Jacobs

Challenging today.
Reinventing tomorrow.

Operations Management
and Facilities Services

Traverse City, Michigan

2021-2022
Annual Report

Jacobs

Contents

Exhibits

Appendix A

A message from Mark Huggard, your new Jacobs project manager

It's hard to believe our partnership between the City of Traverse City and Jacobs formed 33 years ago to operate and maintain your wastewater treatment plant (WWTP), lift stations and industrial pretreatment program (IPP). We are honored in the trust you have placed in us and look forward to the years to come thanks to the recent 10-year contract renewal.

The 2021-2022 contract year was an important year. I officially took on the project manager role, succeeding Liz Hart in October, and I look forward to building on the thriving environment she created for our staff so that the plant continues to be operated and maintained to the highest standard.

Operation and maintenance (O&M) of your WWTP is accomplished by 15 full-time members, and with Jacobs as your partner, you have access to more than 60,000 professionals worldwide. In fact, we logged 1,911 additional hours of support from regional specialists at no additional cost to the City.

As always, we emphasize safety and promote safe behavior among our team members. We are proud to report that our team worked more than 1,070 days without a recordable injury. This is a testament to our company's and our team's dedication to keep each other safe on the job.

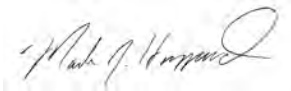
In addition to serving as your partner and caring for your facilities, we are excited to be a part of the vibrant Traverse City community. During the past year we:

- Volunteered on Earth Day by planting trees with the Grand Traverse Conservation District
- Held a public open house at the Traverse City Regional Wastewater Treatment Plant (TCRWWTP)
- Volunteered at the Paddle Antrim event, something we've volunteered for since 2016
- Picked up trash and removed snow along the TART trail and Hall Park
- Made financial donations to each of these nonprofits: Paddle Antrim, Inland Seas and Grand Traverse Bay Watershed
- Worked with Michigan Science, Technology, Engineering and Mathematics (MiSTEM)

In recognition of these efforts, Jacobs awarded us a Teamwork Award for Community Involvement, and we are so proud to receive this notoriety.

Our plans looking ahead to 2022-2023 and beyond include the TCRWWTP rooftop solar and battery energy storage project and the second-annual Innovation Workshop.

On behalf of our team, thank you, once again, for putting your trust in us, and we look forward to continuing this relationship for many years to come.



Mark Huggard
Project Manager

Timeline of project accomplishments and equipment installation and upgrades

1900

1932
- Added four inside settling tanks
- Added digesters #1 and #2

1959
- Added west grit chamber
- Added digesters #3 and #4

1976
- Added east grit chamber
- Added four outside settling tanks
- Installed aeration basin

1985
- Added sludge storage building and pumps

EARLY 1990s
- Selected Jacobs for TCRWWTP operation
- Expanded contract to include IPP; discharge permit issued to industrial users
- Added influent screening
- Installed fiberglass covers helping contain odors

LATE 1990s
- Received second place for U.S. Environmental Protection Agency (U.S. EPA) IPP Excellence Award
- Completed the $1.5 million WWTP upgrade
- Added ultraviolet (UV) disinfection

Happy 90th birthday!

2022 marked the 90th anniversary of the TCRWWTP's completion. When this facility was built to improve both public health and environmental protection, the Great Depression was in full swing; scotch tape and sliced bread made their debuts; and the ballpoint pen and microwave oven hadn't been conceived. A lot has changed since 1932, and as your provider for the last 33 of those years—and next 10 through our renewal—we're honored to be a part of this journey through the past, present and future.

2000

2001
- Added activated carbon system

2004
- $31 million plant upgrade including newest, largest membrane bioreactor (MBR) in North America (both upgrades designed by Jacobs)
- Received the Michigan Water Environment Association (MWEA) Health and Safety Award
- Modified aeration basin
- Added membranes
- Added digester #5

2006
- Received the American Council of Engineering Companies (ACEC) Engineering Excellence Award
- Received the ACEC and Society of Professional Engineers Eminent Conceptor Award for Engineering

2007
- Received the U.S. EPA Region 5 Best Operated and Maintained Facility Award

2012
- Signed new 5-year agreement with the City

2013
- Upgraded fiberglass odor ducts

2015
- Worked with GE water technologists and operating team to replace and upgrade three membrane filtration units in the MBR

2016
- Renewed partnership with the City to operate and maintain TCRWWTP and lift stations

2017
- Oversaw replacement of screw pump and trough reconditioning; and oversaw upgrade of Traverse Bay Academy (TBA) lift station, replacement of the membrane cassettes in train 4, and cleaning and condition assessment of digester 3

2018
- Replaced the cassettes in train 3, upgraded one programmable logic controller (PLC) at the WWTP and at Front Street lift station and replaced the piston pump in the west biosolids storage building with two progressive cavity pumps

