse County Lift Stations and collections System (GTC). The wastewater treatment plant and the lift stations located within the city are operated by CH2M under contract to The City of Traverse City (The City). Working collectively each team is advancing the assets within it's' realm of responsibility. Asset inventories for the city collection system have been entered into GIS and for the TCRWWTP and lift stations into Maintenance Connection (MC). The assets have been arranged by location and process to facilitate accurate collection of data and reporting. Processes are being developed and documented for the continual updating of the asset inventory as assets are replaced or changed. The fixed assets in the GTC lift stations and collection system are currently being located and entered into a GIS system. A more complete reporting of the fixed assets will be available by June 30, 2017.

A complete assessment of the condition of all the assets at the TCRWWTP and city Lift Stations is scheduled to be performed before December 31, 2016 with a condition assessment report available by February 1, 2017. Plans are proceeding to complete an assessment of at least a portion of the assets of the city collections system. Grand Traverse County will begin assessing assets in the GTC collection system and lift stations following the completion of an asset inventory.

An evaluation of the relative risk of assets in the system will be conducted no later than the end of the first quarter of 2017. At present CH2M and The City and meet once at review a matrix system which ranks the consequences of a failure and the likelihood of a failure at the process level. Final agreement on the categories a loss of service represent and the factors which can best predict the likelihood and asset will fail in the future are still being refined. Once the structure of the matrices is complete representatives from The City, plant operations staff and plant maintenance staff will establish a consequence of failure score and a likelihood of failure score for each process. The total risk represented by each process will be calculated using the classic risk formula Consequence of Failure X Likelihood of Failure = Total Risk. These risk scores will then be applied to each asset within the process.

Details of the Asset Management Plan are outlined in greater detail in the following sections and attachments to this report.

2.0 Staffing Plans

Staffing plans for the Traverse City Collection System and the Traverse City Regional Wastewater Treatment Plant (TCRWWTP) and lift stations are highlighted in Exhibits 1 and 2. Staffing for the Grand Traverse County Collections System and Lift Stations Staffing will be determined by July 30, 2017.

Exhibit 1. Traverse City Collection System Staffing

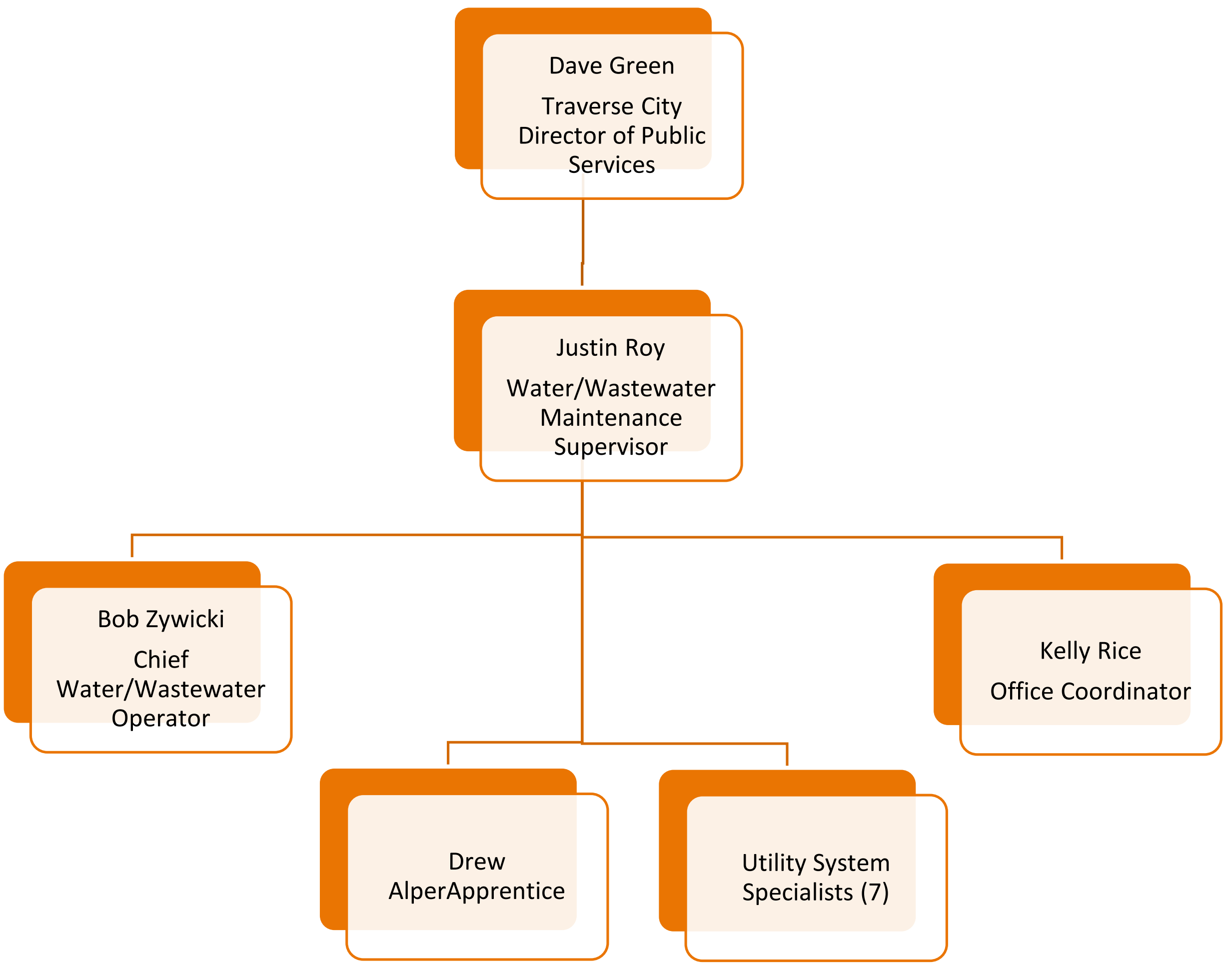
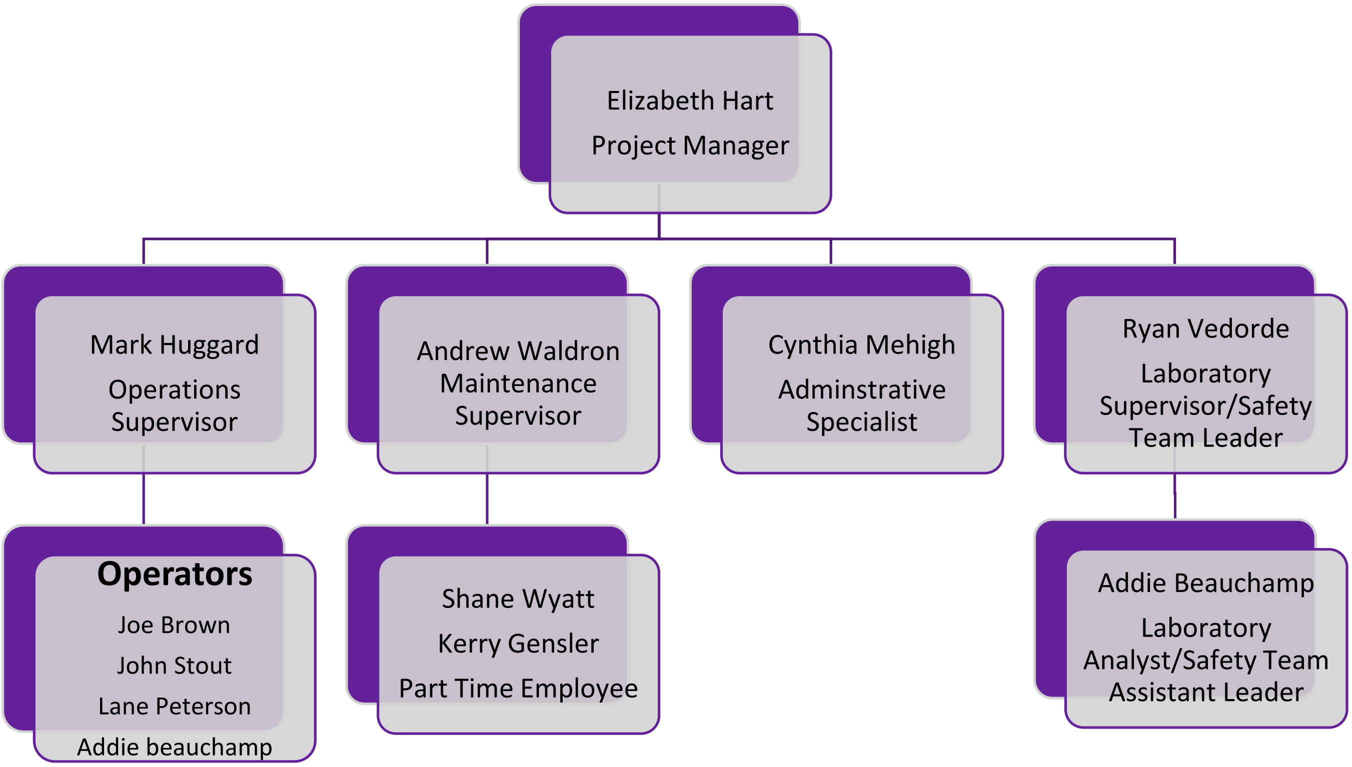


Exhibit 2. CH2M's Staffing for the TCRWWTP and City Lift Stations



CH2M's roles and responsibilities include:

- The project manager oversees the scheduling and planning of capital improvement projects, implementation and scheduling of new preventive maintenance (PM) work orders and corrective maintenance (CM) work orders. This is done with the input and assistance of the supervisory team.
- The operations supervisor assists in planning major repairs, and is responsible for the scheduling of lower level PM tasks. He/she works closely with the maintenance supervisor in prioritizing repairs, scheduling equipment shutdowns, if needed, and coordinating staffing efforts.
- The operations staff, under their supervisor's direction, performs low level PM tasks, assists in CM, and the completion of capital improvement projects.
- The maintenance supervisor schedules and assigns CM work orders, oversees predictive maintenance (PdM), capital improvement projects, and is also charged with the completion of higher-level PM work orders.
- The maintenance staff, under their supervisor's direction, performs higher level PM work orders, CM work orders, PdM, and capital improvement projects.
- All supervisors and the project manager are responsible for making sure PdM, PM, and CM are performed according to CH2M safety standards.
- The administrative specialist helps with creating vendor and contractor accounts, setting up a means to pay invoices, as well as, assisting with safety requirements.
- The safety team leader heads up the safety effort, and is a resource for any safety concerns or questions pertaining to day to day work, or large projects.

3.0 System Description

A map of the Traverse City Collection System, including Lift Stations is located in Attachment 1.

The system description for the Grand Traverse County Collection System will be determined by June 30, 2017.

TCRWWTP and Lift Stations process descriptions are outlined in the remainder of Section 3.

3.1 Effluent Discharge Criteria

The TCRWWTP is designed to comply at a minimum with the current Michigan Department of Environmental Quality (DEQ) requirements for wastewater treatment. However, in order to provide the most environmentally desirable discharge possible, Traverse City has also set voluntary target objectives for the TCRWWTP's effluent quality. The requirements and objectives for TCRWWTP's effluent are listed in Exhibit 3.

Exhibit 3. Traverse City Effluent Objectives and Compliance Criteria

Effluent Parameter	Average Monthly Concentrations (mg/L)	
	Effluent Objective	Discharge Permit Requirement
Biochemical Oxygen Demand (BOD)	4	25
Total Suspended Solids (TSS)	4	30
Ammonia Nitrogen (NH3 - N)	1	11
Phosphorus	0.5	0.5

3.2 Plant Design Criteria

The plant is capable of treating the following influent flows and nutrient loadings, and has the following criteria for its biological system (Exhibit 4.

Exhibit 4. Summary of Plant and Biological System Design Criteria

<table>
<tr><th rowspan="2">Plant Influent Design Criteria</th><th colspan="2">Maximum Flows</th><th colspan="2">Maximum Monthly Loads</th></tr>
<tr><th>(mgd)</th><th>(m^3/d)</th><th>(lb/d)</th><th>(kg/d)</th></tr>
<tr><td>Average Flow</td><td>8.5</td><td>32,000</td><td></td><td></td></tr>
<tr><td>Peak Flow</td><td>17</td><td>64,000</td><td></td><td></td></tr>
<tr><td>BOD</td><td></td><td></td><td>20,200</td><td>9,200</td></tr>
<tr><td>TSS</td><td></td><td></td><td>36,500</td><td>16,550</td></tr>
<tr><td>Ammonia (NH_3)</td><td></td><td></td><td>2,200</td><td>1,000</td></tr>
<tr><th rowspan="2">Biological System Design Criteria</th><th rowspan="2">Minimum Time (days)</th><th colspan="2">Minimum Temperature</th><th rowspan="2">Maximum Concentration (mg/L)</th></tr>
<tr><th>(°F)</th><th>(°C)</th></tr>
<tr><td>Solids Retention Time</td><td>6.5 to 8.5 days at Design Max Month</td><td></td><td></td><td></td></tr>
<tr><td>Wastewater Temperature at Peak Monthly Loadings</td><td></td><td>55</td><td>13</td><td></td></tr>
<tr><td>Maximum MLSS Concentration at the Membranes</td><td></td><td></td><td></td><td>10,000</td></tr>
</table>

3.3 Acronyms and Abbreviation List

The acronyms and abbreviations used throughout this manual are listed in Exhibit 5 in alphabetical order and serve as a reference listing.

Exhibit 5. Acronyms and Abbreviations

Abbreviation/ Acronym	Definition
ADP	Air diaphragm pump
AS	Activated sludge
AT	Aeration Tank
BNR	Biological nutrient removal
BOD	Biochemical oxygen demand
BOD_5	Five-day biochemical oxygen demand
btu	British thermal unit(s)
°C	Degree(s) Celsius
CDS	Concentrated digested sludge
cf/hr	Cubic feet per hour
cfm	Cubic feet per minute
COD	Chemical oxygen demand
cu.	Cubic
CWAS	Concentrated waste activated sludge (WAS)
DO	Dissolved oxygen
DWP	Dynamic wet pressure
°F	Degree(s) Fahrenheit
F/M	Food-to-microorganism ratio
ft.	Foot/feet
GBC	Gravity belt concentrator
gpm	Gallons per minute
GSFD	Gallons per square foot of available membrane area per day
hp	Horsepower
HRT	Hydraulic retention time
Hz	Hertz
in.	Inch(es)
IPP	Industrial Pretreatment Program
kg	Kilogram(s)
lb.	Pound(s)
LCP	Local control panel
LED	Light Emitting Diode
MBR	Membrane Bioreactor
MCC	Motor control center

Exhibit 5. Acronyms and Abbreviations

Abbreviation/ Acronym	Definition
MCRT	Mean cell residence time
mgd	Million gallons per day
mg/L	Milligram(s) per liter
min.	Minute
mL	Milliliters(s)
ML	Mixed liquor
MLR	Mixed liquor recycle
MLSS	Mixed liquor suspended solids
MLVSS	Mixed liquor volatile suspended solids
mm	Millimeter(s)
NH_3-N	Ammonia nitrogen
NO_2-N	Nitrite nitrogen
NO_3-N	Nitrate nitrogen
NTU	Nephelometric turbidity unit(s)
O&M	Operations and maintenance
OUR	Oxygen uptake rate
PDT	Pressure decay test
PA	Process air
PAC	Process air compressor
PAO	Polyphosphate accumulating organism
PID	Proportional, Integral, Derivative (tuning parameters used in computer/PLC controls)
PE	Primary effluent OR Pressure element depending on the context
PI	Primary influent, Pressure indicator, or Proportional-Integral depending on the context
P&ID	Process & Instrumentation Diagrams
PLC	Programmable logic controller
PRS	Recycled primary sludge
PS	Primary sludge
psi	Pounds per square inch
RAS	Return activated sludge
RPS	Recycled primary sludge also referred to as primary recycle
SCADA	Supervisory control and data acquisition
scfm	Standard cubic feet per minute
SDC	Sieve drum concentrator
SOP	Standard operating procedure(s)
SOUR	Specific oxygen uptake rate
SP	Soluble phosphorus

Exhibit 5. Acronyms and Abbreviations

Abbreviation/ Acronym	Definition
SRT	Solids retention time
SVI	Sludge volume index
SWD	Side water depth
TDH	Total dynamic head
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TMP	Trans-membrane pressure
TP	Total phosphorus
TSS	Total suspended solids
UCT	University of Cape Town
UV	Ultraviolet
UVT	Ultraviolet transmissivity
VFA	Volatile fatty acids
VFD	Variable frequency drive
VS	Volatile solids
VSS	Volatile suspended solids
VTS	Total volatile solids
W3	Plant service water
WAS	Waste activated sludge
W/m^3	Watt(s) per cubic meter
WWTP	Wastewater treatment plant
$\mu Wsec/cm^2$	Micro-watts-seconds per centimeter square (measure of UV intensity)
%	Percent

3.4 Glossary of Terminology

This glossary is intended to define certain terms associated with wastewater treatment that are found in the text material.

Activated Sludge: A mixture of microorganisms that accumulates after aeration of wastewater containing organic contaminants and a suitable bacterial seed.

Activated Sludge Process: A biological wastewater treatment process comprised of one or more aeration tanks and secondary clarifiers or membrane bioreactors. The wastewater is brought into contact with the activated sludge in an aeration tank and the sludge is separated from the mixed liquor and returned to the process. A portion of the sludge is wasted to maintain the quantity of microorganisms present in the system in equilibrium. The supernatant or permeate may be further treated (e.g., disinfection and sometimes tertiary treatment) before final discharge to a river, lake, stream, or alternative discharge point.

Aeration: The process of supplying air or oxygen to water, whether by natural or mechanical means.

Aeration Tank: The tank in which air, microorganisms, and wastewater are mixed in an activated sludge process.

Aerobic: A microbial process that occurs in the presence of dissolved oxygen. Also sometimes referred to as oxic.

Aerobic Zone: Also referred to as an Aerated Zone. An environment where dissolved oxygen is present, usually provided by the transfer of oxygen using aeration blowers and diffusers located at the bottom of the Aeration Tank or Membrane Tank. Aerobic microorganisms utilize oxygen to oxidize organic matter and to convert ammonia (NH_3) to oxidized forms of nitrogen (nitrite and/or nitrate), i.e. the nitrification process.

Anaerobic Zone: An environment completely devoid of dissolved oxygen and oxidized forms of nitrogen (typically nitrate). The environment supports only bacteria that grow in the absence of oxygen, i.e. anaerobic bacteria.

Anoxic Zone: An environment completely devoid of dissolved oxygen but where oxidized forms of nitrogen (typically nitrate) are present. The environment supports microorganisms that can use nitrate or nitrite as a source of oxygen for respiration, i.e. the denitrification process; nitrogen gas (N_2) is the primary product of denitrification and is released to the atmosphere.

Aerobic Bacteria: Bacteria that require the presence of oxygen for their growth.

Aerobic Digestion: The stabilization of microorganisms produced by the activated sludge process by prolonged aeration in the absence of food.

Algae: Primitive plants with one or many cells, usually aquatic and capable of synthesizing their carbon source from carbon dioxide and water by photosynthesis.

Aliquot: Equal portion of an equal volume composite sample.

Alkalinity: The capacity of water to neutralize acids due to the presence of carbonate, bicarbonates and hydroxides; expressed in milligrams per liter of equivalent calcium carbonate ($CaCO_3$).

Alum: Name used for commercial hydrated aluminum sulphate (chemical formula: $Al_2(SO_4)_3 \cdot xH_2O$), a metal salt, used in wastewater treatment for phosphorus removal.

Bacteria: A group of unicellular microscopic organisms lacking chlorophyll. Bacteria are usually spheroid, rod-like, curved, or filamentous in shape.

Biochemical Oxygen Demand (BOD): A measure of the strength of wastewater as determined by the oxygen consumed by microorganisms during the aerobic degradation of organic matter. BOD_5 refers to the oxygen consumed during a five-day test period under prescribed incubation conditions.

Biodegradability: The ability of microorganisms to biologically metabolize a specific compound or a wastewater containing a mixture of compounds.

Biological Nutrient Removal (BNR): Removal of phosphorus and or nitrogen using microorganisms.

Biological Slime: A complex population of organisms that form a slime growth within the aeration tank and break down organic matter in the wastewater. These slimes are a viscous characteristic of the activated sludge process and caused by the accumulation of adsorbed but unmetabolized BOD.

Biological Treatment: Wastewater treatment performed by microorganisms, primarily bacteria.

Biomass: General name applied to a biological culture such as the microorganisms in the activated sludge process.

Biosolids: Term used to distinguish between untreated sludges such as primary sludge and waste activated sludge versus solids that have been digested or dried. The digestion or drying process significantly reduce the putrescence, odor, vector attraction, and pathogen concentration characteristics compared to the sludges prior to this treatment.

Bugs: Common name given collectively to the population of microorganisms in the aeration tank.

Bulking sludge: Poor settling sludge floc due to an excessive number of filamentous microorganisms that bridge between solids and thereby inhibit settling and compaction of the activated sludge.

Carbonaceous Biochemical Oxygen Demand (CBOD): As with BOD, a measure of the strength of wastewater as determined by the oxygen consumed by microorganisms during the aerobic degradation of organic matter. $CBOD_5$ refers to the oxygen consumed during a five-day test period under prescribed incubation conditions. The CBOD test differs from the BOD test in that a chemical is added to the CBOD test to inhibit nitrification from occurring. The BOD test frequently over predicts the oxygen demand due to organic matter because of some oxygen consumption associated with partial nitrification.

Chemical Oxygen Demand (COD): The quantity of organic and inorganic matter present in a wastewater, which can be chemically oxidized under controlled test conditions, expressed as an oxygen equivalent.

Clarification: The action of settling suspended solids from the liquid. The liquid discharged from above the settled solids is referred to as supernatant and the settled solids are referred to as sludge.

Clarifier: A settling tank that separates suspended solids from water by gravity as a result of density differences.

Coagulation: The agglomeration of finely dispersed particles into larger particles (flocs) by chemical addition or other physical/chemical means.

Coliform Bacteria: A group of bacteria predominantly inhabiting the intestines of humans or animals but also occasionally found elsewhere. Their presence in water is evidence of contamination by fecal material.

Colloidal Matter: Finely divided solids that will not settle due to the small size of the particles or electrical charges on the particles.

Composite Wastewater Sample: A combination of individual portions of wastewater taken at selected time intervals to minimize the effect of the variability of the individual samples. Individual samples may be of equal volume or may be proportioned to the flow at the time of sampling.

Concentration: Processes that thicken sludge or biosolids by removing water from sludge or biosolids by physical and/or mechanical means (gravity belt thickeners, centrifuges, etc.). More commonly referred to as thickening at other plants. Typically, the term concentration or thickening is used when the thickened sludge or biosolids is in the range of 3% to 10% solids by weight and the term dewatering is reserved for processes that remove more water and thereby generate higher (e.g., typically 15% or greater) solids concentrations.

Declining Growth Phase: The stage of growth of microorganisms at which the depletion of the food supply results in a reduced rate of microbial growth and cell multiplication.

Denitrification: The conversion of nitrate to molecular nitrogen by specific microorganisms under anoxic conditions.

Detention Time: The theoretical length of time required for a given volume of liquid to flow through a tank or unit. It is calculated by dividing the tank volume by the rate of inflow. Also called Retention Time.

Dewatering: Processes that remove water from concentrated sludge or biosolids (usually digested biosolids) by physical and/or mechanical means (centrifuges, belt presses, etc.)

Digested Sludge: Sludge that has been stabilized by long-term exposure to an environment without an external food source. In recent years commonly referred to as biosolids to distinguish it from untreated sludge.

Disinfection: The destruction of potentially harmful or disease-causing microorganisms in water or wastewater, usually by chlorination, ozonation or exposure to ultraviolet radiation.

Dispersed Growth: Non-flocculating microorganisms with poor settling characteristics whose presence in treated wastewater results in a turbid effluent.

Dissolved Oxygen (DO): The free oxygen dissolved in water, usually as a result of contact with air.

Effluent: Discharge from a tank, reservoir, basin or treatment plant; usually partially or completely treated wastewater.

Endogenous Growth Phase. The stage of growth of microorganisms at which they consume their own cellular material due to the depletion of their food source.

Equalization: A process in which variations in flow or strength are averaged or reduced.

Eutrophication: The process by which a lake or other water body becomes enriched with dissolved nutrients (e.g. nitrogen and phosphorus) resulting in higher levels of algae and plant growth.

Extended Aeration Process. A modification of the conventional activated sludge process in which longer detention times in the aeration basin and lower organic loading rates are utilized. The extended aeration process operates in the endogenous phase of the microbial growth curve.

Facultative Bacteria. Bacteria that can grow in either an aerobic or an anaerobic environment. Most activated sludge microorganisms are facultative.

Ferric Chloride: Name used for commercial iron solution (chemical formula: $FeCl_3$), a metal salt, used in wastewater treatment for phosphorus removal. Also referred to as simply *ferric* in wastewater terminology.

Ferrous Chloride: Reduced form of ferric chloride, a waste product of various metal industries. Chemical formula is $FeCl_2$. Can also be used for phosphorus removal.

Filamentous Microorganisms: Species of microorganisms, i.e. bacteria and fungi, which grow in the form of strands or filaments.

Floc: A particle formed by the agglomeration of a number of smaller particles.

Flotation: The raising of suspended matter to the liquid surface by gases.

Food: The substances used by organisms for the growth (synthesis) of new cellular material and the production of energy; see also substrate. Usually measured as BOD_5 or $CBOD_5$ in the wastewater.

Food-to-Microorganism Ratio (F/M): The ratio of the amount of food applied to the biological system relative to the number of microorganisms in the system available to degrade the food, measured as the volatile fraction of the mixed liquor.

Grab Wastewater Sample: A single, independent wastewater sample taken at some instant in time. A composite sample is made up of numerous grab samples.

Gravity Belt Concentrator: Process equipment that is utilized to thicken waste activated sludge or digested sludge. Commonly referred to as a Gravity Belt Thickener in other plants.

High Rate Aeration Process: A modification of the conventional activated sludge process in which relatively short detention times in the aeration basin and higher organic loading rates are experienced.

Hydraulic Loading Rate: The rate of flow applied to a process.

Influent: Water, wastewater, or other liquid flowing into a tank, reservoir, basin, treatment plant, or any unit thereof.

Lagoon: An artificial pond of earthen construction used to hold wastewater for treatment by means of biological stabilization.

Loading Rate: The quantity of waste, expressed in units of volume (hydraulic load) or in mass of BOD, COD, suspended or volatile solids (organic load), that is discharged to a wastewater treatment facility or watercourse.

Logarithmic Growth Phase: The stage of microbial growth in which maximum cell growth and multiplication is taking place due to the presence of an abundant food supply.

Mean Cell Residence Time (MCRT): The average length of time that the activated sludge is maintained in the activated sludge system, calculated as the solids inventory in the Aeration Tanks and Membrane Tanks divided by the sludge wasted plus the solids lost in the secondary effluent. If solids lost in the secondary effluent are insignificant than they are commonly excluded from the calculation. Also referred to as Solids Retention Time SRT.

Membrane Bioreactor (MBR): The Membrane Bioreactor (MBR) as defined for the TCRWWTP is the biological secondary treatment process consisting of the Aeration Tanks, Membrane Tanks, and associated ancillary equipment.

Membrane Tanks: The Membrane Tanks are a major component of the MBR. The Membrane Tanks contain the membranes which perform the separation of the liquids (permeate) from the solids (activated sludge). The Membrane Tanks are aerated tanks which provide additional aerobic treatment to the mixed liquor from the Aeration Tanks.

Microbial: Pertaining to the activity of microorganisms.

Microorganism: Very small organisms that can only be seen through a microscope. Some microorganisms use the wastes in the wastewater for a source of food, thereby removing or altering much of the undesirable matter.

Mixed Liquor: The mixture of activated sludge microorganisms and wastewater in the Aeration Tanks, Membrane Tanks, and channels between these tanks.

Mixed Liquor Suspended Solids (MLSS): A measure of the concentration of residual solids and microorganisms present in the mixed liquor of an activated sludge system.

Mixed Liquor Volatile Suspended Solids (MLVSS): The MLSS that is volatile based on laboratory analysis under defined conditions; usually used to represent the concentration of microorganisms in the aeration tank mixed liquor.

Nitrification: The microbial conversion of ammonia to nitrite and nitrate in the presence of oxygen.

Nutrients: Organic and inorganic compounds, such as nitrogen, phosphorus, and some trace metals, which are required by microorganisms to support growth.

Oil and Grease (O&G): The material that can be extracted from a sample using an organic solvent; also referred to as *Solvent Extractable Material* or SEM. The O&G test indicates the total amount of oils, greases, and fats in the wastewater.

Operator Interface: Refers to the SCADA computer in the operator control station, i.e., the place at which the operator interfaces (controls and monitors) the operating equipment and processes.

Organic Loading: The mass of BOD per day introduced to the biological system. Sometimes expressed per unit volume of the aeration tanks (i.e., the Aeration Tanks and Membrane Tanks in the case of the TCRWWTP).

Organic Loading Rate: The measure of the rate at which organic food (BOD) is applied to a wastewater treatment process or watercourse.

Oxygen Uptake Rate (OUR): The rate at which activated sludge microorganisms consume oxygen during their metabolic processes.

Overflow Rate: Equal to the flow to a clarifier or settling tank divided by the tank surface area. Equivalent to the average up flow velocity.

Pathogenic Organisms: Microorganisms that can cause disease in humans or other animals.

pH: A term used to express the intensity of the acid or alkaline condition of a solution.

Receiving Body (Water): A watercourse, lake, or ocean into which treated or untreated water is discharged.

Recycle/Recirculation: The return of a fluid or solids stream from a treatment process to an upstream location in the wastewater or mixed liquor flow.

Refractory: Resistant to treatment.

Retention Time: See Detention Time; usually expressed as hydraulic retention time or HRT.

Return Activated Sludge: The separated activated sludge that is recirculated from the liquid/solids separation process (clarifier or membrane system) back to the Aeration Tanks to maintain the mixed liquor concentration. Typically abbreviated as RAS. Also called recycle sludge.

Rising Sludge: A condition that can occur in secondary clarifiers in which denitrification of stale sludge leads to the formation of nitrogen gas bubbles. These attach themselves to the sludge mass, causing it to become buoyant and float to the surface of the clarifier.

Screening: The removal of relatively coarse debris and solids from wastewater by straining through grates or screens.

Secondary Treatment: The wastewater treatment process following primary treatment, involving biological waste stabilization. The Activated Sludge process is one example.

Settleability Test: A laboratory determination of the settling properties of solids suspended in a liquid.

Settleable Solids: Those solids in wastewater that settle to the bottom of a sedimentation tank. Also referred to as the volume of solids that settle to the bottom of an Imhoff cone in one hour.

Sludge: Solids produced in treatment processes.

Sludge Age: Synonymous with Solids Retention Time.

Sludge Blanket: The layer of sludge formed in a settling tank (Primary Clarifier; Secondary Clarifier).

Sludge Bulking: Sludge occupying excessive volumes and having poor settling and compaction characteristics due to an excessive number of filamentous microorganisms.

Sludge Digestion: The process by which organic matter in the sludge is converted into more stable compounds through the activities of either anaerobic or aerobic organisms.

Sludge Volume Index: A measure of the settleability/compaction of the mixed liquor, equal to the volume in milliliters occupied by one gram of activated sludge after 30 minutes of settling under laboratory conditions.

Sodium Hypochlorite: Chemical name for commercial liquid chlorine usually delivered as 12.5% active chemical. Used for disinfection of wastewater effluent and/or odor control in some applications (also referred to as hypochlorite). As comparison, household liquid chlorine is typically sold as 5% active chemical.

Solids Loading: An important design parameter for secondary settling tanks which measures the mass of solids applied per unit surface area of the tank.

Solids Retention Time (SRT): See MCRT.

Substrate: The substances (food) used by microorganisms for the growth (synthesis) of new cellular material and the production of energy.

Supernatant: The liquid phase above settling solids and sludge.

Suspended Solids (SS): Solids that are in suspension in liquids; measured as the solids removable by filtration with a specific filter under controlled laboratory conditions.

Toxicity: In wastewater typically used in reference to the inhibition or deleterious effect on microbial activity due to a poisoning or interference with intracellular or extracellular reactions or inhibition or deleterious effect of the treated effluent on aquatic organisms.

Treatment Efficiency: A measure of the amount of a specific pollutant, such as BOD_5 or suspended solids, removed by a waste treatment process, usually expressed in percentage removal.

Volatile Solids: The quantity of solids lost on ignition at 550°C under controlled laboratory conditions; generally considered to be equivalent to the fraction of suspended solids that are biological in origin. See also *MLVSS*.

Waste Activated Sludge: The excess cellular mass produced as a result of microbial degradation of organic matter, i.e., the activated sludge that must be removed from the Activated Sludge system to maintain an appropriate MLSS concentration in the aeration tank to achieve a constant F/M and/or SRT.

Weir Loading Rate: Upflow Rate: The Weir Loading Rate is calculated as the maximum flow that can be applied to the length of the effluent weir. Settling tanks (clarifiers) are designed with a maximum weir loading rate to prevent the influence of excessive density currents causing solids to be re-suspended and carried away in the effluent from the clarifier.

3.5 Preliminary Screening Description

3.5.1 Process Intent or Function

Preliminary treatment is provided to protect all downstream equipment from damage or clogging from rags, debris, or grit. The Preliminary Screening Unit Process is the first process in the treatment plant flow stream. It receives the raw sewage entering the treatment plant from the wastewater collection system and discharges screened wastewater to the grit removal process.

Note: The Preliminary Screening (Headworks) building main equipment room (which contains the main influent channel and bar screen) is a Class 1, Division 1, Group D classified area. All electrical equipment and wiring within this area must comply with NEC requirements for this classification.

3.5.2 Process Description

Wastewater enters the screening building by two forcemains. Isolation valves are available to stop flow to the screen building and divert it directly to the grit system. The purpose of the screen is to prevent large debris from entering the plant and interfering with plant equipment and performance.

The Rotomat screen is automatically cleaned and debris is removed from the flow channel, washed, compressed, and deposited into a hopper for landfill disposal. The automatic screen initiates a cleaning cycle based on an ultrasonic level sensor on the upstream side of the screen. When the level increases to a preset depth, the screen initiates a cleaning sequence. If there is no call from the level controller for a cleaning cycle within a 60-minute period, a timed cleaning cycle will be initiated.

Under normal operations, only the automatic screen is in service. A manual bar screen is also provided for by-pass or emergency operation. The manual bar screen also provides passive operation during periods of very high wastewater levels upstream of the screens.

Discharge from the automatic screens can be directed to the East, West, or to both grit removal units depending on the configuration of the discharge valves. Discharge from the manual bar screen can be directed to the West or both Grit Removal units, but not to the East unit alone.

A detailed description of the equipment operation, start up and shut down procedures, troubleshooting guide, and maintenance requirements can be found in the Lakeside Rotomat Shop Drawing and O&M Manuals located in the ops and maintenance office.

3.6 Grit Removal Description

3.6.1 Process Intent or Function

Two grit tanks (east and west) are available at the plant. Depending on plant flow, only one unit may need to be in operation at any time.

The purpose of the grit tanks is to remove the inorganic sand and grit from the waste stream. Sand and grit enter the wastewater flow from inappropriate storm sewer connections to the sanitary sewer, surface maintenance hole covers and/or from leaky pipe joints. Excessive grit adversely affects the sludge handling systems of the plant and creates excessive wear and tear on pumps and other mechanical equipment. The grit tanks are intended to maintain a minimum velocity to keep lower specific gravity solids (e.g., organic solids) in suspension, and allow heavier grit particles to settle to the bottom.

Note: The grit collector tanks are enclosed tanks and are a confined space and a Class 1, Division 2, Group D classified area. The room housing the grit processing equipment and hopper is a Class 1, Division 2, Group D classified area. All electrical equipment and wiring within these areas must comply with NEC requirements for this classification.

3.6.2 Process Description

The grit collector consists of a square tank, a rotating collector mechanism referred to as a grit scraper arm, a reciprocating grit rake arm for grit removal, and an organic return pump.

Flow entering the tank is uniformly dispersed using a number of adjustable baffles on the inlet end. The tank is sized to produce a velocity necessary to settle grit solids, but keep organic material suspended. The water level in the tank is controlled with an outlet weir.

The settled grit is continually moved from the bottom of the grit tank with a grit scraper arm to the corner of the grit tank where a reciprocating rake arm moves the grit up out of the water on an inclined trough which projects into a building. There is an "organics return pump" (an impeller on a shaft over a hole in the concrete) that circulates wastewater over the grit being raked upwards to rinse organics back into the wastewater flow through the grit tank. There are baffles that can be inserted to control the degree of the rinsing. At the end of the trough the washed grit is discharged into a hopper for landfill disposal. A detailed description of the equipment operation, start up and shut down procedures, troubleshooting guide, and maintenance requirements are provided in the equipment manufacturer’s shop drawings and O&M Manuals located in the maintenance office.

3.7 Primary Settling Description

3.7.1 Process Intent or Function

Primary Clarifiers are provided to reduce TSS and BOD to the activated sludge treatment process. Scum and grease are also removed in this process. Typically, well operated primary clarifiers will remove 50 percent to 65 percent of the TSS and 30 percent BOD.

The goals of operating the primary clarifiers are:

- Remove as much BOD and TSS from the influent as possible upstream of the activated sludge system.
- Thicken settled material into as high a concentration primary sludge as possible for delivery to anaerobic digesters.
- Generate and liberate volatile fatty acids (VFAs) into the primary effluent to improve biological uptake of phosphorous in the activated sludge system.

Note: The Primary Clarifiers are enclosed tanks and are a confined space and a Class 1, Division 1, Group D classified area. All electrical equipment and wiring within this area must comply with NEC requirements for this classification.

3.8 Process Description

3.8.1 General

Wastewater discharges from the grit removal process and enters the Primary Clarifiers. Influent valves allow the wastewater to be distributed to all eight (8) Primary Clarifiers or to be isolated from a specific clarifier. The Primary Clarifiers provide a hydraulic detention time of 1 to 3 hours depending on the flow rate and the number of units in service. This detention time allows solids to settle to the bottom of the tank. Primary effluent overflows effluent weirs and is delivered to the activated sludge process. Floatable material is captured by baffles at the effluent weir and is periodically removed.

A continuously operating chain and flight sludge collector scrapes the bottom of the Primary Clarifier and moves sludge to one end where a hopper is provided for sludge removal. The flights also push floating material towards the scum removal mechanisms.

3.8.2 Scum Removal

Scum is removed by manually activating a helical scraper that moves scum into a scum trough where it is sent by the Primary Sludge Pumps to the digesters.

3.8.3 Primary Sludge Removal

The plant has eight (8) Primary Clarifiers. Each Primary Clarifier has one sludge hopper. Primary Sludge is withdrawn from sludge hoppers located beneath the influent end of the Primary Clarifier. Each hopper has one powered withdrawal valve.

There are two Primary Sludge Pumps (80-P-3A and 80-P-3B). One pump is for duty; the other is a standby. The pumps are pneumatically powered diaphragm type referred to as air operated diaphragm pumps. Stroke filling and emptying times are adjusted locally via suction and discharge air regulator sets. The amount pumped is set by a combination of air operated diaphragm pump strokes per minute and the number of minutes the pump is operated per hopper. The regulators on the air diaphragm pumps' control panels are only adjusted to get full volume per stroke.

Sludge distribution to the five digesters (only three are currently in service digesters 3, 4, and 5) is normally operated automatically, to feed each operating digester in sequence, based on timing entered at a SCADA station.

Primary sludge can also be recycled from the sludge hoppers back to the inlet of the Primary Clarifiers, using the Primary Sludge Pumps. Recycled primary sludge (RPS) aids VFA production in the Primary Clarifiers. VFAs are formed during the decomposition of the sludge. The carbon available in the VFAs, in turn, aids the biological phosphorus removal process in the secondary treatment portion of the plant.

The recycled primary sludge line branches off a common 6-inch primary sludge discharge line. This common primary sludge line also continues on to all five digester inlets via the digester feed header. A pair of automatic block valves, (FV-80-6 and FV-80-7) operating in a flip flop fashion, direct the primary sludge to either the digesters feed header or the primary settling tanks recycle header, respectively. Normally, the primary sludge is recycled. Recycling pauses while feeding the digesters, this occurs on an intermittent basis.

Primary sludge withdrawal from the primary hoppers, delivery and distribution to the five (5) digesters and to the influent header all occur according to operator settings in the plant SCADA.

3.8.4 Primary Sludge Pumps

The duty Primary Sludge Pump never stops operating while the recycled primary sludge program is enabled. There is always one of the eight sludge withdrawal valves open. When advancing to the next sludge hopper, the valve on the previous hopper remains open until the next valve is confirmed open. In the event the plant PLC does not get confirmation from the open-end limit switch from the next valve after a reasonable time, the PLC initiates a fail-to-open alarm, issues a close command to the failed valve, and continues on to try the next available hopper withdrawal valve. The common primary sludge discharge line is always pressurized.

The pumps are arranged such that either or both of the two pumps can be used. Duty selection is made only at the pumps.

While recycling, valve FV-80-7 is open and the Primary Sludge Pump operates at a reduced output. When primary sludge is feeding a digester, the Primary Sludge Pump operates at full output. At a SCADA operator interface, the operator may adjust the pump speed set points. There are two separate setpoints, one for use during recycling and another for use while pumping to digesters.

3.8.5 Primary Recycle (recycled primary sludge) Control Program

Primary recycle should be used to produce the VFA concentrations in the primary effluent necessary to maintain the desired level of biological phosphorus removal in the activated sludge system. With recycling, the sludge concentration may decrease, thereby requiring a higher setting for the pumping time to digesters.

The primary recycle control program includes operator adjustments. At a SCADA station, the operator may:

- Enable or disable the recycling of primary sludge, depending on seasonal needs.
- Adjust control program parameters such as timers.

Note that some adjustments entered in the middle of a valve control sequence will always take effect at the beginning of the next Digester Feed Cycle and/or when the whole auto control strategy is restarted.

While the recycle program is disabled, valve FV-80-6 (to the digester feed header) remains open and valve FV-80-7 remains closed all the time to avoid unnecessary wear on the valves.

3.9 Fine Screening Description

3.9.1 Process Intent or Function

New fine screen equipment provides for the screening of Primary Clarifier effluent, prior to conveyance to the secondary treatment system. Two screening channels, each 2 feet wide, are provided with a mechanically cleaned band screen rated at 10 MGD. The channels have a design water surface depth of approximately 3 feet. The channel depth is controlled by a fixed weir, installed in the effluent channel of each screen. The screened effluent discharges to the influent bay of the screw pumps. The screens have perforated openings of 2 mm, which is the opening size preferred by the membrane system manufacturer.

Material collected on the screen is lifted out of the channel by the rotating screen and removed using a rotating brush and spray water. Each screen discharges the collected screenings to a screenings flume. Effluent water flushes the screenings from the screen and serves as sluicing water to convey the screenings, via the flume, to a screenings compactor for removal of excess water. The compacted or dewatered screenings are bagged to prevent excessive odors with a screenings bagger for periodic removal.

Note: The Fine Screening Building equipment room is a Class 1, Division 1, Group D classified area. All electrical equipment and wiring within this area must comply with NEC requirements for this classification.

3.9.2 Process Description

Normally, one screen is in service at a time. The fine screens operate automatically from the local control panel for each screen. Each screen is equipped with an adjustable speed drive. Each screen will start, based on the differential between the upstream and downstream liquid levels in the screening channel. The screen speed will vary, depending on the differential level. Each screen is anticipated to build up a layer, or mat, of material that will act to prevent slender stringy material from passing thereby enhancing the performance of the screens. This further ensures fouling protection of the membranes.

The screenings compactor will automatically start whenever a screen starts. The compactor will stop, after a time delay, when the screen stops.

In the event that flow exceeds the capacity of the screens, overflow to the screw pump wet well is provided via the two adjustable weir gates. **The weir gates are downward opening and should be positioned at elevation 112.15 (approximately 5 feet below the floor grade). If the weir gates are set higher than 112.15, then overflow would occur through the existing primary effluent overflow directly to the Boardman River.**

3.10 Screened Primary Effluent Pumping and Distribution Description

3.10.1 Process Intent or Function

The purpose of the screened primary effluent pumping and distribution system is to lift the screened primary effluent to the hydraulic level of the Aeration Tank inlet channels and to distribute the flow to the two Aeration Tanks as secondary influent.

Note: The primary effluent screw pumps area is unclassified.

3.10.2 Process Description

Overview. Screened primary effluent is conveyed by gravity from the fine screens to the screw pump influent well. Spiral screw pumps lift the screened primary effluent to the level of the Aeration Tanks. The pump discharge is hydraulically split into two parallel Aeration Tank inlet channels. A motorized slide gate is located in each channel and positioned to adjust the desired flow split between the north and south Aeration Tanks. The secondary influent flow is monitored downstream of the motorized slide gates via Parshall flumes.

Screened Primary Effluent Pumping. Screened primary effluent pumping consists of three (3) constant speed spiral screw pumps. The pumping process is a continuous operation.

During normal operations, the screened primary effluent flows into the screw pump influent well and one screw pump transfers the influent to the Aeration Tank inlet channels. A second pump is started when the flow exceeds the capacity of the first pump. There is also an adjustable flow setpoint on the SCADA that the operator can adjust, at this setpoint the lag screw pump will turn on automatically. This option was added to help better buffer flow during high flow events. The flow setpoint is based off of influent flows in MGD, normally set at 10 MGD. The pumps are normally assigned a lead-lag-standby duty arrangement and the start/stop operation of the second pump is automatic. Should the lead or lag pump fail, the standby pump automatically starts.

Constant speed screw pumps provide a flexible flow rate, even though they rotate at a constant speed. As the level in the influent well increases and more of the pump becomes submerged, the flow delivered by the pump also increases. The pumping rate is proportional to the water depth in the influent well until the water level goes above the top of the bottom end of the center tube. At that point, the pump reaches its maximum capacity and any further level rise will provide the same pumping rate.

Screw pump inlet sluice gates are provided to isolate screw pumps for maintenance purposes. The gates are manually operated.

The pumps are connected to the existing standby generator, to ensure their operation during times of utility company power failures.

Flow Measurement. Each Aeration Tank inlet channel contains an 18-inch Parshall flume. The contraction (18” throat) of the flume allows for accurate flow measurement as a function of level. An ultrasonic level is used for continuous instantaneous level measurement. The level readings are then converted to flow.

Screened Primary Effluent Distribution. Two (2) motorized screened primary effluent flume gates located upstream of the Parshall flumes are used to adjust the flow split between the north channel and south channel. The gates are automatically positioned based on operator selectable flow split parameters.

3.11 Secondary Treatment Description

3.11.1 Process Intent or Function

Secondary treatment is a biological treatment process. Secondary treatment is provided to remove soluble organic matter, particulate organic and inorganic matter, ammonia, and phosphorus. The process provided also removes a portion of the nitrate formed from the oxidation of ammonia.

Note: The Secondary Treatment areas are unclassified.

3.11.2 Basis of Design

The TCRWWTP effluent discharges into the Boardman River and ultimately Grand Traverse Bay. The facility has been designed to comply with the Michigan Department of Environmental Quality requirements for wastewater treatment including monthly average effluent five-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) of 25 mg/L and 30 mg/L respectively. The current discharge permit also establishes a seasonal effluent limit for ammonia nitrogen (NH_3-N) of 11 mg/L and an effluent total phosphorus (TP) limit of 1 mg/L. The Traverse City effluent objectives have been established as 4 mg/L for BOD_5 and TSS, 1 mg NH_3-N /L, and 0.5 mg TP/L.

The Secondary Treatment Process at the TCRWWTP is an activated sludge process that incorporates biological nutrient removal (BNR) and membranes and is herein referred to as a *Membrane Bioreactor* (MBR). The MBR includes Aeration Tanks and Membrane Tanks. The Aeration Tanks include unaerated anaerobic and anoxic zones as well as aerated zones also referred to as aerobic zones. The membrane tanks are aerated tanks with membrane equipment for separation of liquid and solids. The MBR provides biological absorption and oxidation of organic matter (quantified as $CBOD_5$), biological oxidation of ammonia to nitrate, enhanced biological uptake of phosphorus, biological conversion of a portion of the nitrate formed to nitrogen gas, flocculation of colloidal matter, chemical precipitation of phosphorus to supplement biological uptake, and physical separation of liquids and solids.

The process is based on the University of Cape Town (UCT) process configuration, with the anoxic, anaerobic zones and recycle configured to accomplish enhanced biological phosphorus removal. The MBR is capable of treating maximum monthly loads of 20,200 lb/day BOD at 8.5 MGD. The design peak flow is 17 MGD. The membrane bioreactor equipment will allow the effluent TSS and BOD limits to be met, using biological treatment.

The major design criteria for the MBR are presented in Exhibit 6.