2019
- Jacobs Operator Lane Peterson received the MWEA Operator of the Year Award
- Received, in conjunction with the City, the MWEA Large Facility Safety Award

2020
- Replaced and installed the seventh and eighth trains of new membranes
- Completed the pump replacement project at the Riverine lift station
- Collaborated with Michigan State University and Arizona State University to monitor the spread of COVID-19 by detecting its presence in wastewater

2021
- Completed UV project per Administrative Consent Order (ACO) requirements, completion of the digester 3 rehabilitation and the replacement of the eighth and original membrane train cassettes

2022
- Upgraded administration building heating, ventilation and air conditioning (HVAC) system
- Engineering studies at Front Street, Birchwood Bay Street and Riverine lift stations
- Completed interim repairs to primary header
- Refurbished third membrane system scour air blower

Our team

Jacobs has staffed the TCRWWTP for 33 years, with a 10-year contract renewal recently signed. Our team is dedicated to strong principles, a solid work ethic and our longstanding, positive working relationship with the City. We take pride in our work, operating and maintaining your 8.5-million-gallons-per-day (mgd) WWTP, utility systems, 9 lift stations and 8 autosamplers—positioned at each of the townships for the purpose of tracking their individual biochemical oxygen demand (BOD) loadings to the facility—in addition to our other permitted programs, which include: IPP accredited laboratory and National Pollutant Discharge Elimination System (NPDES).

Saying goodbye to longtime project manager Liz Hart

After a long career in the industry and with Jacobs, Liz Hart officially retired. While we are sad to say goodbye, Liz created an excellent working environment—with both the City and the staff—that will be sustainable for years to come.

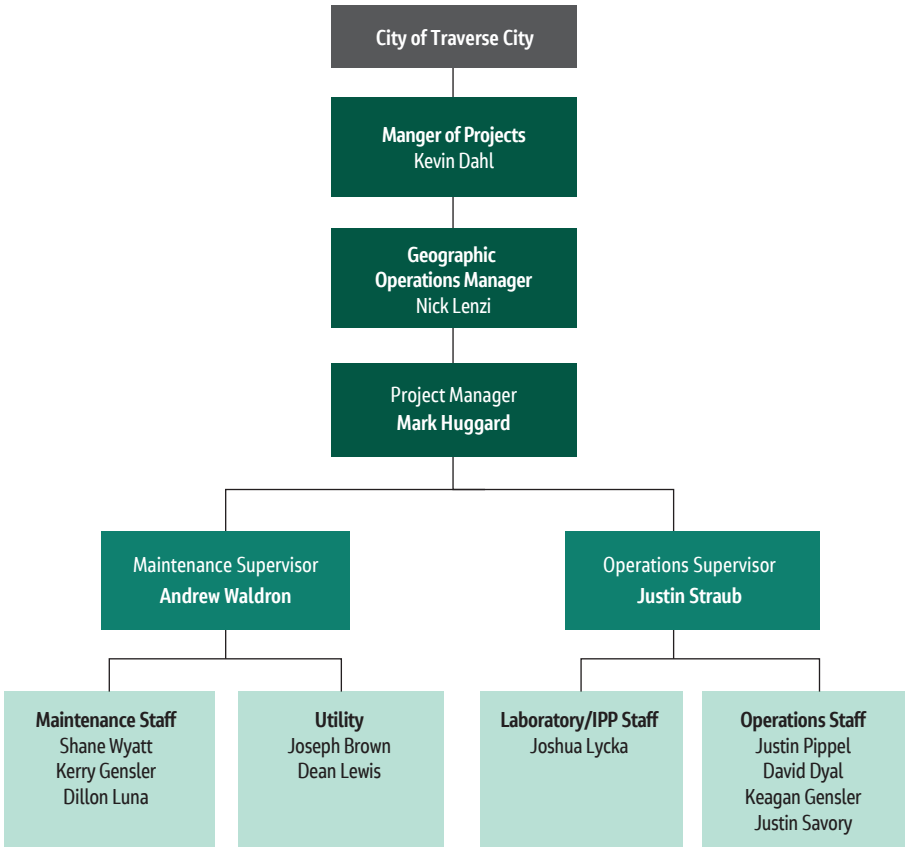
Welcoming Mark Huggard as new project manager

Jacobs' services to Traverse City are guided by Project Manager Mark Huggard who brings 21 years of experience in water and wastewater treatment O&M as well as collection systems. Of the 21 years in the industry, Mark has worked 17 years at the TCRWWTP.

Mark is joined by Maintenance Supervisor Andrew Waldron, who has 7 years of industry experience, and Operations Supervisor Justin Straub, who has 5 years of industry experience. Mark, Andrew and Justin possess the vision, experience and training to lead Traverse City into the future. Exhibit 1 illustrates our organizational structure; Exhibit 2 displays our teammates' names, roles, years of experience and applicable licenses and/or certifications.

Our team

Exhibit 1
Organizational chart



Our team brings Traverse City more than 150 years of combined experience.

Exhibit 2
Our experienced and knowledgeable team

Name and title	Years of experience	Education, certifications and/or licensure
Kevin Dahl Manager of Projects	24	**Degrees:** Bachelor's civil engineering; master's environmental engineering **Certifications:** New England Water Environment Association Class IV Wastewater Collection Systems Operator, Certified Maintenance Reliability Technician (CMRT), Certified Reliability Leader (CRL), Connecticut Class IV Wastewater Treatment Operator and Rhode Island Class IV Wastewater Treatment Operator
Nick Lenzi Geographic Operations Manager	10	**Degree:** Bachelor's mathematics **Certifications:** Wastewater Operator Class 1, Illinois EPA Collections Operator, CRL
Mark Huggard Project Manager	21	**Degree:** Associate degree water environmental technologies **Certifications:** Wastewater A, L1 and L2 and CMRT
Andrew Waldron Maintenance Supervisor	7	**Certifications:** CMRT, CRL, Water Resource Recovery Technician (WRRT), CAT1 Mobius Vibration Analyst
Justin Straub Operations Supervisor	5	**Degree:** Bachelor's biology/conservation and natural resource use **Certification:** Wastewater C
Josh Lycka Operator/IPP Coordinator	5	**Degree:** Bachelor's natural resource management **Certifications:** Wastewater A and CMRT
Justin Pippel Operator	2	**Degree:** Bachelors earth science and biology
Rick Shaw Operator	7	**Certification:** CMRT
Zack Niec Operator	5	**Degree:** Bachelor's environmental science
David Dyal Operator-in-Training	1	N/A
Keagan Gensler Operator-in-Training	1	N/A
Justin Savory Operator-in-Training	1	N/A
Shane Wyatt Mechanic	20	**Certification:** CMRT
Kerry Gensler Mechanic	16	**Certification:** CMRT
Dillon Luna Mechanic	1	**Certifications:** CMRT, boiler maintenance, fork truck and loader, arial platform lifts and crane rigging
Joseph Brown Utility Worker	32	**Certification:** Michigan Wastewater License B
Dean Lewis Utility Worker	1	**Degree:** Bachelor's in forestry **Certification:** HAZWOPER

Increased certifications and licenses

During the past contract year, two of our teammates increased their certifications. Operations Supervisor Justin Straub received his Class C wastewater license, and IPP Coordinator Josh Lycka received his Class A wastewater license.

Training

Our people are our greatest asset. Training and continuous improvement are integral to Jacobs' approach to caring for and developing our people, so they can deliver the best service to Traverse City. We provide our people with regular training in leadership, project management, health and safety, fiscal management, compliance, sustainability, technical best practices and innovation, communications, reporting and employee growth and development.

Jacobs also conducts specialized and practical training with the goal of maintaining and advancing the skills and competency of our staff. Well-trained and knowledgeable operators, technicians and specialists manage facilities more efficiently, achieve and sustain regulatory compliance and maximize equipment life.

Our staff has focused on the areas of safety, process control and asset management/maintenance systems. Jacobs recognizes the importance of training our people, because it increases their knowledge base. It also builds their skills—and with that—their confidence and involvement.

Encouraging our team members to cultivate their professional skills and aim higher is what Jacobs is all about. We reward aspiration, and we value kindness—creating a workplace people enjoy and an environment where respect for one another is the norm.

At Jacobs, managers and supervisors are encouraged to continue their professional development. Leaders and high-potential staff participate in quality and leadership training each year.

We conducted over 110 hours of training topics onsite during 2021-2022.

Examples of Jacobs training courses offered

- Water technology
- Anti-harassment and non-discrimination
- Chlorinator maintenance
- Workplace security
- Pump and motor maintenance
- Confined space entry
- Utility management
- Compliance and reporting
- Daily Safety Topics
- Land application of biosolids
- Occupational Safety and Health Administration (OSHA) 30-hour training
- Working alone standard
- OSHA HAZWOPER 8, 24 and 40
- Smith system driving
- Code of conduct
- Hand and power tools
- Respect in the workplace
- Machine guarding
- Cyber security
- Hand safety
- Safety accountability
- Lock out/tag out
- Conscious inclusion
- Drum handling
- Active shooter
- Electrical safety
- Forklift safety
- Ergonomic awareness
- Fire extinguisher
- Personal protective equipment (PPE)
- Accident prevention plan
- National Fire Protection Association (NFPA) 70 Arc Flash Safety
- BeyondZero safety observations
- Ladder safety
- American Red Cross Adult First Aid, cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED)
- Hazardous communication
- Overhead crane
- Bloodborne pathogens
- Ethics and business conduct
- Defensive driving

Access to regional and nationwide support resources

As always, Jacobs has access to some of the top professionals in their respective fields via our large network of more than 60,000 employees. These people are a phone call, instant message or e-mail away and can assist with any immediate need, either for the site or for Traverse City. Jacobs also operates nearly 300 facilities with a combined water and wastewater treatment capacity of 1.2 billion gallons per day (gpd) daily across our sites. Our integrated resources allow us to support you in a variety of ways. When you hired Jacobs, you hired a vast and expansive knowledge base. Providing the highest quality of service to you is our priority.