Exhibit 6. Design Criteria Table 8-1: MBR – Design Criteria

Parameter	Value/Range1
Number of Aeration Tanks	2
Total Treatment Volume	1.885 MG
Anaerobic Volume	0.059 MG
Anoxic Volume	0.210 MG
Aerated Volume	0.673 MG
Total Volume each Tank	0.942 MG
Solids Retention Time (min SRT)	Min. 6.5 to 8.5 days @ Design Max. Month
Aerated Hydraulic Retention Time	Min. 4.8 hours @ Avg. day flow
Wastewater Temperature	Min. 55^0F (13^0C)
Sludge Yield	0.7-0.8 lb TSS/lb BOD removed
Mixed Liquor Suspended Solids (at membranes)	8,000 - 10,000 mg/L
Mixed Liquor Suspended Solids (Aerated zone)	3,000 – 7,000 mg/L
Oxygen Demand for BOD	0.72 lb/lb BOD applied
Oxygen Demand for TKN	4.6 lb/lb TKN applied
TKN: NH_3-N Ratio	1.2:1
VSS/TSS	70%
Minimum Oxygen Transfer Efficiency	18%
Mixed Liquor Recycle: % Secondary Influent flow rate	
Aerated Zone to Anoxic Zone	100% or 200%
Anoxic Zone to Anaerobic Zone	100% or 200%
Membrane Tanks to Aerated Zone (max.)	400%

3.11.3 Process Description

The influent to the MBR is pumped from the primary effluent screening facility to two (2) secondary influent channels, each with a Parshall flume and individual sluice gates that are controlled to split the flow to the in-service Aeration Tanks.

The Aeration Tanks are arranged in two (2) parallel trains. The tanks are configured in three passes: an anaerobic zone representing a percentage of the first pass, an anoxic zone for the remainder of the first and all of the second passes (with swing zone capabilities) and the final pass an aerated zone. The secondary influent and mixed liquor recycle containing biological solids are introduced into the anaerobic zone. The combined wastewater referred to as mixed liquor because of the presence of biological solids flows through the anaerobic zone, anoxic zones, and aerated zones of the Aeration Tanks. The flow pattern is generally *plug flow* through the individual Aeration Tank zones. The ML ultimately overflows from the discharge end of the aerated zone into a common Membrane Tanks influent channel.

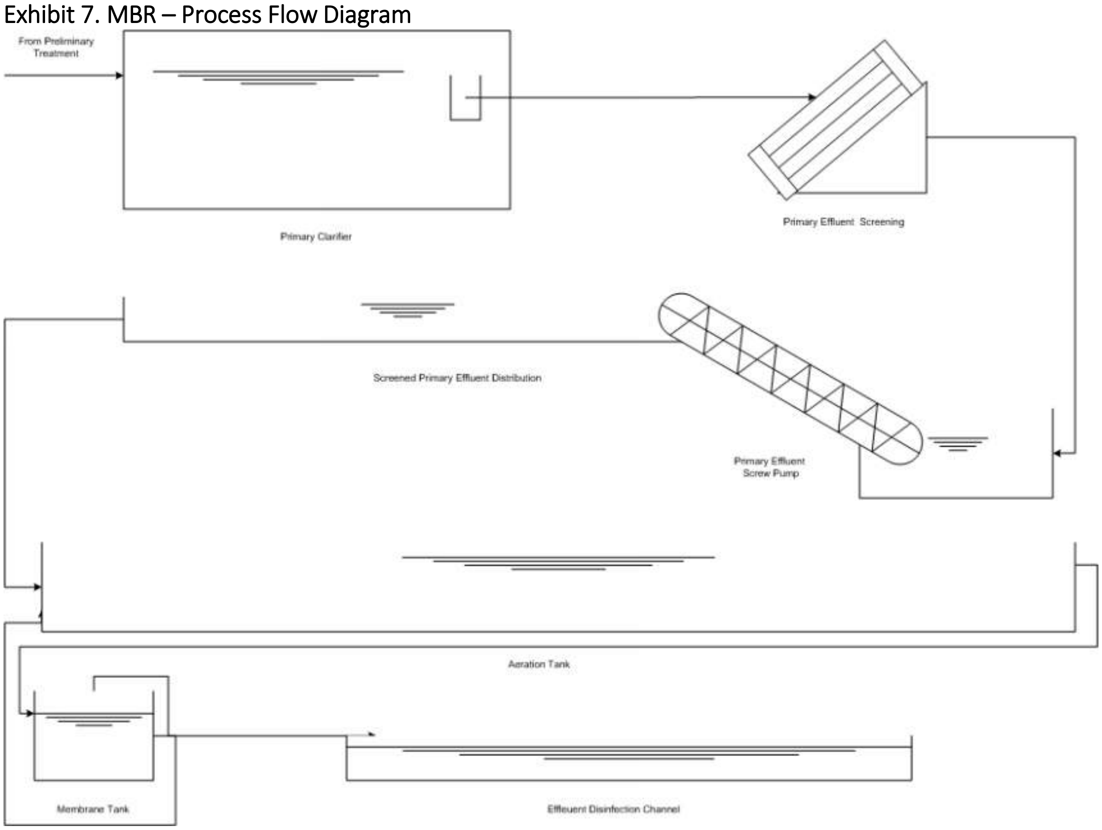
The mixed liquor (ML) from the Aeration Tanks is channeled to the in-service Membrane Tanks. The membrane equipment effectively separates the solids from the liquid phase of the ML by applying suction to the inside of individual membranes with large centrifugal pumps. The separated solids from the ML side (outside) of the membranes, referred to as activated sludge, overflows adjustable gates at the discharge side of the Membrane Tanks. Most of the activated sludge (AS) is recirculated to the front of the aerated zones in the Aeration Tanks as return activated sludge (RAS) and the remaining portion of the activated sludge is directed to the solids handling processes as waste activated sludge (WAS).

Biological phosphorus removal is the main mechanism for phosphorus removal but chemical may be added to the MBR to supplement the phosphorus removal process.

3.11.4 General Arrangement Schematic

Exhibit 7 presents a schematic overview of the Traverse City process flow.

Exhibit 7. MBR – Process Flow Diagram



3.11.5 Relationship to Other Processes

Solids are maintained in the biological system by the return activated sludge (RAS) system, one of three ML recycle systems, that returns the activated sludge solids from Membrane Tanks to the Aeration Tanks. Details are provided in Chapter 10 – RAS Mixed Liquor Recirculation System.

Process air is continuously provided to the aerated zone(s) of the in-service Aeration Tank(s) as supplied by four (4) process air blowers. The aerated zones in the tanks are aerated using a grid system of fine bubble diffusers.

The mixed liquor recycles (MLR) are internal recycles within the Aeration Tanks to allow ML transfer from the final aerated zone to the anoxic zones and from the anoxic zones to the anaerobic zone. The return activated sludge (RAS) system returns biological solids from the Membrane Tanks to the aerated zone of the Aeration Tanks. Excess solids, the *waste* activated sludge (WAS), are removed from the system and directed to Solids Treatment Processes. The WAS is thickened on a Gravity Belt Concentrator and discharged to the Anaerobic Digestion system for further processing.

Recycle streams from Solids Treatment Processes are routed to the Aeration Tanks as internal recycle streams, including the filtrate from the WAS Concentration process and filtrate from the Digested Sludge Concentration process.

Ferric chloride is added to the mixed liquor as it leaves the Aeration Tanks to precipitate remaining phosphorus.

3.12 Membrane Process (MBR) Description

3.12.1 Process Intent or Function

Membrane Bioreactors (MBR) are a combination of suspended growth activated sludge and membrane equipment, with the latter performing the critical solids/liquid separation function that is traditionally accomplished using secondary clarifiers.

MBRs rely upon membrane equipment for liquids/solids separation prior to discharge of the effluent. The membrane equipment installed at the TCRWWTP is an immersed system, i.e. a system that is designed for installation within bioreactor tanks, which utilizes hollow fiber membranes. The system configuration allows the Membranes to withstand the high concentrations and types of solids from the MBR process provided. The MBR design allows:

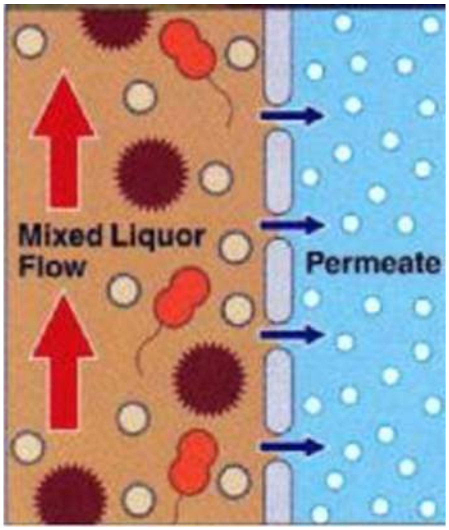
- Biomass to be completely retained; effluent solids concentrations are generally <1 mg/L
- Sufficient solids retention times (SRT) for nitrification;
- SRT to be separate from hydraulic retention time (HRT) allowing independent control of both
- Problems associated with settling and filtration of activated sludge to be eliminated
- Processes to be automated reducing operations requirements
- Reduction of effluent pathogens, such as the chlorine-resistant organisms *Cryptosporidium* and *Giardia*

Note: The Membrane Tanks and equipment areas are unclassified.

3.12.2 Process Description

Membrane Tanks. Mixed liquor flow from the Aeration Tanks is conveyed, by gravity, to the Membrane Tanks. Each of the eight (8) Membrane Tanks are designed to provide continuous treatment of the wastewater (mixed liquor). The number of in-service Membrane Tanks is dependent on the flow. The treated effluent (*permeate*) from the Membrane Tanks is transferred by Membrane Permeate Pumps to the UV Disinfection channel for discharge as plant final effluent (Chapter 11: Effluent Disinfection).

Exhibit 8. Membrane Functional Schematic



The mixed liquor (ML) from the Aeration Tanks is discharged to a ML Channel upstream of the Membrane Tanks. Lowering motorized weir gates at the inlet of each Membrane Tank controls the influent to each of the Membrane Tanks. The Membrane Tank inlet gates are normally fully opened (lowered) to allow unrestricted flow into the in-service tanks.

Each Membrane Tank has an associated variable speed membrane permeate pump. Treated effluent flow is controlled by modulation of the speed of the individual pumps.

The separated activated sludge solids overflow Membrane Tank outlet gates to a common Membrane Tank ML effluent channel referred to as the Return Activated Sludge (RAS) Channel. As in more conventional activated sludge systems the solids are returned to the Aeration Tanks to maintain the biology of the system. The position of the tank outlet gates for the in-service tanks should be similar allowing equal discharge from each tank. Generally, the RAS rate required to *flush* the membranes exceeds the biological requirements and may be as high as 400% of primary effluent flow to the MBR.

The position of the inlet and outlet gates determines whether a tank is in or out of service. The inlet and outlet gates must be fully closed (raised to the maximum position) when a Membrane Tank is taken out of service. Tanks may be off line, i.e. in standby mode or undergoing maintenance and recovery cleaning sequences (discussed in detail in the Maintenance section). The off line (standby) Membrane Tank's membrane permeate pump is also taken out of service. The Membrane Tank service air blowers required during operation for air scour may be operated intermittently to discourage settling and septicity in the off line Membrane Tank.

Membrane permeate pumps are normally controlled such that the flow from the pumps varies with the total flow through the screened primary effluent Parshall flumes. The permeate pump speed control, and therefore the discharge flow, is trimmed based on the level in the RAS Channel. Permeate pumps may be operated to control the differential pressure across the membrane - the trans-membrane pressure (TMP) - at a selected maximum. The level in the Membrane Tanks is monitored such that high level causes the in-service permeate pump speed to increase to a preset maximum. If the level continues to rise the screened primary effluent pump(s) will be stopped.

Note: In the event that primary effluent flow total is zero indicating possible primary effluent flow meter failure, the membrane permeate pumps will vary based off of primary influent flow. This feature was added to the programming to prevent the trains from seeing no flow and going into a standby mode. The system will remain in influent flow mode until primary effluent flow metering is restored and primary effluent flow is selected at the SCADA.

Range of Operation. The permeate rate, i.e. the rate of transfer of liquid across the membrane, is referred to as the flux rate and is measured as gallons per square foot of available membrane area per day. This is typically abbreviated as GSFD. The more concentrated the solids in the feed solution, the lower the flux rate. The remaining (rejected) solids slurry, the difference between the feed rate and the permeate rate, remains as flow through the Membrane Tank. A relatively high ratio of feed volume to permeate volume, controlled in part by the recycle rate, allows the membrane to be self-cleaning. The rejected (recirculated) ML (RAS) continues to concentrate until the flux rate drops to an unacceptable level unless removed from the system, or wasted.

Reduced membrane flux - resulting from short SRT operation - may be related to the fouling of the membrane by the extra-cellular excretions from younger sludge. Immersed membrane operation is not affected significantly by biopolymer fouling provided that the SRT is at least long enough to perform nitrification, a requirement of the TCRWWTP. Fouling that does occur can be effectively controlled by automated membrane clean-in-place (CIP) procedures.

Higher biological life forms in the MBR (i.e. microorganisms such as protozoa and rotifers) consume particulate organics, which results in more dispersed (smaller) floc particles. The shearing action of the air scour system may also result in more dispersed floc particles. The MBR system avoids issues of filamentous sludge bulking and other floc settling and clarification problems.

The mixed liquor suspended solids (MLSS) concentration in the MBR system will range from 6,000 to 10,000 milligrams per liter (mg/L).

3.13 Mixed Liquor Recirculation Description

3.13.1 Process Intent or Function

The mixed liquor recirculation, referred to as the Return Activated Sludge (RAS) process, is a continuous operation to return the activated sludge biomass separated from the permeate in the Membrane Tanks to the Aeration Tanks. This is required to maintain a high population of microorganisms in the Aeration Tanks to biologically treat the wastewater from primary treatment. The rapid recirculation of solids also minimizes high solids concentration at the membranes, which in turn would cause higher trans-membrane pressures (TMP).

Note: The RAS equipment area is unclassified.

3.13.2 Process Description

Three constant speed RAS pumps (one standby) recirculate mixed liquor from the Membrane Tanks to the head of the aerated zones in the Aeration Tanks.

Each RAS pump has a rated capacity of 15 MGD, for a total of 30 MGD with two pumps operating. RAS is pumped from the bottom of the membrane mixed liquor effluent channel and is conveyed to the aerated portion of the Aeration Tanks through two separate pipes.

The dissolved oxygen concentration of the RAS is expected to typically be about 6 mg/L, which reduces the airflow demand in the aerated zones of the Aeration Tanks.

RAS rates to the Aeration Tanks depend on plant flow and mixed liquor suspended solids concentration (MLSS). Flow control valves on the discharge side of the pumps control the RAS flow to the north and south Aeration Tanks to operator adjustable set points and prevent the RAS pumps from running dry by maintaining a minimum level in the mixed liquor effluent channel. The flow rate is monitored by the SCADA for record keeping purposes.

3.14 Process Air Blower Description

3.14.1 Process Intent or Function

The purpose of the process air blower system is to supply the low pressure air to the aerated zones of the Aeration Tanks. The process air is injected to provide the required dissolved oxygen (DO) content and to keep the contents of the aerated zones adequately mixed.

Note: The Air Blower room is unclassified.

3.14.2 Process Description

Overview. The process air blower system consists of four (4) inlet throttled constant speed drive centrifugal multistage process air blowers, a low pressure air piping system, and fine bubble diffusers to supply process air to the aerated zones of the Aeration Tanks. The process air blower output is varied by pneumatic butterfly valves, one valve located on the inlet side of each process air blower, to maintain a pressure set point in the air header.

There are two (2) air flow meters, one for each Aeration Tank. Air flow control valves adjust the air flow rate to the aerated zones of each of the Aeration Tanks. Dissolved oxygen (DO) probes are used to monitor the oxygen level in the aerated zones of each Aeration Tank.

DO Control and Minimum Mixing Air Requirements. When automatic DO control is selected, the air flow control valves respond to the DO level in the corresponding aerated zones of each Aeration Tank and will adjust their position to maintain the selected DO setpoint. The operator selects the desired DO probe and the desired DO setpoint to be used for control in the aerated zones of the north and south Aeration Tanks. The DO control system will not allow air flow to go below the minimum air flow setpoint (0.5 cfm/diffuser). The minimum air flow setpoint to the aerated zones of each Aeration Tanks is an operator adjustable parameter and may be modified at SCADA, if required.

Automatic Process Air Blower Control. When automatic process air blower control is selected, the process air blowers in service will automatically adjust output to maintain the selected air header pressure setpoint. The lag process air blower will start/stop automatically if the base-load process air blower(s) does not provide sufficient flow to satisfy the pressure setpoint.

The automatic process air blower control system operates to optimize energy. Energy savings can be obtained by operating the system at the lowest sufficient pressure. Equilibrium can occur with the most open valve in almost any position, but the most efficient operation is with the most open valve at 70-80% open. The automatic process air blower control system monitors the most open air flow control valve. If the valve is greater than 80% open, the process air blower system will increase the amount of air delivered through the valve by increasing the air header pressure setpoint as required. Conversely, if the most open valve is less than 70% open, the process air blower system will decrease the amount of air by decreasing the air header pressure setpoint as required.

The operator may also start/stop the process air blowers manually from SCADA or locally from the MCC/local control panel.

3.14.3 Chemical System Description

Process Intent or Function. The in-service membranes require cleaning on a regular routine basis. Two methods of in-tank cleaning, also referred to as Clean-In-Place (CIP), have been provided. Separate chemical systems are in place to feed sodium hypochlorite or citric acid to the membranes without removing the membrane cassettes from their respective tanks. The citric acid cleaning system is presented first followed by the sodium hypochlorite system.

Note: The Membrane Building areas are unclassified.

Process Description. The Membrane Building contains a chemical storage area and feed systems used for all membrane cleaning operations. Citric acid is fed to the membranes via a system of pumps and delivery piping. Two (2) citric acid dosing pumps are available and operate as duty-standby to deliver chemical as required. Bulk chemical is delivered in totes to the chemical storage area and transferred to a storage tank in the storage area. Concrete curbs provide containment in the event of a spill.

An alternative is available to cleaning membranes. Individual cassettes can also be cleaned using the Dip Tanks. This is a manual operation where the desired concentration in the dip tank is achieved by manually transferring citric acid with the pneumatic dosing pumps.

Maintenance cleaning with sodium hypochlorite is operator selectable (maximum cleaning interval is once every four (4) days) except on days when cleaning with citric acid is performed (maximum cleaning interval every 12 days). Recovery cleaning of each train of membranes is performed at a maximum interval of three (3) times per year with sodium hypochlorite and one (1) time per year with citric acid.

The operator, using the Zenon PLC via SCADA, will initiate the desired cleaning operation. The backpulse flow rate is pre-set depending on the cleaning operation. The backpulse flow rate is automatically monitored and controlled using a flow meter and flow control valve by the Zenon PLC. The backpulse pump can also be operated manually, with start, stop, and speed controls at the local control panel.

Each citric acid pump is equipped with a high rate and low rate air supply. Air supply pressure regulators permit field adjustment of the high and low delivery rates. The air supply valves will be operated via the Zenon PLC. Depending on the type of cleaning sequence selected, the high rate or low rate will provide the desired volume to achieve the required concentration, by establishing a flow-proportional flow with the backpulse. The required concentration of citric acid is 1000 mg/L when combined with backpulse water for a full tank maintenance cleaning and 2000 mg/L for an empty tank maintenance cleaning. The required concentration of citric acid for recovery cleaning is 8,000 mg/L. The cleaning sequence is initiated by the operator from SCADA and the operator can abort the CIP or maintenance procedure at any step of the sequence. The system will then return the tank to the service mode, including filling and backpulsing.

The level in the membrane tank is continuously monitored with a level sensor. The level signal is used by the Zenon PLC for tank filling, tank draining, and establishing the level of chemical solution for cleaning.

3.15 Ultraviolet Disinfection Description

3.15.1 Process Intent or Function

Disinfection is the final treatment process prior to final discharge. The Ultraviolet (UV) disinfection process uses ultraviolet light to inactivate pathogens (disease causing microorganisms which include certain bacteria, viruses, and protoza) before final effluent discharge.

Note: The UV area is unclassified.

3.15.2 Process Description

Wastewater from the membrane permeate pump enters the UV channel inlet wet well. The inlet wetwell splits the flow into two channels. Normally, both UV channels are in service but isolation gates are available if one channel is in need of service. Isolation gates are also available to stop flow to the UV channel and divert it directly to the outfall.

The channels have locations for fourteen UV lamp modules, seven (7) per channel. However, in order to pass peak design flow only eight (8) modules, four (4) per channel are installed. There is one bank per two modules. Each bank consists of one module in each channel. The two modules in a bank are adjacent to each other in the two channels and turn on and off together when UV dosage is flow paced. Each module contains 40 vertically oriented UV lamps. The modules may be removed and the total number of modules in a channel at any given time can vary. As wastewater flows through each channel it passes through this series of lamps and is disinfected. Banks of modules can be turned on or off to match the proper dosage to the flow.

The water level in the channel must be maintained within a range of 57.5 inches to 62 inches. If the water level is lower than the minimum depth, a portion of the UV lamp may be exposed to the atmosphere. This could lead to lamp overheating, and possible exposure of the UV light to plant operators. If the water depth is higher than the maximum, then some of the wastewater may not be fully disinfected or the electrical components could become flooded.

At the end of the UV channel, an adjustable weir is provided to maintain the proper depth of water in the channel over a wide range of flow conditions. Wastewater passing over the weir falls into a final wetwell and is routed to the plant outfall. During periods of high flow and/or high lake level, the water elevation in the final wetwell may exceed the level of the back of the automatic weir. In this situation the operator should manually lift the weir gate to allow maximum flow over the weir.

3.16 Waste Activated Sludge Concentration Description

3.16.1 Process Intent

The purpose of waste activated sludge (WAS) concentration is to remove water from (i.e., thicken) the waste sludge from the Membrane Bioreactor (MBR), thereby reducing the volume pumped to the anaerobic digesters. This may also reduce the volume stored in the on-site biosolids storage facilities and hauled for land disposal (i.e., injected into farmland).

Note: The WAS Concentration area is unclassified.

3.16.2 Basis of Design

The design criteria are detailed in Exhibit 9.

Exhibit 9. WAS Concentration Design Criteria

Parameter	Value/Range
Design Average WAS Solids	11,600 lb./day
Design Average WAS Concentration	7,000 to 10,000 mg/L
Design Average WAS Flow	139,100 to 198,700 gpd
Design Peak Week WAS Solids	16,100 lb./day
Design Peak Week WAS Concentration	10,000 mg/L
Design Peak Week WAS Flow	193,000 gpd
Average Processing Time	8 hr/day
Thickened WAS Concentration	5.5 percent, dry solids

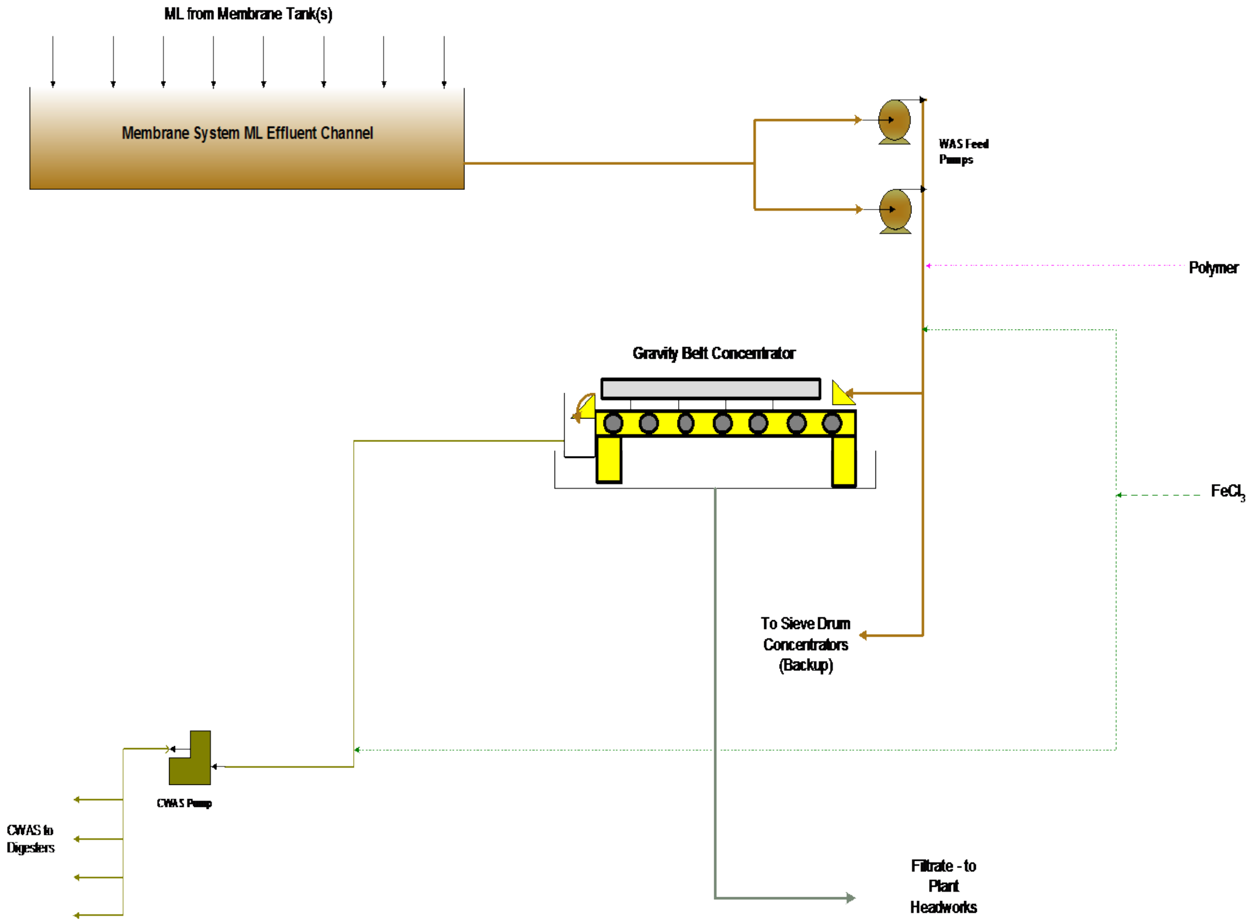
3.16.3 Process Description

The waste activated sludge (WAS) is pumped from the WAS Box to the Gravity Belt Concentrator (GBC). The GBC consists of a permeable, continuous belt that travels horizontally across a series of rollers. Polymer is injected into the WAS in the pump discharge header upstream of the GBC to flocculate the activated sludge solids. Conditioned activated sludge fills a floc tank at the head of the GBC, which is designed to provide adequate mixing and reaction time of the polymer with the sludge solids. The conditioned activated sludge fills the tank and overflows onto the traveling belt. The belt travel speed is operator adjustable to optimize the retention time of the conditioned sludge on the belt to allow maximum water release and, therefore, maximize the concentration of the activated sludge at the end of the belt travel. The lateral position of stationary plows or chicanes along the belt are manually adjustable to create furrows and open clear sections of the belt to aid in free water release and belt drainage. A polyethylene doctor blade, with an adjustable tensioning arm, removes the thickened sludge from the belt at the discharge end of the machine. Concentrated waste activated sludge (CWAS) is discharged to a thickened sludge hopper that directly feeds an open throat progressive cavity pump. From there it is pumped to the Anaerobic Digestion system. The liquid released from the sludge drains through the belt to a filtrate collection box.

Ferric chloride can be added to the WAS upstream or the CWAS downstream of the GBC to chemically fix the phosphorus that was taken up biologically in the activated sludge system.

3.16.4 General Arrangement Schematic

Exhibit 10. WAS Concentration – Process Flow Diagram



3.17 Primary Sludge and CWAS Distribution to Anaerobic Digestion Description

3.17.1 Process Intent or Function

Primary sludge (PS) and concentrated WAS (CWAS) are stabilized within the five anaerobic digesters. Flow control and proper distribution to each digester is important in maintaining effective anaerobic treatment.

Note: Galleries containing digester gas piping are rated as follows:

- Class 1, Division 2 when ventilated at less than 6 air changes per hour
- Unclassified when ventilated at 6 or more air changes per hour

All electrical equipment and wiring within these areas must comply with NEC requirements for this classification.

3.17.2 Process Description

Overview. Concentrated WAS (CWAS) and primary sludge is pumped to the digesters for solids stabilization. See section 1.1.9 for primary sludge removal description.

Concentrated Waste Activated Sludge (CWAS). The digesters also receive concentrated waste activated sludge from CWAS pumps (85-P-1, 80-P-8, and 80-P-9). CWAS is normally produced seven days a week during day shifts. It is continually transferred to all operational digesters via the digester feed header.

3.18 Anaerobic Digestion Process Description

3.18.1 Process Intent or Function

The objectives of anaerobic sludge digestion are:

- Reduction of pathogenic organisms (viruses, bacteria, parasites)
- Decomposition of putrescible organic material
- Reduction of mass of solids for disposal
- Production of methane gas that can be utilized as fuel

Note: Digesters are enclosed tanks and are a confined space and a Class 1, Division 1 classified area. Digester Control Building No. 2 has the following ratings:

- Pump Room: Unclassified when ventilated at 6 or more air changes per hour
- Gas Equipment Room: Class 1, Division 2
- Boiler Room and Electrical Room: Unclassified

Underground Galleries containing digester gas piping:

- Class 1, Division 2 if ventilated at less than 6 air changes per hour
- Unclassified if ventilated at 6 or more air changes per hour
- Within 10 feet of digester gas valves and appurtenances is Class 1, Division 1 at < 6 air changes per hour and Class 1, Division 2 at ≥ 6 air changes per hour

All electrical equipment and wiring within these areas must comply with NEC requirements for this classification.

3.18.2 Description

Overview. The anaerobic digestion system consists of five anaerobic digesters, complete with the following auxiliary systems:

- Sludge recirculation pumping
- Sludge heating system
- Sludge mixing system
- Digester gas handling system

Digestion. The anaerobic digestion process produces acid forming reactions and methane fermentation reactions. Both types of reactions are influenced by temperature, pH and food conditions. The rate of the two types of reactions must be approximately equal in order to maintain a balanced system.

Sludge Recirculation, Heating and Mixing.

Recirculation. The digesters are equipped with recirculation pumps:

- 80-P-1A and 80-P-1B service Digesters 1 and 2
- 95-P-1 and 95-P-2 services Digesters 3 and 4
- 97-P-2A and 97-P-2B service Digester 5

Normally, one sludge recirculation pump per digester will be operating whenever the digester is in service. The operator will adjust valve positions to divert recirculating sludge through heat exchangers to the degree necessary to maintain desired digester operating temperature. The operator normally operates each sludge recirculation pump locally.

The operator will adjust a throttling valve to regulate the portion of the sludge flow which passes through the sludge heater. Closing the throttling valve on the sludge heater bypass line will force more flow through the heater. If the valve is not closed enough, insufficient sludge will be heated and the desired digester temperature might not be maintained.

If the valve is closed too much, insufficient sludge will be recirculated to the mixing nozzles in the digesters and mixing performance might not be maintained.

Normally, the boilers will operate automatically to provide hot water. The boilers will respond to a temperature probe on the hot water supply and will add heat to maintain a selected temperature.

Heating. The temperature in the digesters should be maintained evenly at all levels of the digester at 95°F (+/-1°F). It is important to never change the temperature more than 1°F per day. Maintaining the correct operating temperature in the digesters is an important process requirement. The raw sludge that enters the digesters is well below the operating temperature of 95°F. Therefore, heat is required to raise the temperature of the raw sludge. There is also some heat loss from the digesters and from the piping. That heat loss also represents a demand for thermal energy.

The heat exchangers, or sludge heaters, use hot water from two boiler packages to provide heat to the sludge. The heated sludge is then returned to the originating digester. Sludge is heated by directing a portion of the main flow through the sludge heater. Digester No. 5 has a dedicated sludge heater (97-HE-1). Digesters No. 1 and 2 alternately share a sludge heater (80-HE-1), and Digesters 3 and 4 have a dedicated sludge heater that are piped to allow either digester to be circulated through either heater.

Two boilers provide hot water for all sludge heaters. The boilers use digester gas or natural gas for fuel and are sized to utilize all the digester gas available. Hot water circulation pumps move the hot water around the hot water loop, while each sludge heater is served by a local secondary hot water circulation pump.

Mixing. Digester mixing is essential to the digestion process, the ability of the mixing equipment to keep the tank completely mixed speeds digestion greatly. Several important objectives accomplished in a well-mixed digester are as follows:

- Immediate inoculation of the raw sludge with the microorganisms
- Prevention of a scum blanket
- Maintaining the contents within the tank homogeneous: including the even distribution of food, organisms, alkalinity, heat and waste bacterial products
- Minimum build-up of grit and inert solids on the bottom of the digester, thus enabling the utilization of the maximum total contents and minimizing digester cleaning

The recirculation pumps are used in digester mixing by pumping the sludge through mixing nozzles located throughout digesters No. 1, 2, and 5. Digesters No. 3 and 4 use gas lift mixers for primary mixing, and their sludge recirculation pump provides secondary, or added, mixing.

Digester Gas Handling. Digester gas is generated during the anaerobic digestion process. The gas is withdrawn from the gas collection space above the sludge liquid level. The digester gas flow is primarily utilized for the operation of the boilers and excess digester gas is burned in the waste gas flare.

Digester gas bubbles through the liquid sludge and gathers in the digester headspaces. These headspaces are gas-tight, and retain the gas so that the pressure under the roofs increases as gas production continues. The floating cover on Digester 4 will also rise and fall in response to a digester gas pressure increase or decrease. Free passage of the digester gas from the headspace of each digester to the digester gas utilization system and flares must be maintained at all times to prevent damage to the digester roofs and discharge of digester gas to the atmosphere. Free passage is maintained by ensuring the isolation valve on the digester gas pipe from each digester is open at all times when that digester is in service, by ensuring condensate is drained as frequently as required to keep the digester gas pipes free of water accumulation, and by addressing foaming or high sludge level conditions in the digester to keep the digester gas piping free of solids accumulations.

Pressure/vacuum relief valves (PVRVs) are provided on the roof of Digester's 3, 4, and 5 and water seals are provided on Digesters 1 and 2 to protect the digesters from over pressurization which if allowed to occur would likely do serious structural damage to the digesters. The PVRV assembly on the newest digester, Digester 5, includes two PVRVs and a 3-way isolation valve rather than a traditional manual isolation valve. This 3-way valve ensures that one of the two pressure PVRVs is always open to the atmosphere.

The digester gas in the headspace is at roughly 95 °F (35 °C) and is saturated with respect to water. As the digester gas exits the digesters through the digester gas piping it will cool and water vapor will condense. Therefore, drip traps are provided at low points in the digester gas system to remove the condensate. There are 6 or 7 drip traps. Without regular removal of the condensate the water will block the flow of the digester gas to the boilers and flares. This will result in a release of digester gas through the pressure relief valves on the roof of each digester. This is comparable to a natural gas leak on top of the digesters and represents an explosion risk, fire risk, oxygen deficient atmosphere risk. Also, because hydrogen sulfide is also present in digester gas, a release also represents a toxicity risk. Depending on the concentration, inhalation of hydrogen sulfide can be instantly fatal and has killed many WWTP personnel. The drip traps provide a safe means of removing condensate without risk of releasing digester gas into the room. The drip traps contain a positive shut off so that when opened to drain condensate the drip trap is isolated from the digester gas piping. A sediment trap is also provided from Digester 5 to remove solids carried out in the digester gas and to provide some storage of condensate prior to draining with a drip trap.

Digester gas pressure in the system will be controlled by digester gas utilization in the boilers unless digester gas production exceeds utilization. If this occurs the digester gas pressure will be controlled by the pressure relief valve to the flare and digester gas will be flaring.

3.19 Digested Sludge Description

3.19.1 Process Intent or Function

Digested sludge is stored in the sludge holding tanks before being transported by tanker truck to be land applied.

The purpose of concentrating or thickening the digested sludge is to both reduce the volume of biosolids to be hauled from the plant, as well as provide a suitable product for land application.

Note: The sludge concentration areas are unclassified.

3.19.2 Process Description

Overview. Digested sludge is normally concentrated via two sieve drum concentrators (SDCs), located in Facility 80. Four digested sludge transfer pumps are used to transfer the digested sludge to the SDCs. Polymer is added upstream of the SDCs in order to assist the thickening process.

The concentrated digested sludge, CDS, is pumped to the sludge storage tanks.

Normal Operation - Digested Sludge Concentration. Digested sludge concentration operates daily, usually for an eight-hour shift. All control functions are available at the local control panel, LCP-80-SDC-1A and LCP-80-SDC-2A.

Alternate Operation – Digested Sludge Concentration. In the unlikely event that both sieve drum concentrators are out of service, the gravity belt concentrator (GBC) can be used to concentrate digested sludge. All valving is manually set to provide the desired flow route.

Alternate Operation – WAS Concentration. In the event that the gravity belt concentrator or CWAS pump is out of service, the WAS can be directed to a sieve drum concentrator for processing. Using a sieve drum concentrator will require more processing time, as the hydraulic capacity of a sieve drum concentrator is much lower than a gravity belt concentrator.

WAS is provided by WAS pumps located at the Membrane Building. The concentrated waste activated sludge (CWAS) is pumped from the concentrators to the digesters via the concentrated sludge pumps. All valving is manually set to provide the desired flow route.

3.20 Biosolids Storage and Haul Out Description

3.20.1 Process Intent or Function

Sludge storage tanks provide storage of concentrated digested sludge prior to loading to trucks for agricultural application. Additional sludge storage was created from the former final settling tanks and the former sludge thickener. These tanks are covered and provided with mixing nozzles fed from chopper type recirculation pumps located in the Sludge Loadout Building, which was the former Sludge Return and Thickener Building.

Concentrated digested sludge is normally delivered to the sludge storage facilities by sludge pumps located by the sieve drum concentrators in the Sludge Concentrator and Polymer Addition Building. In the unlikely event that both sieve drum concentrators are out of service, the gravity belt concentrator may be used to process digested sludge and transfer the concentrated digested sludge to storage. Each of the three new storage tanks will be mixed intermittently, using one of the two mixing pumps provided. A branch line off the recirculation pump discharge line is used to load tank trucks up to 9,000 gallons.

Note: The sludge storage tanks are a confined space and a Class 1, Division 1 classified area. All electrical equipment and wiring within these areas must comply with NEC requirements for this classification. The sludge loadout areas are unclassified.

3.20.2 Process Description

The sludge storage recirculation and loading system is operated manually. The operator determines the desired tank to receive sludge and adjusts the valve positions to direct the sludge flow accordingly. Sludge flows to storage from the sieve drum concentrators are monitored with a flow meter. In the event that both sieve drum concentrators are out of service and the gravity belt concentrator is processing digested sludge, the concentrated digested sludge is conveyed to the sludge storage tanks using a different metered line.

In the Sludge Loadout Building, the piping and recirculation pumps are arranged such that either of the two pumps can be used for any one of the three tanks. Normally, only one pump is in service, mixing one tank at any given time. The operator will open and close the appropriate valves to redirect the recirculated sludge flow to a different tank to mix and blend the contents. The incoming concentrated sludge can be directed to the suction line of the operating recirculation pump, or conveyed directly to a storage tank without using the recirculation pump.

A branch line connected to the recirculation pump discharge header is used to load tank trucks periodically. The operator manually opens and closes the loadout valve to start and stop loading, respectively. The operator can start and stop the recirculation pump and adjust the pump speed via local controls at the loading platform. The loading platform controls can be disabled, using a selector switch in the pump house.

In the Sludge Storage Facility, sludge is directed to one of the four sludge storage tanks (Tanks 1 to 4) by opening the appropriate inlet valve. Recirculating mixers are available to mix the sludge if needed. Telescoping valves are available for each tank to decant supernatant.

Sludge loadout is controlled manually using the Marlow pump to fill tanker trucks.

Manual measurements of storage tank levels are used for recordkeeping. Each sludge storage tank is provided with high level float switches, which will initiate an alarm when the tank liquid level reaches a high level.

3.21 Sludge Concentration – Polymer System Description

3.21.1 Process Intent or Function

Polymer conditioning of sludge is required prior to sludge feed to a sieve drum concentrator (SDC) or gravity belt concentrator (GBC). The polymer flocculates the sludge particles so that water can be released from the sludge and the sludge concentrated (i.e., thickened). Polymer conditioning is also necessary to achieve a high solids capture. Concentrating the sludge minimizes the size required for the digesters and sludge storage tanks and high solids capture prevents the solids from being recycled back into the liquid treatment processes.

Note: The Polymer system areas are unclassified.

3.21.2 Process Description

Overview. Polymers are chemicals that assist in binding smaller sludge particles into larger sludge particles or flocs, which can be more easily removed by thickening and dewatering equipment. Polymers can be anionic (negative charge), cationic (positive charge), or non-ionic (neutral charge). Some polymers work better than others, based on the properties of the sludge stream to be conditioned. As a result, the polymer systems have been designed to store, prepare (mix), and meter both cationic and anionic polymers. The actual selection of polymers used at the plant were determined by pilot testing, along with technical and economic analyses. The selected polymer can change over time if sludge characteristics vary, polymer prices change, new polymers become available and is reevaluated every few years or as needed.

Sludge Concentration Polymer Units. The current selection is a high-molecular weight cationic polymer and it is used to condition both the waste activated sludge (WAS) and the digested sludge prior to thickening (concentration).

The polymer is delivered in 50-pound bags, which are manually emptied into the hopper of the polymer make-up system. The dry polymer is mixed with plant service water (W2) and aged in the mix tank. The solution is then gravity drained to the holding tank.

The polymer solution, usually mixed to approximately 0.5% concentration, is further diluted in the post-dilution unit with plant effluent (W3), and pumped to the injection ports upstream of both the gravity belt concentrator and the sieve drum concentrators where it is mixed with the feed sludge.

3.22 Odor Control System

3.22.1 Description

Process Intent or Function. Foul air is generated at several locations at the plant. Two odor control systems are provided to capture and treat foul air to control odors. One system uses activated carbon to remove hydrogen sulfide and other odor producing compounds. The other system uses the aerated zones of the Aeration Tanks to treat foul air.

Process Description. The activated carbon system (Phoenix system) treats foul air from the east and west grit buildings, the primary clarifiers, the sludge concentrator building, and the WAS thickening building. Air is drawn from these buildings by Blower B-2, located outside of the odor control building. Foul air is delivered to the Phoenix system and flows through the activated carbon canisters and is discharged to the atmosphere.

Activated carbon is limited in the amount of H_2S and other compounds it can adsorb. When the carbon is no longer effective at removing odors, it can be regenerated by washing with water. An automatic controller operates the regeneration and drying cycles on the Phoenix system. The length of time between regenerations and other variables are operator adjustable. A detailed description of the operator set points is provided in the manufacturer's O&M manual.

Foul air from the preliminary treatment building, the primary effluent screw pumps and the fine screen building is conveyed in a system of foul air ducts to the intake structure for the process air blowers. The foul air is used as process air in the aerated zones of the Aeration Tanks. The odorous compounds are removed in the activated sludge process by a combination of adsorption onto the biological floc particles and the biological activity in the system. No additional controls are necessary for this system.

3.23 Lift Stations Operated and Maintained by CH2M

3.23.1 Lift Stations Description

CH2M is currently contracted to operate and maintain the following lift stations in Exhibit 11 for the City of Traverse City. This includes routine inspections, maintenance, and emergency response. A 6-inch self-priming diesel bypass pump is available for emergency bypassing.

Exhibit 11. CH2M Operated and Maintained Lift Stations

Lift station	6-inch or 4-inch Bypass Capable	Portable Generator Capable	Standby Generator Onsite
Bay Street	Yes	Yes	No
Birchwood	Yes	No	Yes
Clinch park	Yes	Yes	No
Coast Guard	Yes	Yes	No
Hull Park	No	No	No
Front Street	No	No	Yes
Riverine	Yes	Yes	No
Woodmere	Yes	No	Yes
TBA	Yes	Yes	No

3.23.2 Birchwood Lift Station

Birchwood Lift Station is located at 2060 East Front Street in Traverse City. This station consists of two non-clog dry pit Hydodynamic pumps capable of pumping 800 gpm at 40 foot TDH. The station maintains a wet well level via a milltronics level transducer that cycles the pumps in a lead lag configuration based on the level. The station also consists of high level and low level float switch alarms and power failure alarms that trigger an alarm dialer to call the on-call person or persons. In the event of a loss of power supply to the lift station, a Genset 55 KW diesel powered standby generator with an automatic transfer switch will start and supply power to the station. An alarm will initiate to let the on-call operator know the station is on generator power. The generator has an estimated full tank run time of 24 hours.

3.23.3 Bay Street Lift Station

Bay Street Lift Station is located at 580 Bay Street in Traverse City. This station consists of two 4 inch submersible 9.4 HP pumps capable of pumping 430 gpm at 32 feet TDH. The station maintains a wet well level via a milltronics level transducer that cycles the pumps in a lead lag configuration based on the level. The station also consists of high level and low level float switch alarms and power failure alarms that trigger an alarm dialer to call the on-call person or persons. This station does not have standby generator power and must be supplemented with a portable generator. This station is also equipped with a mixer to help homogenize the waste within the well and aid in buildup of grease and other materials.

3.23.4 Clinch Park Lift Station

Clinch Park Lift Station is located at 111 East Grandview Parkway in Traverse City. This station consists of two submersible 3 inch 2.4 HP Flygt pumps capable of pumping 175 gpm at 21 feet TDH. This station operates via float switches consisting of a low level, stop, start, lag and high level floats with a lead/lag alternator. An alarm dialer is set to call out in the event of a low level, high level or power failure. This station does not have standby generator power and must be supplemented with a portable generator.

3.23.5 Coast Guard Lift Station

Coast Guard Lift Station is located at 911 Airport Access Road in Traverse City. This station consists of two submersible 4 inch 17.5 HP ABS pumps capable of pumping 400 gpm at 70 feet TDH. The station maintains a wet well level via a milltronics level transducer that cycles the pumps in a lead lag configuration based on the level. The station also consists of high level and low level float switch alarms and power failure alarms that trigger an alarm dialer to call the on-call person or persons. This station does not have standby generator power and must be supplemented with a portable generator.

3.23.6 Hull Park Lift Station

Hull Park Lift Station is located at 660 Hannah Avenue in Traverse City. This station consists of one submersible 1 ¼ inch 2.0 HP Hydromatic grinder pump. The station maintains a wet well level via a float switch configuration of pump on, pump off and high level. This station is only operated seasonally and is equipped with an alarm light located on top of the control cabinet that indicates a high level condition. This station is located just outside the Traverse City WWTP gate and is monitored for alarm conditions daily.

3.23.7 Front Street Lift Station

Front Street Lift Station is located at 439 East Front Street in Traverse City. This station consists of three dry pit VFD run ITT A-C pumps capable of pumping 3100 gpm each. Front Street is equipped with a diesel powered 230 KW standby generator with an automatic transfer switch. This delivers the most amount of flow to the TCRWWTP and is the only station currently monitored from the SCADA system at the treatment facility. Front Street is set up with a backup float control system in the event of a milltronics level sensor failure. The station will also contact the on-call operator through the TCRWWTP SCADA system in the event a low level alarm, high level alarm, power failure, VFD failure, or PLC failure occurs.

3.23.8 Riverine Lift Station

Riverine Lift Station is located at 318 East Eight Street in Traverse City. This station consists of two nonclog dry pit 4 inch 7.5 HP pumps capable of delivering 350 gpm at 37 feet TDH. This station is a can-style pump station with a ladder access to access the pump control room below grade. The station is equipped with a fresh air supply blower that starts when the can lid is opened. The pumps operate off a float switch system that includes low level alarm, stop, start, lag pump start, and high level alarm. The low level and high level alarms and loss of power are connected to an auto dialer that calls out to the oncall operator when condition exist. This station does not have a standby generator and in the event of a power loss would need to be supplied with a portable generator.

3.23.9 Woodmere Lift Station

Woodmere Lift Station is located at 645 Woodmere Avenue in Traverse City. This station consists of two submersible 4 inch 6.4 HP Flygt pumps capable of pumping 450 gpm at 25 feet TDH. The station maintains a wet well level via a milltronics level transducer that cycles the pumps in a lead lag configuration based on the level. The station also consists of high level and low level float switch alarms and power failure alarms that trigger an alarm dialer to alert on-call staff. This station is equipped with a standby natural gas powered generator with an automatic transfer switch.

3.23.10 TBA Lift Station

TBA Lift Station is located at 890 Parsons Road in Traverse City. This station is a can-style station equipped with a fresh air blower system that is enabled when the lid is opened. The pumps and control panel are accessed via a ladder into the bottom of the station. This station consists of two dry pit 5 inch 15 HP pumps capable of delivering 700 gpm at 35 feet TDH. The pumps operate off a float switch system that includes low level alarm, stop, start, lag pump start, and high level alarm. The low level and high level alarms and loss of power are connected to an auto dialer that calls out to the on-call operator when condition exist. This station does not have a standby generator and in the event of a power loss would need to be supplied with the portable generator. This station can be bypassed using the 6-inch diesel bypass pump. TBA will be upgraded in summer of 2016, this upgrade includes coating of inside of can, new pumps, controls, and a new control cabinet that will be mounted at grade outside of the can.

4.0 Inventory or Fixed Assets

Refer to Attachment 2 (Traverse City's Collection System Fixed Assets) for the Traverse City Collection System asset inventory. Refer to Attachment 3 (TCRWWTP and Lift Stations Fixed Assets) for the TCRWWTP and Lift Stations. The Grand Traverse County Collection System asset inventory is in the process of being completed.

5.0 Business Risk Evaluation Process

The Traverse City Collection System Risk Evaluation- SAW grant scope of work is scheduled to be completed by June 30, 2017. (See Attachment 4, Traverse City's SAW Grant Scope of Work). The Grand Traverse County Collection System Risk Evaluation schedule has yet to be determined. Meanwhile, CH2M has identified all the major assets at the TCRWWTP and Lift Stations. A condition assessment and an asset management analysis will be performed on these assets by June 30, 2017.

6.0 Operation and Maintenance Budgets/Rate Calculation Process

The Rate Calculation and budget for the Traverse City Collection System is located in Attachment 5A (Traverse City's Wastewater Fund) and 5B (Traverse City's Rate Calculation). The Grand Traverse County Collection System rate calculation is yet to be determined.

CH2M has $115,000 budgeted for equipment repairs for the TCRWWTP and Lift Stations in the coming year. If additional funds are needed, CH2M will request separate funding (Approval) from the City. Capital Improvements and large maintenance expenditures are funded through Traverse City's Wastewater fund and by Grand Traverse County. (Please refer to Attachment 5A and 5B).

7.0 Capital Improvement Plans

Traverse City Collection System, Lift Stations, and TCRWWTP Capital Improvement Plans are located in Attachment 6A (Summary of Traverse City's CIP) and 6B (Narrative of Traverse City's CIP). A plan for the Grand Traverse County Collection System and Lift Stations is yet to be determined.

8.0 Current Improvement Initiatives

Current Improvement Initiatives for the Traverse City Collection System are located in Attachment 4.

Grand Traverse County Collection Improvement Initiatives have yet to be determined.

The TCRWWTP and Lift Stations improvement initiatives are located in Exhibit 12.

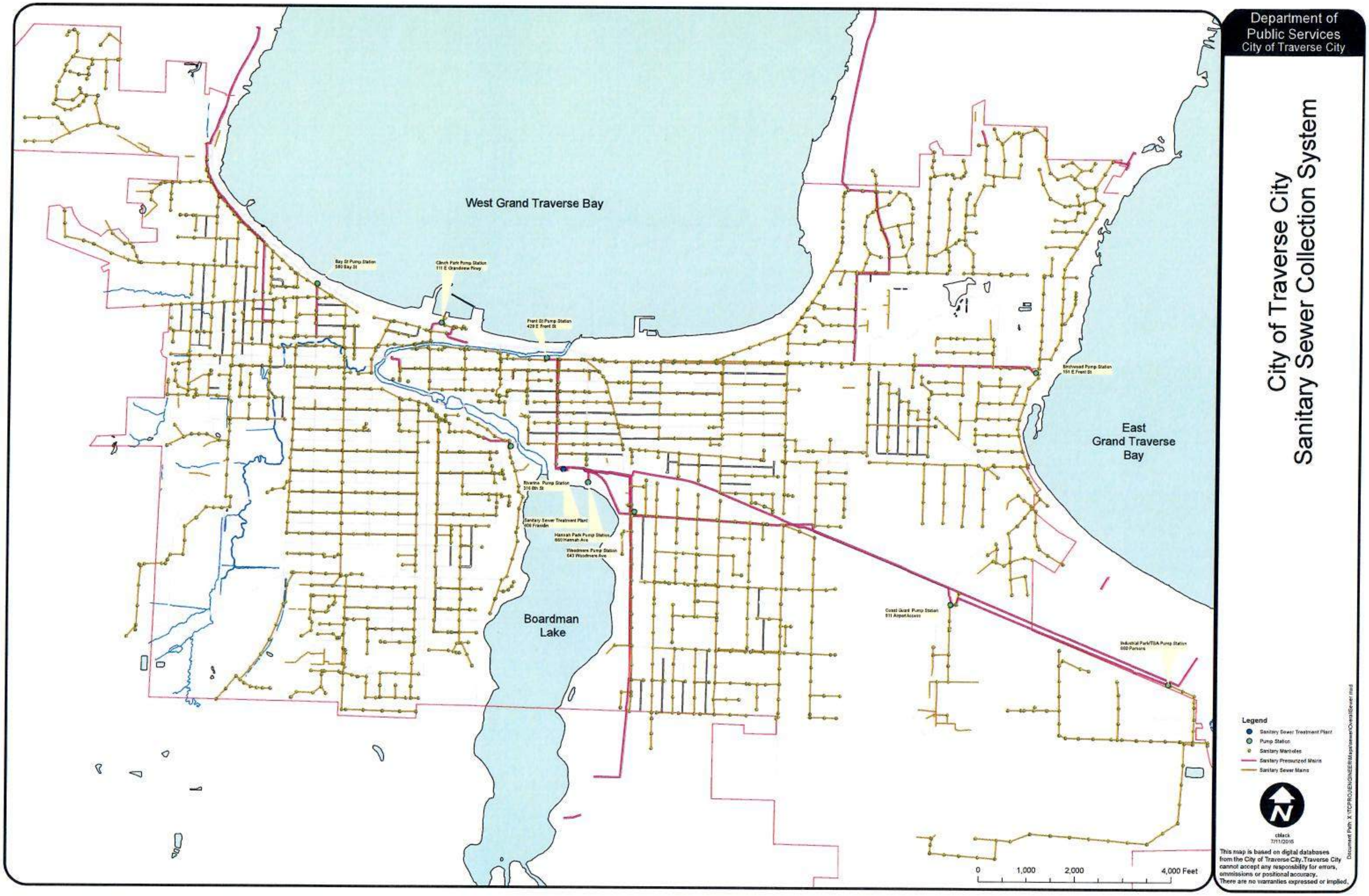
Exhibit 12. TCRWWTP and Lift Stations Improvement Initiatives

Initiative	Description	Completion Date	Responsible Party
TBA Lift Station Upgrade	Install new above ground upgraded control panel, install new pumps, line the lift station can with a tnemac coating and install new cathodic protection	Summer 2017	Elizabeth Hart
Perform Condition Assessment of all Major Assets at the TCRWWTP and Lift Stations	Assess the Condition of all major Assetsat the TCRWWTP and Lift Stations	Summer 2017	Elizabeth Hart
Screw Pump #1-Replacement and trough reconditioning	Overhaul motor, and gear reducer,replace screw body, replace deflector plates, recondition concrete trough and wet well per engineer'srecommendations, replace upper and lower bearings	Fall 2017	Elizabeth Hart
Digest #3 Condition Assessment	Clean Digester #3, have structuralengineer assess the condition of thedigester	Fall 2017	Elizabeth Hart
Headworks Engineering Study	Have engineering study performed onthe preliminary and primary system including screw pumps #2 and #3	Spring 2018	Elizabeth Hart
Riverine Lift Station Engineering Study	Evaluate condition of the can and wetwell assess capacity	Fall 2019	Elizabeth Hart
Upgrade the PLC5 at Front StLift Station and at the TCRWWTP	Upgrade the PLC5s at both locations to a more up to date better support PLC	Fall 2019	Elizabeth Hart
Membrane Gate Replacement	Replace the 8 remaining Aluminum gateassemblies with Stainless Steel gate assemblies	Spring 2020	Elizabeth Hart
Membrane Replacement	Replace the 500C membranes in trains3,4,5, and 8 with 500Ds membranes	Spring 2022	Elizabeth Hart

9.0 Annual Reporting

CH2M submitted the first annual asset management report on behalf of the City of Traverse City on July 30, 2016. CH2M will continue to submit this annual report for the duration of our contract with the City of Traverse City.

Attachment 1
Map of the Traverse City Collection System


Department of
Public Services
City of Traverse City
City of Traverse City
Sanitary Sewer Collection System
West Grand Traverse Bay
East
Grand Traverse
Bay
Boardman
Lake
Bay St Pump Station
580 Bay St
Clinch Park Pump Station
111 E Grandview Pkwy
Front St Pump Station
429 E Front St
Birchwood Pump Station
151 E Front St
Riverine Pump Station
316 8th St
Sanitary Sewer Treatment Plant
606 Franklin
Hannah Park Pump Station
660 Hannah Ave
Woodmere Pump Station
643 Woodmere Ave
Coast Guard Pump Station
511 Airport Access
Industrial Park/TBA Pump Station
600 Parsons
0 1,000 2,000 4,000 Feet
Legend
Sanitary Sewer Treatment Plant
Pump Station
Sanitary Manholes
Sanitary Pressurized Mains
Sanitary Sewer Mains
N
cblack
7/11/2016
This map is based on digital databases from the City of Traverse City. Traverse City cannot accept any responsibility for errors, ommissions or positional accuracy.
There are no warranties expressed or implied.

Attachment 2
Traverse City's Collection System
Fixed Assets

City of Traverse City
Sanitary Sewer System

Main Sizes and Lengths

Sanitary Main Diameter (inches)	Approximate Length of Sanitary Main (feet)	Approximate Length of Sanitary Main (miles)	Percentage of Total (%)
4	94	.02	.02
6	21,139	4.0	4.80
8	246,633	46.71	56.00
9	8,295	1.57	1.88
10	77,358	14.65	17.57
12	41,395	7.84	9.40
15	14,300	2.71	3.25
16	558	.11	.13
18	6,853	1.30	1.56
21	5,337	1.01	1.21
24	12,288	2.33	2.79
Unknown	6,112	1.16	1.39
Total	440,362	83.40	100

Main Materials

Type Distribution	Approximate Length of Sanitary Main (feet)	Approximate Length of Sanitary Main (miles)	Percentage of Total (%)
Asbestos Concrete	2,284	.43	.52
Cast Iron	3,014	.57	.68
Clay	7,735	1.46	1.76
Concrete	2,751	.52	.62
Ductile Iron	1,425	.27	.32
HDPE	509	.10	.12
PVC	73,569	13.93	16.71
Tansite	591	.11	.13
Other	13,520	2.56	3.07
Vitrified Pipe	224,228	42.47	50.92
Unknown	110,736	20.97	25.15
Total	440,362	83.40	100

Approximate Ages

Year Installed	Approximate Length of Sanitary Main (feet)	Approximate Length of Sanitary Main (miles)	Percentage of Total (%)
1930 – 1939	16,376	3.10	3.71
1940 – 1949	136,841	25.91	31.07
1950 – 1959	122,132	23.13	27.73
1960 – 1969	30,162	5.71	6.84
1970 – 1979	24,208	4.58	5.49
1980 – 1989	6,796	1.28	1.54
1990 – 1999	13,333	2.52	3.02
2000 – 2009	36,613	6.93	8.31
2010 – 2015	20,147	3.81	4.57
Unknown	33,754	6.39	7.66
Total	440,362	83.40	100

7/12/2016

Attachment 3
TCRWWTP and Lift Stations
Fixed Assets

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0001	Bldg #010, Rotomat, Preliminary Screening, Course Screening
TRA-0002	Room, Electrical, Rotomat Screening Building
TRA-0003	Flowmeter, Miltronic, Control Panel, Rotomat
TRA-0004	Gas Detector, Rotomat Bldg Electrical Room
TRA-0005	MCC, Rotomat Bldg
TRA-0006	Screening Building Power Rm Space Heater
TRA-0007	Room, Rotomat, Rotomat Screening Building
TRA-0009	Sampler, Primary Influent - Sigma
TRA-0010	Screen, Course, Rotomat (Lakeside)
TRA-0011	Motor, Rotomat Screen
TRA-0012	Rotomat, Sumitomo, Helical, Gearbox
TRA-0013	Screen, Manual Bar, Screening Building
TRA-0014	Screening Bldg Winch To Pull Dumpster
TRA-0015	Sluice Gate, Main influent, Course Screen Building (Bar Screen)
TRA-0016	Sluice Gate, Main influent, Course Screen Building (RotoMat)
TRA-0017	Three Ton Chain Fall
TRA-0018	Bldg #015, Fine Screening Building
TRA-0019	Control Room, Fine Screen Building
TRA-0020	Distribution Panel, Fine Screen
TRA-0021	Fan, Supply, Fine Screen Control Room
TRA-0022	Heating control panel
TRA-0023	Lighting Panel, Fine Screen
TRA-0024	Screening Room, Fine Screening Building
TRA-0025	East Fine Screen
TRA-0026	Fine Screen East Brush Drive Motor
TRA-0027	Fine Screen East Brush Drive Motor Reducer
TRA-0028	Fine Screen East Drive Motor Gear Reducer
TRA-0029	Fine Screen East Screen Drive Motor
TRA-0030	Valve, Gate, Inlet, East Fine Screen
TRA-0031	Valve, Gate, Outlet, East Fine Screen
TRA-0032	West Fine Screen
TRA-0033	Fine Screen West Brush Drive Motor
TRA-0034	Fine Screen West Brush Drive Motor Reducer
TRA-0035	Fine Screen West Drive Motor Gear Reducer
TRA-0036	Fine Screen West Screen Drive Motor
TRA-0037	Valve, Gate, Inlet, West Fine Screen
TRA-0038	Valve, Gate, Outlet, West Fine Screen
TRA-0039	Screw Compactor / Bagger
TRA-0040	Jones & Attwood Compactor Drive Gear
TRA-0041	Jones & Attwood Compactor Rotating Assembly
TRA-0042	Jones & Atwood Compactor Drive Motor
TRA-0043	10' Step Ladder, Orange Fiberglass, Fine Screen Bldg
TRA-0044	16' Extension Ladder, Orange Fiberglass, Fine Screen Bldg
TRA-0045	Eyewash, Bottle, Fine Screen Building

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0046	Fine Screen Building Make Up Air UNIT
TRA-0047	Gas Detector, Fine Screen Bldg
TRA-0048	Overhead Door
TRA-0049	Pump, Circulating, Hot Water In Fine Screen Building
TRA-0050	Pump, Circulation, Glycol In Fine Screen Building
TRA-0051	Screening Building Electric Heated Make Up Air System
TRA-0053	Pump , Organic Return, West Grit Chamber
TRA-0054	Motor, West Organic Return
TRA-0055	Fixed Ladder, Classifier Deck, West Grit Bldg
TRA-0056	Fixed Ladder, Classifier Deck, West Grit Bldg
TRA-0057	Fixed Ladder, Classifier Deck, West Grit Bldg
TRA-0058	Fixed Ladder, Classifier Deck, West Grit Bldg
TRA-0059	Flowmeter, Miltronic, Control Panel, West Grit
TRA-0060	Hoist, West Grit Bldg
TRA-0061	West Grit Building Hot Water Heated Make Up Air System
TRA-0062	West Grit Chamber, Basin
TRA-0064	Collector, West Grit
TRA-0065	Gear Reducer, West Grit Basin
TRA-0066	Motor, West Grit Basin
TRA-0067	Classifier, West Grit
TRA-0068	Gear Reducer, West Grit Classifier
TRA-0069	Motor, West Grit Classifier
TRA-0070	Gate, Sluice, Controlling Flow From The West Grit Chamber To The North Side Of The Primary Header
TRA-0071	Gate, Sluice, Controlling Flow From The West Grit Chamber To The South Side Of The Primary Header
TRA-0072	Bldg #021, East Grit
TRA-0073	Pump, East Organic Return
TRA-0074	Motor, East Organic Return
TRA-0075	East Grit Bldg Hoist
TRA-0076	East Grit Building Hot Water Unit Heater
TRA-0077	East Grit Chamber, Basin
TRA-0078	Transmitter, East Grit, Milltronics
TRA-0079	Collector, East Grit
TRA-0080	Gear Reducer, East Grit Basin
TRA-0081	Motor, East Grit Basin
TRA-0082	Gear Reducer, East Grit Collector
TRA-0083	Classifier, East Grit
TRA-0084	Gear Reducer, East Grit Classifier
TRA-0085	Motor, East Grit Classifier
TRA-0086	Gate, Sluice, Controlling Flow To The North Side Of The Primary Header
TRA-0087	Gate, Sluice, Controlling Flow To The South Side Of The Primary Header
TRA-0088	Eyewash, Bottle, East Grit Bldg
TRA-0089	Fixed Ladder, Classifier Deck, East Grit Bldg

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0090	Fixed Ladder, Classifier Deck, East Grit Bldg
TRA-0091	Flowmeter, Miltronic, Control Panel, East Grit
TRA-0092	Hot Water Circ Pump East Grit Building
TRA-0093	Bldg #030, Primary Clarification Deck
TRA-0095	Clarifier, Primary, #1 North
TRA-0096	Chain and Flight Collector
TRA-0097	Drive, Chain, Primary Clarifier
TRA-0098	Motor, Primary Clarifier Drive 1N/2N
TRA-0099	Skimmer, Scum, Primary Tank 1 North
TRA-0100	Scum Skimmer Gearbox 1North
TRA-0101	Motor, Scum Skimmer 1 North
TRA-0102	Clarifier, Primary, #2 North
TRA-0103	Chain and Flight Collector
TRA-0104	Skimmer, Scum, North Primary Tank 2
TRA-0105	Reducer, Gear, Scum Skimmer 2 North
TRA-0106	Motor, Scum Skimmer, 2 North
TRA-0107	Clarifier, Primary, #3 North
TRA-0108	Chain and Flight Collector
TRA-0109	Drive, Chain, Primary Clarifier
TRA-0110	Motor, Primary Clarifier Drive 3N/4N
TRA-0111	Skimmer, Scum, North Primary Tank 3
TRA-0112	Reducer, Gear, Scum Skimmer 3 North
TRA-0113	Motor, Scum Skimmer, 3 North
TRA-0114	Clarifier, Primary, #4 North
TRA-0115	Chain and Flight Collector
TRA-0116	Skimmer, Scum, North Primary Tank 4
TRA-0117	Reducer, Gear, Scum Skimmer 4 North
TRA-0118	Motor, Scum Skimmer, 4 North
TRA-0119	40' Extension Ladder, Yellow Fiberglass, North Primary Deck
TRA-0120	Primary Tanks and Pipe Gallery
TRA-0121	Fan, Exhaust, North Primary Pipe Gallery
TRA-0122	Fan, Exhaust, South Primary Pipe Gallery
TRA-0123	Primary Pipe Gallery Sump Pump
TRA-0124	Primary Piping System North And South
TRA-0125	Pump, Primary Tank Dewatering
TRA-0126	Motor, Pump, Primary Dewatering
TRA-0127	Valve, Sludge Removal
TRA-0128	Valve, Sludge Removal, Primary Tank #1 North
TRA-0129	Actuator, Valve, Primary Sludge Pumping 1 North
TRA-0130	Valve, Sludge Removal, Primary Tank #1 South
TRA-0131	Actuator, Sludge Removal, Primary Tank # 1 South
TRA-0132	Valve, Sludge Removal, Primary Tank #2 North
TRA-0133	Actuator, Sludge Removal, Primary Tank # 2 North
TRA-0134	Valve, Sludge Removal, Primary Tank #2 South

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0135	Actuator, Sludge Removal, Primary Tank # 2 South
TRA-0136	Valve, Sludge Removal, Primary Tank #3 North
TRA-0137	Actuator, Sludge Removal, Primary Tank # 3 North
TRA-0138	Valve, Sludge Removal, Primary Tank #3 South
TRA-0139	Actuator, Sludge Removal, Primary Tank # 3 South
TRA-0140	Valve, Sludge Removal, Primary Tank #4 North
TRA-0141	Actuator, Sludge Removal, Primary Tank # 4 North
TRA-0142	Valve, Sludge Removal, Primary Tank #4 South
TRA-0143	Actuator, Sludge Removal, Primary Tank # 4 South
TRA-0145	Clarifier, Primary, #1 South
TRA-0146	Chain and Flight Collector
TRA-0147	Drive, Chain, Primary Clarifier
TRA-0148	Motor, Prim Clar 1S/2S
TRA-0149	Skimmer, Scum, South Primary Tank 1
TRA-0150	Reducer, Gear, Scum Skimmer 1 South
TRA-0151	Motor, Scum Skimmer, 1 South
TRA-0152	Clarifier, Primary, #2 South
TRA-0153	Chain and Flight Collector
TRA-0154	Drive, Chain, Primary Clarifier
TRA-0155	Motor, Prim Clar 3S/4S
TRA-0156	Skimmer, Scum, South Primary Tank 2
TRA-0157	Reducer, Gear, Scum Skimmer 2 South
TRA-0158	Motor, Scum Skimmer 2 South
TRA-0159	Clarifier, Primary, #3 South
TRA-0160	Chain and Flight Collector
TRA-0161	Drive, Chain, Primary Clarifier
TRA-0162	Motor, Prim Clar 3S/4S
TRA-0163	Skimmer, Scum, 3N
TRA-0164	Skimmer, Scum, South Primary Tank 3
TRA-0165	Reducer, Gear, Scum Skimmer, 3 South
TRA-0166	Motor, Scum Skimmer, 3 South
TRA-0167	Clarifier, Primary, #4 South
TRA-0168	Chain and Flight Collector
TRA-0169	South Primary Tank 4 Scum Skimmer
TRA-0170	Reducer, Gear, Scum Skimmer Drive, 4 South
TRA-0171	4 South Scum Skimmer Motor
TRA-0172	24' Extension Ladder, Orange, Fiberglass, South Primary Deck
TRA-0173	Bldg #032, Phoenix, Odor Control Building
TRA-0174	Blower, Odor Control
TRA-0175	Motor, Blower, Phoenix Blower
TRA-0176	VFD, South, Odor, Blower
TRA-0177	Blower, Phoenix Odor Bldg
TRA-0178	Gas Analyzer, Odor Logger

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0179	Odor Control Ducting To Phoenix Carbon System And To Aeration Blower Intakes
TRA-0180	Phoenix Odor Filter PLC
TRA-0181	Phoenix Building Electric Heater
TRA-0182	Bldg #045, Aeration Basin Deck
TRA-0183	North Aeration Basin
TRA-0184	Actuator, Valve, North Prim Eff Flume
TRA-0185	Motor, North Primary Effluent Flume Gate
TRA-1675	Mixer, North Aeration #1
TRA-1676	Mixer, North Aeration #2
TRA-1697	Mixer, North Aeration #3
TRA-1677	Mixer, North Aeration #4
TRA-1678	Mixer, North Aeration #5
TRA-1679	Mixer, North Aeration #6
TRA-1680	Mixer, North Aeration #7
TRA-1681	Mixer, North Aeration #8
TRA-0186	Mixer, North Aeration #1
TRA-0187	Mixer, North Aeration #2
TRA-0188	Mixer, North Aeration #3
TRA-0189	Mixer, North Aeration #4
TRA-0190	Mixer, North Aeration #5
TRA-0191	Mixer, North Aeration #6
TRA-0192	Mixer, North Aeration #7
TRA-0193	Mixer, North Aeration #8
TRA-0194	No. Aeration Grid Laterals
TRA-0195	North Aeration Basin Air Header To Diffuser Down Legs
TRA-0196	North RAS Piping In Pump Room
TRA-0197	Panel, Control, Primary Effluent Gate Flow
TRA-0198	Probe, Do, NE Aeration Basin
TRA-0199	Probe, Do, NW Aeration Basin
TRA-0200	Pump, Pre-Aeration, #1 North
TRA-0201	Motor, Pre-Aeration Pump 2 South
TRA-1682	Pump, Return, North Aeration #1
TRA-1683	Pump, Return, North Aeration #2
TRA-1684	Pump, Return, North Aeration #4
TRA-1685	Pump, Return, North Aeration Return #3
TRA-0202	Pump, Return, North Aeration #1
TRA-0203	Pump, Return, North Aeration #2
TRA-0204	Pump, Return, North Aeration #4
TRA-0205	Pump, Return, North Aeration Return #3
TRA-0206	Transmitter, RAS Flow, North
TRA-0207	Valve, Butterfly, 24 North Aeration Basin Air Modulation
TRA-0208	Valve, Butterfly, 30 In. On North RAS Line
TRA-0209	South Aeration Basin

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0210	Actuator, South RAS Control Valve A
TRA-0211	Actuator, South RAS Control Valve B
TRA-0212	Actuator, Valve, South Prim Eff Flume
TRA-0213	Motor, South Primary Effluent Flume Gate
TRA-1686	Mixer, South Aeration Tank No.1
TRA-1687	Mixer, South Aeration Tank No.2
TRA-1688	Mixer, South Aeration Tank No.3
TRA-1689	Mixer, South Aeration Tank No.4
TRA-1690	Mixer, South Aeration Tank No.5
TRA-1691	Mixer, South Aeration Tank No.6
TRA-1692	Mixer, South Aeration Tank No.7
TRA-1698	Mixer, South Aeration Tank No.8
TRA-0214	Mixer, South Aeration Tank No.1
TRA-0215	Mixer, South Aeration Tank No.2
TRA-0216	Mixer, South Aeration Tank No.3
TRA-0217	Mixer, South Aeration Tank No.4
TRA-0218	Mixer, South Aeration Tank No.5
TRA-0219	Mixer, South Aeration Tank No.6
TRA-0220	Mixer, South Aeration Tank No.7
TRA-0221	Mixer, South Aeration Tank No.8
TRA-0222	Pump, Pre-Aeration, #2 South
TRA-0223	Motor, Pre-Aeration Pump 2 South
TRA-1693	Pump, Return, South Aeration #1
TRA-1694	Pump, Return, South Aeration #2
TRA-1695	Pump, Return, South Aeration #3
TRA-1696	Pump, Return, South Aeration #4
TRA-0224	Pump, Return, South Aeration #1
TRA-0225	Pump, Return, South Aeration #2
TRA-0226	Pump, Return, South Aeration #3
TRA-0227	Pump, Return, South Aeration #4
TRA-0228	So. Aeration Grid Laterals
TRA-0229	South Aeration Basin Air Header To Diffuser Down Legs
TRA-0231	Transmitter, Flow, RAS South
TRA-0232	Valve, Butterfly, 24 South Aeration Basin Air Modulation
TRA-0233	Valve, Butterfly, 30 In. On South RAS Line
TRA-0234	Bldg #050, Membrane Filtration Building
TRA-0236	Train #1 Membrane Filter System
TRA-0238	Train #1 Membrane Cassette D
TRA-0239	Train #1 Membrane Cassette D 16 Module Membrane Filter
TRA-0240	Train #1 Membrane Cassette D 8 Module Membrane Filter
TRA-0241	Train #1 Membrane Cassette E
TRA-0242	Train #1 Membrane Cassette E 16 Module Membrane Filter
TRA-0243	Train #1 Membrane Cassette E 8 Module Membrane Filter
TRA-0244	Train #1 Membrane Cassette F

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0245	Train #1 Membrane Cassette F 16 Module Membrane Filter
TRA-0246	Train #1 Membrane Cassette F 8 Module Membrane Filter
TRA-0247	Train #1 Membrane Cassette G
TRA-0248	Train #1 Membrane Cassette G 16 Module Membrane Filter
TRA-0249	Train #1 Membrane Cassette G 8 Module Membrane Filter
TRA-0250	Train #1 Membrane Cassette H
TRA-0251	Train #1 Membrane Cassette H 16 Module Membrane Filter
TRA-0252	Train #1 Membrane Cassette H 8 Module Membrane Filter
TRA-0253	Train #1 Membrane Cassette I
TRA-0254	Train #1 Membrane Cassette I 16 Module Membrane Filter
TRA-0255	Train #1 Membrane Cassette I 8 Module Membrane Filter
TRA-0256	Train #1 Membrane Cassette J
TRA-0257	Train #1 Membrane Cassette J 16 Module Membrane Filter
TRA-0258	Train #1 Membrane Cassette J 8 Module Membrane Filter
TRA-0259	Train #1 Membrane Cassette K
TRA-0260	Train #1 Membrane Cassette K 16 Module Membrane Filter
TRA-0261	Train #1 Membrane Cassette K 8 Module Membrane Filter
TRA-0262	Train #1 Membrane Cassette L
TRA-0263	Train #1 Membrane Cassette L 16 Module Membrane Filter
TRA-0264	Train #1 Membrane Cassette L 8 Module Membrane Filter
TRA-0265	Train #1 Membrane Cassette M
TRA-0266	Train #1 Membrane Cassette M 16 Module Membrane Filter
TRA-0267	Train #1 Membrane Cassette M 8 Module Membrane Filter
TRA-0268	Train #1 Membrane Cassette N
TRA-0269	Train #1 Membrane Cassette N 16 Module Membrane Filter
TRA-0270	Train #1 Membrane Cassette N 8 Module Membrane Filter
TRA-0271	Train #1 Membrane Cassette O
TRA-0272	Train #1 Membrane Cassette O 16 Module Membrane Filter
TRA-0273	Train #1 Membrane Cassette O 8 Module Membrane Filter
TRA-0274	Train #1 Membrane Cassette P
TRA-0275	Train #1 Membrane Cassette P 16 Module Membrane Filter
TRA-0276	Train #1 Membrane Cassette P 8 Module Membrane Filter
TRA-0277	Gate, Inlet, Train #1
TRA-0278	Actuator, Inlet Gate, Train 1
TRA-0279	Gate, Discharge, Train #1
TRA-0280	Actuator, Discharge Gate, Train 1
TRA-0281	Transducer, Level, Train 1
TRA-0282	Valve, Course Air Control, Train 1
TRA-0283	Valve, Train 1 Back Pulse
TRA-0284	Train #2 Membrane Filter System
TRA-0286	Train #2 Membrane Cassette D
TRA-0287	Train #2 Membrane Cassette D 24 Module Membrane Filter
TRA-0288	Train #2 Membrane Cassette D 8 Module Membrane Filter
TRA-0289	Train #2 Membrane Cassette E

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0290	Train #2 Membrane Cassette E 24 Module Membrane Filter
TRA-0291	Train #2 Membrane Cassette E 8 Module Membrane Filter
TRA-0292	Train #2 Membrane Cassette F
TRA-0293	Train #2 Membrane Cassette F 24 Module Membrane Filter
TRA-0294	Train #2 Membrane Cassette F 8 Module Membrane Filter
TRA-0295	Train #2 Membrane Cassette G
TRA-0296	Train #2 Membrane Cassette G 24 Module Membrane Filter
TRA-0297	Train #2 Membrane Cassette G 8 Module Membrane Filter
TRA-0298	Train #2 Membrane Cassette H
TRA-0299	Train #2 Membrane Cassette H 24 Module Membrane Filter
TRA-0300	Train #2 Membrane Cassette H 8 Module Membrane Filter
TRA-0301	Train #2 Membrane Cassette I
TRA-0302	Train #2 Membrane Cassette I 24 Module Membrane Filter
TRA-0303	Train #2 Membrane Cassette I 8 Module Membrane Filter
TRA-0304	Train #2 Membrane Cassette J
TRA-0305	Train #2 Membrane Cassette J 24 Module Membrane Filter
TRA-0306	Train #2 Membrane Cassette J 8 Module Membrane Filter
TRA-0307	Train #2 Membrane Cassette K
TRA-0308	Train #2 Membrane Cassette K 24 Module Membrane Filter
TRA-0309	Train #2 Membrane Cassette K 8 Module Membrane Filter
TRA-0310	Train #2 Membrane Cassette L
TRA-0311	Train #2 Membrane Cassette L 24 Module Membrane Filter
TRA-0312	Train #2 Membrane Cassette L 8 Module Membrane Filter
TRA-0313	Train #2 Membrane Cassette M
TRA-0314	Train #2 Membrane Cassette M 24 Module Membrane Filter
TRA-0315	Train #2 Membrane Cassette M 8 Module Membrane Filter
TRA-0316	Train #2 Membrane Cassette N
TRA-0317	Train #2 Membrane Cassette N 24 Module Membrane Filter
TRA-0318	Train #2 Membrane Cassette N 8 Module Membrane Filter
TRA-0319	Train #2 Membrane Cassette O
TRA-0320	Train #2 Membrane Cassette O 24 Module Membrane Filter
TRA-0321	Train #2 Membrane Cassette O 8 Module Membrane Filter
TRA-0322	Train #2 Membrane Cassette P
TRA-0323	Train #2 Membrane Cassette P 24 Module Membrane Filter
TRA-0324	Train #2 Membrane Cassette P 8 Module Membrane Filter
TRA-0325	Gate, Inlet, Train #2
TRA-0326	Actuator, Inlet Gate, Train 2
TRA-032-600O1N	North Basin D.O. Meter
TRA-0327	Gate, Discharge, Train #2
TRA-0328	Actuator, Discharge Gate, Train 2
TRA-0329	Transducer, Level, Train 2
TRA-0330	Valve, Course Air Control, Train 2
TRA-0331	Train #3 Membrane Filter System
TRA-0334	Train #3 Membrane Cassette A

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0335	Train #3 Membrane Cassette B
TRA-0336	Train #3 Membrane Cassette C
TRA-0337	Train #3 Membrane Cassette D
TRA-0338	Train #3 Membrane Cassette E
TRA-0339	Train #3 Membrane Cassette F
TRA-0340	Train #3 Membrane Cassette G
TRA-0341	Train #3 Membrane Cassette H
TRA-0342	Train #3 Membrane Cassette I
TRA-0343	Train #3 Membrane Cassette J
TRA-0344	Train #3 Membrane Cassette K
TRA-0345	Train #3 Membrane Cassette L
TRA-0346	Train #3 Membrane Cassette M
TRA-0347	Train #3 Membrane Cassette N
TRA-0348	Train #3 Membrane Cassette O
TRA-0349	Train #3 Membrane Cassette P
TRA-0350	Gate, Inlet, Train #3
TRA-0351	Actuator, Inlet Gate, Train 3
TRA-0352	Gate, Discharge, Train #3
TRA-0353	Actuator, Discharge Gate, Train 3
TRA-0354	Transducer, Level, Train 3
TRA-0355	Valve, Course Air Control, Train 3
TRA-0356	Train #4 Membrane Filter System
TRA-0358	Train #4 Membrane Cassette A
TRA-0359	Train #4 Membrane Cassette B
TRA-0360	Train #4 Membrane Cassette C
TRA-0361	Train #4 Membrane Cassette D
TRA-0362	Train #4 Membrane Cassette E
TRA-0363	Train #4 Membrane Cassette F
TRA-0364	Train #4 Membrane Cassette G
TRA-0365	Train #4 Membrane Cassette H
TRA-0366	Train #4 Membrane Cassette I
TRA-0367	Train #4 Membrane Cassette J
TRA-0368	Train #4 Membrane Cassette K
TRA-0369	Train #4 Membrane Cassette L
TRA-0370	Train #4 Membrane Cassette M
TRA-0371	Train #4 Membrane Cassette N
TRA-0372	Train #4 Membrane Cassette O
TRA-0373	Train #4 Membrane Cassette P
TRA-0374	Gate, Inlet, Train #4
TRA-0375	Actuator, Inlet Gate, Train 4
TRA-0376	Gate, Discharge, Train #4
TRA-0377	Actuator, Discharge Gate, Train 4
TRA-0378	Transducer, Level, Train 4
TRA-0379	Valve, Course Air Control, Train 4

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0380	Train #5 Membrane Filter System
TRA-0382	Train #5 Membrane Cassette A
TRA-0383	Train #5 Membrane Cassette B
TRA-0384	Train #5 Membrane Cassette C
TRA-0385	Train #5 Membrane Cassette D
TRA-0386	Train #5 Membrane Cassette E
TRA-0387	Train #5 Membrane Cassette F
TRA-0388	Train #5 Membrane Cassette G
TRA-0389	Train #5 Membrane Cassette H
TRA-0390	Train #5 Membrane Cassette I
TRA-0391	Train #5 Membrane Cassette J
TRA-0392	Train #5 Membrane Cassette K
TRA-0393	Train #5 Membrane Cassette L
TRA-0394	Train #5 Membrane Cassette M
TRA-0395	Train #5 Membrane Cassette N
TRA-0396	Train #5 Membrane Cassette O
TRA-0397	Train #5 Membrane Cassette P
TRA-0398	Gate, Inlet, Train #5
TRA-0399	Actuator, Inlet Gate, Train 5
TRA-0400	Gate, Discharge, Train #5
TRA-0401	Actuator, Discharge Gate, Train 5
TRA-0402	Transducer, Level, Train 5
TRA-0403	Valve, Course Air Control, Train 5
TRA-0404	Train #6 Membrane Filter System
TRA-0406	Train #6 Membrane Cassette D
TRA-0407	Train #6 Membrane Cassette E
TRA-0408	Train #6 Membrane Cassette F
TRA-0409	Train #6 Membrane Cassette G
TRA-0410	Train #6 Membrane Cassette H
TRA-0411	Train #6 Membrane Cassette I
TRA-0412	Train #6 Membrane Cassette J
TRA-0413	Train #6 Membrane Cassette K
TRA-0414	Train #6 Membrane Cassette L
TRA-0415	Train #6 Membrane Cassette M
TRA-0416	Train #6 Membrane Cassette N
TRA-0417	Train #6 Membrane Cassette O
TRA-0418	Train #6 Membrane Cassette P
TRA-0420	Gate, Inlet, Train #6
TRA-0421	Actuator, Inlet Gate, Train 6
TRA-0422	Gate, Discharge, Train #6
TRA-0423	Actuator, Discharge Gate, Train 6
TRA-0424	Transducer, Level Control, Train 6
TRA-0425	Valve, Course Air Control, Train 6
TRA-0426	Train #7 Membrane Filter System

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0428	Train #7 Membrane Cassette D
TRA-0429	Train #7 Membrane Cassette D 16 Module Membrane Filter
TRA-0430	Train #7 Membrane Cassette D 8 Module Membrane Filter
TRA-0431	Train #7 Membrane Cassette E
TRA-0432	Train #7 Membrane Cassette E 16 Module Membrane Filter
TRA-0433	Train #7 Membrane Cassette E 8 Module Membrane Filter
TRA-0434	Train #7 Membrane Cassette F
TRA-0435	Train #7 Membrane Cassette F 16 Module Membrane Filter
TRA-0436	Train #7 Membrane Cassette F 8 Module Membrane Filter
TRA-0437	Train #7 Membrane Cassette G
TRA-0438	Train #7 Membrane Cassette G 16 Module Membrane Filter
TRA-0439	Train #7 Membrane Cassette G 8 Module Membrane Filter
TRA-0440	Train #7 Membrane Cassette H
TRA-0441	Train #7 Membrane Cassette H 16 Module Membrane Filter
TRA-0442	Train #7 Membrane Cassette H 8 Module Membrane Filter
TRA-0443	Train #7 Membrane Cassette I
TRA-0444	Train #7 Membrane Cassette I 16 Module Membrane Filter
TRA-0445	Train #7 Membrane Cassette I 8 Module Membrane Filter
TRA-0446	Train #7 Membrane Cassette J
TRA-0447	Train #7 Membrane Cassette J 16 Module Membrane Filter
TRA-0448	Train #7 Membrane Cassette J 8 Module Membrane Filter
TRA-0449	Train #7 Membrane Cassette K
TRA-0450	Train #7 Membrane Cassette K 16 Module Membrane Filter
TRA-0451	Train #7 Membrane Cassette K 8 Module Membrane Filter
TRA-0452	Train #7 Membrane Cassette L
TRA-0453	Train #7 Membrane Cassette L 16 Module Membrane Filter
TRA-0454	Train #7 Membrane Cassette L 8 Module Membrane Filter
TRA-0455	Train #7 Membrane Cassette M
TRA-0456	Train #7 Membrane Cassette M 16 Module Membrane Filter
TRA-0457	Train #7 Membrane Cassette M 8 Module Membrane Filter
TRA-0458	Train #7 Membrane Cassette N
TRA-0459	Train #7 Membrane Cassette N 16 Module Membrane Filter
TRA-0460	Train #7 Membrane Cassette N 8 Module Membrane Filter
TRA-0461	Train #7 Membrane Cassette O
TRA-0462	Train #7 Membrane Cassette O 16 Module Membrane Filter
TRA-0463	Train #7 Membrane Cassette O 8 Module Membrane Filter
TRA-0464	Train #7 Membrane Cassette P
TRA-0465	Train #7 Membrane Cassette P 16 Module Membrane Filter
TRA-0466	Train #7 Membrane Cassette P 8 Module Membrane Filter
TRA-0467	Gate, Inlet, Train #7
TRA-0468	Actuator, Inlet Gate, Train 7
TRA-0469	Gate, Discharge, Train #7
TRA-0470	Actuator, Discharge Gate, Train 7
TRA-0471	Transducer, Level, Train 7

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0472	Valve, Course Air Control, Train 7
TRA-0473	Train #8 Membrane Filter System
TRA-0475	Train #8 Membrane Cassette A
TRA-0476	Train #8 Membrane Cassette B
TRA-0477	Train #8 Membrane Cassette C
TRA-0478	Train #8 Membrane Cassette D
TRA-0479	Train #8 Membrane Cassette E
TRA-0480	Train #8 Membrane Cassette F
TRA-0481	Train #8 Membrane Cassette G
TRA-0482	Train #8 Membrane Cassette H
TRA-0483	Train #8 Membrane Cassette I
TRA-0484	Train #8 Membrane Cassette J
TRA-0485	Train #8 Membrane Cassette K
TRA-0486	Train #8 Membrane Cassette L
TRA-0487	Train #8 Membrane Cassette M
TRA-0488	Train #8 Membrane Cassette N
TRA-0489	Train #8 Membrane Cassette O
TRA-0490	Train #8 Membrane Cassette P
TRA-0491	Gate, Inlet, Train #8
TRA-0492	Actuator, Inlet Gate, Train 8
TRA-0493	gate, Discharge, Train #8
TRA-0494	Actuator, Discharge Gate, Train 8
TRA-0495	Transducer, Level, Train 8
TRA-0496	Valve, Course Air Control, Train 8
TRA-0497	8' Step Ladder, Orange Fiberglass, Membrane Bldg, West Stairs
TRA-0498	Actuator, Wasting Pit Inlet Gate
TRA-0499	Crane, Membrane Tank Bridge
TRA-0500	Fixed Ladder, Upper Hall, Membrane Bldg
TRA-0501	Membrane Building East Stair Supply Fan
TRA-0502	Membrane Building Upper Hall Supply Fan
TRA-0503	Membrane Building West Stair Supply Fan
TRA-0504	Membrane Cassette Lifting Device 1
TRA-0505	Membrane Cassette Lifting Device 2
TRA-0506	Membrane Dip Tank A
TRA-0507	Membrane Dip Tank B
TRA-0508	Switch, Float, Lowlow Level, Trains 1 - 8
TRA-0509	Switch, No Float Control Switch From 110V 20A Pump
TRA-050BLDG-T6D-08	Train #6 Membrane Cassette D 8 Module Membrane Filter
TRA-050BLDG-T6D-16	Train #6 Membrane Cassette D 16 Module Membrane Filter
TRA-050BLDG-T6E-08	Train #6 Membrane Cassette E 8 Module Membrane Filter
TRA-050BLDG-T6E-16	Train #6 Membrane Cassette E 16 Module Membrane Filter
TRA-050BLDG-T6F-08	Train #6 Membrane Cassette F 8 Module Membrane Filter
TRA-050BLDG-T6F-16	Train #6 Membrane Cassette F 16 Module Membrane Filter
TRA-050BLDG-T6G-08	Train #6 Membrane Cassette G 8 Module Membrane Filter

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-050BLDG-T6G-16	Train #6 Membrane Cassette G 16 Module Membrane Filter
TRA-050BLDG-T6H-08	Train #6 Membrane Cassette H 8 Module Membrane Filter
TRA-050BLDG-T6H-16	Train #6 Membrane Cassette H 16 Module Membrane Filter
TRA-050BLDG-T6I-08	Train #6 Membrane Cassette I 8 Module Membrane Filter
TRA-050BLDG-T6I-16	Train #6 Membrane Cassette I 16 Module Membrane Filter
TRA-050BLDG-T6J-08	Train #6 Membrane Cassette J 8 Module Membrane Filter
TRA-050BLDG-T6J-16	Train #6 Membrane Cassette J 16 Module Membrane Filter
TRA-050BLDG-T6K-08	Train #6 Membrane Cassette K 8 Module Membrane Filter
TRA-050BLDG-T6K-16	Train #6 Membrane Cassette K 16 Module Membrane Filter
TRA-050BLDG-T6L-08	Train #6 Membrane Cassette L 8 Module Membrane Filter
TRA-050BLDG-T6L-16	Train #6 Membrane Cassette L 16 Module Membrane Filter
TRA-050BLDG-T6M-08	Train #6 Membrane Cassette M 8 Module Membrane Filter
TRA-050BLDG-T6M-16	Train #6 Membrane Cassette M 16 Module Membrane Filter
TRA-050BLDG-T6N-08	Train #6 Membrane Cassette N 8 Module Membrane Filter
TRA-050BLDG-T6N-16	Train #6 Membrane Cassette N 16 Module Membrane Filter
TRA-050BLDG-T6O-08	Train #6 Membrane Cassette O 8 Module Membrane Filter
TRA-050BLDG-T6O-16	Train #6 Membrane Cassette O 16 Module Membrane Filter
TRA-050BLDG-T6P-08	Train #6 Membrane Cassette P 8 Module Membrane Filter
TRA-050BLDG-T6P-16	Train #6 Membrane Cassette P 16 Module Membrane Filter
TRA-0510	Transmitter, Temperature, East Membrane Channel
TRA-0511	Transmitter, Temperature, Membrane Building Outside Air
TRA-0512	Transmitter, Temperature, West Membrane Channel
TRA-0513	Bldg 050 Basement
TRA-0514	10' Step Ladder, Orange Fiberglass, Pump Rm, Membrane Bldg
TRA-0515	24' Extension Ladder, Orange Fiberglass, Pump Rm, Membrane Bldg
TRA-0516	Air Compressor, Membrane System, #1
TRA-0517	Air Dryer, refrigerated, #1
TRA-0518	Motor, Compressor, #1
TRA-0519	Air Compressor, Membrane System, #2
TRA-0520	Air Dryer, refrigerated, #2
TRA-0521	Motor, Compressor, #2
TRA-0522	Backflow Preventer, Membrane Bldg , 1.5 In
TRA-0523	Control Air Piping In The Membrane Building And Tanks
TRA-0524	Dryer, Membrane Air System, Hankison
TRA-0525	Exhaust Fan #1, Bldg. 50 Basement
TRA-0526	Exhaust Fan #2, Bldg. 50 Basement
TRA-0527	Exhaust Fan #3, Bldg. 50 Basement
TRA-0528	Eyewash, Bottle, Bldg. 50 Basement
TRA-0529	Final Effluent Sampler
TRA-0530	Flow Meter, RAS Discharge North
TRA-0531	Flow Meter, RAS Discharge South
TRA-0532	Flow Meter, W-3 Service Water, Bldg. 50 Basement
TRA-0533	Flow Meter, WAS, Bldg. 50 Basement
TRA-0534	Membrane Back Pulse Piping

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0535	Membrane Citric Acid Feed Piping
TRA-0536	Membrane Permeate Piping
TRA-0537	Membrane Pump Room East Wall Exhaust Fan (Across From RAS Pumps)
TRA-0538	North RAS Piping Below Grade
TRA-0539	Panel, Fan Control, Bldg. 50 Basement
TRA-0540	Panel, W-3 Service Water Pump Control, Bldg. 50 Basement
TRA-0541	Permeate System
TRA-0542	East Vacuum Priming System
TRA-0543	East Vacuum Priming System Dewatering Drain
TRA-0544	East Vacuum Priming System Drain Pneumatic Actuator
TRA-0545	East Vacuum Priming System Dewatering Inlet Valve
TRA-0546	East Vacuum Priming System Pneumatic Inlet Actuator
TRA-0547	East Vacuum Priming System Dewatering Outlet Valve
TRA-0548	East Vacuum Priming System Outlet Pneumatic Actuator
TRA-0549	East Vacuum Priming System Dewatering Vent Valve
TRA-0550	East Vacuum Priming System Vent Pneumatic Actuator
TRA-0551	West Vacuum Priming System
TRA-0552	West Vacuum Priming System Drain Valve
TRA-0553	West Vacuum Priming System Drain Pneumatic Actuator
TRA-0554	West Vacuum Priming System Inlet Valve
TRA-0555	West Vacuum Priming System Inlet Pneumatic Actuator
TRA-0556	West Vacuum Priming System Outlet Valve
TRA-0557	West Vacuum Priming System Outlet Pneumatic Actuator
TRA-0558	West Vacuum Priming System Vent Valve
TRA-0559	West Vacuum Priming System Vent Pneumatic Actuator
TRA-0560	Pump, Vacuum Priming, #1
TRA-0561	#1 Vacuum Pump Motor
TRA-0562	Vacuum Pump A Inlet Valve
TRA-0563	Vacuum Pump A Pneumatic Actuator
TRA-0564	Pump, Vacuum Priming, #2
TRA-0565	#2 Vacuum Pump Motor
TRA-0566	Vacuum Pump B Inlet Valve
TRA-0567	Vacuum Pump B Pneumatic Actuator
TRA-0568	Pump, Vacuum Priming, #3
TRA-0569	#3 Vacuum Pump Motor
TRA-0570	Vacuum Pump C Inlet Valve
TRA-0571	Vacuum Pump C Pneumatic Actuator
TRA-0572	Permeate Train #1, Bldg 50 Basement
TRA-0573	Permeate Tank #1
TRA-0574	Control Head, Turbidity Sensors #1 & 2
TRA-0575	Train 1 Permeate Tank ARV
TRA-0576	Turbidimeter, Train 1
TRA-0577	Pump, Permeate, Train #1
TRA-0578	#1 Permeate Pump Discharge Check Valve