During this reporting period, the site team tapped into the array of talent available within the Jacobs family. Support personnel from throughout our firm contributed technical expertise and shared insights to help us better use the equipment and personnel we have here.

Examples of regional and nationwide support services included:

- The Jacobs regional maintenance group migrating the site's asset condition assessment data to a new software platform that we used to conduct our three-year condition assessment; assisting with preventive and corrective maintenance during staffing shortages in fall of 2021; and expediting the W3 water delivery system, which substantially lowered our water usage
- The Jacobs technical services group assisted with migrating the plant data to the new Hach WIMS platform from Op10
- The Jacobs compliance group provided support and guidance related to the IPP, laboratory, NPDES reporting and biosolids land application during this reporting period

Being able to tap into our company's larger resource pool supports the onsite team and helps assure your facility has appropriate staffing and technical resources.

Hach WIMS system—what is it?

This database serves as a repository for all facility operational and compliance data. Information from the field and the laboratory are entered into the database and from this single data source, our team can make process calculations, generate regulatory reports and create graphs and tables revealing status trends in our operations. Data is then analyzed and measured how closely we are achieving plant-specific process performance targets. The objective is to have our team run the TCRWWTP, not the TCRWWTP run them.

This is the largest, and perhaps, the only companywide process control monitoring system in the U.S., according to Hach, who was instrumental in creating this unique system. Once a week, scores are calculated and measured on how close each team is to achieving controllable process targets using the process and compliance data recorded in Hach WIMS. Rollup reports are automatically sent to project staff, Jacobs regional process and management teams and Jacobs O&M senior leadership. Direct access to the data management software allows the City to "mine" the database for specific data, as desired. Periodic reports will also provide the City with a quick summary of how the facilities are performing regarding the discharge permits and how individual processes are performing.

Access to regional and nationwide support resources

Exhibit 3 shows hours of regional support from technical, operations and business personnel in the North and throughout Jacobs. Regional experts help guide vital operations activities. Jacobs technical, operations and business resources support efficiency and success at Traverse City.

Hours of additional support by the numbers

603
Administrative support

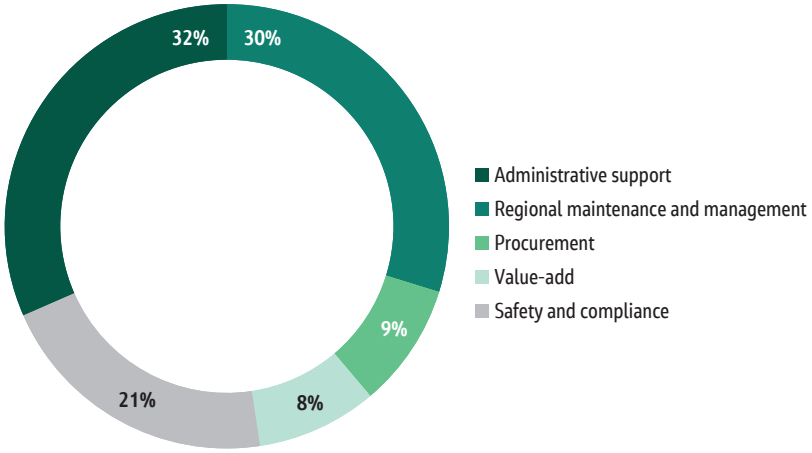
569
Regional maintenance and management

398
Safety and compliance

173
Procurement

168
Value-add

Exhibit 3
Jacobs regional support enhances service and quality without additional cost.



Jacobs logged 1,911 additional labor hours by regional specialists at no additional cost to Traverse City.

OPERATIONS SUPPORT AND OPTIMIZATION. Process control and troubleshooting, repairs, performance testing, quality management and system improvement. Adjustments and improvements that reduce variable costs, benchmarking against a database of more than 100 similar facilities and developing/communicating process data for client review and input.

INFORMATION SYSTEMS. Support for maintenance data management, treatment process control systems and performance trending.

MAINTENANCE AND ASSET MANAGEMENT. Condition assessments using proprietary software; determining facility asset operating longevity, life-cycle cost and risk; and estimating repair and replacement costs and capital replacement costs.

SAFETY. Safety training, job safety analysis, performance data tracking and regulatory reporting.

FINANCIAL, MANAGEMENT AND BUSINESS SYSTEMS. Analysts, project controls personnel and contracts and financial specialists help maintain cost stability, support financial data management and reporting, assess operating risk and develop operating budgets.