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0579	Permeate Motor, Train 1
TRA-0580	Permeate Pump Discharge Valve 1
TRA-0581	Permeate Pump Suction Valve 1
TRA-0582	Meter, Flow, Permeate Train #1, Bldg 50 Basement
TRA-0583	Switch, Pressure, Permeate Header Pressure Train #1 East
TRA-0584	Switch, Pressure, Permeate Header Pressure Train #1 West
TRA-0585	Transmitter, Pressure, Permeate Train #1, Bldg. 50 Basement
TRA-0586	Permeate Train #2, Bldg 50 Basement
TRA-0587	Permeate Tank #2
TRA-0588	Train 2 Permeate Tank ARV
TRA-0589	Turbidimeter, Train 2
TRA-0590	Pump, Permeate, Train #2
TRA-0591	#2 Permeate Pump Discharge Check Valve
TRA-0592	Permeate Motor, Train 2
TRA-0593	Permeate Pump #2 Discharge Valve
TRA-0594	Permeate Pump #2 Suction Valve
TRA-0595	Meter, Flow, Permeate Train #2, Bldg 50 Basement
TRA-0596	Switch, Pressure, Permeate Header Pressure Train #2 East
TRA-0597	Switch, Pressure, Permeate Header Pressure Train #2 West
TRA-0598	Transmitter, Pressure, Permeate Train #2, Bldg. 50 Basement
TRA-0599	Permeate Train #3, Bldg 50 Basement
TRA-0600	Permeate Tank #3
TRA-0601	Control Head, Turbidity Sensors #3 & 4
TRA-0602	Train 3 Permeate Tank ARV
TRA-0603	Turbidimeter, Train 3
TRA-0604	Pump, Permeate, Train #3
TRA-0605	#3 Permeate Pump Discharge Check Valve
TRA-0606	Permeate Motor, Train 3
TRA-0607	Permeate Pump #3 Discharge Valve
TRA-0608	Permeate Pump #3 Suction Valve
TRA-0609	Meter, Flow, Permeate Train #3, Bldg 50 Basement
TRA-0610	Switch, Pressure, Permeate Header Pressure Train #3 East
TRA-0611	Switch, Pressure, Permeate Header Pressure Train #3 West
TRA-0612	Transmitter, Pressure, Permeate Train #3, Bldg. 50 Basement
TRA-0613	Permeate Train #4, Bldg 50 Basement
TRA-0614	Permeate Tank #4
TRA-0615	Train 4 Permeate Tank ARV
TRA-0616	Turbidimeter, Train 4
TRA-0617	Pump, Permeate, Train #4
TRA-0618	#4 Permeate Pump Discharge Check Valve
TRA-0619	Permeate Motor, Train 4
TRA-0620	Permeate Pump #4 Discharge Valve
TRA-0621	Permeate Pump #4 Suction Valve
TRA-0622	Meter, Flow, Permeate Train #4, Bldg 50 Basement

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0623	Switch, Pressure, Permeate Header Pressure Train #4 East
TRA-0624	Switch, Pressure, Permeate Header Pressure Train #4 West
TRA-0625	Transmitter, Pressure, Permeate Train #4, Bldg. 50 Basement
TRA-0626	Permeate Train #5, Bldg 50 Basement
TRA-0627	Permeate Tank #5
TRA-0628	Control Head, Turbidity Sensors #5 & 6
TRA-0629	Train 5 Permeate Tank ARV
TRA-0630	Turbidimeter, Train 5
TRA-0631	Pump, Permeate, Train #5
TRA-0632	#5 Permeate Pump Discharge Check Valve
TRA-0633	Permeate Motor, Train 5
TRA-0634	Permeate Pump #5 Discharge Valve
TRA-0635	Permeate Pump #5 Suction Valve
TRA-0636	Permeate Pump #5 VFD
TRA-0637	Meter, Flow, Permeate Train #5, Bldg 50 Basement
TRA-0638	Switch, Pressure, Permeate Header Pressure Train #5 East
TRA-0639	Switch, Pressure, Permeate Header Pressure Train #5 West
TRA-0640	Transmitter, Pressure, Permeate Train #5, Bldg. 50 Basement
TRA-0641	Permeate Train #6, Bldg 50 Basement
TRA-0642	Permeate Tank #6
TRA-0643	Train 6 Permeate Tank ARV
TRA-0644	Turbidimeter, Train 6
TRA-0645	Pump, Permeate, Train #6
TRA-0646	#6 Permeate Pump Discharge Check Valve
TRA-0647	Motor, Permeate Pump, Train 6
TRA-0648	VFD, Permeate, pump, Train #6
TRA-0649	Permeate Pump #6 Discharge Valve
TRA-0650	Permeate Pump #6 Suction Valve
TRA-0651	Meter, Flow, Permeate Train #6, Bldg 50 Basement
TRA-0652	Switch, Pressure, Permeate Header Pressure Train #6 East
TRA-0653	Switch, Pressure, Permeate Header Pressure Train #6 West
TRA-0654	Transmitter, Pressure, Permeate Train #6, Bldg. 50 Basement
TRA-0655	Permeate Train #7, Bldg 50 Basement
TRA-0656	Permeate Tank #7
TRA-0657	Control Head, Turbidity Sensors #7 & 8
TRA-0658	Train 7 Permeate Tank ARV
TRA-0659	Turbidimeter, Train 7
TRA-0660	Pump, Permeate, Train #7
TRA-0661	#7 Permeate Pump Discharge Check Valve
TRA-0662	Motor, Permeate Pump, Train 7
TRA-0663	Permeate Pump #7 Discharge Valve
TRA-0664	Permeate Pump #7 Suction Valve
TRA-0665	Meter, Flow, Permeate Train #7, Bldg 50 Basement
TRA-0666	Switch, Pressure, Permeate Header Pressure Train #7 East

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0667	Switch, Pressure, Permeate Header Pressure Train #7 West
TRA-0668	Transmitter, Pressure, Permeate Train #7, Bldg. 50 Basement
TRA-0669	Permeate Train #8, Bldg 50 Basement
TRA-0670	Permeate Tank #8
TRA-0671	Sensor, Turbidity, Train #8
TRA-0672	Train 8 Permeate Tank ARV
TRA-0673	Turbidimeter, Train 8
TRA-0674	Pump, Permeate, Train #8
TRA-0675	#8 Permeate Pump Discharge Check Valve
TRA-0676	Permeate Motor, Train 8
TRA-0677	Permeate Pump #8 Discharge Valve
TRA-0678	Permeate Pump #8 Suction Valve
TRA-0679	Meter, Flow, Permeate Train #8, Bldg 50 Basement
TRA-0680	Switch, Pressure, Permeate Header Pressure Train #8 East
TRA-0681	Switch, Pressure, Permeate Header Pressure Train #8 West
TRA-0682	Transmitter, Pressure, Permeate Train #8, Bldg. 50 Basement
TRA-0683	Pump, Backpulse, Pump #1
TRA-0684	Motor, Back Pulse, Pump #1
TRA-0685	Pump, Backpulse, Pump #2
TRA-0686	Motor, Back Pulse, Pump 2
TRA-0687	Pump, Membrane Building Sump #1
TRA-0688	Pump, Membrane Building Sump #2
TRA-0689	Pump, Recirculation, 50-P-10A
TRA-0690	Motor, Recirculation 50-P-10A
TRA-0691	Pump, Recirculation, 50-P-10B
TRA-0692	Motor, 50-P-10B
TRA-0693	Pump, Return, RAS Unit A
TRA-0694	Motor, RAS Pump A
TRA-0695	Pump, Return, RAS Unit B
TRA-0696	Motor, RAS Pump B
TRA-0697	Pump, Return, RAS Unit C
TRA-0698	Motor, RAS Pump C
TRA-0699	Pump, Sump Drain, Train 1-8
TRA-0700	Membrane Tank Drain Pump Motor
TRA-0701	Pump, W-3 Service Water, #1
TRA-0702	Motor, W-3, #1
TRA-0703	Pump, W-3 Service Water, #2
TRA-0704	Motor, W-3, #2
TRA-0705	Pump, WAS, Unit A
TRA-0706	Motor, Was Unit A
TRA-0707	Pump, WAS, Unit B
TRA-0708	Motor, WAS, Unit B
TRA-0709	Sensor, Temperature, Membrane Mixed Liquor Trains 1 - 4
TRA-0710	Sensor, Temperature, Membrane Mixed Liquor Trains 5 - 8

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0711	Separator, Pre Air Filter / Oil, Hankison Membrane Dryer
TRA-0712	South RAS Piping Below Grade
TRA-0713	Sump Pump Duplex Control Panel; Membrane Bldg Basement
TRA-0715	Valve Actuator, Discharge Valve, RAS, North
TRA-0716	Valve Actuator, Discharge Valve, RAS, South
TRA-0717	Valve, Drain, Membrane Tanks
TRA-0718	Valve, Drain, Membrane Tank #1, Bldg. 50 Basement
TRA-0719	Valve, Drain, Membrane Tank #2, Bldg. 50 Basement
TRA-0720	Valve, Drain, Membrane Tank #3, Bldg. 50 Basement
TRA-0721	Valve, Drain, Membrane Tank #4, Bldg. 50 Basement
TRA-0722	Valve, Drain, Membrane Tank #5, Bldg. 50 Basement
TRA-0723	Valve, Drain, Membrane Tank #6, Bldg. 50 Basement
TRA-0724	Valve, Drain, Membrane Tank #7, Bldg. 50 Basement
TRA-0725	Valve, Drain, Membrane Tank #8, Bldg. 50 Basement
TRA-0726	VFD, Toshiba, Control For RAS Pump 3
TRA-0727	VFD, Toshiba, Control For RAS Pump 1
TRA-0728	VFD, Toshiba, Control For RAS Pump 2
TRA-0729	Bldg 050 Blower Room
TRA-0730	Blower, Scour Air, Blower A
TRA-0731	Motor, Membrane Scour Blower
TRA-0732	Blower, Scour Air, Blower B
TRA-0733	Motor, Membrane Scour Blower
TRA-0734	Blower, Scour Air, Blower C
TRA-0735	Motor, Membrane Scour Blower
TRA-0736	Blower, Scour Air, Blower D
TRA-0737	Motor, Membrane Scour Blower
TRA-0738	Blower, Scour Air, Blower E
TRA-0739	Motor, Membrane Scour Blower
TRA-0740	Crane and Hoist, Membrane Building Blower Room
TRA-0741	Doors, Membrane Blower Room Equipment
TRA-0742	Membrane Blower Room Exhaust Fan 7
TRA-0743	Membrane Blower Room Exhaust Fan 8
TRA-0744	Membrane Blower Room Exhaust Fan 9
TRA-0745	Panel, Fan Control, Bldg. 50 Blower Room
TRA-0746	Bldg 050 Chemical Room
TRA-0747	1 Bleach Feed Pipe Valves 1-12
TRA-0748	6' Step Ladder, Chemical Rm, Membrane Bldg
TRA-0749	Containment Basin, Bldg. 50 Chemical Room
TRA-0750	Door, Membrane Chemical Room East Roll Up
TRA-0751	Door, Membrane Chemical Room West Roll Up
TRA-0752	Exhaust Fan, Membrane Bldg, Chemical Rm
TRA-0753	Eyewash/Safety Shower, Bldg. 50 Chemical Room
TRA-0754	Membrane Bleach Feed Piping
TRA-0755	Membrane Building Chemical Room Heating Control Panel PLC

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0756	Pump, Diaphragm, Citric Acid, East
TRA-0757	Pump, Diaphragm, Citric Acid, West
TRA-0758	Pump, Diaphragm, Sodium Hypochlorite, East
TRA-0759	Pump, Diaphragm, Sodium Hypochlorite, West
TRA-0760	Pump, Metering, Bleach Feeder For W-2 Water
TRA-0761	Tank, Citric Acid, Bldg. 50 Chem Room
TRA-0762	Tank, Sodium Hypochlorite, Bldg. 50 Chem Room
TRA-0763	Bldg 50 Electrical Room
TRA-0764	8' Step Ladder, Yellow Fiberglass, Membrane Bldg, Electrical Rm
TRA-0765	Electrical Main Disconnect Panel, Bldg. 50 Elect. Room
TRA-0766	Exhaust Fan, Membrane Electric Room South Wall
TRA-0767	MCC F1, Bldg 50
TRA-0768	MCC F2, Bldg 50
TRA-0771	Panel, Fan Control, Bldg 50 Elect. Room
TRA-0772	PLC, Membrane Train 1 and 2
TRA-0773	PLC, Membrane Train 3 and 4
TRA-0774	PLC, Membrane Train 5 and 6
TRA-0775	PLC, Membrane Train 7 and 8
TRA-0776	Soft Start For Course Air Blower Motor B
TRA-0777	Supply Fan, Membrane Electric Rm
TRA-0778	Supply Fan, Membrane Electric Room
TRA-0779	Transfer Panel, Generator, Membrane Elect. Room
TRA-0780	Main Breaker, Membrane Bldg., Generator ID#7829
TRA-0781	Main Breaker, Membrane Bldg., Line Power ID#7830
TRA-0782	Main Breaker, Membrane Bldg., Tie ID#7831
TRA-0783	PLC, Generator Transfer Panel, Membrane Elect. Room
TRA-0784	Uninterrupted Power Supply Cabinet
TRA-0785	Uninterrupted Power Supply #1
TRA-0786	Uninterrupted Power Supply #2
TRA-0787	Uninterrupted Power Supply #3
TRA-0788	Uninterrupted Power Supply #4
TRA-0789	Uninterrupted Power Supply #5
TRA-0790	Uninterrupted Power Supply #6
TRA-0791	Uninterrupted Power Supply #7
TRA-0792	VFD, Back Pulse Pump 1
TRA-0793	VFD, Back Pulse Pump 2
TRA-0794	VFD, Permeate Pump 1
TRA-0795	VFD, Permeate Pump 2
TRA-0796	VFD, Permeate Pump 3
TRA-0797	VFD, Permeate Pump 4
TRA-0798	VFD, Permeate Pump 5
TRA-0799	VFD, Permeate Pump 6
TRA-0800	VFD, Permeate Pump 7
TRA-0801	VFD, Permeate Pump 8

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0802	Emergency Diesel Generator, Membrane Building
TRA-0803	Diesel Engine, Membrane Bldg EDG
TRA-0804	Step Stool, Generator, Membrane Bldg
TRA-0805	Transformer, Primary, Membrane Building New (10/2010)
TRA-0806	Vacuum Priming System Control Switches
TRA-0807	Yard Breaker For Membrane Building
TRA-0808	Bldg #060, Ultra-violet Disinfection
TRA-0809	UV Treatment Channels
TRA-0810	Final Sampler - Sigma
TRA-0811	T Spreader For Lifting Uv Modules Out Of The Channel
TRA-0812	Bldg #070, East SST
TRA-0813	SST Tank #5
TRA-0814	Switch, Float, SST Tank 5 Level
TRA-0815	SST Tank #6
TRA-0816	Switch, Float, SST Tank 6 Level
TRA-0817	SST Tank #7
TRA-0818	Switch, Float, SST Tank 7 Level
TRA-0819	Truck Loading Station, East Load Out Building
TRA-0820	North Truck Loadout Valve
TRA-0821	Truck Loading Pipe Isolation Valve
TRA-0822	Truck Loading Valve At The Truck (8)
TRA-0823	Valve, Loading
TRA-0824	Bldg 070 Basement
TRA-0825	6' Step Ladder, Orange Fiberglass, East Load Out Bldg
TRA-0826	Backflow Preventer, East SST Bldg, 2 In
TRA-0827	Eyewash, Bottle, SST East Basement
TRA-0828	Pump, Sludge Loading Station, North
TRA-0829	Motor, East Sludge Loading Pump
TRA-0830	Valve, 12 Discharge Check, 41P1 North
TRA-0831	Pump, Sludge Loading Station, South
TRA-0832	Motor, East Sludge Loading South Pump
TRA-0833	Valve, 12 Discharge Check, 41P2 South
TRA-0834	Pump, Sump, East, SST East Basement
TRA-0835	Pump, Sump, West, SST East Basement
TRA-0836	SST 7 Upper North Chain Valve
TRA-0837	SST 7 Upper South Chain Valve
TRA-0838	Bldg 070 Control Room
TRA-0839	Panel, Light Control, SST East
TRA-0840	Security Camera 1, East Loadout
TRA-0841	Security Camera 2, East Loadout
TRA-0842	Security DVR, East Load Out
TRA-0843	SST East Exhaust Fan
TRA-0844	Supernate Pump, Moyno
TRA-0845	VFD Drive North Sludge Loading Pump 41P1A

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-0846	VFD Drive South Sludge Loading Pump 41P1B
TRA-0847	Bldg #072, West SST
TRA-0848	SST Cell #1
TRA-0849	Switch, Float, Level, Cell 1 SST West
TRA-0850	Valve, SST Cell 1, Lower Valve
TRA-0851	Valve, SST Cell 1, Upper Valve
TRA-0852	SST Cell #2
TRA-0853	Switch, Float, Level, Cell 2 SST West
TRA-0854	Valve, SST Cell 2, Lower Valve
TRA-0855	Valve, SST Cell 2, Upper Valve
TRA-0856	SST Cell #3
TRA-0857	Switch, Float, Level, Cell 3 SST West
TRA-0858	Valve, SST Cell 3, Lower Valve
TRA-0859	Valve, SST Cell 3, Upper Valve
TRA-0860	SST Cell #4
TRA-0861	Switch, Float, Level, Cell 34 SST West
TRA-0862	Valve, SST Cell 4, Lower Valve
TRA-0863	Valve, SST Cell 4, Upper Valve
TRA-0864	Bldg 072 SST West Basement
TRA-0865	Pump, SST Centrifugal
TRA-0866	Motor, SST Centrifugal Pump
TRA-0867	Pump, SST Piston
TRA-0868	Motor, SST Piston Pump
TRA-0869	Pump, Sump North, SST West Basement
TRA-0870	Pump, Sump South, SST West Basement
	SST Basement sump pump control panel
TRA-0871	SST Pump Room Exhaust Fan
TRA-0872	Step Stool, Pump Rm, West SST Bldg
TRA-0873	UNIT Heater In The SST Pump Room
TRA-0874	Bldg 072 SST West Electrical Room
TRA-0875	6' Step Ladder, Yellow Fiberglass, Control Rm, West SST Bldg
TRA-0876	Hoist Gantry, SST West Electrical Room
TRA-0877	MCC, SST West
TRA-0878	Bldg #080, SDC Building
TRA-0879	ADP Room - SDC Bldg
TRA-0880	Pump, South SDC Feed
TRA-0881	Motor, South SDC Feed Pump
TRA-0882	Pump, North SDC Feed
TRA-0883	Motor, North SDC Feed Pump
TRA-0884	Switch, Pressure, SDC Feed Pumps - ADP Room
TRA-0885	4' Step Ladder, Orange Fiberglass, ADP Rm, SDC Bldg
TRA-0886	Exchanger, Heat, Glycol System
TRA-0887	Gas Regulator, Digestive System - ADP Room
TRA-0888	Panel, Control, ADP Pump

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Asset ID	Asset Name
TRA-0889	Pump, Air Diaphragm, Unit A
TRA-0890	Separator, Moisture ADP Pump A
TRA-0891	Pump, Air Diaphragm, Unit B
TRA-0892	Separator, Moisture ADP Pump B
TRA-0893	Pump, Digester Chopper North, Small - ADP Room
TRA-0894	Pump, Digester Chopper South, Small - ADP Room
TRA-0895	Pump, Digester Circulating, Hot water
TRA-0896	Pump, Glycol Circulation - ADP Room
TRA-0897	Pump, Hot Water Booster - ADP Room
TRA-0898	Pump, Hot Water Circulation - ADP Room
TRA-0899	Pump, Water, Digester 1&2 Heat Exchanger
TRA-0900	T-control, Spiral Heater Exchanger
TRA-0901	Transmitter, Sludge Discharge Pressure
TRA-0902	Valve, Discharge, ADP Pump To Digesters
TRA-0903	Valve, Discharge, ADP Pump To GBC
TRA-0904	Valve, Plug, Primary Sludge Co-mingling
TRA-0905	SDC Room - SDC Bldg
TRA-0906	Concentrator, Sieve Drum #1 (West)
TRA-0907	Motor, SDC No.1 Drum
TRA-0908	Reducer, Gear, SDC No.1 Drum Drive
TRA-0909	Mixer, SDC No.1 Tank
TRA-0910	Motor, SDC No.1 Mix Tank
TRA-0911	Reducer, Gear, SDC No.1
TRA-0912	Pump, Discharge, West #1 SDC
TRA-0913	Motor, No. 1 SDC Discharge Pump
TRA-0914	Reducer, Gear, SDC No.1 Discharge Pump
TRA-0915	VFD, SDC No.1 Discharge Pump
TRA-0916	Pump, Wash Water, SDC No.1
TRA-0917	Control, Panel, SDC 1, West
TRA-0918	Concentrator, SDC #2 East
TRA-0919	Motor, SDC No.2 Drum
TRA-0920	Reducer, Gear, SDC No.2 Drum Drive
TRA-0921	Mixer, SDC No.2 Tank
TRA-0922	Motor, SDC No.2 Mix Tank
TRA-0923	Reducer, Gear, SDC No.2 Mix Tank Gear
TRA-0924	Pump, Discharge, East No. 2 SDC
TRA-0925	Motor, Pump, No. 2 SDC Discharge
TRA-0926	Reducer, Gear, SDC No.2 Discharge Pump
TRA-0927	VFD, SDC No. 2 Discharge Pump
TRA-0928	Pump, Centrifical, SDC No.2 Wash Water
TRA-0929	Control, Panel,SDC 2, East
TRA-0930	Articulating Ladder, SDC Rm, SDC Bldg
TRA-0931	Flowmeter, Magnetic, CDS To SST Cell
TRA-0932	Step Stool, SDC Rm, SDC Bldg

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Asset ID	Asset Name
TRA-0933	Semblex Room - SDC Bldg
TRA-0934	Semblex Polymer Mixing System
TRA-0935	Panel, Control, SemBlex Polymer Control System
TRA-0937	Pump, Feed, North Polymer Feed
TRA-0938	Motor; North Polymer Pump; SDC
TRA-0939	VFD, North SDC Polymer Pump Dc Motor
TRA-0940	Pump, Feed, South Polymer To SDC'S
TRA-0941	Motor; South Polymer Pump; SDC
TRA-0942	VFD, South SDC Polymer Pump Dc Motor
TRA-0944	Motor, Dry Chemical Feed, Symblex System
TRA-0945	Reducer, Gear, Dry Polymer Feed
TRA-0946	Tank, Symblex Polymer Storage, 1 East
TRA-0947	Tank, Symblex Polymer Storage, 2 West
TRA-0948	Portable Stair, Simplex Rm, SDC Bldg
TRA-0949	Bldg #085, GBC Building
TRA-0950	Bldg 085 GBC Room
TRA-0951	Concentrator, Gravity Belt
TRA-0952	Transmitter, CWAS Flow
TRA-0953	Control, Master, Gravity Belt Concentrator
TRA-0954	Pump, Booster, Wash Water For The GBC
TRA-0955	Pump, Discharge, GBC
TRA-0956	Motor, Pump, GBC Discharge
TRA-0957	Reducer, Gear, GBC Discharge
TRA-0958	VFD, Pump, GBC Discharge
TRA-0959	Pump, Filtrate Return, GBC, 2 in
TRA-0960	Reducer, Gear, GBC Belt
TRA-0961	Switch, Level, GBC Hopper
TRA-0962	GBC Building Motor Control Center
TRA-0963	8' Step Ladder, Yellow Fiberglass, GBC Rm, GBC Bldg
TRA-0964	Control, Pump, East Polymer Injection
TRA-0965	VFD, Pump, East Polymer Feed
TRA-0966	Control, Pump, West Polymer Injection
TRA-0967	VFD, Pump, West Polymer Feed
TRA-0968	Eyewash Station, Bottle - GBC Room
TRA-0969	GBC Building Roll Up Door
TRA-0970	GBC Room Heating Control Panel PLC
TRA-0971	GBC Room Make Up Air Handler And Heater
TRA-0972	Gravity Belt Concentrator Room Overhead Crane
TRA-0973	Portable Stair, GBC Rm, GBC Bldg
TRA-0974	Pressure Switch, Discharge Pump PSI - GBC Room
TRA-0975	Pump, Booster, Glycol - GBC Room
TRA-0976	Pump, Polymer Feed A
TRA-0977	Motor, Polymer Feed Pump A
TRA-0978	Pump, Polymer Feed B, West

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Asset ID	Asset Name
TRA-0979	Motor, Polymer Feed Pump B
TRA-0980	Transmitter, Flow, Poly Feed East
TRA-0981	Transmitter, Flow, Poly Feed West
TRA-0982	Bldg 085 Polymer Room
TRA-0983	Backflow Preventer, GBC Polymer Rm , 1.5 In
TRA-0984	Eyewash/Safety Shower - Bldg 085 Polymer Room
TRA-0985	Fan, Air Supply - Bldg 85 Polymer Room
TRA-0986	Mixer, East Poly Blend Unit
TRA-0987	Mixer, Polymer A East
TRA-0988	Drive, Angle, East Polymer Mixing Tank Mixer
TRA-0989	Valve, Control, Dilution Water Poly Feed A
TRA-0990	Mixer, West Poly Blend Unit
TRA-0991	Mixer, Polymer B West
TRA-0992	Drive, Angle, West Polymer Mixing Tank
TRA-0993	Valve, Control, Dilution Water Poly Feed B
TRA-0994	Portable Stair, US Filter Rm, GBC Bldg
TRA-0995	Pump, Boiler Water Booster - Bldg 85 Polymer Room
TRA-0996	Bldg #090, Digesters 1 and 2 Pipe Gallery Building
TRA-0997	Articulating Ladder, Digester 2 Coupla, Dig 2
TRA-0998	In Ground Pipe For Digester 2S
TRA-0999	Piping, In Ground, Digester 1N
TRA-1000	Pump, Circulating
TRA-1001	Pump, Circulating, Hot Water
TRA-1002	Pump, Circulating, Hot Water
TRA-1003	Pump, Feed
TRA-1004	Transmitter, Level Indicating, Small Digester # 1
TRA-1005	Transmitter, Level Indicating, Small Digester # 2
TRA-1006	Valve, Feed, 6
TRA-1007	No. Small Digester Feed Valve Actuator
TRA-1008	Valve, Feed, 6
TRA-1009	Actuator, Feed
TRA-1010	Bldg #095, Old Locker Rm, Digester 3 and 4 Building
TRA-1011	Bldg 95 Basement - Digesters 3 and 4 Pipe Gallery
TRA-1012	12' Extension Ladder, Orange Fiberglass, HX Rm
TRA-1013	Fixed Ladder, Digester 3 Piping, HX Rm
TRA-1014	Fixed Ladder, Digester 4
TRA-1015	Fixed Ladder, Digester 4 Piping, HX Rm
TRA-1016	Heat Exchanger, Flat Bed (South)
TRA-1017	Heat Exchanger, Spiral (North)
TRA-1018	In Ground Pipe For Digester 3N
TRA-1019	In Ground Pipe For Digester 4S
TRA-1020	Large Digester Transfer Pump - Horizontal. Cornell
TRA-1021	Pump, Circulating, Hot Water
TRA-1022	Pump, Circulating, Hot Water

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-1023	Pump, Circulating, Hot Water
TRA-1024	Pump, Circulation, Hot Water For #4 South Digester
TRA-1025	Pump, Circulation, North Spiral Hx Hot Water
TRA-1026	Pump, Circulation, Old Locker Rm
TRA-1027	Pump, Recirculation, Digester 3, Vaughan, Chopper
	Motor, Recirculation, Digester 3, Vaughan
TRA-1028	Pump, Recirculation, Digester 4, Vaughan, Chopper
TRA-1029	Motor, Recirculation, Digester 4, Vaughan
TRA-1030	Transmitter, Level Indicating, Large Digester # 3
TRA-1031	Transmitter, Level Indicating, Large Digester # 4
TRA-1035	Bldg 95 Old Locker Room
TRA-1036	Fan, Exhaust, Heat Exchange Room
TRA-1037	South Digester Cent. Pump Recirc Motor - Vertical Cornell
TRA-1038	South Gas Compressor Motor Digester 4
TRA-1039	Bldg #097, Boiler and Digester 5 Building
TRA-1040	6' Step Ladder, Orange Fiberglass, Stairwell, Dig 5 Bldg
TRA-1041	Bldg 097 Basement - Boiler and Digester 5 Bldg
TRA-1042	Backflow Preventer, Boiler Bldg, 2 In
TRA-1043	Control, Temperature, Sludge Temperature
TRA-1044	Drip Trap Next To Circular Heat Exchange
TRA-1045	Drip Traps On The Methane Mixers & Lines
TRA-1046	Eyewash, Bottle - Bldg 97 Basement
TRA-1047	Flow Meter, Sludge Transfer, Bldg 97 Basement
TRA-1048	Heat Exchanger, Sludge, Digester 5 - Bldg 97 Basement
TRA-1049	Hot Water Heating Piping System
TRA-1050	Motor Control Bucket 3 Hp Hx Circ Pump
TRA-1051	Piping, In Ground And Above Ground For Digester 5
TRA-1052	Pump, Cornell, Vertical, Large Digester Transfer Pump; Hx Room
TRA-1053	Pump, Hot Water Circulating, Bldg 97 Basement
TRA-1054	Pump, Hot Water Circulation Digester 5 Hx
TRA-1055	Motor, Hot Water Circulation Pump
TRA-1056	Pump, Recirculation Digester 5 East (2)
TRA-1057	Motor, Recirculation Pump, Digester 5 (East)
TRA-1058	Pump, Recirculation, Digester 5 West (1)
TRA-1059	Motor, Digester 5 Recirculation Pump 1 (West)
TRA-1060	Pump, Sump, #1, Bldg 97 Basement
TRA-1061	Pump, Sump, #2, Bldg 97 Basement
TRA-1062	Pump, Sump, Duplex Control Panel; Digester 5 Bldg Basement
TRA-1063	Pump, Transfer, Digester 5 East (2)
TRA-1064	Gear Reducer, Digester 5 Transfer Pump
TRA-1065	Motor, Transfer Pump, Digester 5 East (2)
TRA-1066	Switch, Hi Pressure, Transfer Pump 2 (East)
TRA-1067	Pump, Transfer, Digester 5 West (1)
TRA-1068	Gear Reducer, Digester 5 Transfer Pump

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Asset ID	Asset Name
TRA-1069	Motor, Digester 5 West (1) Transfer
TRA-1070	Switch, Hi Pressure, Transfer Pump 1 (West)
TRA-1071	South Digester Heat Exchanger
TRA-1072	Step Stool, Pump Rm, Dig 5 Bldg
TRA-1073	Valve, Digester Feed, # 5
TRA-1074	Valve, Relief, Digester #5 Recirculation Line
TRA-1075	Valve, Relief, Digester #5 Recirculation Line
TRA-1076	Bldg 097 Boiler Room - Boiler and Digester 5 Bldg
TRA-1077	#1 Hurst HW Boiler
TRA-1078	Boiler #1 Digester Gas Boiler Valve
TRA-1079	Boiler #1 Digester Gas Isolation Valve
TRA-1080	Boiler #1 Natural / Digester Gas Boiler Valve
TRA-1081	Boiler #1 Natural Gas Isolation Valve
TRA-1082	Digester Gas Fire Control Butterfly Valve Boiler #1
TRA-1083	Hurst Boiler Circulating Pump 1 Mtr
TRA-1084	Natural / Digester Gas Fire Control Butterfly Valve Boiler #1
TRA-1085	Pump, Circulating, Hurst Boiler #1
TRA-1086	#2 Hurst HW Boiler
TRA-1087	Boiler #2 Digester Gas Boiler Valve
TRA-1088	Boiler #2 Digester Gas Isolation Valve
TRA-1089	Boiler #2 Natural / Digester Gas Boiler Valve
TRA-1090	Boiler #2 Natural Gas Isolation Valve
TRA-1091	Digester Gas Fire Control Butterfly Valve Boiler #2
TRA-1092	Hurst Boiler Circulating Pump 2 Mtr
TRA-1093	Natural / Digester Gas Fire Control Butterfly Valve Boiler #2
TRA-1094	Pump, Circulating, Hurst Boiler #2
TRA-1095	8' Step Ladder, Yellow Fiberglass, Boiler Rm
TRA-1096	Boiler Room Heating Control Panel
TRA-1097	Condensate/Sediment Trap
TRA-1098	Controller, Exhaust Fan, Bldg 97 Boiler Room
TRA-1099	Digester Building Boiler Room Exhaust Fan
TRA-1100	Fan, Exhaust, Digester Building Boiler Room
TRA-1101	Motor, Fan, Makeup Air Unit
TRA-1102	Flow Switch, Boiler 1, Bldg 97 Boiler Room
TRA-1103	Flow Switch, Boiler 2, Bldg 97 Boiler Room
TRA-1104	Gas Detector, Bldg 97 Boiler Room
TRA-1105	Micro Iv Lead-Lag Boiler Control Panel
TRA-1106	Pump, Glycol Booster, Bldg 97 Boiler Room
TRA-1107	Pump, Hot Water Booster, Bldg 97 Boiler Room
TRA-1108	Room, Electrical, Boiler and Digester 5 Bldg
TRA-1109	Digester Building PLC
TRA-1110	MCC, Digester 5 Equipment
TRA-1111	Supply Fan Digester Control Power Rm
TRA-1112	UPS For The Digester/Boiler Electrical Room Panel

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Asset ID	Asset Name
TRA-1113	VFD, Digester 5 Recirculation
TRA-1114	VFD, Digester 5 Recirculation
TRA-1115	VFD, Digester 5 Transfer Pump East (2)
TRA-1116	VFD, Digester 5 Transfer Pump West (1)
TRA-1117	Room, Explosion Proof, Boiler and Digester 5 Bldg
TRA-1118	Drip Trap, East End Of The Digester Gas Header In The Boiler Room
TRA-1119	Drip Trap, West End Of The Digester Gas Header In The Boiler Room
TRA-1120	Fan, Supply/Exhaust, Explosion Proof Room, Boiler and Digester 5 Bldg
TRA-1121	Gas Monitor, Explosion Proof Room, Boiler and Digester 5 Bldg
TRA-1122	Bldg #100, Administration Building
TRA-1124	Screw Pump # 1
TRA-1125	Motor, Screw Pump #1
TRA-1126	Reducer, Gear, Screw pump # 1
TRA-1127	Coupling, Output, Between The Reduction Gear Output Shaft And The #1 Screw Pump Shaft
TRA-1128	Lower Bearing, Screw Pump #1
TRA-1129	Screw Pump # 2
TRA-1130	Motor, Screw Pump #2
TRA-1131	Reducer, Gear, Screw pump # 2
TRA-1132	Coupling, Output, Between The Reduction Gear Output Shaft And The #2 Screw Pump Shaft
TRA-1133	Lower Bearing, Screw Pump #2
TRA-1134	Screw Pump # 3
TRA-1135	Motor, Screw Pump #3
TRA-1136	Reducer, Gear, Screw pump # 3
TRA-1137	Coupling, Output, Between The Reduction Gear Output Shaft And The #3 Screw Pump Shaft
TRA-1138	Lower Bearing, Screw Pump 3
TRA-1139	10' Step Ladder, Yellow Fiberglass, Upper Hall, Membrane Bldg
TRA-1140	Admin Basement
TRA-1141	Ferric System
TRA-1142	Pump, Ferric Feed #1
TRA-1143	Motor, Ferric Feed Pump 1
TRA-1144	Pump, Ferric Feed #2
TRA-1145	Motor, Ferric Feed Pump 2
TRA-1146	Pump, Ferric Feed #3
TRA-1147	Motor, Ferric Feed Pump 3
TRA-1148	Panel, Control, Ferric Pump #3 Feed Control
TRA-1149	Pump, Ferric Feed #4
TRA-1150	VFD Drive For The #4 Ferric Chloride Pump
TRA-1151	6' Step Ladder, Yellow Fiberglass, Admin Basement
TRA-1152	Admin Bldg Air Line Moisture Separator For Lab Air
TRA-1153	Administration Basement Hot Water Heater
TRA-1154	Administration Bldg Sump Pump #1 North

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Asset ID	Asset Name
TRA-1155	Administration Bldg Sump Pump #2 South
TRA-1156	Aeration Flow Transmitter North
TRA-1157	Aeration Flow Transmitter South
TRA-1160	Aeration Header Pressure Transmitter
TRA-1161	Aeration Tank Drain Pump #1 North
TRA-1162	Aeration Tank Drain Pump #2 South
TRA-1163	Air Modulation Valve North
TRA-1165	Air Modulation Valve South
TRA-1166	Backflow Preventer, Lab, Cold Water Supply
TRA-1167	Backflow Preventer, Lab, Hot Water Supply
TRA-1168	Circulating Pump P-15 For Glycol System
TRA-1169	Eyewash/Safety Shower - Admin Basement
TRA-1170	Hot Water Circ Pump HVAC
TRA-1171	Programmable Logic Controller Admin Basement
TRA-1172	Rotary Screw Air Compressor 1 North
TRA-1173	Air Dryer, North, Admin Basement
TRA-1174	Air Receiver, North, Admin Basement
TRA-1175	Rotary Screw Air Compressor 2 South
TRA-1176	Air Dryer, South, Admin Basement
TRA-1177	Air Receiver, South, Admin Basement
TRA-1179	Vacuum Pump For Lab
TRA-1180	Administration Building Elevator
TRA-1181	Administration Building HVAC System
TRA-1182	Admin HVAC Hot Water Circulating Pump Motor
TRA-1183	Handicapped Bathroom Exhaust Fan
TRA-1184	Locker Room Exhaust Fan
TRA-1185	Orange Lab Exhaust Fan
TRA-1186	Window Mounted Ac For The Admin Front Office
TRA-1187	Aeration Blower Room
TRA-1188	Blower, Aeration #1
TRA-1189	#1 Blower Inlet Valve And Actuator
TRA-1190	Aeration Blower Motor No.1
TRA-1191	Blower, Aeration #2
TRA-1192	#2 Blower Inlet Valve And Actuator
TRA-1193	Aeration Blower Motor No.2
TRA-1197	Blower, Aeration #4
TRA-1198	Motor, Aeration Blower #4
TRA-1199	Panel, Control, #4 Blower
TRA-1200	12' Step Ladder, Orange Fiberglass, Blower Rm, Admin Bldg
TRA-1201	Admin Bldg, MCCB
TRA-1202	Main Plant Automatic Transfer Switch
TRA-1203	Fan, Exhaust, Blower Room North
TRA-1204	Fan, Exhaust, Blower Room South
TRA-1205	Fan, Odor Control, Efp-1

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Asset ID	Asset Name
TRA-1207	Panel, Lighting, A In Aeration Blower Rm
TRA-1208	Primary Effluent Sampler - Aeration Blower Room
TRA-1209	Step Stool, Blower Rm, Admin Bldg
TRA-1212	GE Rack Out Breaker, Admin Bldg, Screw Pumps, ID#3455
TRA-1213	GE Rack Out Breaker, BGC Bldg, Dig #5 Bldg, ID#7827
TRA-1214	GE Rack Out Breaker, Blower 1, ID#7828
TRA-1215	GE Rack Out Breaker, Blower 2, ID# 3460
TRA-1216	GE Rack Out Breaker, Blower 3, ID#3459
TRA-1217	GE Rack Out Breaker, Blower 4, ID#3457
TRA-1218	GE Rack Out Breaker, East Sludge Loadout, ID#7826
TRA-1219	GE Rack Out Breaker, Main Tie, ID#3456
TRA-1220	GE Rack Out Breaker, North Transformer, ID#3465
TRA-1221	GE Rack Out Breaker, Rotomat, Old Locker Rm ID#3464
TRA-1222	GE Rack Out Breaker, South Transformer, ID#3462
TRA-1223	GE Rack Out Breaker, West SST, ID#3458
TRA-1225	North Transformer, Main Plant, Primary To 480V
TRA-1226	South Transformer, Main Plant, Primary To 480V
TRA-1227	Transmitter, North Flume, Primary Effluent, Miltronics
TRA-1228	Transmitter, South Flume, Primary Effluent, Miltronics
TRA-1229	Fixed Ladder, Admin Bldg, North Hall
TRA-1230	Gas Detection Equipment
TRA-1231	CGM 929 3-Gas Monitor
TRA-1232	Combustible Gas Calibration Kit, Draeger
TRA-1233	Detector, Cgm 900 Ii Autocal
TRA-1234	Detector, CGM Ii Gas
TRA-1235	Detector, CGM Ii Gas
TRA-1236	Generator Room
TRA-1237	10' Step Ladder, Generator RM, Admin Bldg
TRA-1238	4' Step Ladder, Generator Rm, Admin Bldg
TRA-1239	Back Flow Preventer, Portable, 1.5 In Rpz
TRA-1240	Crane - Generator Room
TRA-1241	Eyewash/Safety Shower - Generator Room
TRA-1242	Kohler Emergency Diesel Generator At WWTP
TRA-1243	Lab
TRA-1244	Analytical Balance
TRA-1245	Autoclave
TRA-1246	Autoclave Sterilizer
TRA-1247	Blue Lab Exhaust Fan
TRA-1248	BOD Probe
TRA-1249	Centrifuge
TRA-1250	De-Ionized Water System
TRA-1251	Discrete Analyzer
TRA-1252	Dissolved Oxygen Probe
TRA-1253	Drying Oven

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Asset ID	Asset Name
TRA-1254	Fecal Incubator Bath
TRA-1255	Fume Hood
TRA-1256	Fume Hood Exhaust Fan
TRA-1257	Lab Dish Washer
TRA-1258	Magnetic Stirring Hot Plate.#1
TRA-1259	Magnetic Stirring Hot Plate.#2
TRA-1260	Muffle Furnace
TRA-1261	Pan Balance
TRA-1262	Ph Probe
TRA-1263	Precision Low Temperature Incubator 1
TRA-1264	Precision Low Temperature Incubator 2
TRA-1265	Refrigerator, Sample #1
TRA-1266	Refrigerator, Sample #2
TRA-1267	Stove In Lab Area
TRA-1268	TC Plant Alarm Dialer
TRA-1269	Lighting Panel A In Admin Upper Hall North East Corner
TRA-1270	Raven Infrared Blanket Detector A
TRA-1271	RM #120, Maintenance and Assoc. Area
TRA-1272	4 Wheels And 2 Cross Beams And 4 Mounting Plates For Moving Large Motors Pumps And Blowers
TRA-1273	A-frame,. portable, gantry, crane, Aluminum
TRA-1274	Chemix Room Hoist
TRA-1275	Crane, Shop, P&H, 2 tom cap
TRA-1276	Fixed Ladder, Screw Pump Wet Well
TRA-1277	Gas Powered Tools & Equipment
TRA-1278	Cub Cadet Two Stage Snow Thrower
TRA-1279	Gas, Honda, Pressure Washer
TRA-1280	Hotsy, Steam, Pressure Washer
TRA-1281	MTD Push Mower
TRA-1283	Snapper Snow Blower
TRA-1284	Hand, Power Tools
TRA-1285	Ac/Dc Clamp Meter With Ir Temperature
TRA-1286	Ac/Dc Clamp Meter With Ir Temperature
TRA-1287	Don's Tool Bag Multi Meter W/ Clamp Amp Probe
TRA-1288	Dx-460 Power Nailer
TRA-1289	Fluke Model 321 Clamp Meter
TRA-1290	Fluke Model 322 Clamp Meter
TRA-1291	Grinder
TRA-1292	Pm Operators Tool Bag
TRA-1293	Clamp Meter Pm Tool Bag
TRA-1294	Portable Battery Operated Drills And Hammer Drills
TRA-1295	Te 6-S Hammer Drill
TRA-1296	Lights
TRA-1297	Main Pipe Gallery And Shop Basement Heated Make Up Air System

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-1298	Maintenance Basement
TRA-1299	12 Ton Shop Press
TRA-1300	Backflow Preventer, WWTP Main, 3 In
TRA-1301	Pallet Jack
TRA-1302	Pallet Jack, Adjustable
TRA-1303	Portable Heating & Cooling
TRA-1304	60,000 BTU, Propane, Portable, Heater
TRA-1305	Free Standing Window Exhaust Ac
TRA-1306	Heater, Oil Core, Portable
TRA-1307	Window Mounted Ac For The Maintenance Office
TRA-1308	Portable Pumps
TRA-1309	2 Portable Submersible Pump W/ Float Sw
TRA-1310	2 Portable Sump Pump
TRA-1311	Pump, Honda, 2 Decant, WMP20X
TRA-1312	Pump, Honda, 2 Decant, WMP20X
TRA-1313	Pump, Honda, 2 Trash, WT20X
TRA-1314	Pump, Honda, 4 Trash, WT40X
TRA-1315	Shop Area Hoist
TRA-1316	Digesters
TRA-1317	Digester, # 3 North
TRA-1318	Compressor, Gas, Digester 3
TRA-1319	Motor, Gas Compressor
TRA-1320	Flame Arrestor, Digester 3
TRA-1321	Digester, #4 South
TRA-1322	Compressor, Gas, Digester 4
TRA-1323	Flame Arrestor, Digester 4
TRA-1324	Digester, #5
TRA-1325	Flame Arrestor, Digester 5 East
TRA-1326	Flame Arrestor, Digester 5 West
TRA-1327	Transmitter, Level, Ultrasonic, Digester #5
TRA-1328	Pump, Gas Driven, Multiquip 3 In. Diaphragm Pump
TRA-1329	Ferric Chloride Storage Area
TRA-1330	Tank, Ferric Chloride Storage Structure
TRA-1331	Ferric Chloride Truck Unloading Piping
TRA-1332	Fixed Ladder, Ferric Tank
TRA-1333	Indicator, Level, Ferric Storage Tank
TRA-1334	Containment, Ferric Chloride
TRA-1335	Eyewash/Safety Shower - Ferric Chloride Storage Area
TRA-1336	General Facility
TRA-1337	Milltronics East Influent Flow Control Panel
TRA-1338	Milltronics West Influent Control Panel
TRA-1339	SCADA And Communications
TRA-1340	56K Phone Modem For Zenon Data Collection Computer
TRA-1341	Acp-5 PLC Panel

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-1342	Battery Backup Units
TRA-1343	Apc 1000 Individual Back Up Power Supply
TRA-1344	Apc Dla1500 Smart UPS
TRA-1345	Apc Dla1500 Smart UPS
TRA-1346	Apc Smart UPS 1000
TRA-1347	Back Up Battery Supply For SCADA Computers
TRA-1348	Back Up Power Supply For SCADA Computer In The Orange Lab
TRA-1349	Back Up Power Supply For SCADA Computer In The Orange Lab
TRA-1350	Uninterrupted Power Supply Battery Pack
TRA-1351	Uninterrupted Power Supply Digester #5 BLDG
TRA-1352	Uninterrupted Power Supply WWS02
TRA-1353	Uninterrupted Power WWS01
TRA-1354	UPS Power Supply #1
TRA-1355	UPS Power Supply #2
TRA-1356	UPS Power Supply #3
TRA-1357	UPS Power Supply #4
TRA-1358	UPS Power Supply #5
TRA-1359	UPS Power Supply #6
TRA-1360	UPS Power Supply #7
TRA-1361	Data Communications Switch Admin Basement
TRA-1362	Data Communications Switch In Membrane Electrical Room
TRA-1363	Fiber Optic --> Digital Converter Between Admin Bldg And Membrane Network
TRA-1364	Fiber Optic To Digital Converter Between Admin Building Network And Boiler Room
TRA-1365	Fiber Optic To Digital Converter Between Admin Building Network And The Membrane Building Network Including 24 Port Switch
TRA-1366	GBC Building PLC
TRA-1367	Intellution Software Program
TRA-1368	Membrane Building Back Up CPU
TRA-1369	Modem In The Orange Lab For SCADA Computer To Connect To 8170 Dsl Line
TRA-1370	Monitor; Membrane CPU
TRA-1371	Plant Main CPU
TRA-1372	Plant Slave CPU
TRA-1373	20 Gig Hard Drive And Back Up Drive
TRA-1374	Office Network
TRA-1375	Computer and Networking
TRA-1376	Front Office Desk Top Computer
TRA-1377	Local Back Up Battery 370 W For Maintenance Office Computer
TRA-1378	Local Back Up Battery, 370 W For Ops Computer
TRA-1379	Local Back Up Battery, 370W For Front Office Computer
TRA-1380	Maintenance Department Hand Held Computer
TRA-1381	Maintenance Department Lap Top

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-1382	Maintenance Managers Lap Top Computer
TRA-1383	Netopia Dsl Modem And Router
TRA-1384	Networking Switch, Maint, Netgear, S wall
TRA-1385	Networking Switch, Maint,, Netgear, NE corner
TRA-1386	Operations Department Hand Held Computer
TRA-1387	Ops Office Desk Top Computer
TRA-1388	Orange Lab East Wall Desk Top Computer
TRA-1389	Project Managers Lap Top Computer
TRA-1390	Video Projector
TRA-1391	County Samplers Cabinets and Equipment
TRA-1392	Elmwood Twp County Samplers
TRA-1393	Garfield Meter Pit Sampler
TRA-1394	Garfield Twp County Sampler
TRA-1395	Peninsula Dr County Sampler
TRA-1396	Sampler At The 6Th Street Location Sampler
TRA-1397	Sampler, Flow, Acme Township
TRA-1398	Sampler, Flow, Bunker Hill Rd
TRA-1399	Sampler, Flow, Indian Trail
TRA-1400	Sampling Device
TRA-1401	Emergency Lighting At Wwtp
TRA-1402	Facility Ladders
TRA-1403	HVAC Equipment
TRA-1404	Membrane HVAC
TRA-1405	Gas Unit Heater East Stair Well Entrance
TRA-1406	Gas UNIT Heater East Stair Well Entrance
TRA-1407	Gas Unit Heater In Membrane Building Electric Room
TRA-1408	Gas UNIT Heater In Membrane Building Electric Room
TRA-1409	Gas Unit Heater In Membrane Building Upper Hall
TRA-1410	Gas UNIT Heater In Membrane Building Upper Hall
TRA-1411	Gas Unit Heater In Membrane Building West Stair
TRA-1412	Gas UNIT Heater In Membrane Building West Stair
TRA-1413	Membrane Blower Room Heated Make-Up Air
TRA-1414	Membrane Building Electrical Room Heating Control Panel PLC
TRA-1415	Membrane Building Pump Room Heating Control Pannel PLC
TRA-1416	Membrane Chemical Room Heated Make Up Air
TRA-1417	Membrane Pump Room Heated Make-Up Air
TRA-1418	Safety Equipment
TRA-1419	Electrical Protection
TRA-1420	Arc Flash Kit, XLG
TRA-1421	Gloves, Electrical Protection, Class 0, XLG
TRA-1422	Arc Flash Kit, Lg,
TRA-1423	Gloves, Electrical Protection, Class 0, LG
TRA-1424	Arc Flash Kit, Med
TRA-1425	Gloves, Electrical Protection, Class 0, MED

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-1426	Arm Protector Set
TRA-1427	Gloves, Electrical Protection, Class 0, XLG, Maintenance
TRA-1428	Rubber Glove Liner Class 00 L/ S7194 R/7194
TRA-1429	Rubber Glove Liner Class 00 L/ S7194 ; R/ S6309
TRA-1430	Rubber Glove Liner, Class 2
TRA-1431	Rubber Glove Liner; Class 0 L/M1155 ; L/ J2755
TRA-1432	Rubber Glove Liner; Class 00 Left S6443 ; Right S7898
TRA-1433	Fire Extinguishers
TRA-1434	Chevrolet S-10 Pick Up, Dr. Green, Behind The Seat; Project Managers
TRA-1435	Fire Extinguisher Bc Ford F-250 Truck
TRA-1436	Room, Electrical, Preliminary Screening Bldg.
TRA-1437	Fire extinguishers - Spare
TRA-1438	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1439	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1440	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1441	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1442	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1443	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1444	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1445	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1446	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1447	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1448	Spare Abc Fire Extinguisher; Admin Basement N.E. Stair Well
TRA-1449	Septic Station Unloading Station Pump
TRA-1450	Vehicles
TRA-1451	2007 Ford Ranger 4X2 White Pick Up
TRA-1452	2008,Ford, F-250, 4x4
TRA-1453	2014, Ford, F150, 4x4
TRA-1454	OOS-2015, Ford, F150, 4X4
TRA-1456	Nissan Forklift
TRA-1457	TCWWTP Lift Stations
TRA-1459	Bay Street Lift Station
TRA-1460	Alarm Dialer At Bay Street Lift Station
TRA-1461	Bay Street LS Pump #1
TRA-1462	Bay Street LS Pump 1 Motor
TRA-1463	Bay Street LS Pump #2
TRA-1464	Bay Street LS Pump 2 Motor
TRA-1465	Bay Street LS Wet Well Mixer (submersible mixer)
TRA-1466	Bay Street LS Wetwell Mixer Motor
TRA-1467	Flow Meter
TRA-1468	Panel, Control, Bay St. Lift Station
TRA-1469	Transducer, Level, Miltronics, Bay St. Lift Station
TRA-1470	Birchwood Lift Station
TRA-1471	15# Abc Fire Extinguisher At The Birchwood LS

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-1472	Alarm Dialer At Birchwood Lift Station
TRA-1473	Birchwood Emergency Diesel Generator
TRA-1474	Motor, Diesel, Birchwood LS EDG
TRA-1476	Fan, Exhaust, Birchwood LS
TRA-1477	Panel, Control, Birchwood Lift Station
TRA-1478	Pump, # 1
TRA-1479	Motor, Birchwood LS Pump #1
TRA-1480	Pump, # 2
TRA-1481	Motor, Birchwood LS Pump #2
TRA-1482	Pump, Sump, Birchwood LS
TRA-1483	Transducer, Level, Miltronics, Birchwood Lift Station
TRA-1484	Clinch Park Lift Station
	Control Panel, Clinch Park Lift Station
TRA-1485	Pump, Lift Station, # 1
TRA-1486	Pump, Lift Station, # 2
TRA-1487	Coast Guard Lift Station
TRA-1488	Alarm Dialer At Coast Guard Lift Station
TRA-1489	Chart Recorder At Coast Guard LS
TRA-1490	Flow Meter
TRA-1491	Miltronics Multi Ranger 2 At Coast Guard
TRA-1492	Panel, Control, Coast Guard LS Duplex Pump
TRA-1493	Pump, LS, #1
TRA-1494	Motor, Coast Guard LS Pump 1
TRA-1495	Pump, LS, #2
TRA-1496	Motor, Coast Guard LS Pump 2
TRA-1497	Front Street Lift Station
TRA-1498	Back Up Power Supply For The Front Street Lift Station PLC
TRA-1499	Backflow Preventer, Front St LS, Main Floor, 1 In Rpz
TRA-1500	Backflow Preventer, Front St LS, Basement, 1 In Rpz
TRA-1501	Battery Charger, Front St. Lift Station
TRA-1502	Fan, Exhaust, Front Street LS
TRA-1503	Hoist, Front Street LS
TRA-1504	Main EIM Surge Filter At Front Street
TRA-1505	Miltronics Multi Ranger Plus Telemetry
TRA-1506	PLC, Front Street Lift Station
TRA-1507	Pump Control Panel And PLC Enclosure
TRA-1508	Pump, Centrifical, # 2
TRA-1509	Motor, Front Street LS Pump 2
TRA-1510	Valve, Check, #2 Pump At Front Street
TRA-1511	VFD Front St Pump No.2
TRA-1512	Pump, Centrifical, # 3
TRA-1513	Motor, Front Street LS Pump 3
TRA-1514	Valve, Check, #3 Pump At Front Street
TRA-1515	VFD Front St Pump No. 3

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
TRA-1516	Pump, Centrifical, # 4
TRA-1517	Motor, Front Street LS Pump 4
TRA-1518	Valve, Check, #4 Pump At Front Street
TRA-1519	VFD Front St Pump No.4
TRA-1520	Pump, Sump, Front Street LS
TRA-1521	Standby Generator Front Street LS
TRA-1522	Motor, EDG, Front Street LS
TRA-1523	Hull Park Lift Station
TRA-1524	Pump, Grinder. Hull Park Lift Station
TRA-1525	Portable Generator
TRA-1526	Riverine Lift Station
TRA-1527	Alarm Dialer At Riverine Lift Station
TRA-1528	Control Panel, Pumps
TRA-1529	Pump, Lift Station, # 1
TRA-1530	Motor, Riverine Lift Station Pump 1
TRA-1531	Pump, Lift Station, # 2
TRA-1532	Motor, Riverine Lift Station Pump 2
TRA-1533	Riverine Lift Station Dehumidifier
TRA-1534	Riverine LS Exhaust Fan
TRA-1535	Riverine LS Sump Pump
TRA-1536	TBA Lift Station
TRA-1537	Alarm Dialer At TBA Lift Station
TRA-1538	Panel, Pump Control
TRA-1540	TBA Lift Station Exhaust Fan
TRA-1541	TBA Lift Station Pump #1
TRA-1542	Motor, TBA Lift Station Pump #1 South
TRA-1543	TBA Lift Station Pump #2
TRA-1544	Motor, TBA Lift Station Pump #2 South
TRA-1545	TBA Lift Station Sump Pump
TRA-1546	Woodmere Street Lift Station
TRA-1547	Alarm Dialer At Woodmere LS
TRA-1548	Flow Meter
TRA-1549	Panel, Pump Control, Woodmere Lift Station
TRA-1550	Pump, Woodmere LS #1
TRA-1551	Motor, Woodmere LS Pump #1
TRA-1552	Pump, Woodmere LS #2
TRA-1553	Motor, Woodmere LS Pump 2
TRA-1631	Control Panel, East Fine Screen
TRA-1632	Control Panel, West Fine Screen
TRA-1633	Transformer
TRA--32-600SO1S	South Basin D.O. Meter
TRA-520-600MX1N	North RAS Mixer
TRA-520-600MX1S	Axial Mixer
TRA-9999	South RAS Piping In Pump Room

INSERVICE ASSET LIST FOR TCRWWTP AND LIFT STATIONS AS OF JULY 2016

Asset ID	Asset Name
VEHICLES-TRUCK-36	2007 Ford Ranger 4X2 White Pick Up
VEHICLES-TRUCK-37	2007 Ford Ranger 4X2 White Pick Up
VFD-427	Variable Frequency Drive
VFD-428	Variable Frequency Drive
TRA-1656	Gate Valve, 1N Aeration Basin
TRA-1657	Gate Valve, 2N Aeration Basin
TRA-1658	Gate Valve, 3N Aeration Basin
TRA-1659	Gate Valve, 4N Aeration Basin
TRA-1660	Gate Valve, 5N Aeration Basin
TRA-1661	Gate Valve, 6N Aeration Basin
TRA-1662	Gate Valve, 7N Aeration Basin
TRA-1663	Gate Valve, 8N Aeration Basin
TRA-1647	Gate Valve, 1S Aeration Basin
TRA-1648	Gate Valve, 2S Aeration Basin
TRA-1649	Gate Valve, 3S Aeration Basin
TRA-1650	Gate Valve, 4S Aeration Basin
TRA-1651	Gate Valve, 5S Aeration Basin
TRA-1652	Gate Valve, 6S Aeration Basin
TRA-1654	Gate Valve, 7S Aeration Basin
TRA-1655	Gate Valve, 8S Aeration Basin
TRA-1646	Gate Valve, Membrane Inlet East
TRA-1645	Gate Valve, Membrane Inlet West

Attachment 4
Traverse City's SAW Grant
Scope of Work

ATTACHMENT B – SCOPE OF WORK

Tasks required to complete this project are outlined below.

1. INVENTORY
    a. Review GIS database and identify data needs. Determine key gaps in the wastewater collection system data and use this information to identify locations for sewer survey. Also identify additional attributes required to complete the Asset Management Plan.
    b. Perform a field survey of manhole structures to add critical information such as rim elevations, invert elevations, confirm pipe sizes, and determine system connectivity. Based on GIS data available, additional information is required for about 20% of the sanitary system manholes, or about 390 manholes.
    c. Import the survey data into the GIS database for the sanitary sewer system.
    d. Update the GIS as necessary to include new attributes as deemed necessary to complete the Asset Management Plan.
    e. Research as-built drawings and other historical documents to determine pipe age and confirm pipe material. Enter the data into the GIS.

2. CONDITION ASSESSMENT
    a. Manhole Inventory (MACP): Perform physical inspections of sanitary sewer manholes within the City's wastewater collection system. It is anticipated that approximately 1,000 manholes will be inspected as part of this effort (about 50% of the total sanitary sewer system).
    b. Pump Station Evaluation: The City owns and operates eight (8) pump stations. Each pump station will be physically evaluated to determine the structural condition of the substructure (i.e. wet wells or pits), condition of the pumps/motors, and the condition of control systems.
    c. Forcemain Evaluation: Much of the City's wastewater collection system relies on a network of pump stations and forcemains. Many of the forcemains are aging and the structural condition of these forcemains is unknown. Six (6) locations will be selected to evaluate the internal and external condition of key forcemains. This work will include the following:
        i. Pump station drawdown test: using known wet well volume and a timer, estimate the flow rate during pumping operations. Compare this to the rated pump capacity and note any significant discrepancies (major discrepancies can be attributable to forcemain deterioration).
        ii. Insert a "poly pig" to clean the forcemain prior to inspection (requires temporary shutdown of the pump station).
        iii. Dewater the forcemain to the fullest extent possible.
        iv. Select a forcemain reach for physical inspection. Ideally, this would be a section where air buildup is possible (high point in system), which is generally more susceptible to sulfuric acid corrosion and also more accessible under a partially-dewatered scenario. Excavate to the forcemain and evaluate exterior pipe condition.
        v. Where possible, dewater forcemain and cut a section from the forcemain to allow for internal (CCTV) inspection. This process may require bypass pumping. CCTV inspections will be performed using PACP methodology. Although it is not expected that the entire length of forcemain will be evaluated during this process, the video inspection will provide an adequate sampling of the forcemain condition, and a decision can be made relative to rehabilitation or replacement.
        vi. Where video inspection cannot be performed, cut a section of forcemain and extract it for material analysis. Repair the section of extracted forcemain, backfill, and restore surface.
    d. Asset Management Plan
        i. Import CCTV and manhole inspection data into sanitary sewer GIS database. Use these ratings to establish a Risk of Failure variable to be assigned to each component.

ii. Work with City staff to determine appropriate characteristics to use to establish a Consequence of Failure variable. Characteristics may include: population served, roadway traffic impacted during system repair, potential for basement backup, etc.
iii. Using the Risk/Consequence factors, establish a priority ranking ("Criticality Index") to be used to develop a list of repair/replacement/rehab needs.
iv. Using the roadway (PASER) and sanitary sewer pipe ratings, use GIS to determine where coincidental high priority areas exist and add these to the list of Early Action Projects to be added to the Capital Improvement Plan.
v. Develop a Deterioration Forecasting Model based on current asset condition, depth, material, and age. This will be used to forecast system repair/rehab/replacement needs.
vi. Provide recommendations for future (ongoing) system inspection needs, including CCTV, detention pond inspection, BMP inspection, bridge/culvert inspections, and streambank inventories.

3. METERING / MODELING
   a. Temporary Flow Metering: The City of Traverse City experiences higher than normal baseflows, with monthly averages well above the EPA-established level of 120 gpcd which defines excessive baseflow. Since metering is currently limited to the treatment plant and current documented flows are calculated on a monthly basis, it is not known where the key sources of inflow/infiltration are in the City's collection system or how the system flows peak during wet weather. The work under this scope will include the installation and monitoring of flows under varying antecedent moisture conditions, on an hourly (or sub-hourly) basis, so as to determine wet weather response and to develop appropriate hydrologic parameters to model the main components of the collection system under design flow conditions in order to determine Level of Service.
      i. Install 8 temporary flow meters for a duration of 6 months. The meters will be installed at existing pump stations within the City's collection system. This will allow for the capture of local sewer flow response under varying antecedent moisture conditions. Download meter data at a 2-week interval.
   b. Develop hydrologic models for each metered district. The Antecedent Moisture Model (AMM) will be used to calibrate the rainfall derived inflow and infiltration (RDII). The calibrated models will be used to calculate 10-year and 25-year recurrence interval peak flows by applying the calibrated models to long-term rainfall and temperature data.
      i. Analyze baseflows and calculate capture coefficients for each metered district to confirm the source(s) of elevated baseflows and higher wet weather flow responses. This will be used to prioritize future sewer investigation and potential rehabilitation efforts.
   c. Develop a hydraulic model of the main components of the wastewater collection system, focusing on the trunk system for which flow meter data will be available. The hydraulic model will be run against the 10-year and 25-year recurrence interval flow events as defined in the hydraulic model.
      i. Prepare a Technical Memorandum summarizing the hydrologic responses and hydraulic performance of the wastewater collection system. Note specific problems relating to elevated baseflows and wet weather flows, and identify hydraulic deficiencies under design flow conditions.
   d. Upon the completion of the modeling effort, transition the hydrologic/hydraulic model files to City staff and conduct staff training on the model to ensure sufficient local understanding of the model structure and capabilities.

4. PURCHASE GIS AND ASSET MANAGEMENT SOFTWARE AND HARDWARE
    a. Specific hardware and software purchases are included as part of the Stormwater Asset Management Plan scope.

5. SEWER CLEANING AND TELEVISING (PACP RATINGS)
    a. Based on the City's existing GIS database, the total length of City-owned sanitary sewer is about 420,000 lineal feet. Of this sewer, about 50% has been cleaned and televised within the last 5 years. The cleaning and CCTV effort will focus on the remaining 50% of the system that is older than 20 years old and has not recently been cleaned and televised. This translates to a quantity of about 200,000 lineal feet. Of this, about 110,000 lineal feet will be cleaned/televised by a private contractor and about 90,000 lineal feet will be cleaned/televised by City staff (see details below):
        i. Based on estimates received from a cleaning/televising contractor (contractor estimate included with this grant application), the following costs are assumed for contractor-led sanitary sewer pipe cleaning and televising:

Sewer Size Class	Unit Price	Quantity	Total
All sizes	$2.05	110,000 LF	$225,500
		Total	$225,500
		Total (with 10% contingency)	$248,050

        ii. In order to better utilize existing City-owned equipment (vactor truck and sewer video equipment), the City will dedicate their equipment to 60 days of full-time use to supplement the contractor-led cleaning/CCTV effort. Based on an assumed cleaning and televising rate of about 1,500 lineal feet per day for City crews, approximately 90,000 lineal feet will be cleaned and televised by the City.

    b. Cleaning/CCTV Contract Administration: throughout the duration of the sanitary sewer cleaning and CCTV project, coordinate with the contractor to ensure the following:
        i. Conformance to PACP methodology
        ii. Ensure data is collected, coded, and stored such that it can be transferred to the City's GIS environment
        iii. Review pay requests and provide recommendations for payment
        iv. Provide assistance to identify locations of sewers to be televised
        v. Provide assistance to identify alternate sewer reaches to televise in the event that the contractor encounters sewers that are difficult or impossible to inspect due to debris buildup or structural failure
    c. Transfer the MACP sewer condition coding into the City's GIS.

6. LEVEL OF SERVICE EVALUATION
    a. Organize 2 public meetings to receive feedback from residents on any areas of concern, focusing on basement backups. These meetings will also be used to discuss appropriate Level of Service for the City's wastewater collection system, including a discussion of the City's regulatory obligations for wastewater collection and treatment.
    b. Capital Improvement Plan (CIP)
        i. Using the data from the modeling effort and the initial output from the Asset Management Plan, develop a 5-10 year CIP to address the more critical projects. Prepare planning-level construction cost estimates. Projects to be considered may include:

1. Pump station upgrades
2. Forcemain rehabilitation / replacement
3. Manhole rehabilitation
4. New pumping/storage facilities (if deemed necessary during the modeling effort)
5. Sewer replacement to address hydraulic deficiencies (if identified during the modeling process)

7. RATE STUDY / REVENUE RECOMMENDATIONS
   a. Review all existing capital and O&M costs related to the City's sanitary sewer assets. This will result in a comprehensive set of system needs that the City can use to determine total system revenues necessary to address its wastewater infrastructure. This will include a tabulation of costs for the following system components:
      i. High Priority Capital Improvement Needs from the AMP
      ii. Annual maintenance/repair/rehabilitation needs identified in the AMP
   b. Identify annual funding needs based on the costs determined above, and prepare a 10-year cash flow plan to address the identified needs.
   c. Review the long-term system needs in the context of the existing rate structure, existing debt, and existing fund balances. Determine if a funding gap exists, and, if so, prepare a 5-year plan to adjust sewer rates to meet the needs identified in the Asset Management Plan.

8. OTHER: GRANT APPLICATION / GRANT ADMINISTRATION
   a. The consultant will coordinate with City staff to develop a scope of work for Asset Management Planning and will submit the final application to the MDEQ.
   b. The City will provide grant administration services, including reimbursement requests and other documentation required by the MDEQ.

Attachment 5a
Traverse City's Wastewater Fund

WASTEWATER FUND

Mission Statement: *To reliably treat the community's wastewater to a level of quality such that it will have no impact on receiving waters and to do so efficiently, minimizing consumption of energy and resources, carbon footprint, and inconvenience to neighbors.*

Traverse City and the surrounding townships are way out in front in environmental leadership and in executing their responsibility to reflect the local environmental ethic in its policies.

The Wastewater Treatment Plant treats sewage from the City of Traverse City and the townships of Acme, East Bay, Elmwood, Garfield, Peninsula, and Blair. All are parties to the Master Sewer Agreement, original adopted in 1987 and revised in 2001. The City has a unique and central role under that agreement; the plant is located in the City, the City is responsible for its operation, and holds the NPDES permit to discharge to the Boardman River. The City is also the entity to which the role of "Control Authority" is delegated by the other parties, that is, the City administers the system-wide Industrial Pretreatment Program and enforces township as well as City sewer use ordinances. The above is accomplished through a management contract with CH2M Hill.

The Traverse City Plant was upon start up, the largest operating plant on the continent using membrane bioreactor technology. It has the capacity to meet area growth needs into the forseeable future and produces an effluent of extraordinary clarity so that it will have no impact on the receiving waters.

SUMMARY OF BUDGET CHANGES – OPERATING REVENUES

Rate Increase – The City Treasurer has recommended a rate increase of $2.00 per the first 600 cubic feet, and $2.00 per each additional thousand cubic feet to take effect in the fiscal year ending June 30, 2017.

GOALS – WWTP and Pump Stations

1. Finalize strategy for membrane replacement and establish funding for implementation.
2. Complete five planned facility sustaining capital projects at the Wastewater Treatment Plant.
3. Establish a plan for Wastewater Treatment Plant staff leadership succession.

PERFORMANCE MEASUREMENTS – WWTP AND PUMP STATIONS

	Performance Indicators	2010/11	2011/12	2012/13	2013/14	2014/15
Output	Billions of gallons treated	1.4619	1.5608	1.5120	1.7200	1.7100
	Millions of pounds of BOD treated	3.43M	3.50M	3.37M	3.28M	3.19M
	Recordable safety incidents	0	0	1	0	1
Efficiency	Percentage of effluent in compliance with NPDES permit	100%	100%	100%	100%	100%
	Kilowatt hours used/pound of BOD treated	1.2980	1.2880	1.3000	1.4100	1.4500
	Total recordable rates	0	0	9%	0	5.5%
	Days away restricted transfer	0	0	0	0	2

WASTEWATER FUND – MAINTENANCE AND REPAIRS

Mission Statement: *To maintain the sanitary sewer collection system, keeping in mind at all times the health and welfare of the public.*

Responsibilities include:

- Cleaning, televising and repairing 79 miles of gravity sewer and 19 miles of forced main sanitary sewer.
- Cleaning and maintaining 1,830 sewer manholes.
- Administering the Cross Connection Inspection Program.
- Identifying illicit roof drain connections to the storm water system.
- Locating all water, sanitary and storm lines for MISS DIG.
- Assisting all DPS Divisions with confined space entries.
- Maintaining 11 storm water treatment systems on outfalls

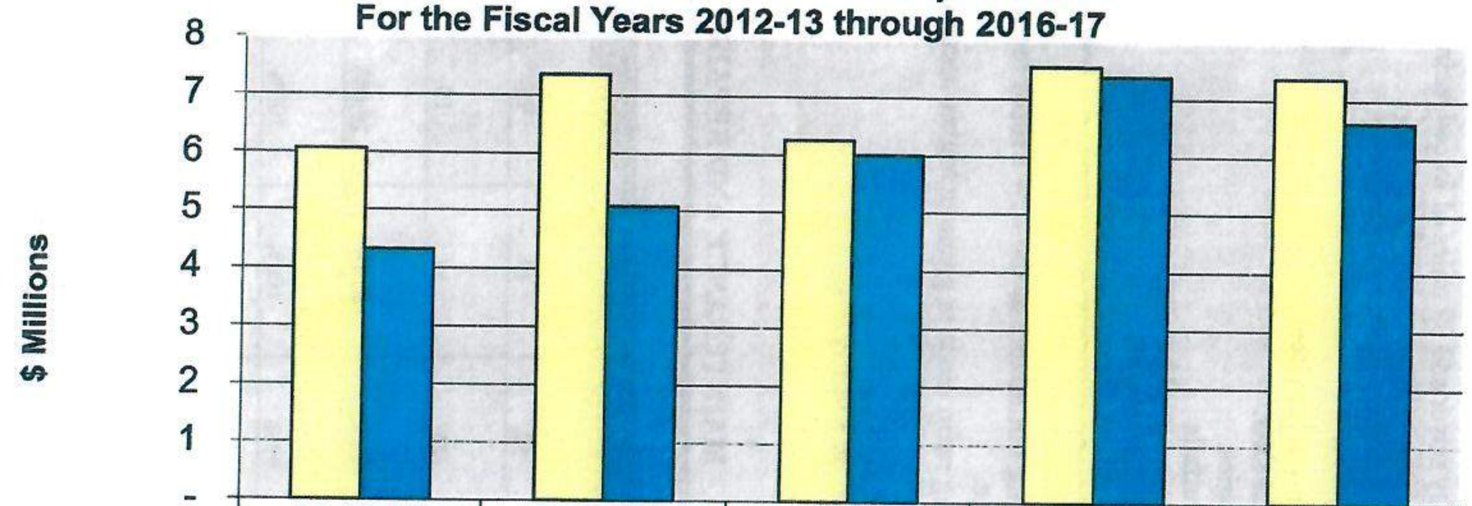
GOALS – MAINTENANCE AND REPAIRS

1. Continue with the implementation plan for changing out meters to the new Sensus meters, which are highly accurate for a longer period of time.
2. Continue with the implementation plan on installing radio reads to promote higher accuracy of reads.
3. Increase efforts to reduce the number of sewer calls.
4. Attempt to clean thirty percent of the sanitary system on a yearly basis.

PERFORMANCE MEASUREMENTS - MAINTENANCE AND REPAIRS

	Performance Indicators	2009/10	2010/11	2011/12	2012/13	2013/14
Output	Sewer maintenance calls	54	58	73	96	84
	Number of storm sewer filters cleaned with vactor	16	25	17	15	15
	Footage of sewers cleaned	98,340	39,681	40,466	29,603	63,422
Efficiency	Percentage of maintenance calls responded to within one hour	100%	99%	100%	100%	100%
	Percentage of sewer backups that were homeowner responsibility	82%	78%	73%	76%	86%
	Average times cleaned per year	1.4	2.3	1.3	1.1	1.1
	Percentage of annual sewers cleaned	24%	10%	10%	7%	15%

City of Traverse City, Michigan
Wastewater Fund Revenues and Expenditures
For the Fiscal Years 2012-13 through 2016-17



	2012-13 Actual	2013-14 Actual	2014-15 Actual	2015-16 Projected	2016-17 Requested
□ Revenue	$6,067,832	$7,362,225	$6,262,990	$7,555,100	$7,378,300
■ Expenses	$4,323,077	$5,080,955	$6,007,830	$7,386,900	$6,618,900

Fiscal Years

City of Traverse City, Michigan
ENTERPRISE FUND
WASTEWATER FUND
For the Budget Year 2016-17

	FY 13/14 Actual	FY 14/15 Actual	FY 15/16 Budget	FY 15/16 Projected	FY 16/17 Requested
OPERATING REVENUES					
Sewer Service Charges	$ 4,712,414	4,764,079	$ 4,750,000	$ 4,850,000	$ 5,092,500
Public Authority	2,422,098	1,228,679	1,225,000	1,382,200	1,629,800
Industrial Pretreatment	6,441	3,800	6,000	6,000	6,000
Septage Treatment	11,435	12,359	11,000	11,000	11,000
Forfeited Discounts	13,217	15,291	13,000	13,000	14,000
Interdepartmental Sales	-	87,675	1,000	1,000	1,000
Merchandise and Jobbing	-	500	1,000	1,000	1,000
Miscellaneous	187,787	65,918	135,000	135,000	121,000
TOTAL OPERATING REVENUES	7,353,392	6,178,301	6,142,000	6,399,200	6,876,300
OPERATING EXPENSES					
WWTP AND PUMP STATIONS					
Salaries and Wages	-	-	-	-	25,000
Fringe Benefits	-	-	-	-	9,000
Professional Services	2,747,189	3,326,616	4,821,000	5,011,400	4,199,000
Septage Contract	-	-	-	-	-
Industrial Pretreatment Costs	1,668	-	1,000	1,000	1,000
Insurance and Bonds	41,284	51,893	50,000	60,000	60,000
Total WWTP and Pump Stations	2,790,141	3,378,509	4,872,000	5,072,400	4,294,000
MAINTENANCE AND REPAIRS					
Salaries and Wages	325,453	392,081	328,500	368,000	377,000
Fringe Benefits	129,219	170,408	158,000	143,000	161,000
Office/Operation Supplies	30,250	19,246	30,000	30,000	30,000
Professional Services	148,130	130,722	106,000	96,000	106,000
Communications	-	123			1,200
Transportation	9,679	8,354	12,000	12,000	8,000
Professional Development	7,556	4,513	6,500	6,500	6,500
Public Utilities	3,601	5,033	10,000	10,000	7,500
Insurance and Bonds	5,547	622	1,500	1,500	1,500
Repairs and Maintenance	28,558	300,377	20,000	30,000	20,000
Rentals	78,643	81,596	98,000	98,000	110,000
Total Maintenance and Repairs	766,636	1,113,075	770,500	795,000	828,700
ADMINISTRATIVE AND GENERAL					
Salaries and Wages	138,011	146,384	149,000	133,000	149,000
Fringe Benefits	59,237	72,349	72,300	59,000	72,300

City of Traverse City, Michigan
ENTERPRISE FUND
WASTEWATER FUND
For the Budget Year 2016-17

	FY 13/14 Actual	FY 14/15 Actual	FY 15/16 Budget	FY 15/16 Projected	FY 16/17 Requested
ADMINISTRATIVE AND GENERAL (Continued)					
Office/Operation Supplies	16,061	14,956	17,300	17,300	17,300
Professional Services	15,347	19,999	17,000	17,000	17,000
Communication	116	74	200	200	200
Professional Development	305	1,527	2,500	2,500	2,500
Printing and Publishing	1,020	2,173	3,000	3,000	3,000
Rentals	2,412	4,531	5,000	5,000	5,000
Collection Costs	6,168	(4,631)	2,000	2,000	2,000
Transportation	1,861	1,330	2,500	2,500	2,500
Miscellaneous	2,483	2,651	3,400	3,400	3,400
Depreciation & Amortization	613,449	610,844	636,500	636,500	613,000
Total Administrative and General	856,470	872,187	910,700	881,400	887,200
TOTAL OPERATING EXPENSES	4,413,247	5,363,771	6,553,200	6,748,800	6,009,900
OPERATING INCOME	2,940,145	814,530	(411,200)	(349,600)	866,400
NON OPERATING REVENUES (EXPENSES)					
Federal revenue	-	-	-	-	-
Reimbursements	8,409	84,403	1,183,000	1,153,900	500,000
Interest Revenue	424	286	2,000	2,000	2,000
Gain (Loss) on sale of capital assets	(16,594)	-	-	-	-
Interest/Finance Charges	(347,862)	(338,934)	(370,000)	(319,600)	(279,000)
Total Non-Operating Revenues (Expenses)	(355,623)	(254,245)	815,000	836,300	223,000
Income Before Transfers	2,584,522	560,285	403,800	486,700	1,089,400
Transfers Out - City Fee	(303,252)	(305,125)	(307,000)	(318,500)	(330,000)
CHANGE IN NET POSITION	2,281,270	255,160	96,800	168,200	759,400
Net position, beginning of year	13,334,854	15,616,124	15,871,284	15,871,284	16,039,484
Net position, end of year **	$ 15,616,124	$ 15,871,284	$ 15,968,084	$ 16,039,484	$ 16,798,884
Distribution Personnel Services % F.T.E. Employees = 5.5	59.31%	50.53%	63.14%	64.28%	64.92%
Adminstrative Personnel Services % F.T.E. Employees = 2.75	23.03%	25.08%	24.30%	21.78%	24.94%

** Ending net position represents the difference between total assets (including long-term fixed assets) and total liabilities the cash balance at 6/30/14 was $ 548,662.

This fund was created to account for the costs of collecting and treating wastewater. Revenues are chiefly from service charges to customers. These revenues are also used to pay principal and interest on wastewater revenue bonds which were used to finance improvements.

Attachment 5b
Traverse City's Rate Calculation

CITY OF TRAVERSE CITY

MEMORANDUM

To:	Marty Colburn, City Manager
From:	William E. Twietmeyer, City Treasurer/Finance Director W. E. T.
Subject:	Sewer Fund Projections
Date:	April 27, 2016

My annual review of the Sewer Fund is concluded. My communication last year recommended no rate increase in the Sewer Fund for the 2015-2016 fiscal year. **However, this time I am recommending a rate increase for the Sewer Fund for the 2016-2017 fiscal year.**

The last time the City increased its sewer rates it was effective July 1, 2013. At that time the rates were increased to $34.00 for the first 600 cubic feet and $40.00 per thousand for each additional thousand cubic feet. That increase along with previous rate increases were necessitated by the need to pay for the various capital improvement and maintenance projects both to the collection system and to the wastewater treatment plant. This scenario has not changed with regard to the sewer fund. The annual purchase of new replacement membranes at the wastewater treatment plant is ongoing and OMI has added the digester condition assessment and digester 3 and 4 reconditioning to the list of new projects along with the primary header replacement. One new project on the collection side is the automated metering infrastructure project for $750,000 per year for the next two years.

Therefore, I am recommending that the sewer rates be increased to $36.00 for the first 600 cubic feet and $42.00 per thousand for each additional thousand cubic feet of usage. The impact is $242,500 in just the next fiscal year alone. I anticipate that additional rate increases will be necessary both next year and in future years if the various maintenance projects at the plant and in the collection system must proceed forward. Please note that this will not be sufficient to cover the cost of the automated metering infrastructure project. My recommendation if we plan to pursue this project would be to issue revenue bonds to provide the necessary funds because of the enormity of the cost.

Attached for your review is a copy of a spreadsheet showing nine years of historical financial data for the Sewer Fund, along with the current year projected expenses, next year's budget and three future years of projections. Also included is a copy of the proposed rate structure. Please let me know if you desire any additional information.

Encl.

SEWER FUND PROJECTED MULTI YEAR REVENUE AND EXPENSES

FOR YEAR ENDED JUNE 30

	2007	2008	2009	2010	2011	2012	2013	2014	2015	Projected 2016	Budget 2017	2018	2019	2020
OPERATING REVENUE														
Sewer Sales	$3,362,915	$3,413,516	$3,292,019	$3,390,974	$3,697,780	$4,203,540	$4,529,789	$4,712,414	$4,764,079	$4,850,000	$5,092,500	$5,117,963	$5,143,552	$5,169,270
Township Revenue	$1,242,477	$1,374,972	$1,604,479	$1,287,416	$1,151,974	$1,189,726	$1,263,574	$1,256,363	$1,232,479	$1,382,200	$1,629,800	$1,930,016	$2,000,589	$2,087,057
Septage Treatment	$364,284	$474,016	$494,396	$521,016	$461,563	$451,419	$12,434	$11,435	$12,359	$11,000	$11,000	$14,000	$14,000	$14,000
Other Revenue	$141,016	$50,476	$20,655	$29,467	$51,814	$20,846	$56,921	$1,382,014	$215,652	$25,000	$25,000	$25,000	$25,000	$25,000
Total Revenue	$5,110,692	$5,312,980	$5,411,549	$5,228,873	$5,363,131	$5,865,531	$5,862,718	$7,362,226	$6,224,569	$6,268,200	$6,758,300	$7,086,979	$7.183.141	$7,295,327
OPERATING EXPENSES														
Treatment Plant	$2,658,745	$3,003,382	$2,857,372	$2,847,840	$2,753,947	$2,744,145	$2,384,992	$2,790,140	$3,378,509	$5,072,400	$4,294,000	$3,895,032	$4,036,178	$4,209,113
Collection & Maint	$620,361	$614,865	$478,003	$486,166	$564,197	$746,099	$673,263	$766,635	$1,113,075	$795,000	$828,700	$845,274	$862,179	$879,423
Customer Acctg	$344,481	$387,737	$449,979	$454,792	$523,378	$560,785	$525,042	$546,266	$566,468	$563,400	$604,200	$616,284	$628,610	$641,182
Total Expenses	$3,623,587	$4,005,984	$3,785,354	$3,788,798	$3,841,522	$4,051,029	$3,583,297	$4,103,041	$5,058,052	$6,430,800	$5,726,900	$5,356,590	$5,526,967	$5,729,718
DEBT SERVICE														
1971 Bond Prin & Int	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
1995 Bond Prin & Int	$136,171	$132,314	$136,245	$154,747	$156,921	$153,550	$165,969	$164,872	$184,446	$0	$0	$0	$0	$0
1998 Bond Prin & Int	$71,640	$61,812	$66,044	$73,885	$71,485	$72,986	$71,734	$0	$0	$0	$0	$0	$0	$0
2002 Bond Prin & Int	$1,186,410	$1,179,927	$1,167,343	$1,184,416	$1,183,224	$1,083,208	$1,150,259	$1,153,929	$1,314,086	$1,397,040	$1,390,560	$1,394,640	$1,402,800	$1,399,800
Total Debt Service	$1,394,221	$1,374,053	$1,371,632	$1,413,048	$1,411,630	$1,309,744	$1,387,962	$1,318,801	$1,498,532	$1,397,040	$1,390,560	$1,394,640	$1,402,800	$1,399,800
SUB NET INCOME	$92,884	($67,057)	$254,563	$27,027	$109,979	$504,758	$891,459	$1,940,384	($332.015)	($1,559.640)	($359,160)	$335,749	$253,374	$165,809
Capital Improvements	$320,271	$562,575	$132,473	$194,844	$568,304	$509,602	$576,965	$297,816	$111,761	$901,000	$1,280,000	$1,503,871	$500,000	$579,860
Township Share Reimbursed										$1,153,900	$500,000			
NET INCOME	($227,387)	($629,632)	$122,090	($167,817)	($458,325)	($4,844)	$314,494	$1,642,568	($443,776)	($1,306,740)	($1,139,160)	($1,168,123)	($246,626)	($414,051)
TOTAL CASH BALANCE	$1,373,527	$743,895	$865,985	$698,168	$239,843	$234,999	$549,493	$2,192,061	$1,748,285	$441,545	($697,615)	($1,865,738)	($2,112,363)	($2,526,414)

Please note the following assumptions:

This projection assumes a change in rates effective july 1, 2016.
The base rate changes from $34.00 to $36.00 and usage over 600 cubic feet increases from $40.00 / thousand cubic feet to $42.00 / thousand cubic feet.

Growth in sales is estimated to increase 1/2% per year.

Growth in Township Revenue is estimated to increase 3% per year.

Treatment Plant Expenses are projected to increase 3.0% per year.
Collection & Maint and Customer Acctg expenses are projected at 2% per year.

The City's portion of debt service is estimated to be 60% of the total debt service.

The Capital Improvements are as provided in the six year public improvements plan.

Analysis Run 4-27-16.

SEWER RATES

Current Rates

Inside City Limits

$34.00 per first 600 cubic feet
$40.00 per thousand for each additional thousand cubic feet

Customers outside City limits are charged 1 1/2 times the City rate.

Proposed Rates

Inside City Limits

$36.00 per first 600 cubic feet
$42.00 per thousand for each additional thousand cubic feet

Customers outside City limits are charged 1 1/2 times the City rate.

Run 4-27-16

Attachment 6a
Summary of Traverse City's CIP

CITY OF TRAVERSE CITY, MICHIGAN
SIX YEAR CAPITAL IMPROVEMENT PLAN
Budget Year 2016-2017 by Fund

All Projects Submitted for 2016/17

Date/Time Printed: 6/20/2016 12:14:49 PM

Bold -Indicates projects occurring in the first FY of the plan.
+ -Indicates projects with multiple funding sources.
* -Indicates new projects submitted for review.

WASTE WATER FUND

Sewer Collection System

Project ID		Cat	Carry Forward 2015-16	Fiscal Year 2016-17	Fiscal Year 2017-18	Fiscal Year 2018-19	Fiscal Year 2019-20	Fiscal Year 2020-21	Fiscal Year 2021-22	Project Cost	City Funds	Non-City Funds
366	**WW-Annual Sewer Rehab/Replace**	M	$450,000.00	$450,000.00	$450,000.00	$450,000.00	$450,000.00	$450,000.00	$450,000.00	$3,150,000.00	$3,150,000.00	$0.00
13	**WW-Annual Storm Water Management Program**	M	$50,000.00	$50,000.00	$50,000.00	$50,000.00	$50,000.00	$50,000.00	$50,000.00	$350,000.00	$350,000.00	$0.00
987	***WW-Automated Metering Infrastructure (+ Water)**	C	$0.00	$750,000.00	$750,000.00	$0.00	$0.00	$0.00	$0.00	$1,500,000.00	$1,500,000.00	$0.00
293	**WW-Catch Basin & Manhole Casting Replacement**	M	$0.00	$30,000.00	$30,000.00	$0.00	$0.00	$0.00	$0.00	$60,000.00	$60,000.00	$0.00
968	*WW-Clinch Park Lift Station/Bay Street/Birchwood Upgrade of Control Panels	M	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$117,000.00	$117,000.00	$117,000.00	$0.00
967	*WW-Engineering Evaluation of Clinch Park Lift Station Capacity	M	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$50,000.00	$50,000.00	$50,000.00	$0.00
910	*WW-Front Street Lift Station Pump Around Hookup	M	$0.00	$0.00	$0.00	$0.00	$0.00	$30,000.00	$0.00	$30,000.00	$30,000.00	$0.00
913	*WW-Lift Station Telemetry System	M	$0.00	$0.00	$0.00	$0.00	$0.00	$90,000.00	$0.00	$90,000.00	$90,000.00	$0.00
898	*WW-Riverine Lift Station Equipment Upgrade	M	$0.00	$0.00	$107,865.00	$0.00	$0.00	$0.00	$0.00	$107,865.00	$107,865.00	$0.00
899	*WW-SCADA Upgrade at Front Street Lift Station and the TCRWWTP for PLC 5	M	$0.00	$0.00	$116,006.00	$0.00	$0.00	$0.00	$0.00	$152,639.00	$116,006.00	$36,633.00
892	*WW-TBA LIFT STATION EQUIPMENT UPGRADE	M	$75,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$75,000.00	$75,000.00	$0.00
909	*WW-Woodmere Lift Station Upgrade	M	$0.00	$0.00	$0.00	$0.00	$79,860.00	$0.00	$0.00	$79,860.00	$79,860.00	$0.00
	Total Sewer Collection System		**$575,000.00**	**$1,280,000.00**	**$1,503,871.00**	**$500,000.00**	**$579,860.00**	**$620,000.00**	**$667,000.00**	**$5,762,364.00**	**$5,725,731.00**	**$36,633.00**

Project ID	**Bold** -Indicates projects occurring in the first FY of the plan. + -Indicates projects with multiple funding sources. * -Indicates new projects submitted for review.	Cat	Carry Forward 2015-16	Fiscal Year 2016-17	Fiscal Year 2017-18	Fiscal Year 2018-19	Fiscal Year 2019-20	Fiscal Year 2020-21	Fiscal Year 2021-22	Project Cost	City Funds	Non-City Funds
	WASTE WATER FUND											
	Sewer Plant & Buildings											
969	*WW-Administration Building Screw Compressor Inspection/Overhaul	M	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$5,200.00	$10,000.00	$5,200.00	$4,800.00
906	*WW-Arc Flash Evaluation at the Plant	M	$0.00	$0.00	$0.00	$13,000.00	$0.00	$0.00	$0.00	$25,000.00	$13,000.00	$12,000.00
948	***WW-Digester 3 and 4 Reconditioning per 2017/2018 Condition Assessment**	**M**	$0.00	$50,000.00	$0.00	$50,000.00	$0.00	$0.00	$0.00	$200,000.00	$100,000.00	$100,000.00
966	***WW-Digester Condition Assessment**	**M**	$0.00	$13,500.00	$13,500.00	$0.00	$0.00	$0.00	$0.00	$54,000.00	$27,000.00	$27,000.00
971	*WW-Enclose Membrane Trains	C	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$260,000.00	$500,000.00	$260,000.00	$240,000.00
900	*WW-Membrane Distribution and RAS Channel Aeration Line Replacement	M	$0.00	$0.00	$47,700.00	$0.00	$0.00	$0.00	$0.00	$95,400.00	$47,700.00	$47,700.00
786	**WW-Membrane Gate Replacement**	**M**	$25,000.00	$25,000.00	$25,871.00	$29,991.00	$0.00	$0.00	$0.00	$211,724.00	$105,862.00	$105,862.00
970	*WW-Plant PLC Upgrade	M	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$52,000.00	$100,000.00	$52,000.00	$48,000.00
890	***WW-Plant-Membrane Replacement**	**M**	$1,200,000.00	$772,560.00	$772,560.00	$772,560.00	$772,560.00	$0.00	$0.00	$8,212,000.00	$4,290,240.00	$3,921,760.00
904	*WW-Primary Clarifier Supports and Structure	M	$0.00	$0.00	$0.00	$0.00	$52,000.00	$52,000.00	$0.00	$200,000.00	$104,000.00	$96,000.00
902	***WW-Primary Header Replacement**	**M**	$0.00	$250,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$500,000.00	$250,000.00	$250,000.00
912	*WW-Reconditioning Digesters 1 and 2	M	$0.00	$0.00	$0.00	$0.00	$0.00	$40,000.00	$0.00	$80,000.00	$40,000.00	$40,000.00
905	*WW-Replace the Chains and Flights in Primary Clarifiers	M	$0.00	$0.00	$0.00	$0.00	$260,000.00	$260,000.00	$0.00	$1,000,000.00	$520,000.00	$480,000.00
795	WW-SCADA Upgrade	M	$0.00	$0.00	$0.00	$0.00	$47,500.00	$0.00	$0.00	$95,000.00	$47,500.00	$47,500.00
893	*WW-Screw Pump Replacement	M	$100,000.00	$0.00	$115,369.00	$121,138.00	$0.00	$0.00	$0.00	$673,014.00	$336,507.00	$336,507.00
894	*WW-West Biosolids Storage Tank Pump Upgrade	M	$0.00	$0.00	$0.00	$52,206.00	$0.00	$0.00	$0.00	$104,412.00	$52,206.00	$52,206.00
764	**WW-Window Replacement 503 Hannah Ave.**	**M**	$0.00	$30,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$60,000.00	$30,000.00	$0.00
	Total Sewer Plant & Buildings		**$1,325,000.00**	**$1,141,060.00**	**$975,000.00**	**$1,038,895.00**	**$1,132,060.00**	**$352,000.00**	**$317,200.00**	**$12,120,550.00**	**$6,281,215.00**	**$5,809,335.00**
	TOTAL WASTE WATER FUND		**$1,900,000.00**	**$2,421,060.00**	**$2,478,871.00**	**$1,538,895.00**	**$1,711,920.00**	**$972,000.00**	**$984,200.00**	**$17,882,914.00**	**$12,006,946.00**	**$5,845,968.00**

Attachment 6b
Narrative of Traverse City's CIP

943 - SAW-Waste Water Asset Management Plan

PROJECT INFORMATION

Submitted By:	Larry LaCross	*Department:*	Not Specified
Category:	Capital	*Department Head:*	Dave Green
Fund Group:	SAW Grant Fund	*Department Priority:*	Imperitive (must do):
Fund Detail:	Not Specified	*Project Start Date:*	07/01/2014
Date Submitted:	01/15/2015	*Project End Date:*	06/30/2017
Date Last Edited:	01/04/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Federal / State Grant	$0	$231,000	$184,421	$0	$0	$0	$0	$415,421
Inkind	$0	$12,500	$573,023	$0	$0	$0	$0	$585,523
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

This project will create an Asset Management Plan for Sewer and Storm along with creating a Storm Water Management Plan.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$1,000,944
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

June 2014 the City of Traverse City was awarded two SAW Grants from the MDEQ with an overall budget of $2.44 million. The City was awarded the Storm Water Asset Management Plan coupled with the Storm Water Management Plan with a total project cost of $1,443,500.00 and a Waste Water Asset Management Plan with a total project cost of $1,000,944.00.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

969 - WW-Administration Building Screw Compressor Inspection/Overhaul

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2021
Date Submitted:	01/27/2016	*Project End Date:*	06/30/2022
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$0	$0	$0	$5,200	$5,200
Private	$0	$0	$0	$0	$0	$0	$4,800	$4,800
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Inspect screw compressors and replace necessary components to maintain its function.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

366 - WW-Annual Sewer Rehab/Replace

PROJECT INFORMATION

Submitted By:	Justin Roy	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2012
Date Submitted:	01/01/2010	*Project End Date:*	06/30/2018
Date Last Edited:	01/04/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$450,000	$450,000	$450,000	$450,000	$450,000	$450,000	$450,000	$3,150,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Provide $450,000 annually in both the water and wastewater funds to continue systematic improvements (repair and replacement) of our underground infrastructure.