COMPLIANCE. Regulatory compliance specialists assess permits and help with permit renewal, assist with compliance plans and address compliance and regulatory challenges.

Value-added services

Our commitment to high-quality service is reinforced by the extra support we seek to provide. Value-added services benefit **Traverse City,** as Jacobs self-performs certain upgrades or major maintenance activities with onsite staff—and using our regional maintenance team at reduced hourly rates—as compared to third-party contractors. Additional benefits include reduced interruptions or equipment downtime achieved by minimizing the time and resources required to complete projects.

Ferric chloride storage tank pipe

Our Jacobs team is proud to provide value-added services and improvements to enhance your TCRWWTP. For example, the ferric chloride storage tank withdrawal pipe repair. Unfortunately, the project experienced delays due to contractor availability in addition to receiving an extremely high estimate totaling more than $10,000. **Jacobs devised and implemented a plan to complete the repair safely and for less than $1,000.**

Sieve drum concentration connection

Through an OOS agreement with the City, we connected the plant effluent water to our sieve drum concentrator system, thereby reducing the use of city water.

Front office renovation

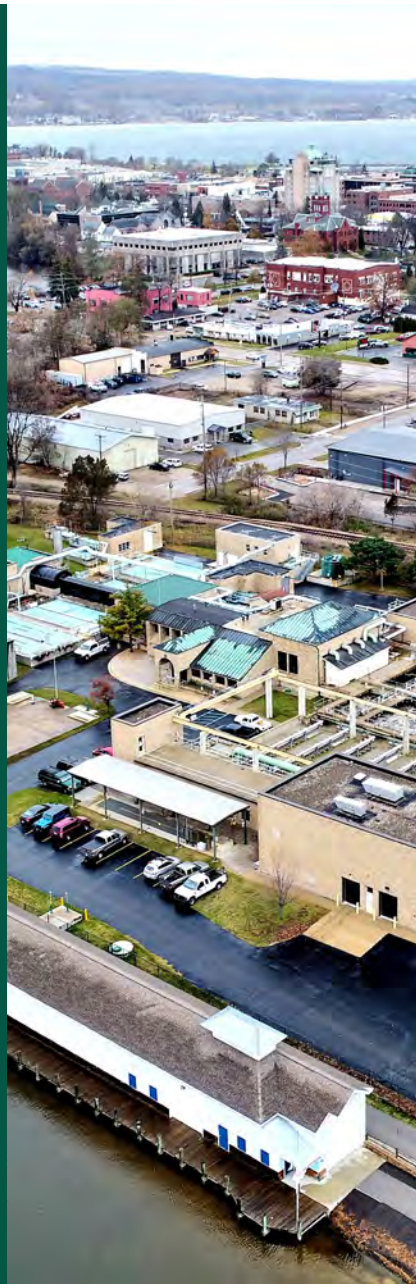
In fall 2021, we renovated the front office at no cost to the City.

Operations and maintenance

Our Jacobs team provides O&M services for Traverse City's 8.5-mgd TCRWWTP. The following key operating facts for July 1, 2021-June 30, 2022, are as follows:

Key operating facts

- **Total wastewater treated July 1, 2021-June 30, 2022** – 1.8 billion gallons
- **Total reclaimed water produced** – 28 million gallons (mg)
- **Land-applied biosolids October 1, 2021-September 30, 2022:**
  - **Total gallons** – 5.1 mg
  - **Total dry tons** – 1,040
- **Average flow per day** – 4.8 mgd
- **Peak flow** – 9.4 mg
- **Preventive/corrective/safety work orders completed** – 4,591
- **Recordable injuries** – 0
- **Exceptional pollutant removal efficiency (%):**
  - **BOD** – 99% equating to removal of over 3.5 million pounds
  - **Total suspended solids (TSS)** – 99.5% equating to removal of over 3.2 million pounds
  - **Ammonia (NH3)** – 99.5% equating to removal of over 400,000 pounds (only permitted for half of the year)
  - **Phosphorus (PO4)** – 92.6% equating to removal of over 75,000 pounds



Serving and protecting Traverse City for 33 years

Jacobs began our partnership with Traverse City in 1990 to help address the ever-increasing plant operations and regulatory compliance challenges. Since then, our onsite staff has applied knowledge and technical skills to save energy, produced higher-quality water, reduced wear and tear and extended the useful equipment life.

During this time, Jacobs and Traverse City have built a solid partnership, maintained the TCRWWTP and helped promote a healthier and safer community. Traverse City's wastewater facilities are part of the Jacobs' family of well-managed, well-supported O&M projects. Jacobs is committed to continuous improvement, and we look forward to continuing our relationship for years to come.

Operations and maintenance

Operations activities 2021-2022

WASTEWATER TREATMENT PRODUCTION AND ACTIVITIES

1 Influent Screening (added in 1994) Wastewater passes through a quarter-inch automatic screen to remove rags, plastic bags, toys, etc. Screenings are disposed of in a sanitary landfill. Influent is measured by parshall flume.