PROJECT JUSTIFICATION:

-Maintains or improves existing infrastructure or facilities

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

13 - WW-Annual Storm Water Management Program

PROJECT INFORMATION

Submitted By:	Tim Lodge	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Tim Lodge
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2012
Date Submitted:		*Project End Date:*	06/30/2020
Date Last Edited:	01/28/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$350,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

This line item will guarantee funds to construct and repair city storm sewer lines. Funds may be used to disconnect sanitary sewers as well as water quality related infrastructure.

PROJECT JUSTIFICATION:

-Maintains or improves existing infrastructure or facilities

LOCATION DESCRIPTION:

City of
TRAVERSE CITY

Six Year Capital Improvement Program

906 - WW-Arc Flash Evaluation at the Plant

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Important (could do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2018
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2019
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$0	$0	$13,000	$0	$0	$0	$13,000
Private	$0	$0	$0	$12,000	$0	$0	$0	$12,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Evaluate motor control centers for ARC flash rating and label appropriately.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

987 - WW-Automated Metering Infrastructure (+ Water)

PROJECT INFORMATION

Submitted By:	Dave Green	*Department:*	Sewer Collection System
Category:	Capital	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2016
Date Submitted:	03/16/2016	*Project End Date:*	06/30/2018
Date Last Edited:	03/22/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$750,000	$750,000	$0	$0	$0	$0	$1,500,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Install water meters and software to accommodate smart metering capabilities that will provide for the migration to electronic advanced meters that will assist utility customers on energy use, reliability and provide reads to utility billing. Will also drive future system engineering and planning as well as provide metrics on completed items to show project results.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

293 - WW-Catch Basin & Manhole Casting Replacement

PROJECT INFORMATION

Submitted By:	Mark Jones	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2010
Date Submitted:	11/09/2009	*Project End Date:*	06/30/2016
Date Last Edited:	01/04/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$30,000	$30,000	$0	$0	$0	$0	$60,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Broken manhole and catch basin castings constitute a hazard to people and vehicles.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Along with street repair the storm sewer (castings) infrastructure is in disrepair.

PROJECT JUSTIFICATION:

-Protects health, safety, lives of citizens -Maintains or improves existing infrastructure or facilities
-Achieves City Commission Goal or Priority along with street repair our storm sewer (castings) infrastructure is in disrepair we used almost 12,000 out of our budget for casting purchases fo the summer of 2009.

LOCATION DESCRIPTION:

Streets

City of
TRAVERSE CITY **Six Year Capital Improvement Program**

968 - WW-Clinch Park Lift Station/Bay Street/Birchwood Upgrade of Control Panels

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2021
Date Submitted:	01/27/2016	*Project End Date:*	06/30/2022
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$0	$0	$0	$0	$0	$117,000	$117,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Upgrade control panels to replace obsolete equipment and add remote connection capability.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of
TRAVERSE CITY

Six Year Capital Improvement Program

948 - WW-Digester 3 and 4 Reconditioning per 2017/2018 Condition Assessment

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2016
Date Submitted:	11/24/2015	*Project End Date:*	06/30/2019
Date Last Edited:	02/03/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$50,000	$0	$50,000	$0	$0	$0	$100,000
Private	$0	$50,000	$0	$50,000	$0	$0	$0	$100,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Maintain operability of the Digesters.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Perform actions outlined by third party condition assessment of digesters.Cost is TBD by condition assessment.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

966 - WW-Digester Condition Assessment

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2016
Date Submitted:	01/27/2016	*Project End Date:*	06/30/2018
Date Last Edited:	02/03/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$13,500	$13,500	$0	$0	$0	$0	$27,000
Private	$0	$13,500	$13,500	$0	$0	$0	$0	$27,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Digesters need to be assessed so they can be reconditioned as needed.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY

Six Year Capital Improvement Program

971 - WW-Enclose Membrane Trains

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Capital	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Important (could do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2021
Date Submitted:	01/27/2016	*Project End Date:*	06/30/2022
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$0	$0	$0	$260,000	$260,000
Private	$0	$0	$0	$0	$0	$0	$240,000	$240,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Each train has a value of over $1 million and the enclosure would protect those assets.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Construct a building around membrane trains to keep them out of the elements preventing possible freezing, etc., and making it possible to do recovery cleaning in the winter months.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

967 - WW-Engineering Evaluation of Clinch Park Lift Station Capacity

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2021
Date Submitted:	01/27/2016	*Project End Date:*	06/30/2022
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$0	$0	$0	$0	$0	$50,000	$50,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Evaluate current capacity to assure it can meet the growing need of the Clinch Park vicinity.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

910 - WW-Front Street Lift Station Pump Around Hookup

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2020
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2021
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$0	$0	$30,000	$0	$30,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

In place of pump 1, currently abandoned in place, install pump around hookup

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

913 - WW-Lift Station Telemetry System

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Important (could do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2020
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2021
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$0	$0	$90,000	$0	$90,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Add and or upgrade telemetry at lift stations

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

900 - WW-Membrane Distribution and RAS Channel Aeration Line Replacement

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2017
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2018
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$47,700	$0	$0	$0	$0	$47,700
Private	$0	$0	$47,700	$0	$0	$0	$0	$47,700
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Maintain adequate mixing in the membrane distribution and RAS channels.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Remove and replace aging aeration line in the membrane distribution and RAS channel with SCH 80 PVC.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of
TRAVERSE CITY

Six Year Capital Improvement Program

786 - WW-Membrane Gate Replacement

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2014
Date Submitted:	12/03/2013	*Project End Date:*	06/01/2019
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$25,000	$25,000	$25,871	$29,991	$0	$0	$0	$105,862
Private	$25,000	$25,000	$25,871	$29,991	$0	$0	$0	$105,862
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

50% of cost covered by Townships

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replace the gate valves at the beginning and end of each membrane train.

PROJECT JUSTIFICATION:

Aluminum gates have corroded and need replacement with stainless steal.

LOCATION DESCRIPTION:

WWTP

City of TRAVERSE CITY

Six Year Capital Improvement Program

970 - WW-Plant PLC Upgrade

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2021
Date Submitted:	01/27/2016	*Project End Date:*	06/30/2022
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$0	$0	$0	$52,000	$52,000
Private	$0	$0	$0	$0	$0	$0	$48,000	$48,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Upgrade PLC (Programmable Logic Controls) to maintain current plant functioning.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

890 - WW-Plant-Membrane Replacement

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2015
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2020
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$1,200,000	$772,560	$772,560	$772,560	$772,560	$0	$0	$4,290,240
Private	$1,180,000	$685,440	$685,440	$685,440	$685,440	$0	$0	$3,921,760
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Maintain Plant Capacity

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replace 1 Train of Membranes each year until remaining 4 trains of 500C membrane cassettes are replaced.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

904 - WW-Primary Clarifier Supports and Structure

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2019
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2021
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$0	$0	$0	$52,000	$52,000	$0	$104,000
Private	$0	$0	$0	$0	$48,000	$48,000	$0	$96,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

The I-beams support the primary clarifier covers and thus keep orders in. The failing structure can introduce large pieces of cement into the tank damaging the sludge collection system and down stream pumps.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replace I-beam supports in Primary Clarifiers on the South side of the Plant. Repair and recoat the concrete in the Primary Clarifiers on the South side of the plant.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

902 - WW-Primary Header Replacement

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2016
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2017
Date Last Edited:	04/06/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$250,000	$0	$0	$0	$0	$0	$250,000
Private	$0	$250,000	$0	$0	$0	$0	$0	$250,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Repair primary header. The top of the Header has some exposed areas. Header has never been full so doesn't leak, but should be repaired. Install two isolation valves. Currently , there is no way of isolating one primary deck from the other which makes maintenance very difficult.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

912 - WW-Reconditioning Digesters 1 and 2

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2020
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2021
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$0	$0	$0	$0	$40,000	$0	$40,000
Private	$0	$0	$0	$0	$0	$40,000	$0	$40,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Would allow for us to operate as Seconday Digesters.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Install flame arrestors, and PRVs. Identify all leaks, and plug. Test vessels for proper functioning.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of
TRAVERSE CITY **Six Year Capital Improvement Program**

905 - WW-Replace the Chains and Flights in Primary Clarifiers

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2019
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2021
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$0	$260,000	$260,000	$0	$520,000
Private	$0	$0	$0	$0	$240,000	$240,000	$0	$480,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

The Chain and Flights in use have been in place for decades. The chain is beginning to elongate, which causes the chain to jump off the sprockets and ultimately keeps us from collect the solids that settle out and float in the clarifiers. The flights are becoming worn and cracked and less efficient in sludge accumulation.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replace the chains and flights in the Primary Clarifiers on the South side of the Plant.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY **Six Year Capital Improvement Program**

898 - WW-Riverine Lift Station Equipment Upgrade

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2017
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2018
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$0	$107,865	$0	$0	$0	$0	$107,865
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replace pumps, check valves,wet well mixer,update controls and reline pump housing

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of TRAVERSE CITY

Six Year Capital Improvement Program

795 - WW-SCADA Upgrade

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Important (could do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2019
Date Submitted:	12/03/2013	*Project End Date:*	06/30/2020
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$0	$0	$0	$47,500	$0	$0	$47,500
Private	$0	$0	$0	$0	$47,500	$0	$0	$47,500
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

50% paid for by Townships

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Upgrade SCADA system that controls the plant.

PROJECT JUSTIFICATION:

Last done in 2013. Routine upgrade. If controls fail there is no backup.

LOCATION DESCRIPTION:

WWTP

City of TRAVERSE CITY **Six Year Capital Improvement Program**

899 - WW-SCADA Upgrade at Front Street Lift Station and the TCRWWTP for PLC 5

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2016
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2017
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$116,006	$0	$0	$0	$0	$116,006
Private	$0	$0	$36,633	$0	$0	$0	$0	$36,633
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Front Street Lift Station's PLC and the TCRWWTP's PLC 5 are out of date and need to be upgraded to maintain reliable functioning.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Upgrade the PLC at the Front Street Lift Station and the PLC5 at the TCRWWTP-to be performed by a third party.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of
TRAVERSE CITY

Six Year Capital Improvement Program

893 - WW-Screw Pump Replacement

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2015
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2019
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$100,000	$0	$115,369	$121,138	$0	$0	$0	$336,507
Private	$100,000	$0	$115,369	$121,138	$0	$0	$0	$336,507
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Maintain primary effluent pumping capabilities to meet influent flow demand.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replacement of one screw body,gear box reconditioning and trough reconditioning.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of
TRAVERSE CITY

Six Year Capital Improvement Program

892 - WW-TBA LIFT STATION EQUIPMENT UPGRADE

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2015
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2016
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$75,000	$0	$0	$0	$0	$0	$0	$75,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replace the pumps,check valves and reline pump housing(can)

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of
TRAVERSE CITY

Six Year Capital Improvement Program

894 - WW-West Biosolids Storage Tank Pump Upgrade

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2018
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2019
Date Last Edited:	02/08/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$52,206	$0	$0	$0	$52,206
Private	$0	$0	$0	$52,206	$0	$0	$0	$52,206
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

Improve biosolids mixing, and biosolids loading capabilities.

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Upgrade West Biosolids Storage Tank Pump.Install a pump rated for a TDH of 52' that can pump 8% solids at a rate of 533gpm. This will allow for suitable mixing of the Storage cells and eliminate the need for separate mixers in each cell.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

City of
TRAVERSE CITY

Six Year Capital Improvement Program

764 - WW-Window Replacement 503 Hannah Ave.

PROJECT INFORMATION

Submitted By:	Justin Roy	*Department:*	Sewer Plant & Buildings
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Essential (should do):
Fund Detail:	Sewer Plant & Buildings	*Project Start Date:*	07/01/2013
Date Submitted:	01/07/2013	*Project End Date:*	06/30/2014
Date Last Edited:	01/28/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	*Prior Year*	*2016/2017*	*2017/2018*	*2018/2019*	*2019/2020*	*2020/2021*	*2021/2022*	*Total*
Sewer Fund	$0	$30,000	$0	$0	$0	$0	$0	$30,000
Water Fund	$0	$30,000	$0	$0	$0	$0	$0	$30,000
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$60,000
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

Replace original single pane windows and doors with new energy efficient windows and doors.

PROJECT JUSTIFICATION:

New energy efficient windows and garage doors would help reduce heating costs.

Current windows are single pane, original to the building.

LOCATION DESCRIPTION:

503 Hannah Ave.

City of TRAVERSE CITY **Six Year Capital Improvement Program**

909 - WW-Woodmere Lift Station Upgrade

PROJECT INFORMATION

Submitted By:	Elizabeth Hart	*Department:*	Sewer Collection System
Category:	Maintenance	*Department Head:*	Dave Green
Fund Group:	Waste Water	*Department Priority:*	Imperitive (must do):
Fund Detail:	Sewer Collection System	*Project Start Date:*	07/01/2019
Date Submitted:	11/24/2014	*Project End Date:*	06/30/2020
Date Last Edited:	01/27/2016	*Project Completed:*	No

FUNDING SOURCES:

Sources:	***Prior Year***	***2016/2017***	***2017/2018***	***2018/2019***	***2019/2020***	***2020/2021***	***2021/2022***	***Total***
Sewer Fund	$0	$0	$0	$0	$79,860	$0	$0	$79,860
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0
	$0	$0	$0	$0	$0	$0	$0	$0

SERVICE IMPACT:

COST DETAIL:

Study:	$0
Land Acquisition/ROW:	$0
Engineering/Design:	$0
Construction:	$0
Annual Maint. Cost:	$0
Maint. Year Start:	

PROJECT DESCRIPTION:

New pumps,check valves and controls installed.

PROJECT JUSTIFICATION:

LOCATION DESCRIPTION:

2016 ASSET CONDITION ASSESSMENT REPORT

Traverse City Regional Wastewater Treatment Plant and Lift Stations

Prepared for

City of Traverse City
400 Boardman Avenue
Traverse City, MI 49684

February 1, 2017

ch2m

606 Hannah Ave
Traverse City, MI 49684

Executive Summary

The current City of Traverse City Regional Wastewater Treatment NPDES permit requires an Asset Management Plan (AMP). As part of the AMP, the City is required to have a current assessment of the condition of the critical assets. There have been two previous assessments performed on parts of the facility, one in 2008 and the second in 2010. This is the first complete assessment of all the critical assets at the main plant, as well as the nine lift stations owned and operated by the City of Traverse City.

A series of workshops was held with the plant staff to develop criteria for assessing the assets and identifying risk. A team of four maintenance specialists arrived in Traverse City on Monday, October 10, and worked for 2 weeks assessing the 861 critical assets identified during the previous workshops. A final workshop held on Thursday, November 10, 2016, with representatives from the City of Traverse City, Grand Traverse County, CH2M HILL (CH2M) Traverse City plant staff, and CH2M maintenance and asset management specialists.

The condition assessment and risk data were put into the CH2M Asset Condition Evaluation System (ACES). The overall result of the assessment is shown in **Figure 1**.

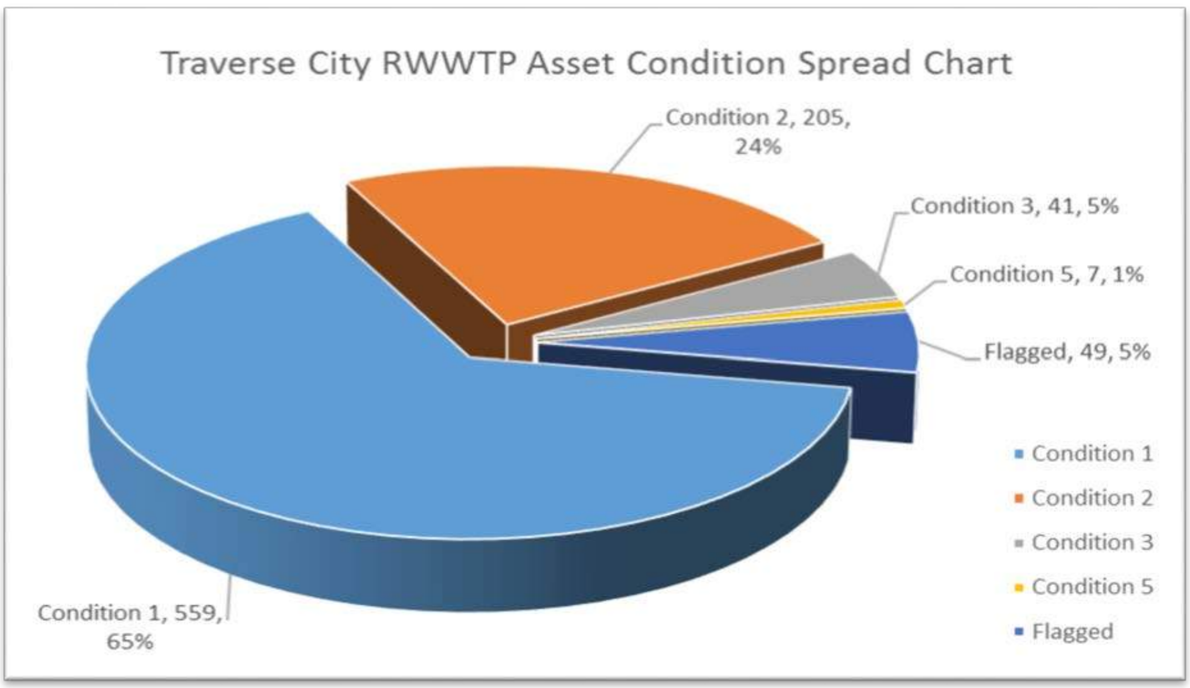


Figure 1. Traverse City RWWTP Asset Condition Spread Chart

The results show that 89 percent of the critical assets at the main plant and lift stations are in very good condition. Only 6 percent of the assets will require some immediate maintenance or repair, and 5 percent could not be accurately assessed at the time of this visit.

Based on the results, 65 percent of the critical assets are in Condition 1, which indicates that these assets are receiving the proper level of maintenance, and up to 95 percent of the assets' normal useful life remains. Another 24 percent of the assets are in Condition 2, which indicates that these assets may require some minimal immediate maintenance, but they still have up to 75 percent of normal useful life remaining.

A more detailed analysis of the process used by CH2M and the results of the assessment are contained in Sections 1 and 2 of this report and the five attached appendixes.

Contents

Acronyms and Abbreviations

ACES®	Asset Condition Evaluation SYSTEM
AMP	Asset Management Plan
CH2M	CH2M HILL
CMMS	Computerized Maintenance Management System
COF	Consequence of Failure
IIMM	International Infrastructure Management Manual
LOF	Likelihood of Failure
TCRWWTP	Traverse City Regional Wastewater Treatment Plant

Condition Assessment Process

CH2M uses a condition assessment process based on research published in the International Infrastructure Management Manual (IIMM) 2006 edition. The process centers on development of a set of questions and answers that use both observable and measurable data to evaluate the condition of an asset. Since different assets display different observable and measurable characteristics as they deteriorate, it is necessary to group assets that display similar characteristics together. The groups are referred to as asset types. In some cases, asset types can be very general and cover a variety of assets such as motors or generators. In other cases, asset types need to be more specific such as pumps that need to be broken down more. Some examples would be centrifugal pumps and vertical turbine pumps. A list of critical assets was selected from the asset registry in Maintenance Connection, the plant Computerized Maintenance Management System (CMMS), and grouped into asset types.

Table 1 contains a complete list of the asset types used to assess the assets at the Traverse City Regional Wastewater Treatment Plant (TCRWWTP).

Table 1. Asset Types

Asset Types		
ACTUATOR	HVAC	PUMP-VAC
AIR RECEIVER	INSTRUMENT	SAMPLER
ANAEROBIC DIGESTER (S)	INSTRUMENT-FLOW ELEMENT	SCREEN
BAR SCREEN	INSTRUMENT-H2S	SCREEN-ROTARY
BLOWER	INSTRUMENT-LEVEL	SCUM
BOILER	INSTRUMENT-PRESSURE	SOFT START
CHANNEL	INSTRUMENT-TURBIDITY	STRUCTURE
CLARIFIER	MCC	TANK-CHEMICAL
CLASSIFIER	MEMBRANE	TANK-CONCRETE
COMPACTOR	MIXER	TANK-FIBERGLASS
COMPRESSOR-AIR	MIXER-SUBMERSIBLE	TANK-METAL
COMPRESSOR-GAS	MOTOR	UNIT HEATER
CONTROL PANEL	PLC	VACUUM SYSTEM
CRANE	POLYBLEND	VALVE
DOOR-ROLL UP	PUMP	VALVE-ARV
DRYER	PUMP SUMP	VALVE-BACKFLOW
ELECTRICAL DISTRIBUTION	PUMP-CENT	VALVE-BUTTERFLY
ELECTRICAL PANEL	PUMP-DIA	VALVE-CHAIN
EMERGENCY DIESEL GENERATOR SET	PUMP-DRY PIT SUB	VALVE-CHECK
FAN	PUMP-METERING	VALVE-PLUG
FLOW METER	PUMP-PD	VALVE-PRV
GEARBOX	PUMP-PROG CAV	VALVE-SLUICE
GRAVITY BELT	PUMP-SCREW	VFD
HEAT EXCHANGER	PUMP-SUB	WELL-WET WELL

Using a database of asset type questions and answers developed by CH2M and used to assess similar assets for hundreds of clients, the plant staff and maintenance professionals developed a set of asset questions and answers for each asset type in **Table 1**. The answers to each question have scores between 1 and 5, with 1 being the best condition and 5 being the worst condition. The answer score of each question is rolled to an overall condition score for each asset. To adjust for the fact that not all questions have the same level of impact in determining the condition of an asset, each question is weighted. Giving a greater weight to answers for a question about how a valve functions, whether it opens and closes smoothly, than to a question about the condition of the coating on the valve provides a more accurate overall score. A greater accuracy in assessing the condition of assets is possible when measurements can be taken and compared to known standards. An example of a measurement that provides greater insight into the condition of an asset is the measured Insulation resistance of a motor, or the peak vibration reading of a motor bearing. Questions where measurements can be taken and compared to known standards can be set up as overriding questions. The score for an overriding question is set up such that no matter what the scores of the remaining questions, the overall score for the asset can never be less than the score for the overriding question. **Appendix A** contains a complete list of all the asset type questions, answer sets with question weightings, and overriding questions.

The procedure used by CH2M to identify the current condition of an asset is to have two experienced maintenance specialists answer the asset type questions for each critical asset, using both measured and observed data. Observed data included conditions like noise, corrosion, physical damage, missing parts, and non-functional components. The field measurements collected during this assessment include peak vibration measurement, voltage and amperage measurements under load, thermal graphic imaging, and insulation resistance. To be accurately assessed, assets must be operating under normal operating conditions or as close to normal as possible. Equipment that cannot be observed and measured under normal operating conditions is either partially evaluated or not evaluated at the discretion of the field assessment team. The data collected is used to answer question related to the current condition of the asset and calculate an overall asset condition score as discussed above. To facilitate the evaluation of assets, the overall asset scores are grouped into ranges and assigned a condition category. **Table 2** shows the range of overall asset scores that make up each condition category.

Table 2. Condition Categories

Asset Condition Category	Overall Asset Score	
	Minimum Score	Maximum Score
Condition 1	1.00	1.49
Condition 2	1.50	2.49
Condition 3	2.50	3.49
Condition 4	3.50	4.49
Condition 5	4.50	5.00

Based on information from IIMM 2006, general statements about the condition of assets and the future maintenance requirements can be made. As shown in **Table 3**, each condition category has a brief description of the future maintenance requirements of the asset, as well as the likely maximum percentage of the assets' normal service life remaining.

Table 3. Condition Category Description

Condition Category	Description	Estimated % of Remaining Service Life
Condition 1	Indicates the asset is in like new condition. Continuation of the current maintenance and operating procedures is indicated.	95
Condition 2	Indicates asset is in good condition. Some minor additional maintenance may be required along with the current maintenance and operating procedures.	75
Condition 3	Indicates the asset is in fair condition. These assets have one or more issues that require immediate attention. The current maintenance and operating procedures or intervals may need to be modified or adjusted to avoid a reoccurrence of the identified issues.	50
Condition 4	Indicates the asset is in poor condition. Planning for a major overhaul or replacement should begin. A review of current maintenance practices and procedures is needed. If this is a critical asset, a predictive maintenance program should be considered to prevent the asset from reaching this condition in the future.	30
Condition 5	Indicates the asset is in very poor condition. Failure of the asset to provide the desired level of service is likely. Greater than 50% of assets will require replacement. If this is a critical asset, a comprehensive maintenance analysis is recommended to prevent the asset from reaching this condition in the future.	5

1.1 Risk Based Condition Assessment

The approach CH2M used incorporates risk into the condition assessment. In a risk-based condition assessment, the asset condition, as described in the previous section, is only one component of the assessment. While the current condition of an asset is widely accepted as the primary indicator of an asset's likelihood of failing, there are additional risk factors that can more accurately help us define the best repair and replacement strategy. Applying the concept of relative risk ranking provides the ability to make fact-based and defensible decisions for the maintenance, rehabilitation, and replacement of infrastructure assets. Using a relative risk ranking concept is the industry standard for managing infrastructure assets effectively. Understanding the risk of assets failing will enable the City of Traverse City to make better use of these condition assessment results. The City can prioritize capital projects and maintenance actions based upon the extent to which the actions/investments could reduce the relative risk posed by failure of individual assets. This will help to optimize financial resources and mitigate the greatest amount of potential risk.

Risk can be defined as:

> *The potential for realization of unwanted, adverse consequences to organizational and service delivery strategies.*

In the context of utility asset management, the focus is on the risk of asset failure, where failure is not only the physical breakdown of an asset, but also the inability of an asset to meet its intended purpose. The risk that an asset failure will result in the City not meeting its established levels of service can be quantified as a function of the consequence of the asset failure, and the likelihood that the asset will fail, as shown by the following classic risk equation:

$$\text{Risk} = \text{Consequence} \times \text{Likelihood}$$

Section 1.2, Consequence of Failure, and 1.3, Likelihood of Failure, discuss the scoring system used to quantify the consequence of failure and the likelihood of failure for the City's infrastructure assets. The basis for the scoring system is found in the following sources:

- *International Infrastructure Management Manual*. Version 3.0. Association of Local Government Engineering New Zealand, Inc. and the Institute of Public Works Engineering of Australia. 2006.
- *Implementing Asset Management – A Practical Guide*. National Association of Clean Water Agencies, Association of Metropolitan Water Agencies, and Water Environment Federation. 2007.

1.2 Consequence of Failure

The risk posed by an asset failing is determined by quantifying the consequences that may result from the failure and the likelihood of the failure occurring. The consequence of asset failure focuses on the impact a failure may have on the City's ability to meet its established level of service targets.
The consequences of an asset failing are usually static unless (1) there is a change to the required level of service, (2) major equipment is changed, which results in lower consequence of failure, or (3) there is a redesign of part of the plant. The static nature of the consequence of failure makes the consequence score for a process or asset a potential way of assigning criticality to the assets. A criticality number is often assigned to assets in a Computerized Maintenance Management System (CMMS) to prioritize work orders based on the criticality of the asset being worked on. This works well for routine preventative maintenance or predictive maintenance work orders. Criticality falls short of providing the level of information we need when it comes to capital planning. In capital planning, the likelihood, or how soon an asset will fail, becomes as significant a factor as the criticality (consequence) of the asset failing. **Table 4** shows the Consequence of Failure Matrix, which was developed during the workshop Thursday, November 10, with representatives of the City of Traverse City, Grand Traverse County, and the Traverse City CH2M staff. It lists the level of service categories and the range of consequences (negligible to severe) with scores (1-10).

Table 4. Consequence of Failure Matrix

Consequence of Failure (COF)				City of Traverse City Traverse City RWWTP	
LOS Category	**Weight**	**Negligible = 1**	**Low = 4**	**Moderate = 7**	**Severe = 10**
Public Confidence	25%	No social or economic impact on the community. No reactive media coverage. Any media coverage is a result of proactive announcements by Utility. No complaints.	Minor disruption (e.g., traffic, dust, noise). No adverse media coverage.	Substantial but short-term disruption. Adverse media coverage due to public impact. Localized media coverage.	Long-term impact. Area-wide disruption. Regional media coverage.
Safety of Public and Employees	25%	No Injuries or Adverse Health Effects.	No lost-time injuries or medical attention required beyond first aid.	Lost-time injury or medical attention required.	Loss of life or widespread outbreak of illness.
Regulatory Compliance	20%	No State or County permit violations.	Technical violation	Probable enforcement action, but fines or surcharge unlikely	Regulator consent order.
System Delivery	20%	No impact.	Minor impact to process or out of service less than 4 hours.	Major impact to process, out of service <8 hours.	Major impact to process, out of service >24 hours.
Financial Impact	10%	Can be repaired within Utility budget (<$9,000).	Can be repaired between $9,000 and $50,000.	Can be repaired between $51,000 to $149,000.	Greater than $150,000. Sealed bids.

1.3 Likelihood of Failure

During the same workshop, a similar matrix was developed to score the likelihood of an asset failing. The result is presented in **Table 5**. Each likelihood category was assigned a weighted value based on its contribution to the likelihood of an asset failing to meet its intended purpose over a range of likelihood (negligible to very likely) with scores (1–10). Since the current condition of an asset is widely considered the major factor in predicting the likelihood an asset will fail, a weight of 60 percent was given to the condition rating calculated during the condition assessment. The likelihood that an asset will fail is also the common way to change the total risk that processes and assets pose to the City. While changing the consequence of a failure, as discussed above, usually requires a redesign of a process or complete changes to the assets or systems in use, likelihood can be changed more easily. Likelihood can be changed by rebuilding an asset or improving maintenance procedures. The successful application of predictive technologies to certain assets can also reduce the likelihood of a failure. These are all things that can be done without the need for major asset replacements or plant redesigns.

Table 5. Likelihood of Failure Matrix

Likelihood of Failure (LOF)					City of Traverse City Traverse City RWWTP	
Likelihood Category	**Weight**	**Negligible = 1**	**Unlikely = 3**	**Possible = 5**	**Likely = 7**	**Very Likely = 10**
Physical Condition	60%	Very Good. Condition Grade 1. New or Nearly New. Only Normal Maintenance Required.	Good. Condition Grade 2. Minor Wear.	Fair. Condition Grade 3. Major Wear Affecting Level of Service.	Poor. Condition Grade 4. Unable to Meet Level of Service Life. Failure Imminent.	Very Poor. Grade 5. Requires Complete Rehabilitation or Replacement. Failed.
O and M Protocols	20%	Complete accurate, Up-To-Date, Written, Easily Accessible and Is Being Used.	Complete, Written, Up-To-Date, Being Used but not easily accessible.	Partially Developed.	Written, But Out-Date and Not Used.	No Written Protocols.
Performance	10%	Sufficient capacity to meet average and peak flow requirements. Appropriate utilization and function.	Underutilized or oversized.	Sufficient capacity, but does not meet functional requirements, or over-utilized.	Able to meet current average capacity demand, but not peak demands.	Unable to meet current average capacity needs.
Reliability	10%	No Unscheduled corrective work order events within 12 months.	1 Unscheduled corrective work order events within 12 months.	2 Un scheduled corrective work order events within 12 months.	3 Unscheduled corrective work order events within 12 months.	4 Unscheduled corrective work order events within 12 months.

During the workshop on November 10 with representatives of The City of Traverse City, Grand Traverse County, CH2M plant staff, and CH2M maintenance and asset management specialists, each process area and lift station was scored. The results of the workshop are shown in **Table 6**.

Table 6. Process Area and Lift Station Risk Scores by Total Risk

Ranked by Total Risk	Consequence						Likelihood					
	Safety of Public and Employees	Financial Impact	Public Confidence	Regulatory Compliance	Service Delivery	Consequence of Failure	Physical Condition (1-10)	O&M Protocols (i.e., PMs, SOPs,	Performance	Reliability	Likelihood of Failure	Total Risk
	25%	10%	25%	20%	20%		60%	20%	10%	10%		
Process Area												
Digestion	10	10	10	7	4	8.200	1	5	5	5	2.600	21.320
Primary Treatment	7	10	10	7	10	8.650	1	3	1	7	2.000	17.300
Membrane Filtration	7	10	10	7	4	7.450	1	3	1	10	2.300	17.135
Solids Handling	7	4	7	1	10	6.100	1	5	1	10	2.700	16.470
Front Street LS	7	10	10	7	4	7.450	1	5	1	1	1.800	13.410
UV disinfection	1	4	4	10	4	4.450	1	5	7	5	2.800	12.460
TBA LS	4	4	7	4	4	4.750	1	5	1	5	2.200	10.450
Clinch Park LS	4	1	7	7	1	4.450	1	5	1	3	2.000	8.900
Secondary Treatment	1	10	1	1	10	3.700	1	5	5	3	2.400	8.880
Woodmere LS	4	4	4	4	4	4.000	1	5	1	5	2.200	8.800
Riverine LS	1	4	7	4	7	4.600	1	5	1	1	1.800	8.280
Bay St LS	1	4	7	7	4	4.600	1	5	1	1	1.800	8.280
Hull Park LS	4	1	7	4	4	4.450	1	5	1	1	1.800	8.010
Coast Guard LS	1	4	4	4	4	3.250	1	5	1	7	2.400	7.800
Birchwood LS	4	4	4	4	4	4.000	1	5	1	1	1.800	7.200
Odor Control	7	7	4	1	7	5.050	1	3	1	1	1.400	7.070
Fine Screens	1	10	1	1	4	2.500	1	5	1	1	1.800	4.500
Preliminary Treatment	4	10	1	1	1	2.650	1	3	1	1	1.400	3.710
Structures and support	1	4	1	1	4	1.900	1	3	1	3	1.600	3.040
Grit Removal	1	4	1	1	1	1.300	1	5	1	1	1.800	2.340

Figure 2 shows the ranking of processes and lift stations using the assumption that all the assets were in new or like new condition. The purpose of this graph is to show where risk exists at the plants and lift stations where condition is not a factor.

Figure 2. Process and Lift Station Risk Ranking without Considering Risk

Condition Assessment Findings

The results of the condition assessment are shown in the asset condition spread chart, **Figure 3**.
The results indicate that 559 (65 percent) of all the critical assets are in Condition 1. This means that the current maintenance plan is effective with up to 95 percent of useful asset life remaining. Another 205 (24 percent) of all critical assets are in Condition Category 2. These assets may require some minor additional maintenance with up to 75 percent of useful life remaining. These two condition categories represent 89 percent of all the critical assets. The remaining 87 (11 percent) of all critical assets may require additional attention in the near future.

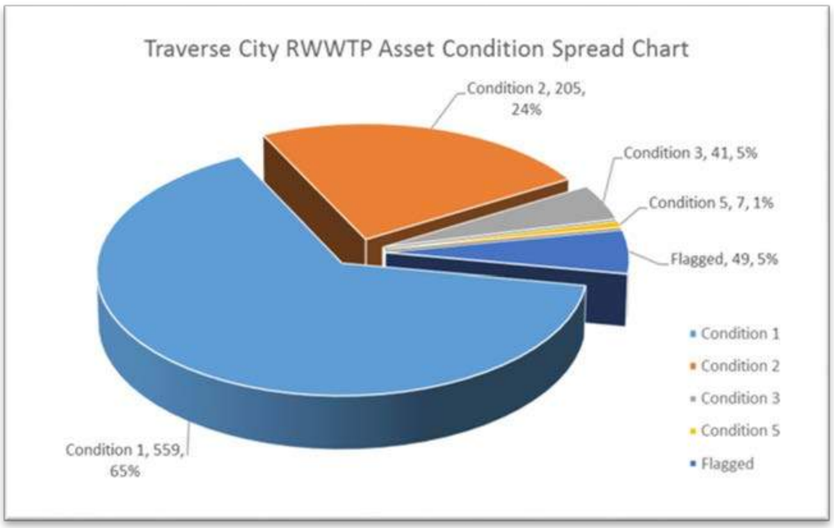


Figure 3. Asset Condition Spread

A report detailing the assessment of each asset, including comments from the assessment team and pictures of concerns identified by the assessment team, can be found in **Appendix B.**

Looking at the assets at the Main Plant and the lift stations separately, the asset condition spread remains very close to the same. **Figure 4** shows the asset condition spread for the Main Plant, and **Figure 5** shows the asset condition spread for the lift stations.

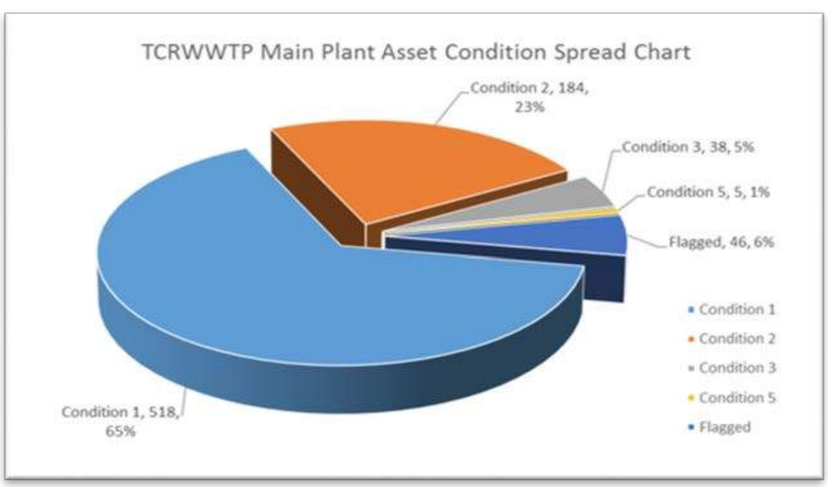


Figure 4. Main Plant Asset Condition Spread

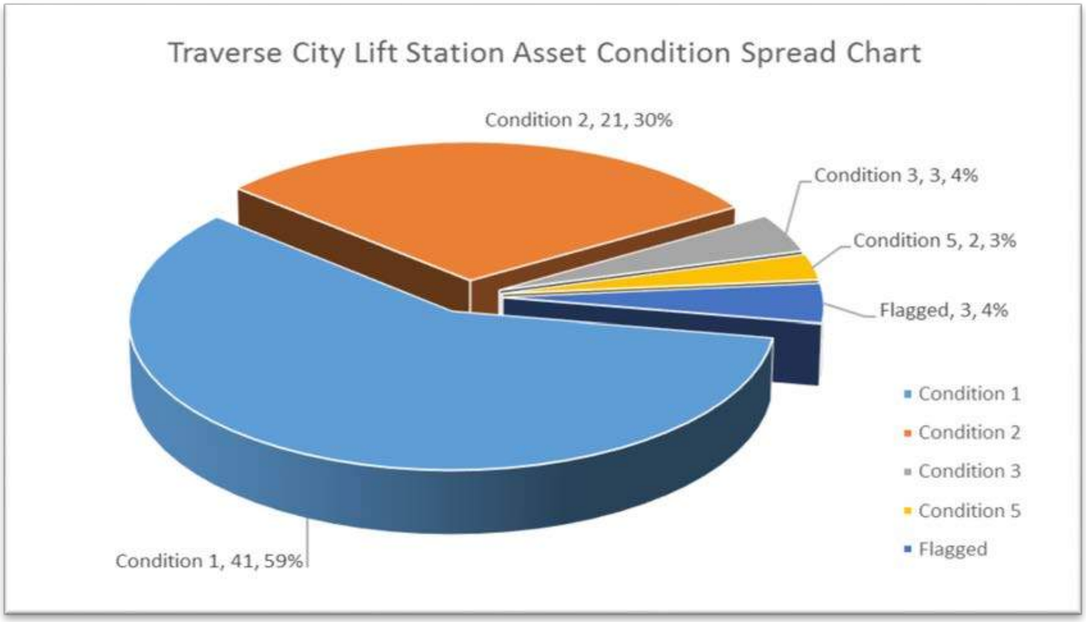


Figure 5. Lift Station Asset Condition Spread

The area's average condition scores for the processes at the main plant show how they rank (**Table 7**). Grit Removal, Preliminary Treatment, and Digestion have the highest average asset condition scores. When risk is factored into the equation, the process ranking changes slightly, with Digestion being the highest average total risk, followed by Primary Treatment and Membrane Filtration (**Table 8**).

Table 7. Main Plant Process Area Average Condition Score Ranking

Plant Process area by Average Condition Score	Number of Assets	Average Asset Condition Score	Average Total Risk	Process Area Consequence	Process Area Likelihood
Grit Removal	14	1.92	3.79	1.30	2.91
Preliminary Treatment	27	1.90	6.30	2.65	2.38
Digestion	50	1.76	28.40	8.20	3.46
UV disinfection	2	1.70	15.13	4.45	3.40
Fine Screens	22	1.60	6.20	2.50	2.48
Primary Treatment	69	1.57	22.57	8.65	2.61
Odor Control	4	1.48	8.59	5.05	1.70
Solids Handling	129	1.47	19.02	6.10	3.12
Structures and support	132	1.46	3.87	1.90	2.04
Secondary Treatment	76	1.38	9.87	3.70	2.67
Membrane Filtration	217	1.32	19.28	7.45	2.59
Laboratory	5	1.27	0.00	0.00	0.00

Table 8. Main Plant Process Area Average Total Risk Score Ranking

Plant Process area by Average Total Risk Score	Number of Assets	Average Asset Condition Score	Average Total Risk	Process Area Consequence	Process Area Likelihood
Digestion	50	1.76	28.40	8.20	3.46
Primary Treatment	69	1.57	22.57	8.65	2.61
Membrane Filtration	217	1.32	19.28	7.45	2.59
Solids Handling	129	1.47	19.02	6.10	3.12
UV disinfection	2	1.70	15.13	4.45	3.40
Secondary Treatment	76	1.38	9.87	3.70	2.67
Odor Control	4	1.48	8.59	5.05	1.70
Preliminary Treatment	27	1.90	6.30	2.65	2.38
Fine Screens	22	1.60	6.20	2.50	2.48
Structures and support	132	1.46	3.87	1.90	2.04
Grit Removal	14	1.92	3.79	1.30	2.91
Laboratory	5	1.27	0.00	0.00	0.00

Tables 7 and **8** we show that the process areas at the main plant with the highest average condition score do not have the highest average total risk. This does not mean there are not individual assets that may require attention. What it does tell us is that after dealing with the individual assets in poor condition with high total risk, processes ranking highest in total risk should be looked at next. The graph in **Figure 6** displays the average condition score and the average total risk for each process area at the main plant. Four processes stand out as requiring attention to mitigate risk to the City.

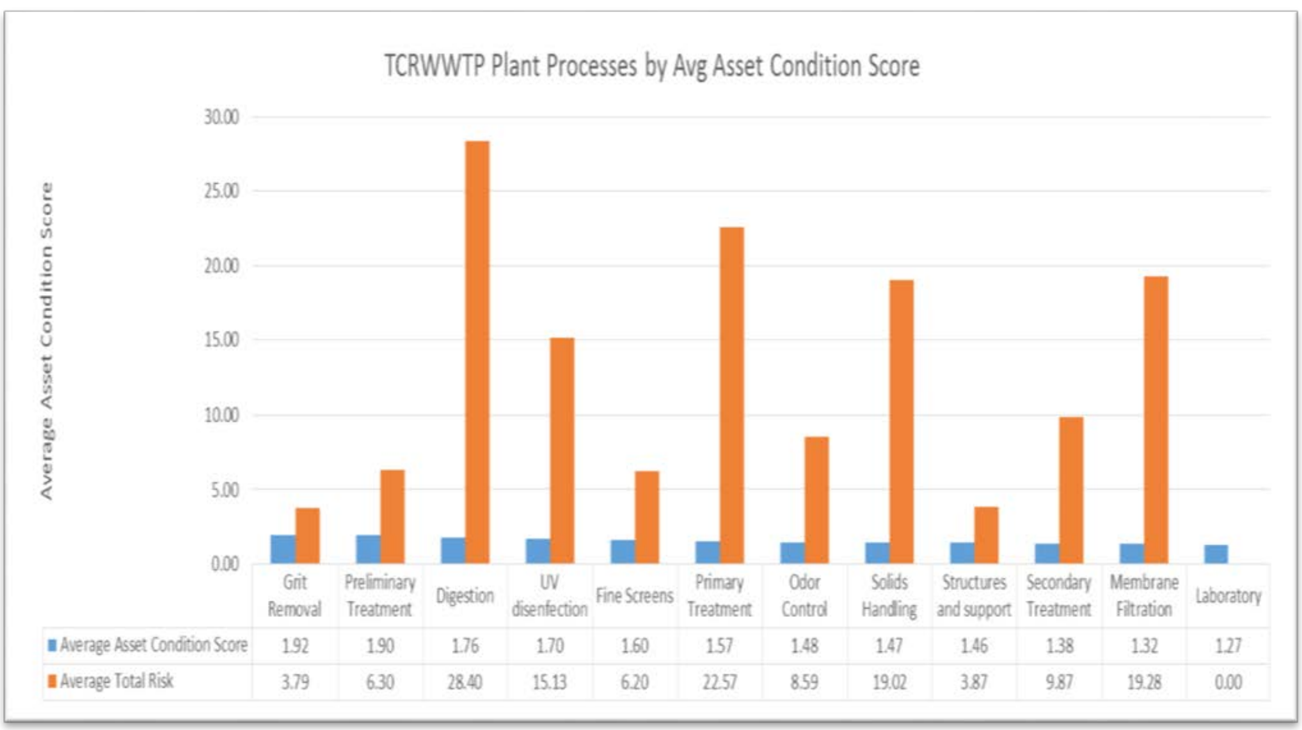


Figure 6. Main Plant Process Area Average Scores Ranked by Condition Score

A detailed report of the asset condition and total risk scores for the main plant is contained in **Appendix C** at the end of this report.

The average condition and risk scores for the lift stations show that, while the asset condition spread for the lift stations and Main Plant is very similar, there are many fewer assets in each lift station than in each process area. The result is that the average condition scores are higher. When the lift stations are ranked by average condition, Clinch Park and Woodmere have the highest average condition scores. When risk is factored into condition, Clinch Park is also the highest average total risk. The Front Street lift station is the fourth highest in average condition score but the second highest in total risk. As with the process areas, after individual high-risk poor condition assets are accounted for, the highest-risk lift stations need to be looked at to lower the City's overall risk. The stations would be Clinch Park, Front Street, Woodmere, and TBA. The ranking of lift stations by average condition score are shown in **Table 9** and by average total risk are shown in **Table 10**. **Figure 7** displays the average condition score and average total risk ranked by average condition score. **Appendix D** contains a detailed report showing all the lift station assets with their individual condition scores and total risk scores.

Table 9. Lift Station Average Condition Score Ranking

Lift Stations by Average Condition Score	Number of Assets	Average Asset Condition Score	Average Total Risk	Process Area Consequence	Process Area Likelihood
Clinch Park LS	2	3.10	20.92	4.45	4.70
Woodmere LS	7	2.01	13.94	4.00	3.49
Coast Guard LS	6	1.70	10.40	3.25	3.20
Front Street LS	23	1.66	18.07	7.45	2.43
Bay St LS	7	1.54	9.86	4.60	2.14
TBA LS	5	1.43	13.87	4.75	2.92
Riverine LS	8	1.42	9.66	4.60	2.10
Birchwood LS	8	1.31	7.80	4.00	1.95

Table 10. Lift Station Average Total Risk Score Ranking

Lift Stations by Average Total Risk Score	Number of Assets	Average Asset Condition Score	Average Total Risk	Process Area Consequence	Process Area Likelihood
Clinch Park LS	2	3.10	20.92	4.45	4.70
Front Street LS	23	1.66	18.07	7.45	2.43
Woodmere LS	7	2.01	13.94	4.00	3.49
TBA LS	5	1.43	13.87	4.75	2.92
Coast Guard LS	6	1.70	10.40	3.25	3.20
Bay St LS	7	1.54	9.86	4.60	2.14
Riverine LS	8	1.42	9.66	4.60	2.10
Birchwood LS	8	1.31	7.80	4.00	1.95

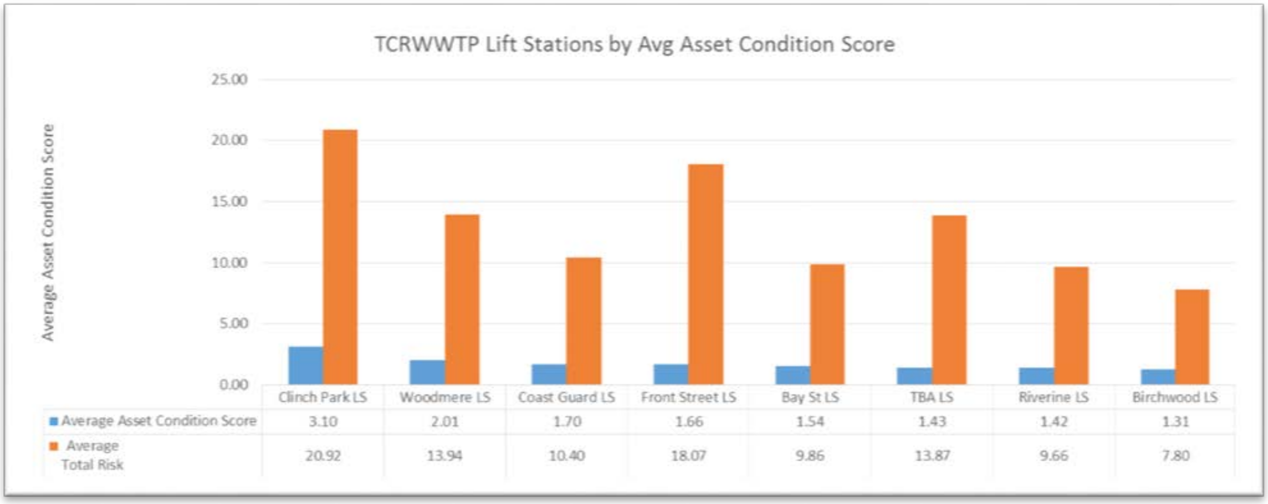


Figure 7. Lift Station Average Scores Ranked by Condition Score

There are 31 assets that were flagged as not functional or partially evaluated. Assets receiving either of these two flags automatically receive an overall score of 3 because these assets could not be observed operating under normal operating condition. The score highlights the assets in the assessment results so that whatever issues existed at the time of the assessment can be addressed, and an accurate assessment can be made by the plant staff. The overall score of 3 moves the assets higher in the ranking, but stops short of listing them as failed assets (overall score of 5). A description of each flag and how many assets are included follows.