2 Grit removal (west grit chamber 1959, east grit chamber 1976) Grit (heavy, sandy, settleable material) is settled from wastewater. Grit is disposed of in a sanitary landfill.

3 Settling tanks (primary clarifiers) – four inside tanks (1932), four outside tanks (1976) Primary sedimentation removes the settleable solids, which are pumped to the anaerobic digesters for treatment. Materials that float (fats, oils and grease [FOG]) are mechanically skimmed from the surface.

4 Fine screens (added in 2004) Two-millimeter perforated plate screens (holes about the size of the lead in a wooden pencil) remove small debris and fiber. Fine screenings are disposed of in a sanitary landfill.

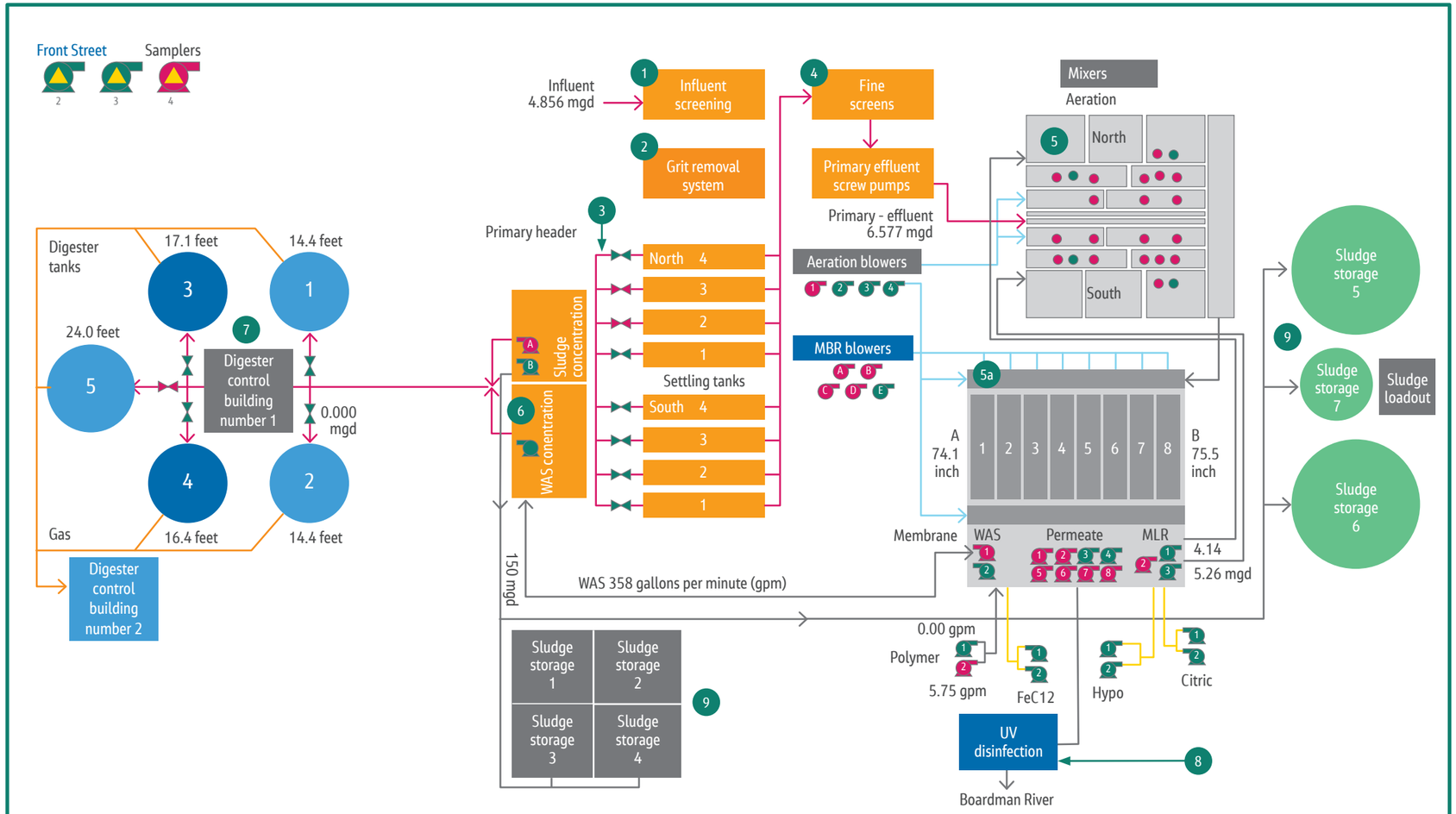
5 5a Aeration and membrane process (MBR) – aeration basin originally installed in 1976, last modified in 2004, membranes added in 2004 The MBR is a pairing of biological treatment with a membrane separation process. In the aeration basins, aerobic and facultative microorganisms consume the dissolved pollutants remaining in the wastewater after primary sedimentation. The aeration basins are divided into compartments where treatment biology is subject to conditions favorable for bacterial uptake of nitrogen and phosphorus. Ferric chloride can be added to precipitate phosphorus that may not be removed biologically. The mixture of water and microorganisms then flows to the membrane tanks. There, water is withdrawn from the treatment biology by pulling it through membranes having a pore size smaller than bacteria. Automatic air scour, back pulse and chemical cleanings keep membranes from fouling. Pumps recirculate the concentrated microorganisms (return activated sludge [RAS]) from the downstream end of the membrane vessels back to the aeration basins.