- Not Functional—A not functional asset is one that would not operate at the time of the inspection. There are 13 assets flagged as not functional. The following are examples of the reasons assets are flagged as not functional:
  - Assets removed or locked out of service for repair
  - Assets that would not operate at the time of inspection or that operated such that they would not be operated under normal circumstances
- Partially Evaluated—A partially evaluated asset is an asset that could not be operated at the time of the inspection, but the assessment team determined that some of the questions could be answered without operating the asset and still provide valuable information. There are 18 assets flagged partially evaluated. Examples of the reasons assets are flagged partially evaluated are as follows:
  - The asset could not be operated under normal operating conditions, but could be operated sufficiently that the assessment team determined they could evaluate the condition of the asset.
  - Some questions could be answered without operating the asset that would provide valuable information about the asset.

There are also 49 flagged assets that received no score. These assets are flagged Needs Review, Nonexistent, Not Evaluated, or Not Found. A description of each flag and how many assets are included follows.

- Not Evaluated—A not evaluated asset is an asset that could not be operated at the time of the assessment, but there was no indication that the asset was in a failed condition. Since the asset cannot be operated under normal operating condition, the assessment team flagged the asset not evaluated and gave it a score of 0. There are 35 assets flagged as not evaluated. Examples of the reasons assets are flagged not evaluated are as follows:

  - The asset could not be operated under normal operating conditions.
  - The asset was associated with an out of service or not functional asset, and it could not be operated under normal operating conditions.
  - Operational considerations prohibited the asset from being operated.

- Needs Review—An asset that needs review is an asset that has an asset description that is not complete enough for the field team to be certain which asset it is. By flagging the asset, the asset description can be changed to better identify the asset. There was 1 asset flagged needs review.
- Non-Existent—Assets flagged as nonexistent are assets that the assessment team, working with the plant staff, determined have been permanently removed from service. These assets are flagged so they may be removed from the asset registry. There are 6 assets flagged nonexistent.
- Not Found—Assets flagged as not found are assets that the assessment team, working with the plant staff, could not positively identify, but also could not confirm that they had been permanently removed from service. There are 7 assets flagged not found.

A complete listing of all the flagged inspections is contained in **Appendix E**.

Appendix H: Capital Improvement and Revenue Analysis

Appendix H: Capital Improvement and Revenue Analysis

Traverse City Regional Waste Water Treatment Plant and Collection System Costs (10-year Horizon)

Collection System	Fiscal Year 2017-2018	Fiscal Year 2018-2019	Fiscal Year 2019-2020	2020-2021	Fiscal Year 2021-2022	Fiscal Year 2022-2023	Fiscal Year 2024-2025	Fiscal Year 2025-2026	Fiscal Year 2026-2027	Fiscal Year 2027-2028	Project Cost
Automated Metering Infrastructure	$750,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$750,000.00
Annual pipe and manhole inspection and cleaning program	$160,000	$160,000	$160,000	$160,000	$160,000	$160,000	$160,000	$160,000	$160,000	$160,000	$1,600,000.00
Manhole rehabilitation & repair	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$1,500,000.00
Gravity sewer rehabilitation & repair	$680,000	$680,000	$680,000	$680,000	$680,000	$500,000	$500,000	$500,000	$500,000	$500,000	$5,900,000.00
Force Main Replacement	$400,000	$400,000	$400,000	$400,000	$400,000	$78,200	$78,200	$78,200	$78,200	$78,200	$2,391,000.00
Collection System SSES (District 3)	$15,000	$15,000	$0	$0	$0	$0	$0	$0	$0	$0	$30,000.00
Additional Metering - District 3	$0	$0	$15,000	$15,000	$0	$0	$0	$0	$0	$0	$30,000.00
Front Street Lift Station Pump and Valve Replacement/Repair	$40,000	$40,000	$25,000	$0	$0	$0	$0	$0	$0	$0	$105,000.00
Other Lift Stations Pump and Valve Replacement/Repair	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$150,000.00
Lift Station General Maintenance	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$50,000.00
Hydraulic Upgrades - Oak Street Sanitary Sewer	$0	$0	$0	$0	$0	$0	$0	$245,000	$1,460,000	$1,000,000	$2,705,000.00
Clinch Park Lift Station/Bay Street/Birchwood Upgrade of Controls	$0	$0	$0	$117,000	$0	$0	$0	$0	$0	$0	$117,000.00
Engineering Evaluation of Clinch Park Lift Station Capacity	$0	$0	$0	$0	$0	$50,000	$0	$0	$0	$0	$50,000.00
Clinch Park Lift Station Upgrade per Engingeering Study/Condition Assessment and Addition of Flow metering	$0	$0	$0	$0	$0	$0	$0	$160,000			$160,000.00
Front Street Lift Station Pump Around Hookup	$0	$0	$0	$0	$80,000	$0	$0	$0	$0	$0	$80,000.00
Engineering Evaluation/Condition Assessment Birchwood Lift Station	$0	$0	$0	$0	$0	$50,000	$0	$0	$0	$0	$50,000.00
Birchwood Lift Station Upgrade per Engineering Study and Addition of Flow metering	$0	$0	$0	$0	$0	$0	$300,000	$0	$0	$0	$300,000.00
Front Street Lift Station VFD -Pipe and Pump-Wet Well Upgrade and addition of Flow Metering	$0	$0	$0	$0	$598,000	$0	$0	$0	$0	$0	$598,000.00
Front Street Lift Station Engineering Evaluation-To look at Capacity and options for upgrade	$0	$0	$0	$50,000	$0	$0	$0	$0	$0	$0	$50,000.00
Lift Station Telemetry	$0	$0	$0	$90,000	$0	$0	$0	$0	$0	$0	$90,000.00
Riverine Lift Station Engineering Study-Evaluation of Capacity	$0	$0	$0	$0	$0	$50,000	$0	$0	$0	$0	$50,000.00
Riverine Lift Station Upgrade per Engineering Study	$0	$0	$0	$0	$0	$0	$160,000	$0	$0	$0	$160,000.00
Coast Guard Lift Station Engineering Study-Evaluation of Capacity	$0	$0	$0	$0	$0	$0	$0	$50,000	$0	$0	$50,000.00
Coast Guard Lift Station Upgrade per Engineering Study	$0	$0	$0	$0	$0	$0	$0	$0	$300,000	$0	$300,000.00
SCADA upgrade for Front Street Lift Station and the TCWWTP for PLC 5	$152,639	$0	$0	$0	$0	$0	$0	$0	$0	$0	$152,639.00
Pump Station (annual replacement fund)	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$10,000.00	$100,000.00
Pump Stations: capital (assets > 25 yrs)	$8,500.00	$36,000.00	$55,000.00	$15,000.00	$54,000.00	$45,000.00	$0.00	$0.00	$0.00	$260,000.00	$473,500.00
Collection System Total (CIP)	$2,386,139	$1,511,000	$1,515,000	$1,707,000	$2,152,000	$1,113,200	$1,378,200	$1,373,200	$2,678,200	$2,178,200	$17,992,139
WWTP	**Fiscal Year 2017-2018**	**Fiscal Year 2018-2019**	**Fiscal Year 2019-2020**	**2020-2021**	**Fiscal Year 2021-2022**	**Fiscal Year 2022-2023**	**Fiscal Year 2024-2025**	**Fiscal Year 2025-2026**	**Fiscal Year 2026-2027**	**Fiscal Year 2027-2028**	**Project Cost**
WWTP Flow Meter Upgrade	$10,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$10,000.00
Plant Pump and Valve replacement/repair	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$50,000	$500,000.00
Plant General Maintenance	$87,000	$87,000	$87,000	$87,000	$87,000	$87,000	$87,000	$87,000	$87,000	$87,000	$870,000.00
Digester 3&4 Reconditioning per Condition Assessment	$208,000	$208,000	$0	$0	$0	$0	$0	$0	$0	$0	$416,000.00
Digester Condition Assessment	$50,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$50,000.00
Enclose Membrane Trains	$0	$0	$0	$0	$0	$500,000	$0	$0	$0	$0	$500,000.00
Membrane Distribution and RAS Channel Aeration Line Replacement	$0	$95,400	$0	$0	$0	$0	$0	$0	$0	$0	$95,400.00
WW-Membrane Gate Replacement	$51,742	$59,982	$0	$0	$0	$0	$0	$0	$0	$0	$111,724.00
Plant PLC Upgrade	$0	$0	$0	$0	$243,024	$0	$0	$0	$0	$0	$243,024.00
Plant-Membrane Replacement	$860,000	$860,000	$860,000	$860,000	$0	$940,000	$940,000	$940,000	$940,000	$940,000	$8,140,000.00
Primary Clarifier Supports and Structure	$0	$0	$0	$363,654	$0	$0	$0	$0	$0	$0	$363,654.00
Replace the chain and flights in Primary Clarifiers	$0	$0	$0	$1,000,000	$0	$0	$0	$0	$0	$0	$1,000,000.00
Primary Header Replacement	$0	$500,000	$0	$0	$0	$0	$0	$0	$0	$0	$500,000.00
Reconditioning Digesters 1 &2	$0	$0	$0	$0	$0	$80,000	$0	$0	$0	$0	$80,000.00
SCADA Upgrade	$0	$0	$95,000	$0	$0	$0	$0	$0	$0	$95,000	$190,000.00
Screw Pump Replacement	$0	$500,000	$500,000	$0	$0	$0	$0	$0	$0	$0	$1,000,000.00
UV System and Structure Modifications	$500,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$500,000.00
Engineering Study Related to Facility's Plan	$200,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$200,000.00
Projects Related to Facility Plan Engineering Study(Costs are strictly for budgeting purposes-projects have not yet been indentified nor have related cost estimates been established)	$0.00	$0.00	$0.00	$0.00	$1,000,000.00	$1,000,000.00	$1,000,000.00	$1,000,000.00	$1,000,000.00	$1,000,000.00	$6,000,000.00
West Biosolids Storage Tank Pump Upgrade	$122,512.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$122,512.00
Sewer Plant Total (CIP)	$2,139,254	$2,360,382	$1,592,000	$2,360,654	$1,380,024	$2,657,000	$2,077,000	$2,077,000	$2,077,000	$2,172,000	$20,892,314
Fiscal Year Total (CIP)	$4,525,393	$3,871,382	$3,107,000	$4,067,654	$3,532,024	$3,770,200	$3,455,200	$3,450,200	$4,755,200	$4,350,200	$38,884,453

Operating Expenses (From FY16/17 Budget)		
Maintenance and Repairs - Salaries, Wages, Supplies, Etc.	$467,000	(base assumption: 50% of current $829K budget will be dedicated to CIP budget for rehab, repair, inspection, etc. - remainder is represented in the CIP budget)
WWTP Operating Costs	$2,663,000	(base WWTP operating costs, per CH2M and City Treasurer)
Administrative and General	$273,000	(from current City budget, excluding depreciation expenses)
Debt Service	$1,220,000	(from current City budget, expires in FY21/22)
Transfers Out (City Fee)	$450,000	(5% of revenues, increased to reflect potential increased revenues)
Subtotal: Operating+Finance+Transfers	$5,073,000	
AVERAGE TOTAL CIP (next 10 years)	$3,890,000	(collection system + WWTP + pump stations: no adjustment for inflation - all costs assumed to be 2017 Dollars)
Total Recommended Wastewater Budget	**$9,000,000**	(Recommended budget for FY 17/18 - annual adjustments likely necessary to keep up with inflation)

APPENDIX H: PUBLIC HEARING DOCUMENTATION

City of Traverse City
Public Hearing Notice Regarding
the Application to the Michigan Department of Environment,
Great Lakes, and Energy (EGLE) for funding assistance
through the Clean Water State Revolving Fund

The City of Traverse City will hold a public hearing on the application to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) for funding assistance through the Clean Water State Revolving Fund, better known as the State Revolving Fund (SRF) Program for the proposed Wastewater System Improvements project. The public hearing is being held for the purpose of receiving comments from interested persons.

The hearing will be held at 7:00 p.m. on Monday, May 17, 2021 during the City Commission Regular Meeting, conducted as a Remote Participation Meeting. The meeting will be conducted over the Zoom Platform, and any individual may give public comment during the meeting by calling (312) 626-6799; meeting ID is 827-1362-9783. Alternatively, you may give public comment by joining the meeting using the following link: https://us02web.zoom.us/u/keIhrecwy9

The proposed Wastewater System Improvements project descriptions and details are organized into a comprehensive 20-year Project Plan. If the SRF application is successful, the City will have the ability to employ the grant program to fund the proposed project. The project construction will include improvements to the influent pumping and screening equipment, grit removal equipment, settling tanks, primary effluent pumps, and the UV system. In addition, the project will include reconstruction of the lower Boardman River Wall sanitary sewer replacement, sewer rehabilitation, East Front Street sewer improvements, and US-31 sewer improvements. Work will occur at the existing wastewater treatment plant site, located at 606 Hannah Avenue as well as other existing locations within the collection system.

Impacts of the proposed project may include:

> **Noise:** Noise due to construction activities such as construction equipment, machinery, generators, compressors, etc. will be kept to a minimum, as practicable. The work hours will be maintained in accordance with local ordinances.
>
> **Traffic Disturbance:** Traffic control devices and temporary lane closures will be necessary during construction in the collection system. This may impact vehicular and pedestrian traffic flow patterns. Construction activities will be coordinated by location to mitigate any cumulative impacts.

The total cost of the improvements is estimated to be $27.5 million. The repayment of the SRF loan, if approved, will be apportioned to City sewer customers at a monthly rate of approximately $13 per residential service. The estimated user costs to finance the proposed project have been determined assuming SRF financing with a 2.0% interest rate (current SRF interest rate) and a 20-year debt retirement. The apportionment costs are based on an annual average over a 20-year period to provide an estimate of the average charge per residential service.

Copies of the Wastewater System Draft Project Plan detailing the proposed project is available for review beginning on Thursday, April 15, 2020 at:

- City of Traverse City - City Hall, 400 Boardman Avenue, Traverse City, Michigan, 49684 and at the City's website www.traversecitymi.gov.

Written comments received before the hearing record is closed on May 17, 2020 will receive responses in the Final Project Plan. Written questions should be sent to:

Benjamin Marentette, City Clerk, City Hall, 400 Boardman Avenue, Traverse City, Michigan, 49684 *Or* tcclerk@traversecitymi.gov

IF YOU ARE PLANNING TO ATTEND THE PUBLIC MEETING AND YOU HAVE A DISABILITY REQUIRING ANY SPECIAL ASSISTANCE, PLEASE NOTIFY THE ADA COORDINATOR AT 992-4440 OR TDD #922-4412 AS SOON AS POSSIBLE.

The City of Traverse City does not discriminate on the basis of disability in the admission or access to, or treatment or employment in, its programs or activities. Penny Hill, Assistant City Manager has been designated to coordinate compliance with the non-discrimination requirements contained within Section 35.107 of the Department of Justice regulations. Information concerning the provisions of the Americans with Disabilities Act, and the rights provided thereunder, are available from the ADA Coordinator.

Published on April 15, 2021 in the Traverse City Record-Eagle

Benjamin Marentette, MMC, City Cerk

AFFIDAVIT OF PUBLICATION

LEGAL NOTICE

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Published on April 15, 2021 in the Traverse City Record-Eagle

Benjamin Marentette, MMC, City Cerk

STATE OF MICHIGAN
County of Grand Traverse

Paul Heidbreder being duly sworn deposes and says the annexed printed copy of notice was taken from the Traverse City RECORD EAGLE, a newspaper printed and circulated in said State and County, and that said notice was published in said newspaper on the following dates:

04/15/2021

that he or she is the agent of the printers of said newspaper, and knows well the facts stated herein

Paul J. Heidbreder

Subscribed and sworn to before this 15th of April, 2021 .

Denise A. L

Denise A. Lingerfelt
Notary Public, State of MI
County of Grand Traverse
09/28/2023
Acting in County of Grand Traverse

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PURPOSE OF THE PUBLIC HEARING

- Present State Clean Water State Revolving Fund (CWSRF) Project Plan
- Provide a Forum for Community Participation
  - SRF Loan Program Overview
  - Project Plan and Alternatives
  - User and Overall Project Costs
  - Social & Environmental Impacts
  - Mitigation of the Impacts
  - Schedule
  - Questions

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WHAT IS THE SRF LOAN PROGRAM?

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Provides low-interest loans (currently 2.0%) for planning, designing, and construction eligible wastewater projects. Administered by Michigan EGLE Revolving Loan Section.

To qualify, the City must:

- Prepare and submit an EGLE approvable Project Plan
- Provide a Public Hearing and Comment Opportunity for the Plan
- Pass a Resolution adopting the Plan

Final EGLE approval and City acceptance of the loan is decided later in the SRF Loan Program.

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WHAT IS A WASTEWATER TREATMENT PLANT (WWTP)?

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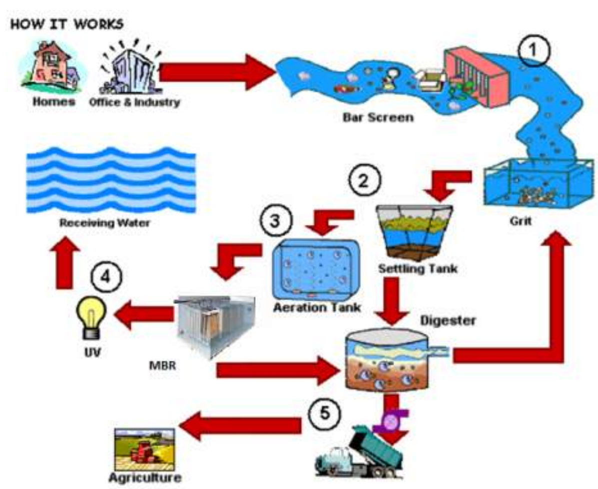

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HISTORY OF THE TRAVERSE CITY REGIONAL WWTP

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- The Traverse City Regional Wastewater Treatment Plant (TCR WWTP) is the City of Traverse City's municipal wastewater treatment facility.
  - The WWTP provides treatment to all commercial and domestic (residential) wastewater.
  - Wastewater from the City of Traverse City and associated townships is pumped to the WWTP.
  - The WWTP treats the wastewater in accordance with its NPDES permit with subsequent discharge into the Boardman River
- Originally constructed in 1932
- The plant was modified and/or expanded in 1959, 1976, 1985, 1994, 1995, and 2004

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WWTP PROJECT LOCATION

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COLLECTION SYSTEM PROJECT LOCATIONS

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WASTEWATER SYSTEM PROJECTS INTRODUCTIONS AND NEEDS

- WWTP Upgrades
- Collection System Upgrades
- Need for Projects
  - Continued NPDES Permit Compliance
  - Infiltration and Inflow in Collection System
  - Aging and Inefficient Headworks and Primary Treatment to Protect Membranes
  - UV Disinfection Upgrades
    - *Required under EGLE Administrative Consent Order (ACO)*

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ALTERNATIVE ANALYSIS

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- No Action Alternative
  - Not considered a favorable option
  - No Action will result in:
    - Continued degradation of existing facilities
      - Potential damage to membranes and other components
    - Increasing difficulty in meeting discharge permit
    - Risk of surface water quality issues
    - Higher energy consumption
    - More costly intervention in the future

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ALTERNATIVE ANALYSIS

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Questions

- Lower Boardman River Sanitary Sewer Improvements
- Addresses old sanitary sewer compromised by subsidence and potential failure of retaining wall

https://www.record-eagle.com/news/local_news/river-wall-scoured-out-connected-to-sewer-line/article_455eaa5c-72d7-11eb-8c4c-ab88ed44d6aa.html

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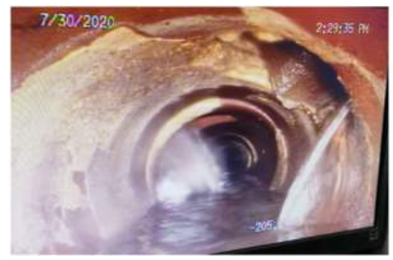
ALTERNATIVE ANALYSIS

- Infiltration & Inflow Removal



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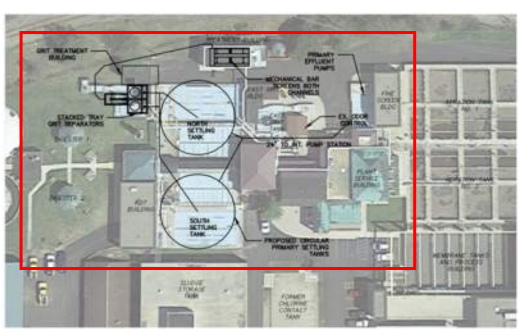
ALTERNATIVE ANALYSIS

- Headworks and Primary Treatment Improvements



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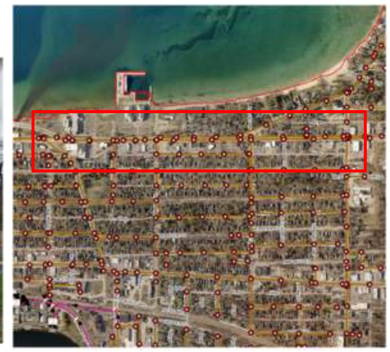
ALTERNATIVE ANALYSIS

- US-31 Sewer Replacement

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ALTERNATIVE ANALYSIS

- East Front Sewer Improvements
  - Between Park and Railroad Avenue


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ALTERNATIVE ANALYSIS

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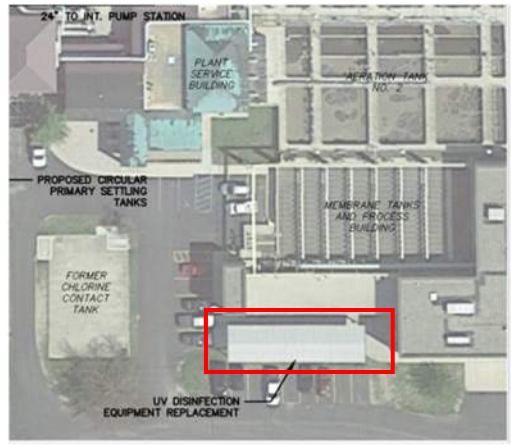
- UV Disinfection Upgrades
- Address EGLE ACO


Current UV Unit



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PROJECT COST ESTIMATES

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Project	Estimated Cost
Lower Boardman River Wall Sanitary Sewer Improvement	$2,853,000
Infiltration and Inflow Removal	$6,064,000
Headworks and Primary Treatment Improvements	$14,544,000
US-31 Sewer Replacement	$416,000
East Front Sewer Improvements	$860,000
UV Disinfection Upgrades	$2,699,000
Total	**$27,492,000**

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PROJECT USER COST ESTIMATES

- Project cost over a 20-year period

Funding Source	Total Cost of Projects	Monthly Cost for Project Per Residential Connection
CWSRF at 2.00%	$27,492,000	$11.68

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IMPACTS OF PROJECT PLAN

- Long-Term Impacts:
  - Positive Impacts
    - NPDES permit compliance
    - Improved efficiency and reliability at the WWTP
    - Ability to continue adequate wastewater treatment and public health protection
    - Improved processing and reduced equipment wear
  - Negative Impacts
    - None anticipated
- Short-Term Impacts:
  - Positive Impacts
    - Increase in jobs, and workers utilizing community amenities and local contractors
  - Negative Impacts
    - Noise, dust, & traffic related to construction

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IMPACTS OF PROJECT PLAN

- Irreversible Direct/Indirect Impacts:
  - Non-recoverable resources (public capital, energy, labor & materials) committed to project are traded off to provide necessary repair and replacement of aging and worn-out structures and equipment
  - Possible construction damage or accidents

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MITIGATION OF IMPACTS

- Mitigation of Long-Term Impacts
  - Activities will prohibit the impact to shoreline, wetlands, floodplains, or other sensitive areas
- Mitigation of Short-Term Impacts related to Construction Activities
  - Comply with any required permits (soil erosion, endangered species, etc.)
  - Follow regulations related to disposal and handling of asbestos containing material, lead paint, and any contaminated soils/groundwater, if encountered

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PROJECT PLAN SCHEDULE

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Task	Completion
Public Hearing Notice	April 15, 2021
Draft Project Plan Available	April 15, 2021
Commission Study Session	May 10, 2021
Formal Public Hearing	May 17, 2021
City Passes Resolution Adopting the Project Plan	May 17, 2021
Submit Final Project Plan to EGLE	by June 1, 2021

HRC

CITY of TRAVERSE CITY MICHIGAN

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WASTEWATER SYSTEM IMPROVEMENT PROJECTS SCHEDULE

Overview

Project Plan

Cost

Impacts

Schedule

Questions

Project	Construction Timeframe
Lower Boardman River Wall Sanitary Sewer	FY 2022
Infiltration and Inflow Removal	FY 2023 to 2026
Headworks and Primary Treatment Improvements	FY 2023
US-31 Sewer Replacement	FY 2024
East Front Sewer Improvements	FY 2024
UV Disinfection Upgrades	FY 2025

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QUESTIONS?

Overview

Project Plan

Cost

Impacts

Schedule

Questions

HRC

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CITY OF TRAVERSE CITY

PUBLIC HEARING

CITY COUNCIL MEETING

MAY 17, 2021

EXCERPT RE: East Eighth Street, Cass Street & Park Street Bridge Rehabilitation Project

DATE: Monday, May 17, 2021

TIME: 7:00 p.m.

LOCATION: Remotely VIA Zoom

CITY COMMISSION MEMBERS:

Mayor Jim Carruthers
Mayor Pro-Tem Amy Shamroe
Commissioner Christine Minervini
Commissioner Timothy Werner
Commissioner Ashlea Walter
Commissioner Lauren Trible
Commissioner Roger Putman
Commissioner Brian McGillivary

CITY STAFF MEMBERS:

Lauren Trible-Laucht, City Attorney
Martin Colburn, City Manager
Benjamin Marentette, City Clerk
Harry Burkholder, Downtown Department Authority Chief Operating officer
Timothy Lodge, City Engineer
Zack Cole, Engineering Department
Art Krueger, Director Municipal Utilities
Liz Hart, Managing Wastewater Treatment Plant
Frank Dituri, Director of Public Services
Jean Derenzy, Downtown Development Authority CEO
Jeff O’Brien, Police Chief
Jim Tuller, Fire Chief
Kelly Martin, City Treasure and Finance Director
Karla Myers-Beman, Traverse City Light and Power Controller
Nicole Vanes, Transportation Mobility Director
Penny Hill, Assistant City Manager
Shawn Winter, Planning Director
Tim Ahrens, Traverse City Light and Power Executive Director

OTHERS PRESENT:

Todd Sneathen, Consultant, Hubbell, Roth, & Clark, Inc.

REPORTED BY: Tulane Woodworth, Hubbell, Roth & Clark, Inc

MR. CARRUTHERS: Public hearing application for clean water state revolving fund loan. Before we open it up and state the rules Mr. Colburn do you have anything introduce today.

MR. COLBURN: Introduces Art Krueger, Municipal Utilities Director. As we have brought forward to you a number of different studies now and as referenced in past communications and particular this last year. Much of our focus has been to study the intricacy and difficulties as well as some of the threats to our water, wastewater, and stormwater. Some of these different studies have now been coming to you and for the record have now been passed on and are being passed on and communicated to the Grand Traverse County Board of Public works as well as recently as our meeting last Thursday. That being said right now this public hearing is in regard to a requirement in a step by EAGL, Michigan Department Quality now EAGL and it is a step in which you authorized us to approve development a project plan by our consultant Hubbell, Roth, & Clark. At this point, I'll turn it over to Mr. Art Krueger.

MR. KRUEGER: Thank you, Marty. I'd like to just mention a few things before I turn it over to our consultant Todd Sneathen to provide the presentation tonight. Little more detail of the overview of the project plans for the clean water state revolving fund. As you know this is EGLE low-interest loan program. Last meeting on the 10th of May I went over some of the highlights of the project plan, kind of introduced it to you then. In my memo, I wanted to bring to light that by passing this resolution it just gives the city the opportunity to be considered for the state funding at a low-interest loan program that is less than bond interest rates so it does not commit the city to complete all the projects that are included in this plan or the timing schedule that is mentioned in this plan. It is a plan that's subject to change and is a 5-year outlook of potential projects that we included to that if we wanted to go for funding we'd have that option if we are chosen through this program. So, with that I'd like to introduce Todd Sneathen he's vice president of Hubbell, Roth, & Clark our consultant engineering firm. He's going to provide a presentation with slides that are in your packet. Thank you.

MR. SNEATHEN: Good Evening. As Art indicated my name is Todd Sneathen I'm the vice president at Hubbell, Roth, & Clark we are a municipal consultant, engineering consulting firm and we with the help of city staff went through and prepared the project plan to develop the needs and priorities of Traverse City. With that being said as part of the public hearing and part of the requirements of the clean water state revolving fund project plan program like to make a brief presentation. Everybody the slides are located in the packet; the council packet and I will walk through those with you at this point. So going to the second page, slide number 2, oops I am sorry. So, the purpose of the public hearing is to present the clean water state revolving fund or CWSRF Project Plan.

MR. COLBURN: Todd we aren't seeing any of the displays yet

MR. MARENTETTE: Is that your intention or are you just referring commissioners to the page’s numbers within the packet for this agenda item?

MR. SNEATHEN: Based on the discussion I was just going to refer to the slides in the packet. I’m happy to share the screen if that would be helpful or really whatever works best.

MR. MARENTETTE: I think you can just refer to the pages in the packet unless someone prefers otherwise.

MR. SNEATHEN: Ok that is what I’ll do. So, slide 2, page 2 of the presentation, the purpose of the public hearing is to present clean water state revolving fund project plan. This provides a forum for community participation to be aware of the different pieces of the project plan which involves the description of the CWSRF loan program, alternatives, project cost, social, and environmental impacts, mitigation of those impacts, schedule for the project, and ultimately public questions. So what is the CWSRF loan program? It provides, as Mr. Krueger said it provides low-interest loans for planning and designing construction eligible wastewater program which is administered by Michigan Environmental Great Lakes and Energy Revolving Loan Section. To qualify for these funds the city must do 3 things. Prepare and submit an EGLE approvable project plan, provide a public hearing, and comment opportunity for the plan and ultimately pass a resolution for adopting the plan. EGLE approval and city acceptance for the loan is decided later in the CWSRF loan program.

Slide 4 is just a very schematic overview of what your existing wastewater treatment plant looks like and that you take waste in. It goes through a number of processes as part of your plant, ultimately is returned to the receiving waters as clean disinfected water or solids are returned to agriculture. Traverse City Regional Wastewater Treatment Plant is a full wastewater facility. It provides treatment for all commercial and domestic wastewater for the city of Traverse City and the associated townships. The wastewater treatment plant treats the wastewater in accordance with the national pollution discharge elimination permit and is subsequently discharged into the Boardman River after it's clean. The plant was original constructed in 1932 and has been modified or expanded multiple times in that time period.

Slide 6 shows an overview of the exciting wastewater treatment plant. Slide 7 is the potential collection system project locations. Which are sewer replacement, sanitary sewer evaluation studies, infiltration studies, and review of the existing pump station.

To introduce the needs of the city in regards to the needs of the plan as I discussed there are several wastewater treatment upgrades, there is collection system upgrades, and why does Traverse City need these projects. They need them to continue to meet your NPDES permits at the wastewater treatment plant. Which is determines what levels of chemicals and quality of water you can discharge. We also be looking at infiltration and inflow into your collection system, it would look at your aging and inefficient headwork which is the very beginning of your plan and primary treatment process, and finally the UV disinfection upgrades which is a function of the EGLE administrative consent order and is required based on the consent order that was signed.

This is a 5-year planning period and as Mr. Krueger said adopting this plan tonight has no bearing on you being required to do any of these projects as they are laid out in this plan. This is just an opportunity to access funding. So, you have to do an alternative analysis for each one of the projects. The first option is to look at no action, this is not considered favorable for a number of reasons the inability to continue to discharge and meet your permit limits, risk of surface water quality issues to Boardman River and ultimately Lake Michigan, higher energy costs through in efficient of the system or plant, then ultimately if nothing was to be done there would significantly more costly in the future to make any upgrades.

Looking at the different projects located slide number 10, first project listed is sanitary sewer replacement in the 100 and 200 blocks front street or also known as the Lower Boardman River Sanitary Sewer Improvements this existing sanitary sewer behind a retaining wall that was built in the 1930s. The plan would be to move this sewer that is currently there into the alley, south end of the alley to allow a number of sanitary sewer leads that are there to be upgraded and reduce the inflow and infiltration into the system.

Next project slide 11 infiltration and inflow removal. This project will help address the sanitary sewer overflow that occurred over the summer of 2022 I’m sorry of 2020 this would be a sanitary sewer evaluation study where a number of different methods would be used to inspect the sewers and also hydraulic model will be developed. Based on that rehabilitation would be done or ultimately replacement there’s a number of options that are available that would be explored as part of the study.

Slide number 12 for an alternative analysis of the headworks and primary treatment improvements. The headworks are the very beginning as water enters the wastewater treatment plant. Be looking at the screening and grit removal at the beginning of the plant which has been a topic of discussion at previous study sessions and also looking at doing further primary treatment to improve the aging of the infrastructure that is currently there.

Slide number 13 would be a project to remove 32 hundred feet of sewer under as part of the US 31 sewer replacement project.

Slide number 14 would be the east front street sewer improvement this would be completed with the DDA streetscape it would include 500 ft of force being replacement and 720 ft of sewer lining to address aging piping that is located in this area. The final project would be a UV disinfection upgrade as part of an administrative consent order that was issued by EGLE to the city in July of 2019. All UV system modifications are required to be completed within one year after signing that administrative consent order. Those modifications were completed and were made. The next phase of the consent order is to do system replacement. The new UV system would be constructed and installed, need to be fully operational no later than July 1, 2026. The existing UV equipment has reached the end of its useful life and the new equipment would be better suited for the current situation and some additional upgrades will be made at that point. With that being said that those are the alternatives.

Moving to slide 16 is project cost assessment each one of the projects have an estimated cost and the total of these 6 projects is $27,500,000.00. These are all preliminary numbers and as we said these

are not a commitment to actually do all this work and bond it for all of this money. We have to do a very basic user cost estimate for what this would mean to the user of the system, project cost which would be paid back over 20 years. Remember this is not an automatic rate increase this is a high-level review of the proposed impact on the rates.
Any additional rate study, I'm sorry an additional rate study would be required as part of the project moving forward with any type of SRF funding which would include significantly more detail than this and as you may recall this $27.5 mill was for all the projects it wouldn't be implemented all at one time there are also some other things that were included in the memo in regard to debt service retirement and that would ultimately change the monthly cost for the users.

Another thing we need to talk about is the impact of the project plans which is slide 18. The long-term impacts of this would ensure permit compliance, improved efficiency and reliability at the wastewater plant, adequate protection of wastewater treatment public health, and improved processing and reduced equipment wear. Negative impacts long term we see none would be anticipated. From a short-term perspective, the positive impacts would be increased jobs and workers utilizing community amenities and also the ability for local contractors to be involved in these projects. Negatively just like any other construction project noise, dust, and traffic-related to construction would be the negative impacts. Slide 19 we need to look at irreversible direct and indirect impacts, nonrecoverable resources would be used for these projects which would include public capital, energy, labor, and materials would be committed but there is a trade-off along with that to provide necessary repair and replacement that aging and worn-out infrastructure and equipment. Another potential issue would be possible construction damage or accident that would occur as part of the project.

Slide 20 so how would we mitigate some of these impacts, mitigation of the long term impacts these activities would provide, will prohibit I'm sorry the impact to the shoreline, natural features, and a number of the other sensitive areas in the Traverse City area. Short term mitigation there would be required compliance with any required permits which include soil erosion, endangered species, building permits, any type of permits that were issued, and ultimately, they would also be required to follow any regulations related to the disposal of hazardous materials such as asbestos, lead paint, and any contaminated soil or groundwater that was encountered.

In order to move forward with this, the project plan had to be developed, public hearing notice, and the draft plan were made available on April 13^{th}. There was a commission study session where we presented the findings on May 10^{th}. Tonight, the formal public hearing on May 17^{th} We would be looking for the city to pass a resolution adopting the proposed project plan at the meeting this evening and ultimately we would be forwarding on the EGLE June $1^{st.}$

This is a slid 22 shows the wastewater treatment schedule as you can see this is stretched out over 5 years this doesn’t tie these projects to these dates but this is where we would anticipate that it may make sense to do them. Infiltration and removal you can see that spread over a number of years because there is a number of locations where that would be done.

With that being said I would like to ask if there are any questions and ultimately if there are any public comments if people could state their name and address for the public record as minutes will need to be kept and become part of the project plan.

MR. COLBURN: This is Martin Colburn City Manager I wanted to address page 19 impacts of the project plan and we talked about referenced the irreversible direct and indirect impacts. What this is really hitting on is risk management. I can assure you that the risk of not maintaining these facilities puts the community and our legal liability at a much higher rate than the risk of not doing it so I just wanted to talk about when we talk about unfortunately when we do any do construction projects there always the safety discussion, processes, the equipment we use but the risk in terms of the damage if we don’t maintain this equipment that it can do not just our facility but to our community and natural resources are much higher, so I just want to point that out that this is really a discussion about risk management and how important these projects are to the community. Thank you.

MR. CARRUTHERS: Thank you Mr. Colburn and thank you, Mr. Sneathen. I’m sure you are sticking around for the public hearing. This is the public hearing on our final plan for the wastewater improvements. Mr. Marentette will you read the rules for our public hearing.

MR MARENTETTE: Yes, as you mentioned Mr. Mayor this is a public hearing regarding the application for the clean water state revolving loan fund and this public hearing once the mayor opens it officially it's an opportunity for the public to express and city commissioners to consider your comments regarding the proposed application and potential adoption of and supporting it. With that Mr. Mayor are you ok with opening the public hearing?

MR. CARRUTHERS: Yes, I open the public hearing.

MR. MARENTETTE: Yes, and when I call on members of the public in the virtual waiting room please indicate comment or pass. If you do have a comment please state your name and address, indicate if you are a city resident, non-city resident, or city business owner and we will begin with caller 8424, 8424 please unmute yourself and *6 comment or pass. 8424 please unmute yourself and *6 and say comment or pass. I know they have been unresponsive in the past but I will as one more time caller 8424 please unmute yourself and *6 and say comment or pass. Looks like they just hung up, so we go on to caller 2842 please unmute yourself and *6 and say comment or pass. Caller Passed. Next, we will turn to Mr. Wagner please say comment or pass. Mr. Wagner comment or pass. Mr. Wagner comment or pass. I will ask a final 3rd time, oh there you are.

Mr. Wagner passed.

Mitchel Treadwell. Mr. Treadwell comment or pass.

Mr. Treadwell no comment, supports this endeavor.

And Next. Yarrow Brown pass

MR. CARRUTHERS: I can close the public hearing. Are there any comments from the commission. Mr. Werner

MR. WERNER: Thank you, Mr. Mayor. Yeah, I'll continue to push on I&I so on page 17 the $11.67 per residential connection per month as far as what potential is the cost, I know it was addressed not necessarily as the cost the more and the sooner we address I&I the more we can drive down that cost and so to me that part of urgency of why we needed to get started on that sooner rather than later. Thank you

MR. CARRUTHERS: Is there any more from the commission? I don’t see any other hands. Mr. Sneathen any final thoughts?

MR. SNEATHEN: No, I appreciate your time tonight and look forward to continue working with the City of Traverse City.

MR. CARRUTHERS: Thank you for your presentation and work with the city. Mr. Colburn do you have anything to add.

MR. COLBURN: Just that the staff will now formally take this to EGLE to go through and finish this process. We will let you know of the final results. But the bottom line is that we present the plan this will make us eligible for a competitive process with the state for the low interest funding.

(Whereupon this excerpt was concluded at 9:23 p.m.)

APPENDIX I: RESOLUTION

City of Traverse City

Office of the City Clerk

GOVERNMENTAL CENTER
400 Boardman Avenue
Traverse City, MI 49684
(231) 922-4480
tcclerk@traversecitymi.gov

CITY of TRAVERSE CITY

TRAVERSE CITY
CITY COMMISSION RESOLUTION

ADOPTION OF A FINAL PROJECT PLAN FOR WASTEWATER IMPROVEMENTS AND DESIGNATION OF AN AUTHORIZED PROJECT REPRESENTATIVE

WHEREAS, the City of Traverse City recognizes the need to make improvements to its existing wastewater treatment and collection system; and

WHEREAS, the City of Traverse City authorized Hubbell, Roth and Clark to prepare a Project Plan, which recommends the construction of Wastewater Improvements; and

WHEREAS, said Project Plan was presented at Public Hearing May 17, 2021 and all public comments have been considered and addressed;

WHEREAS, adoption of the Project Plan and approval of the loan program does not obligate the City to accept any funding that may be approved through the application process, if approved by the State, it allows the City to be a candidate for SRF loan consideration; and

NOW THEREFORE BE IT RESOLVED, that the City of Traverse City formally approves and adopts said Project Plan and Program Application for the Michigan Department of Environment, Great Lakes and Energy State Revolving Fund Loan.

BE IT FURTHER RESOLVED, that the City Manager, a position currently held by Martin Colburn, is designated as the authorized representative for all activities associated with the project referenced above, including the submittal of said Project Plan as the first step in applying to the State of Michigan for a Clean Water State Revolving Fund (CWSRF) Loan to assist in the implementation of the selected alternative.

I, Benjamin Marentette, City Clerk of the City of Traverse City, do hereby certify that the above is a true and correct copy of a resolution adopted at the meeting of the City Commission of the City of Traverse City on May 17, 2021, at which a quorum was present and voted.

Benjamin Marentette, Clerk
City of Traverse City, Michigan

APPENDIX J: GREEN PROJECT RESERVE BUSINESS CASES

HUBBELL, ROTH & CLARK, INC
CONSULTING ENGINEERS SINCE 1915

TO: Kathy Roeder (EGLE)

FROM: Doug Urquhart, PE (HRC)

DATE: May 21, 2021

SUBJECT: Clean Water State Revolving Fund HRC Job No. 20210140
Green Project Reserve Business Cases and Clean Water Plan Business Cases

Attached to this memorandum are the business cases to provide the justification and construction cost estimation for the portions of the City of Traverse City Wastewater Improvements eligible for Green Project Reserve and Michigan Clean Water Plan funding. The projects will include several components to meet the EPA FY 2012 Clean Water State Revolving Loan Fund 10% Green Project Reserve Requirements. The estimated total loan amount is $27,500,000. The total estimated cost of the items eligible for green project reserve are summarized as follows:

Project	Estimated Cost	Project Eligibility
Lower Boardman River Wall Sanitary Sewer (FY 2022)	$2,853,000	• Section 1.2-2: "Wet weather management systems for parking areas including ... bioretention, trees … designed to mimic natural hydrology." • Section 1.2-7: "Restores permanent riparian buffers" and "other natural features, including vegetated buffers or soft bioengineered stream banks."
UV Disinfection Upgrades (FY 2025)	$2,699,000	• Section 3.2.-2: Achieves "greater than a 20% reduction in energy consumption."
Infiltration and Inflow Removal and Management (FY2023 to FY 2026)	$6,1200,00	• Addresses sanitary sewer overflows

Notes:

1. US EPA, "2012 Clean Water State Revolving Fund 10% Green Project Reserve Guidance for Determining Project Eligibility" EPA Website
2. EGLE, "Helping Communities Access Water Infrastructure Funding Webinar (recorded 3/10/21)" EGLE Website

LOWER BOARDMAN RIVER WALL SANITARY SEWER – BUSINESS CASE

This project will address the issues with the sanitary sewer and existing river wall in the 100 and 200 Blocks of Front Street. This river wall supports the original 24-inch concrete sanitary sewer that is constructed adjacent to the Boardman River. River scouring under the wall has cause soil subsidence which cause destabilization of the wall and sanitary sewer. This loss of support can cause pipe segments to drop and increased likelihood of groundwater infiltration and potential breaks. The various sanitary sewer leads are also subject to increased infiltration due to the lower vertical movement of the main.

In summer of 2020, high levels of West Grand Traverse Bay coincided with significant wet weather events causing sanitary overflows upstream of this sewer and releases to the Boardman River. The poor condition of this sewer and high dry weather (groundwater) infiltration contributed to the hydraulic limitations during these storm events which caused the overflows. Rehabilitation of the river wall and relocating the 100 Block sanitary sewer to the alley will address these issues.

Green Infrastructure

Riparian Buffers

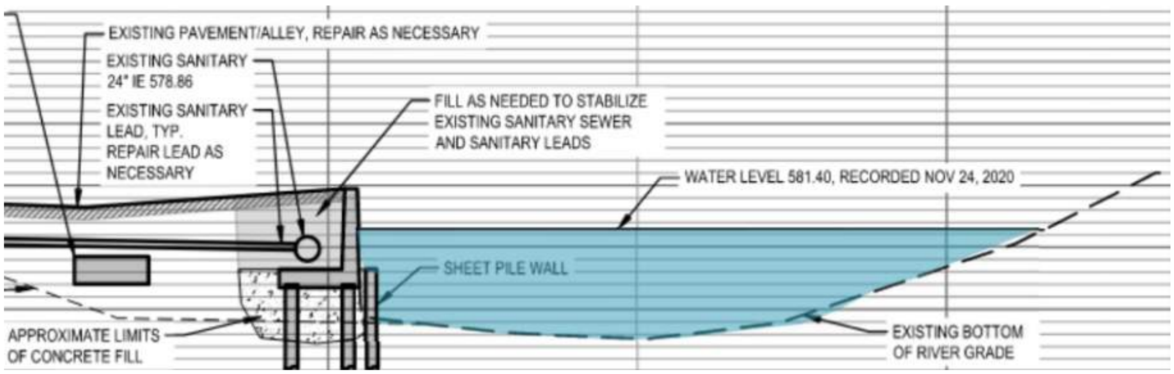
The project components in the 100 Block of Front Street will incorporate the following riverbank improvements:

- Providing public access
- Softening the shore treatment and providing a natural edge
- Reducing the parking near the riverbank
- Utilizing best practices to manage stormwater to improve water quality
- Maintain natural and passive river corridor

Recommended Improvements to the 100 Block Looking East (Courtesy SmithGroup)

Wet Weather Management

High groundwater infiltration has been measured in the sewers to be replaced by the City in 2020 due to high levels of West Grand Traverse Bay. Replacement of the sanitary sewer leads in the 200 block and repairing any compromised sewer leads will address this infiltration. A rain garden will be constructed to manage stormwater from the reduced parking area in the 100 Block.



Recommended Improvements to the 200 Block (Courtesy SmithGroup)

Conclusion

This project will provide riparian buffer and wet weather management and is deemed eligible for GPR funding per the 2012 Clean Water State Revolving Fund 10% Green Project Reserve: Guidance for Determining Project Eligibility:

- Section 1.2-2 as it "Wet weather management systems for parking areas including ... bioretention, trees … designed to mimic natural hydrology."
- Section 1.2-7 as it "Restores permanent riparian buffers" and "other natural features, including vegetated buffers or soft bioengineered stream banks."

Cost

The estimated cost of the project is provided as follows.

River Wall Construction	$2,445,000
Engineering, Legal, Administrative	$408,000
Total Project Cost	**$2,853,000**

ULTRAVIOLET DISINFECTION UPGRADES - BUSINESS CASE

General

The existing ultraviolet disinfection (UV) system is inefficient when compared to proposed newer units. Currently, the UV system is operated without adjusting the lamp power output resulting in over applying the UV dose to achieve the necessary effluent disinfection. Replacing the system with adjustable UV will result in energy savings over the current model.

Energy Reduction

The replacement UV system will have higher efficiency lamps and the ability to adjust the UV lamp dose based on the quality of the wastewater and the effluent flow. The original existing UV system uses four banks of 320 lamps (each 165 W) in two channels that cannot be modulated. The proposed UV system will use two banks of 18 lamps (each 250 W).

The estimated energy reduction for UV disinfection is provided as follows:

Energy Usage (two banks) before Improvements

At 8.5 mgd (average): 320 lamps x 165 W per lamp x 24 hr/d / 1000 W/kW = 1267 kWh/d

At 17 mgd (design): 320 lamps x 165 W per lamp x 24 hr/d / 1000 W/kW = 1267 kWh/d

Energy Usage (two banks) after Improvements

At 8.5 mgd (average): 160 lamps x 200 W per lamp x 24 hr/d / 1000 W/kW = 768 kWh/d

At 17 mgd (design): 160 lamps x 250 W per lamp x 24 hr/d / 1000 W/kW = 960 kWh/d

At the design flow of 17 mgd, the proposed project will reduce the energy consumption from an estimated 1267 kWh/d to 960 kWh/d when comparing the nameplate for the original system versus the proposed UV disinfection. As the lamp power output will be adjusted lower at average flows, the estimated average energy reduction will be greater than 40%.

Conclusion

The upgraded UV system will provide up to 40% average energy reduction in the disinfection energy usage at the WWTP. The project is deemed eligible for GPR funding per the 2012 Clean Water State Revolving Fund 10% Green Project Reserve Guidance for Determining Project Eligibility

- Section 3.2.-2 as it achieves “greater than a 20% reduction in energy consumption.”

Cost

The estimated cost of the new UV system is provided as follows.

UV System Construction	$2,313,000
Engineering, Legal, and Administrative	$386,000
Total Project Cost	**$2,699,000**

INFILTRATION AND INFLOW REMOVAL AND MANAGEMENT - BUSINESS CASE

General

Infiltration and inflow have been a concern in the City which can cause the TCRWWTP to treat low strength waste at a higher cost to rate payers. In addition, the substantial volumes of wastewater during wet weather events which reach the plant are difficult to manage. Nine (9) temporary sewer flow meters and one rain gauge were installed for a period of five months, from April – August 2015. The flow meters were used to identify areas for future condition assessment, to assess the system capacity, as an indicator of current system function, and to help capture the amount of infiltration and inflow in the system. Infiltration and inflow mitigation efforts have been completed on portions of the collection system including sump pump disconnections, sealing manholes, and additional inspections.

During the spring/summer of 2020, the City of Traverse City (City) experienced three major storm events with >50-year frequency which resulted in sanitary sewer overflows (SSOs) at the downstream end of the Boardman River sanitary sewer siphon. In 2020, the City had three SSO events that unfortunately flowed into the Boardman River just upstream from Union Street occurring on May 28, June 10 and July 18, 2020. The estimated total for all events was 57,700 gallons and was reported to EGLE and the Grand Traverse Health Department within several hours after they occurred. All three SSO's occurred shortly after high intensity/short duration rainfall events that recorded between 2.5 to 3 inches of rainfall in 30 minutes to 1 hour duration.

Many of the City's storm sewers are inundated from the impact of record high water levels and cannot drain at their normal capacity. Therefore, during these large storm events, many streets are flooded for extended period of time, allowing more Infiltration & Inflow (I&I) into sewers.

A table showing the SSO and rainfall data is provided as follows:

Rainfall Event	Est. SSO Vol. (gal)	Locations	Duration
5/28/2020	54,000	SSM-1395, SSM-1396, SSM-1397	9
6/10/2020	2,500	SSM-1395, SSM-1396, SSM-1397	2
7/18/2020	1,200	SSM-1395, SSM-1396, SSM-1397	1

Prior to 2020, there had been two previous large scale SSOs. One occurred in September 2000 from 4-inch rainfall over short duration that resulted in a similar SSO into the river just upstream of Union Street (same location). There was no reported volume as it was not able to be determined. In July 1999, a similar SSO into river at the same location and also at the Front St Lift Station which was caused by an approximately 4 to 5-inch rainfall over a 2 hour period.

After the second recent SSO on June 10, 2020 EGLE responded to an email from a concerned resident. A copy of this email is provided below and demonstrates EGLE's support of the City.

Art Krueger <akrueger@traversecitymi.gov>

FW: Traverse City Sewer System
2 messages

Brady, Donal (EGLE) <BradyD6@michigan.gov> Thu, Jun 11, 2020 at 7:07 PM
To: "Riley, Jacob (EGLE)" <RileyJ6@michigan.gov>, Arthur Krueger <akrueger@traversecitymi.gov>, "Hart, Elizabeth/TRA" <Elizabeth.Hart@jacobs.com>
Cc: "Christian, Barry (EGLE)" <ChristianB2@michigan.gov>

Just an FYI. Will try and call you all tomorrow. Keep on keeping on.

Kind Regards,

Donal Brady, P.E.
Environmental Engineer
Water Resources Division / Cadillac District Office
Michigan Department of Environmental, Great Lakes, and Energy
120 West Chapin Street, Cadillac, MI 49601
231-383-5039 cell | BradyD6@michigan.gov
Follow Us | michigan.gov/EGLE

-----Original Message-----
From: Brady, Donal (EGLE)
Sent: Thursday, June 11, 2020 7:06 PM
To: [redacted]
Subject: FW: Traverse City Sewer System

Hello [redacted]

I am one of the Department staff who works with the City of Traverse City and the City's sanitary sewer collection system. Thanks for your email and concern for the environment.

The Department and City were/are extremely disappointed and troubled by the sewer overflow events that occurred recently. The City is very diligent with the operation and maintenance of the sanitary sewer system and wastewater treatment plant. I am confident the City is going to do everything it can to keep future overflows from occurring. It is inaccurate to characterize the recent events as intentional or premeditated.

The overflows were primarily the result of extreme rain storms. The event that occurred at the end of May was due to a 200 year storm (expected to occur once every 200 years) and the event that occurred this week was due to a 50 year storm. A large volume of rain from these storms, entered into, and filled up the sanitary sewers, causing the wastewater (and rain water) to flow out of sewer system and into the river. There is a limit to what sewer systems are designed for. Infrastructure needs to be practical and affordable. The State of Michigan does not require sanitary sewer systems to be designed for 50 year or 200 year storms.

The large rain events that occurred recently and the near record high lake elevations (and corresponding high groundwater elevations) were a double whammy for the City. The City is experiencing high groundwater flows into the sanitary sewer pipes even when it is not raining because of the high lake/groundwater levels. Some groundwater leaks into the old sanitary sewer pipes and some groundwater is pumped into the sewer from building sumps and foundation drains. Unfortunately all of the aging sewer pipes can't be replaced at once and all the sumps/drains can't be disconnected at once. The City continuously works to replace old sewer lines and invests significant dollars every year for sewer replacement/repair.

All that being said, sewer overflows are not allowed and are considered a violation. The goal is to eliminate all sewer overflows. The Department exercises enforcement discretion when the overflows are related to extreme rain events and will continue to do so. The City is investigating where groundwater is entering into the sewers and working to eliminate or reduce these flows. The City also increased the capacity of its sanitary sewer system in response to the recent events. The City and the Department will be closely monitoring the situation this summer and making adjustments and improvements, as needed, in an effort to eliminate the overflows. We are also hoping Traverse City does not receive any more storms this summer that are supposed to occur once in a lifetime.

Kind Regards,

Donal Brady, P.E.
Environmental Engineer
Water Resources Division / Cadillac District Office Michigan Department of Environmental, Great Lakes, and Energy
120 West Chapin Street, Cadillac, MI 49601
231-383-5039 cell | BradyD6@michigan.gov Follow Us | michigan.gov/EGLE

-----Original Message-----

In general, the data shows an approximate 30-year cycle between high and low lake levels for the past 100 years. The red horizontal line represents the average lake level. In 2013, there were near record low levels, but 2020 so far has exceeded the previous 1986 all-time record high levels each month since February. So in just seven years, the level has gone from low to high extremes, which is very fast and unusual compared to the typical 30-year cycles in the past.

This rapid change in lake levels trends with the increase in annual average Wastewater Treatment Plant (WWTP) average daily flows. As the lake levels increased, the average annual WWTP flows also increased indicating that infiltration is increasing as the lake level gets higher. It should be noted that high lake levels correspond to high groundwater levels, which submerge more of the sewer mains increasing infiltration and ultimately flows to the WWTP.

To better understand the sources of high flows, the City purchased four area velocity laser flow meters and installed August 31st, 2020, to further evaluate the flows in the West Front. High dry weather infiltration was observed in two district:

1. Meter District M09 (West Front; 100 feet west of Front Street Lift Station in SSM-1414)
2. Meter District M04 (Parking Lot; at the corner of the building, CCM-1387)

These flows are directly correlated with the high groundwater levels due to the high levels in West Grand Traverse Bay specifically in sewers below the levels of the bay (582.9' NAVD88). CCTV inspections of sewers near Bay Street in August 2020 identified high sources of infiltration from sanitary sewer leads.

An initial hydraulic model simulation of the West Front Street Sewer was developed using SewerGEMS, using the City's GIS shapefiles of the sewers and manholes. The estimated design flows from the flow monitoring study completed as part of the Wastewater AMP in addition to the increased dry weather flows from these events as a result of the high groundwater elevations predict SSOs downstream of this siphon in manholes SSM-1395, SSM-1396, and SSM-1397. This modeling effort confirmed the high wet weather flows over the capacity of the sewer downstream of the Boardman River siphon from the three major storm events caused the overflows at the location of the siphon were due to:

- High infiltration from the elevated water levels of Lake Michigan (WSL 580.5 to 582.9' NAVD88) during these summer events relative to the past monitoring in 2015 (WSL 579.5' to 580.0' NAVD88)
- Significant rainfall events exceeded the capacity of the sanitary sewer downstream of this siphon causing the surcharging and overflow events. The three storms were 50-yr and 150-yr events.

Addressing Sanitary Sewer Overflows

The additional treatment expense of infiltration and inflow equates to approximately $100 per additional one million gallons of wastewater. In one year, this equates to approximately $36,500 for every one million gallons per day.

Although these costs are nominal relative to other expenses, the risks of sanitary sewer overflows has other monetary impacts including discharges to the Boardman River and Grand Traverse Bay that affects public usage, aquatic species, among others.

Cost

The estimated cost of the system is provided as follows.

SSES and Hydraulic Modeling	$200,000
Sanitary Sewer Rehabilitation	$1,720,000
Wet Weather Equalization/Diversion	$4,200,000
Total Project Cost	**$6,120,000**

APPENDIX K: PROJECT PRIORITY LIST (PPL) SCORING DATA FORM

SRF/SWQIF Project Nos. ________________

Project Priority List (PPL) Scoring Data Form

Please complete the information requested below and indicate the page numbers or appendices in the project plan which verify the information provided. Enter "N/A" if information is not pertinent.

PROJECT APPLICANT: City of Traverse City

PROJECT LOCATION: City of Traverse City

1. Water Pollution Severity Data (0 to 500 points)

page 2-27 **1. Pre-project conditions, including wastewater collection/treatment deficiencies and water quality problems currently occurring.**

page 4-1, 6-1 **2. Post-project conditions, including proposed facilities and water quality improvements.**

Does the existing facility (or facilities) being upgraded, expanded, or replaced by this project file either surface water or groundwater discharge monitoring reports?

☐ **YES, Proceed to Section C** **or** ☒ **NO, Proceed to Section A or B**

Note: If a project with either a surface water or groundwater discharge is also causing a nitrate problem in the groundwater (i.e., leaky lagoons), please be sure to complete Item B.5. Projects may receive points for both surface water and groundwater contamination.

A. Data on Existing Surface Water Discharge

page 2-17 **1. Discharge type:**

☒ Continuous

☐ Seasonal

☐ Intermittent ***(if CSO, or SSO, please complete Sections E and F below)***

page 2-20 **2. Flow.** For facilities that discharge to regional treatment plants and do not file surface water discharge monitoring reports, provide the average daily metered flow *(identify whether units are MGD or MGY)*

8.5 MGD (Average Design)
17 MGD (Peak)

page 2-20 **3. Identify Receiving Water and Type** Boardman River (surface)

page 2-3 **4. Location** (*town, range, and section*) Township 27, Range 11, Section 11

page 2-25 **5. Existing Treatment**

☐ Untreated ☒ Secondary ☐ Combined Sewer Overflow ☐ Tertiary

☐ Primary (including septic systems with direct surface water discharge)

page 2-25 **6. Existing Disinfection Process:**

☐ None

☐ Chlorination

☒ Alternative Technology (*specify type*) Ultraviolet Disinfection

B. Data on Existing Groundwater Discharge

page ______ **1. Discharge Type:**

☐ Continuous

☐ Seasonal

☐ Intermittent

page ______ **2. Flow.** For unsewered areas, flow should be calculated using a figure of 70 gpcd. For facilities that do not file groundwater discharge monitoring reports, provide the existing metered flow figure *(identify whether units are MGD or MGY)* ______________________

page ______ **3. Location** (*provide town, range, and section*) ______________________

page ______ **4. Existing Treatment**

☐ Untreated ☐ Primary (including septic with tile field) ☐ Secondary

page ______ **5. Nitrate contamination of public or private wells caused by the discharge of effluent/waste from the treatment system or systems**

☐ Public well(s) in vicinity contains nitrates > 10 mg/L (100 points)

☐ Private well(s) in vicinity contains nitrates > 10 mg/L (75 points)

☐ Monitoring well(s) in vicinity contains nitrates > 10 mg/L (50 points)*

☐ No evidence of nitrate contamination in local wells

*Note: If only the total inorganic nitrogen ("TIN" ammonia + nitrite + nitrate) concentration is available, a separate sampling and nitrate analysis should be performed to document the nitrate concentration.

C. Information on Proposed Surface Water/Groundwater Discharge

(Attach additional pages if necessary; a copy of the effluent limits letter/permit table may suffice.)

page ______ **1. Discharge Type:**

☐ Continuous

☐ Seasonal Identify all discharge points and receiving waters.

☐ Intermittent

page ______ **2. Average Design Flow** *(identify units as MGD or MGY)* ______________________

page ______ **3. Identify receiving water for a surface water discharge** ______________________

page ______ **4. Location** (*town, range, and section*) ______________________

5. List Effluent Limits:

Minimum Dissolved Oxygen ______________________

$CBOD_5$ ______________________

Ammonia ______________________

Phosphorus ______________________

Total Inorganic Nitrogen (TIN) (from Groundwater Permit) ______________________

page ______ **6. Will the proposed facility address <u>documented</u> total residual chlorine (TRC) violations?**

☐ YES, proceed to 7 ☐ NO

7. Will the proposed disinfection improvements involve either dechlorination or an alternative disinfection technology (e.g. ultraviolet disinfection, ozonation) that eliminates the use of chlorine?

☐ YES ☐ NO

D. Data on Existing (<u>Pre-Project</u>) CSO and SSO Discharges

*Information must be provided **for each outfall** directly associated with the proposed correction project.*

Outfall #	Receiving Stream	Location* Town/Range/Section	Estimated Overflow Volume (MG) for 1-year, 1-hour storm event
001			

Outfall #	Estimated Overflow Duration (Hours)	Estimated Annual Overflow Volume (MG)	Tributary Residential Population
001			

* A map showing the discharge locations by number is highly preferable and can be attached to this sheet.

E. Data on Future (<u>Post-Project</u>) CSO and SSO Discharges

List each outfall from Section E. For outfalls which will cease to function as combined sewer outfalls upon the completion of this project, simply enter "Eliminated" under Receiving Stream. *List any new outfalls (e.g., for a retention/treatment basin) created by this project and include its associated discharge data.*

Outfall #	Receiving Stream	Location* Town/Range/Section	Estimated Overflow Volume (MG) for 1-year, 1-hour storm event
001			

Outfall #	Estimated Overflow Duration (Hours)	Estimated Annual Overflow Volume (MG)	Detention Time Prior to Discharge for 1-year, 1-hour storm event
001			

* A map showing the discharge locations by number is highly preferable and can be attached to this sheet.

Please attach additional pages if necessary.

2. Enforcement Actions (0 or 300 points)

Is the proposed project necessary for compliance with a fixed-date construction schedule established by an order, permit, or other document issued by the DEQ, or entered as part of an action brought by the state against a municipality?

☒ **YES, Proceed to Item A** **or** ☐ **NO, Proceed to Section 3**

page 2-27 **A. Copy of the enforcement action, order, permit or other DEQ document.** see attached

3. Population Data (30 to 100 points)

page 2-2 **A. Existing residential population to be served by the proposed project:** 30,492

page 2-2 **B. Existing population of the POTW service area:** 30,492

4. Dilution Ratio (25 to 100 points)

*The data for the dilution ratio scoring category is collected from several questions in the Water Quality Severity Data section of this document and information in DEQ files, therefore, **no action is required from the applicant for the completion of this item of the PPL Scoring Data Form**. The primary purpose of this section is to clarify and document the figures utilized in the dilution ratio calculation. Please note that for new collection system projects, the existing discharge is calculated by multiplying the residential population to be served by the proposed project by 70 gallons per capita per day (gpcd). For projects with existing Groundwater and NPDES permits, the Discharge Monitoring Report (DMR) data will be obtained by the DEQ staff. For projects that discharge to regional facilities and do not have individual discharge permits, the existing discharge will be based on the average daily metered flow.*

The following information will be completed by DEQ staff:

The dilution ratio is _____________ and was calculated from _______________/_____________.

(Specify the units for both the numerator and denominator).

5. Failing On-Site Septic Systems (0 or 100 points)

Does the project propose to correct failing on-site septic systems that have no suitable replacement?

☐ **YES, Proceed to Item A** **or** ☒ **NO, Proceed to Section 6**

page ______ **A. Documentation of site limitations that prevent septic system replacement.**

6. Septage Receiving/Treatment Facilities (0 or 100 points)

Does the project propose to construct, upgrade, or expand a septage receiving or treatment facility?

☐ **YES, Proceed to Item A** **or** ☒ **NO**

page ______ **A. Description of the proposed septage facility improvements.**

STATE OF MICHIGAN

DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

LANSING

EGLE

GRETCHEN WHITMER
GOVERNOR

LIESL EICHLER CLARK
DIRECTOR

July 3, 2019

CERTIFIED MAIL 7014 0150 0001 0740 3632

CITY MANAGER'S OFFICE

JUL - 9 2019

RECEIVED

Mr. Marty Colburn, City Manager
City of Traverse City
400 Boardman Avenue
Traverse City, Michigan 49684

Dear Mr. Colburn:

SUBJECT: Traverse City, Wastewater Treatment Plant (WWTP), Administrative Consent Order (ACO)

Enclosed with this letter, please find one fully executed original of ACO-05357 entered between the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division, and the city of Traverse City. The ACO became effective July 2, 2019.

Provided in Section II, Compliance Schedule, of the ACO is a detailed schedule of the actions the city of Traverse City shall take to comply and prevent violations to Part 41, Sewerage Systems, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Deadlines for each action are specified throughout Section II of the ACO. Should the Traverse City WWTP require a reasonable extension, the city shall adhere to Section IV, General Provisions, Paragraph 13, Extensions, of the ACO.

EGLE appreciates your cooperation and resolution of this matter. Should you have any questions regarding compliance with Michigan's water protection laws, please contact Mr. Jake Riley, Cadillac District Office, at 231-429-3159 or Rileyj6@michigan.gov. If you have any questions regarding the ACO you may contact me at 517-331-6571; schoenk@michigan.gov; or EGLE, P.O. Box 30458, Lansing, Michigan 48909-7958.

Sincerely,

Kailey Schoen

Kailey Schoen, Environmental Quality Analyst
Enforcement Unit
Water Resources Division

Enclosure

cc: Mr. Luis Saldivia, EGLE
Mr. Brian Jankowski, EGLE
Mr. David Pingel, EGLE

**THIS DOCUMENT IS FOR SETTLEMENT DISCUSSIONS ONLY AND
FOIA AND NOT ADMISSABLE IN COURT UNDER MRI**

**STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND EI
WATER RESOURCES DIVISION**

ADMINISTRATIVE CONSENT ORDER

In the matter of:

ACO-05357
Date Entered: 7-2-19

SECTION I

FACILITY OWNER OR MUNICIPALITY

FULL LEGAL NAME OF FACILITY OR MUNICIPALITY City of Traverse City			
DEPARTMENT OF LICENSING AND REGULATORY AFFAIRS IDENTIFICATION NUMBER, if applicable			
ADDRESS 400 Boardman Avenue			
CITY Traverse City	STATE Michigan	ZIP 49684	
AUTHORIZED SIGNATORY Marty Colburn, City Manager			FACILITY OWNER PHONE # 231-922-4440

FACILITY NAME AND LOCATION

FACILITY NAME Traverse City WWTP			
FACILITY ADDRESS 606 Franklin Street			
CITY Traverse City	STATE Michigan	ZIP 49684	
COUNTY Grand Traverse			
FACILITY CONTACT NAME Art Krueger, Director of Municipal Utilities			PHONE # 231-922-4900

Executive Order 2019-06 signed by Governor Gretchen Whitmer on February 20, 2019 renamed the Department of Environmental Quality (DEQ) as the Department of Environment, Great Lakes, and Energy (EGLE). Effective April 22, 2019 a reference to the Department of Environmental Quality (DEQ) will be deemed to be a reference to EGLE. After April 22, 2019 a reference to the director of the DEQ will be deemed to be a reference to the director of EGLE.

This document results from allegations by the Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division (WRD). EGLE alleges that the above-referenced Traverse City Wastewater Treatment Plant (WWTP) is in violation of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), the administrative rules promulgated under this statute, and applicable permits issued to the City of Traverse City, as identified below. The WWTP does not meet the Recommended Standards for Wastewater Facilities referenced by the NREPA.

THIS DOCUMENT IS FOR SETTLEMENT DISCUSSIONS ONLY AND IS EXEMPT FROM FOIA AND NOT ADMISSABLE IN COURT UNDER MRE 408

STATUTE		PERMIT(S)
Part 41, Sewerage Systems, MCL 324.4101 *et seq.*	☒	Permit Number: NA

The City of Traverse City and EGLE agree to resolve the Traverse City WWTP deficiencies set forth herein through entry of this Administrative Consent Order (ACO). This ACO, in its entirety, shall consist of Section I; the attached Sections II, III, and IV; and any other referenced attachments, exhibits, or appendices. This ACO shall be considered null and void if it does not include, at a minimum, Sections I, II, III, and IV.

Signatories

DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Teresa Seidel

Teresa Seidel, Director
Water Resources Division

7/2/19
Date

Marty Colburn, City Manager
City of Traverse City

I undersigned CERTIFY that I am fully authorized by the party identified above to enter into this ACO to comply by consent and to EXECUTE and LEGALLY BIND that party to it. I further attest that all information provided herein is accurate and true.

Marty Colburn
By:

City Manager
Title:

6/19/2019
Date

SECTION II - COMPLIANCE SCHEDULE

IT IS THEREFORE AGREED AND ORDERED THAT THE City of Traverse City shall take the following actions to comply with and to prevent violations of Part 41, Sewerage Systems, of the NREPA.

1. The City of Traverse City (hereinafter "City") shall comply with its National Pollutant Discharge Elimination System Permit (NPDES) number MI0027481 (NPDES Permit), issued and effective November 16, 2016, and expiring October 1, 2019; and the City shall comply with any NPDES Permit that is reissued to the City,

2. Not later than six (6) months of the effective date of this ACO, the City shall submit to EGLE, WRD, a Part 41 permit application for proposed modifications to the Traverse City WWTP's existing ultraviolet (UV) disinfection system. The modifications to the UV system were proposed by the City in the UV system evaluation report submitted to the WRD in November 2017, and also in a May 21, 2018, electronic correspondence to the WRD. The proposed UV system modifications include:

   a. Raising the UV system electrical equipment out of the wastewater flow channel and sealing the electrical components. Non-water tight electrical equipment will be raised at least 12 inches above the top of the UV channel concrete. The electrical equipment for at least six UV modules or lamp banks will be raised.

   b. Raising the electrical conduits associated with the raised UV modules at least 12 inches above the top of the UV channel concrete.

   c. Relocating the weir plates in the UV channel (that function to maintain upstream levels and prime on the membrane bioreactor back pulse pumps) to the permeate discharge structure.

   d. Raising the permeate discharge structure rim or top of concrete (TOC) at least 1.1 feet above its current elevation.

3. Not later than one (1) year after EGLE, WRD issues the Part 41 Permit for the UV system modifications listed in item II.2 above, the City shall construct the UV system modifications, in accordance with the Part 41 Permit.

4. Once the existing UV system modification is complete and until a new UV system is installed and operational, the City will operate the existing UV system with a minimum of six UV modules operating simultaneously.

5. Once the existing UV system modification is complete, until a new UV system is installed and operational, and whenever the flow through the existing UV system exceeds 9.8 million gallons per day (MGD), the City will monitor the water elevation in the UV flow channel relative to the top or highest elevation of the UV module lamps (the top of lamp

elevation is understood to be 593.13 feet above mean sea level relative to the NAVD 88 datum). The water elevations will be monitored manually by personnel or automatically with an electronic device. If the City installs an electronic device for monitoring water elevation, installation of the device will be included in the Part 41 permit application submitted in accordance with II.2 above.

6. Once the existing UV system modification is complete, until a new UV system is installed and operational, and whenever the water elevation in the existing UV channel exceeds the top or highest elevation of the UV module lamps, the City will complete the following:

   a. Report the water above the top lamp elevation as a discharge of partially treated sewage and test the affected waters for *Escherichia coli* in accordance with Part I.A.4. of the NPDES Permit

   b. Collect and analyze the outfall samples for fecal coliform. The samples will be collected during the period of time when the water level in the UV channel is above the top of the lamps. At least one sample per day shall be collected. The sample results will be included in the calculation and reporting of values on the City's Discharge Monitoring Reports, as required in Part II.C.4. of the NPDES Permit.

7. Not later than December 31, 2024, the City shall submit an application to EGLE, WRD for a Part 41 permit for a new UV disinfection system meeting the design standards referenced, at the time of application, by Part 41, Sewerage Systems, of the NREPA, MCL 324.4101 *et seq.*, and the administrative rules promulgated thereunder being 2012 AACS R 299.2901 *et seq.*, as amended.

8. Not later than July 1, 2026, the City shall complete the construction/installation of the new UV system in accordance with the Part 41 Permit issued by EGLE, WRD and be fully operational. Upon receipt of the approved Part 41 permit, the City will construct the new UV system listed in item II.7 above.

9. If prior to October 1, 2024, new recreational water quality criteria for pathogen indicators, other than fecal coliform or *Escherichia coli*, are incorporated into Michigan's surface water quality standards (established by Part 31, Water Resources Protection, of the NREPA, MCL 324.3101 *et seq.* and the administrative rules promulgated thereunder being 2006 AACS R 323.1041 *et seq.*, as amended), the City will evaluate the receiving water (the Boardman River) relative to the new water quality standards, if requested by EGLE, WRD.

Sections III and IV of this ACO shall not be altered in any way, including adding or eliminating any language, striking terms or parts of terms, retyping in whole or in part, or using a different format. Any changes to this document without written approval from EGLE renders the ACO null and void.

SECTION III - STIPULATIONS

The City and EGLE stipulate as follows:

1. EGLE reserves all rights afforded to it under the law or laws under which this ACO is being entered. EGLE is authorized to enter this ACO to comply with state law under Section 3112(4) of Part 31 of the NREPA.

2. The City consents to the issuance and entry of this ACO and stipulates that the entry of this ACO constitutes a final order of EGLE and is enforceable as such under the appropriate provisions of state law identified in Section I this ACO. The City agrees not to contest the issuance of this ACO, and that the resolution of this matter by the entry of this ACO is appropriate and acceptable. It is also agreed that this ACO shall become effective on the date it is signed by the director of the WRD, delegate of the director of EGLE.

3. The City and EGLE agree that the signing of this ACO is for settlement purposes only and does not constitute an admission by the City that the law has been violated.

4. The Signatory to this ACO on behalf of the City agrees and attests that it is fully authorized to assure that the City will comply with all requirements under this ACO.

5. The City shall achieve compliance with the aforementioned regulations in accordance with the requirements contained in Section II of this ACO.

SECTION IV – GENERAL PROVISIONS

1. With respect to any violations not specifically addressed and resolved by this ACO, EGLE reserves the right to pursue any other remedies to which it is entitled for any failure on the part of the City to comply with the requirements of the NREPA and its rules. Entry of this ACO does not relieve the City from future liability for the potential need to conduct remedial actions if contaminants originating from the discharge are discovered at limits that exceed the criteria under applicable law. EGLE further expressly reserves the right to pursue the City for injunctive relief and costs associated with overseeing and conducting these remedial actions.

2. EGLE and the City consent to enforcement of this ACO in the same manner and by the same procedures for all final orders entered pursuant to the provisions of the NREPA.

3. This ACO in no way affects the City's responsibility to comply with any other applicable state, federal, or local laws or regulations.

4. The WRD reserves its right to pursue appropriate action, including injunctive relief to enforce the provisions of this ACO and applicable statutory fines for any violation of this ACO.

5. Nothing in this ACO is or shall be considered to affect any liability the City may have for natural resource damages caused by the City's acts or omissions. The State of Michigan does not waive any rights to bring an appropriate action to recover such damages to the natural resources.

6. In the event the City sells or transfers the facility, it shall advise any purchaser or transferee of the existence of this ACO in connection with such sale or transfer. Within 30 calendar days, the City shall also notify the WRD District Supervisor, in writing, of such sale or transfer, the identity and address of any purchaser or transferee, and confirm the fact that notice of this ACO has been given to the purchaser and/or transferee. The purchaser and/or transferee of this ACO must agree, in writing, to assume all of the obligations of this ACO. A copy of that agreement shall be forwarded to the WRD District Supervisor within 30 days of assuming the obligations of this ACO.

7. The provisions of this ACO shall apply to and be binding upon the parties to this action and their successors and assigns.

8. This ACO constitutes a civil settlement and satisfaction as to the resolution of the violations specifically addressed herein; however, it does not resolve any criminal action that may result from these same violations.

9. REPORTING
The City shall verbally report any violation(s) of the terms and conditions of this ACO to the WRD District Supervisor by no later than the close of the next business day following detection of such violation(s) and shall follow such notification with a written report within five business days following detection of such violation(s). The written report shall include a detailed description of the violation(s), as well as a description of any actions proposed or taken to correct the violation(s). The City shall report any anticipated violation(s) of this ACO to the above-referenced individual in advance of the relevant deadlines whenever possible.

10. RETENTION OF RECORDS
Upon request by an authorized representative of EGLE, the City shall make available to EGLE all records, plans, logs, and other documents required to be maintained under this ACO or pursuant to applicable laws or rules. All such documents shall be retained by the City for at least a period of three years from the date of generation of the record unless a longer period of record retention is required by the applicable law or its rules.

11. RIGHT OF ENTRY
The City shall allow any authorized representative or contractor of EGLE, upon presentation of proper credentials, to enter upon the premises of the facility at all reasonable times for the purpose of monitoring compliance with the provisions of this ACO. This paragraph in no way limits the authority of EGLE to conduct tests and inspections pursuant to the NREPA and the rules promulgated thereunder, or any other applicable statutory provision.

12. EGLE APPROVAL OF SUBMITTALS
For any work plan, proposal, or other document, excluding applications for permits or licenses, that are required by this ACO to be submitted to EGLE by the City, the following process and terms of approval shall apply:

a. All work plans, proposals, and other documents required to be submitted by this ACO shall include all of the information required by the applicable statute and/or rule, and all of the information required by the applicable paragraph(s) of this ACO.

b. In the event EGLE disapproves a work plan, proposal, or other document, it will notify the City, in writing, specifying the reasons for such disapproval. The City shall submit, within 30 days of receipt of such disapproval, a revised work plan, proposal, or other document that adequately addresses the reasons for EGLE's disapproval. If the revised work plan, proposal, or other document is still not acceptable to EGLE, EGLE will notify the City of this disapproval.

c. In the event EGLE approves with specific modifications, a work plan, proposal, or other document, it will notify the City, in writing, specifying the modifications required to be made to such work plan, proposal, or other document prior to its implementation and the specific reasons for such modifications. EGLE may require the City to submit, prior to implementation and within 30 days of receipt of such approval with specific modifications, a revised work plan, proposal, or other document that adequately addresses such modifications. If the revised work plan, proposal, or other document is still not acceptable to EGLE, EGLE will notify the City of this disapproval.

d. Upon EGLE approval, or approval with modifications, of a work plan, proposal, or other document, such work plan, proposal, or other document shall be incorporated by reference into this ACO and shall be enforceable in accordance with the provisions of this ACO.

e. Failure by the City to submit an approvable work plan, proposal, or other document, within the applicable time periods specified above, constitutes a violation of this ACO and shall subject the City to the enforcement provisions of this ACO.

f. Any delays caused by the City's failure to submit an approvable work plan, proposal, or other document when due shall in no way affect or alter the City's responsibility to comply with any other deadline(s) specified in this ACO.

g. No informal advice, guidance, suggestions, or comments by EGLE regarding reports, work plans, plans, specifications, schedules, or any other writing submitted by the City will be construed as relieving the City of its obligation to obtain written approval if and when required by this ACO.

13. EXTENSIONS

The City and EGLE agree that EGLE may grant the City a reasonable extension of the specified deadlines set forth in this ACO. Any extension shall be preceded by a written request to the WRD District Supervisor no later than ten business days prior to the pertinent deadline and shall include:

a. Identification of the specific deadline(s) of this ACO that will not be met.

b. A detailed description of the circumstances that will prevent the City from meeting the deadline(s).

c. A description of the measures the City has taken and/or intends to take to meet the required deadline.

d. The length of the extension requested and the specific date on which the obligation will be met.

No change or modification to this ACO shall be valid unless in writing from EGLE and, if applicable, signed by both parties.

14. TERMINATION

This ACO shall remain in full force and effect until terminated by a written Termination Notice (TN) issued by EGLE. Prior to issuance of a written TN, the City shall submit a request consisting of a written certification that the City has fully complied with the requirements of this ACO and has made payment of any fines, including stipulated penalties, required in this ACO. Specifically, this certification shall include:

a. The date of compliance with each provision of the compliance program in Section II, and the date any fines or penalties were paid.

b. A statement that all required information has been reported to the WRD district supervisor.

c. Confirmation that all records required to be maintained pursuant to this ACO are being maintained at the facility.

EGLE may also request additional relevant information. EGLE shall not unreasonably withhold issuance of a TN.

APPENDIX L: PROJECT PLAN SUBMITTAL FORM

Michigan Department of Environment, Great Lakes, and Energy
Gretchen Whitmer, Governor
Liesl Eichler Clark, Director

http://www.michigan.gov/egle

Clean Water Revolving Funds
SRF/SWQIF Project Plan Submittal Form

Name of the Project CWSRF Wastewater Improvements	**Applicant's Federal Employer Identification Number (EIN)** 386027348
Legal Name of Applicant (The legal name of the applicant may be different than the name of the project. For example, a county may be the applicant for bonding purposes, while the project may be named for the particular village or township it serves.) City of Traverse City	**Areas Served by this Project** Counties Grand Traverse, Leelanau Congressional Districts 1st
Address of Applicant (Street, P O Box, City, State & Zip) 400 Boardman Avenue PO Box 592 Traverse City, MI 49686	State Senate Districts 35, 37 State House Districts 101, 104
NPDES Permit Number (if permit holder) MI0027481	**Associated SAW Grant Number** (if applicable) 1442-01
Brief Description of the SRF/SWQIF Project Wastewater improvements within the City of Traverse City Wastewater Treatment Plant and throughout the collection system including: Lower Boardman River Wall Sanitary Sewer, Primary Treatment Improvements, UV Disinfection Update, I&I Removal, East Front Street Sewer Improvements, and a US-31 Utility Replacement.	
Disadvantaged Community Determination ☐ The applicant is requesting a disadvantaged community determination, and a completed *Disadvantaged Community Status Determination Worksheet* is attached. Determination completed	
Estimated Total Cost of the SRF/SWQIF Project $27,492,000.00	**SRF/SWQIF Construction Start Target Date** March 2022
Name and Title of Applicant's Authorized Representative Marty Colburn, City Manager	
Address of Authorized Representative (if different from above)	**Telephone** (231) 922-4440 **E-Mail Address** mcolburn@traversecitymi.gov
Signature of Authorized Representative Marty Colburn	**Date** 5/20/21
Joint Resolution(s) of Project Plan Adoption/Authorized Representative Designation is attached. **check here** ☑	

A final project plan, prepared and adopted in accordance with the Department's *Clean Water Revolving Funds (SRF and SWQIF) Project Plan Preparation Guidance*, must be submitted by July 1st in order for a proposed project to be considered for placement on a Project Priority List for the next fiscal year. Please send your final project plan with this form to:

WATER INFRASTRUCTURE FINANCING SECTION
FINANCE DIVISION
MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
P O BOX 30457
LANSING MI 48909-7957

APPENDIX M: PROJECT COST ANALYSIS CERTIFICATION FORM

Project Useful Life and Cost Analysis Certification Form

Project Information

Applicant Name: City of Traverse City

SRF Project to be Funded: Wastewater Improvements

Per Section 602(b)(13) of the Federal Water Pollution Control Act (FWPCA), all Clean Water State Revolving Fund (CWSRF) assistance recipients must certify that they have conducted the studies and evaluations described in 602(b)(13)(A) and (B), collectively known as a cost and effectiveness analysis.

☒ 1) The applicant has studied and evaluated the cost and effectiveness of the processes, materials, techniques, and technologies for carrying out the proposed project or activity for which assistance is sought under the CWSRF; and

☒ 2) The applicant has selected, to the maximum extent practicable, a project or activity that maximizes the potential for efficient water use, reuse, recapture, and conservation, and energy conservation, taking into account the cost of:
- constructing the project or activity;
- operating and maintaining the project or activity over the life of the project; and
- replacing the project or activity.

☒ 3) The applicant has completed a Project Useful Life analysis for the project or activity. **Attach appropriate documentation**

I certify that requirements (1), (2), and (3) as checked above have been met.

Douglas I. Urquhart

Name of Professional Engineer *(Please Print or Type)*

Douglas Urquhart 5/17/21

Signature of Professional Engineer Date

Martin A. Colburn, City Manager

Name and Title of Authorized Representative *(Please Print or Type)*

Martin A. Colburn 5/20/21

Signature of Authorized Representative Date

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

Lower Boardman River Wall Sanitary Sewer
Present Worth Calculations

CAPITAL COST		CAPITAL COST	SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	1,430,167	50	$	614,000
Structural	$	1,013,250	50	$	435,000
Mechanical/Electrical	$	-	20	$	-
TOTAL CAPITAL COST	**$**	**2,443,417**		$	1,049,000
INTEREST DURING CONSTRUCTION				$	98,000
Assumes 2 year interest at 2.0%					
ANNUAL OPERATION AND MAINTENANCE COST					
ANNUAL O, M & R COST (NON-ENERGY)		$	(13,140)		
PRESENT WORTH OF OM&R COST (NON ENERGY)				$	(256,000)
ANNUAL O, M & R COST (ENERGY)		$	(34,164)		
PRESENT WORTH OF OM&R COST (ENERGY)				$	(619,000)
ANNUAL VALUE OF SAVINGS ON LABOR		$	-	$	-
PRESENT WORTH				**$**	**272,000**
AVERAGE ANNUAL EQUIVALENT COST				**$**	**14,000**

Notes:

(1) Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

(2) Assumes reduction in 250 gpm in infiltration at $100 per MG (non-fixed non-energy)

(3) Assumes reduction in 250 gpm in infiltration at 2600 kWh per MG (ex. energy to treat and convey) at $0.1 per kWh

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

Headworks and Primary Treatment Improvements
Present Worth Calculations

CAPITAL COST		CAPITAL COST	SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	366,659	50	$	157,000
Structural	$	2,655,735	50	$	1,140,000
Mechanical/Electrical	$	9,442,056	20	$	9,442,000
TOTAL CAPITAL COST	**$**	**12,464,449**		$	10,739,000
INTEREST DURING CONSTRUCTION Assumes 2 year interest at 2.0%				$	498,000

ANNUAL OPERATION AND MAINTENANCE COST				
ANNUAL O, M & R COST (NON-ENERGY)	$	121,825		
PRESENT WORTH OF OM&R COST (NON ENERGY)			$	2,374,000
ANNUAL O, M & R COST (ENERGY)	$	14,262		
PRESENT WORTH OF OM&R COST (ENERGY)			$	258,000
ANNUAL VALUE OF SAVINGS ON LABOR	$	-	$	-
PRESENT WORTH			**$**	**13,869,000**
AVERAGE ANNUAL EQUIVALENT COST			**$**	**712,000**

Notes:

[1] Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

[2] Assumes $0.01 per kWh

Estimated O, M &R (Non-Energy)

Headworks	
HVAC at Headworks	$13,826
Bar Screens & W-C	$1,175
Primary metering	$400
Screen and Washer Compactor	$1,375
Total O&M Cost for Headworks	**$16,776**

Grit Removal	
HVAC	$737
Labor	$16,640
Power	$442
Downstream Equip Wear	$25,090
Total O&M Cost for Grit Removal	**$42,909**

Primary Settling	
Mechanism Operation (tank down every 4 years)	$12,416
Total O&M Cost for New Primary Settling	**$12,416**

Primary Effluent Pumping	
Pump replacement (every 5 years)	$27,800.00
Same	$3,540.00
Submersible Pump Lubrication	$11,480.00
Electrical	$1,000.00
OM Labor (pull one pump each year)	$5,904.00
Total O&M Cost for Primary Effluent Pumping	**$49,724**

Total O, M, & R for Headworks and Primary Treatment **$121,825**

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

Sewer Rehabilitation (I/I Alternative 1)
Present Worth Calculations

CAPITAL COST		CAPITAL COST	SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	1,473,000	50	$	632,000
Structural	$	-	50	$	-
Mechanical/Electrical	$	-	20	$	-
TOTAL CAPITAL COST	**$**	**1,473,000**		$	632,000

INTEREST DURING CONSTRUCTION Assumes 2 year interest at 2.0%			$	58,000

ANNUAL OPERATION AND MAINTENANCE COST

ANNUAL O, M & R COST (NON-ENERGY) [2]	$	(13,140)		
PRESENT WORTH OF OM&R COST (NON ENERGY)			$	(256,000)
ANNUAL O, M & R COST (ENERGY) [3]	$	(16,819)		
PRESENT WORTH OF OM&R COST (ENERGY)			$	(305,000)
ANNUAL VALUE OF SAVINGS ON LABOR	$	-	$	-
PRESENT WORTH			**$**	**129,000**
AVERAGE ANNUAL EQUIVALENT COST			**$**	**7,000**

Notes:

(1) Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

(2) Assumes reduction in 500 gpm in infiltration at $50 per MG (non-energy)

(3) Est. reduction in 500 gpm in infiltration at 640 kWh per MG (ex. non-fixed electrical to treat and convey) at $0.1 per kWh

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

Lift Station and FM
Present Worth Calculations

CAPITAL COST		CAPITAL COST	SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	1,200,000	50	$	515,000
Structural	$	-	50	$	-
Mechanical/Electrical	$	2,400,000	20	$	2,400,000
TOTAL CAPITAL COST	**$**	**3,600,000**		$	2,915,000
INTEREST DURING CONSTRUCTION Assumes 2 year interest at 2.0%				$	144,000
ANNUAL OPERATION AND MAINTENANCE COST					
ANNUAL O, M & R COST (NON-ENERGY)			$ 25,000		
PRESENT WORTH OF OM&R COST (NON ENERGY)				$	487,000
ANNUAL O, M & R COST (ENERGY)		(2)	$ 17,820		
PRESENT WORTH OF OM&R COST (ENERGY)				$	323,000
ANNUAL VALUE OF SAVINGS ON LABOR			$ -	$	-
PRESENT WORTH				**$**	**3,869,000**
AVERAGE ANNUAL EQUIVALENT COST				**$**	**199,000**

Notes:

(1) Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

(2) Assume pump station with average flow of 2 MGD at 100' TDH, 67% efficiency, reduction in energy at Front Street pum

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

Retention Basin
Present Worth Calculations

CAPITAL COST		CAPITAL COST	SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	3,120,000	50	$	1,339,000
Structural	$	-	50	$	-
Mechanical/Electrical	$	480,000	20	$	480,000
TOTAL CAPITAL COST	**$**	**3,600,000**		$	1,819,000
INTERREST DURING CONSTRUCTION				$	144,000
Assumes 2 year interest at 2.0%					

ANNUAL OPERATION AND MAINTENANCE COST

ANNUAL O, M & R COST (NON-ENERGY)	(2)	$	100,000		
PRESENT WORTH OF OM&R COST (NON ENERGY)				$	1,948,000
ANNUAL O, M & R COST (ENERGY)	(3)	$	142		
PRESENT WORTH OF OM&R COST (ENERGY)				$	3,000
ANNUAL VALUE OF SAVINGS ON LABOR		$	-	$	-
PRESENT WORTH				**$**	**3,914,000**
AVERAGE ANNUAL EQUIVALENT COST				**$**	**201,000**

Notes:

(1) Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

(2) Assumes routine tank cleaning and odor control

(3) Assume pump station with average flow of 1000 gpm at 20' TDH, 67% efficiency, 250 hours per year

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

UV Disinfection Update
Present Worth Calculations

CAPITAL COST		CAPITAL COST	SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	-	50	$	-
Structural	$	-	50	$	-
Mechanical/Electrical	$	2,311,767	20	$	2,312,000
TOTAL CAPITAL COST	**$**	**2,311,767**		$	2,312,000
INTEREST DURING CONSTRUCTION				$	92,000
Assumes 2 year interest at 2.0%					

ANNUAL OPERATION AND MAINTENANCE COST

ANNUAL O, M & R COST (NON-ENERGY)	$	5,000		
PRESENT WORTH OF OM&R COST (NON ENERGY)			$	97,000
ANNUAL O, M & R COST (ENERGY) [2]	$	(18,250)		
PRESENT WORTH OF OM&R COST (ENERGY)			$	(330,000)
ANNUAL VALUE OF SAVINGS ON LABOR	$	-	$	-
PRESENT WORTH			**$**	**2,171,000**
AVERAGE ANNUAL EQUIVALENT COST			**$**	**111,000**

Notes:

[1] Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

[2] Assumes 500 kWh per day reduction at $0.1 kWh per day

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

US-31 Reconstruction - Utility Replacement
Present Worth Calculations

CAPITAL COST		CAPITAL COST		SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	354,360		50	$	152,000
Structural	$	-		50	$	-
Mechanical/Electrical	$	-		20	$	-
TOTAL CAPITAL COST	**$**	**354,360**			$	152,000
INTEREST DURING CONSTRUCTION Assumes 2 year interest at 2.0%					$	14,000
ANNUAL OPERATION AND MAINTENANCE COST						
ANNUAL O, M & R COST (NON-ENERGY)			$	-		
PRESENT WORTH OF OM&R COST (NON ENERGY)					$	-
ANNUAL O, M & R COST (ENERGY)			$	-		
PRESENT WORTH OF OM&R COST (ENERGY)					$	-
ANNUAL VALUE OF SAVINGS ON LABOR		[2]	$	(3,000)	$	58,000
PRESENT WORTH					**$**	**224,000**
AVERAGE ANNUAL EQUIVALENT COST					**$**	**11,000**

Notes:

[1] Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

[2] Assumes reduction in sewer maintenance with removal of sewer (2 hr per month)

City of Traverse City
CWSRF Project Plan
Wastewater System Improvements

East Front Sewer Improvements
Present Worth Calculations

CAPITAL COST		CAPITAL COST	SERVICE LIFE (YEARS)		PRESENT WORTH[1]
Civil / Site Work	$	735,876	50	$	316,000
Structural	$	-	50	$	-
Mechanical/Electrical	$	-	20	$	-
TOTAL CAPITAL COST	**$**	**735,876**		$	316,000
INTEREST DURING CONSTRUCTION Assumes 2 year interest at 2.0%				$	30,000

ANNUAL OPERATION AND MAINTENANCE COST

ANNUAL O, M & R COST (NON-ENERGY)	$	-		
PRESENT WORTH OF OM&R COST (NON ENERGY)			$	-
ANNUAL O, M & R COST (ENERGY)	$	-		
PRESENT WORTH OF OM&R COST (ENERGY)			$	-
ANNUAL VALUE OF SAVINGS ON LABOR [2]	$	(3,000)	$	58,000
PRESENT WORTH			**$**	**404,000**
AVERAGE ANNUAL EQUIVALENT COST			**$**	**21,000**

Notes:

[1] Cost is based on a study period of 20 years and a discount rate of 0.25%.
Present Worth Costs are based on Straight Line Depreciation and no inflation.

[2] Assumes reduction in sewer maintenance with removal of sewer (2 hr per month)