6 Waste activated sludge (WAS) The population of microorganisms in the MBR constantly grows in proportion to the number of pollutants it removes from the wastewater. The excess biology, WAS, is removed from the system. WAS is dosed with polymer coagulant and concentrated in a gravity belt concentrator (concentrated waste activated sludge [CWAS]).

7 Digester tanks (anaerobic digestion) – digesters #1 and #2 1932, digesters #3 and #4 1959, digester #5 2004 Solids removed from the treatment processes (FOGs, primary sludge and CWAS) are stabilized creating a sludge that is suitable for land application. This process generates a gas mixture that is mostly methane, which the plant burns as a fuel. Digested sludge is dosed with a polymer coagulant and concentrated in sieve drum concentrators (concentrated digested sludge [CDS]).

8 UV disinfection – added in 1995 The treated water from the membrane process is then introduced into the disinfection system where UV light destroys any present pathogens making the water safe for discharge to the Boardman River.

9 Sludge storage (biosolids storage) – building and pumps added in 1985 CDS (biosolids) is stored in tanks having a total capacity of 3.05 mg. Biosolids are hauled and subsurface injected in to farm fields. Around 4.5 mg are injected annually containing roughly 940 tons of biosolids (dry basis).



Primary tank.

Aeration 5.

Digester #7.

Operations and maintenance

The Traverse City wastewater treatment facility achieved a compliance rate of 100% with the NPDES permit.

Exhibit 4 illustrates plant performance compared to permit requirements. Exhibit 5 displays TCRWWTP percent removals versus the NPDES permit requirement. Exhibit 6 shows plant effluent maximum monthly average CBOD and TSS concentrations versus the NPDES permit monthly average concentration requirements. Exhibit 7 shows plant effluent maximum monthly average nutrient concentrations versus the NPDES permit monthly average concentration requirements. Exhibit 8 displays plant effluent minimum DO concentration versus the NPDES permit requirement. Exhibit 9 illustrates plant effluent maximum and minimum pH values versus the NPDES permit limits. Exhibit 10 shows the plant effluent maximum seven-day fecal coliform geomean versus the NPDES permit effluent requirement. Exhibit 11 shows the plant effluent maximum mercury concentration versus the NPDES permit mercury concentration requirement. And Exhibit 12 illustrates the plant effluent maximum copper concentration versus the NPDES permit copper concentration requirement.

Exhibit 4

Plant performance compared to permit requirements

Parameter description	Effluent permit limit	Plant effluent quality	Importance
Carbonaceous biochemical oxygen demand (CBOD) is the measure of the amount of pollutants in present.	85% removal/monthly average concentration of 25 milligrams per liter (mg/L)	91% removal/maximum monthly average concentration <2 mg/L (refer to Exhibits 5 and 6)	When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen available in the water is consumed by the bacteria. Since less DO is available in the water, fish and other aquatic organisms may not survive.
TSS are the measure of material suspended in a known volume of water that is trappable in a filter.	85% removal/monthly average concentration of 30 mg/L	99% removal/maximum monthly average concentration <1.0 mg/L (refer to Exhibits 5 and 6)	High TSS in water can block sunlight, decreasing the growth of vegetation in water ways, even killing of vegetation. This vegetation produces the DO needed to support life in a body of water. Reduced vegetation would impact the health and growth of other organisms, such as fish. In addition, the decrease in water clarity caused by TSS can affect the ability of fish to see and catch food. Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease and prevent egg and larval development.
Total phosphorus (TP) is the measure of organic and inorganic phosphorus compounds in water.	Monthly average concentration of 0.5 mg/L	Maximum monthly average concentration 0.5 mg/L Note: The addition of ferric chloride is used to remove total phosphorus from the wastewater. To reduce the expense of purchasing ferric chloride, we monitor the concentration of total phosphorus in the plant effluent closely and only add ferric chloride as needed to meet the permit requirement. (refer to Exhibit 7)	Phosphorus is an essential element for plant life, but when there is too much of it in water, it can speed up eutrophication (a reduction in DO in water bodies caused by an increase of mineral and organic nutrients).
Ammonia nitrogen (NH3-N) is the measure of the amount of ammonia, which is a toxic pollutant often found in landfill leachate and in waste products, such as sewage, liquid manure and other liquid organic waste products.	Monthly average concentration of 11 mg/L (May 1 - September 30)	Maximum monthly average concentration <1 mg/L (refer to Exhibit 7)	NH3-N in excess of recommended limits is toxic to humans and other organisms.

Parameter description	Effluent permit limit	Plant effluent quality	Importance
DO is the measure of the amount of oxygen in water.	DO concentration limit (September 1-May 31) 4 mg/L and DO concentration limit (June 1 - August 31) 6 mg/L	Plant effluent minimum DO concentration 7.0 mg/L (refer to Exhibit 8)	Low DO primarily results from excessive algae growth caused by phosphorus. This can result in insufficient amounts of DO available for fish and other aquatic life. Die-off and decomposition of submerged plants also contributes to low DO.
pH is the measure of how acidic/basic water is.	Minimum pH limit 6.5 standard units (s.u.)/ maximum pH limit 9 s.u.	Minimum pH value 6.8 s.u./ maximum pH value 7.3 s.u. (refer to Exhibit 9)	Extremes in pH can make a waterways inhospitable to life. Acidic water also speeds the leaching of heavy metals harmful to fish.
Fecal coliform alone are typically not pathogenic; they are indicator organisms, which means they may indicate the presence of other pathogenic bacteria.	Plant effluent fecal coliform seven-day geomean limit 200 counts/ 100 milliliters (mls)	Plant effluent fecal coliform maximum seven-day geomean <1 counts/100 mls (refer to Exhibit 10)	The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals.
Mercury	Required to monitor and report mercury concentrations monthly. Further requirements are triggered if effluent results exceed 5 nanograms per liter (ng/L)	Plant effluent maximum concentration <0.5 ng/L (refer to Exhibit 11)	Mercury in excess of recommended limits is toxic to aquatic organisms, wildlife and humans.
Copper	Monthly average concentration requirement	Plant effluent maximum concentration 6.7 micrograms per liter (ug/L) (refer to Exhibit 12)	Copper in excess of recommended limits is toxic to aquatic organisms, wildlife and humans.

Operations and maintenance

Exhibit 5

2021-2022 TCRWWTP percent removals versus NPDES permit requirement

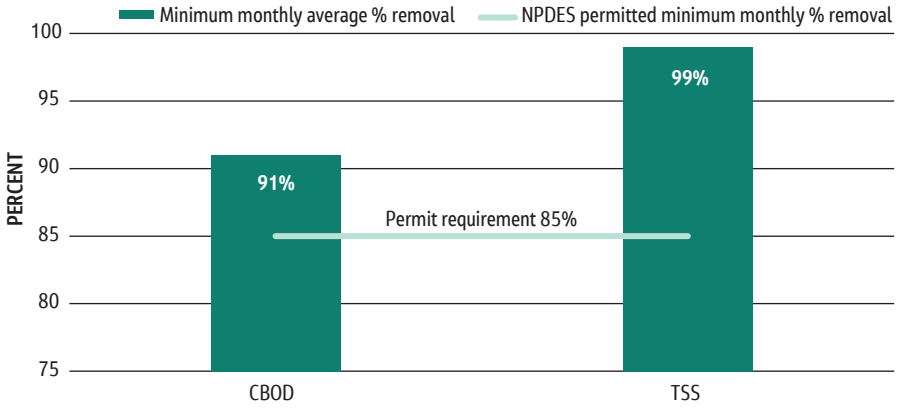


Exhibit 6

2021-2022 plant effluent maximum monthly average CBOD and TSS concentrations versus NPDES permit monthly average concentration requirements

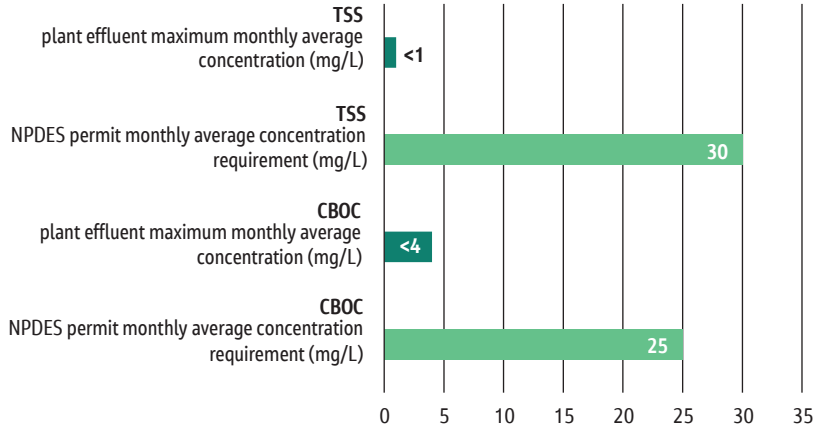


Exhibit 7

2021-2022 plant effluent maximum monthly average nutrient concentrations versus NPDES permit monthly average concentration requirements

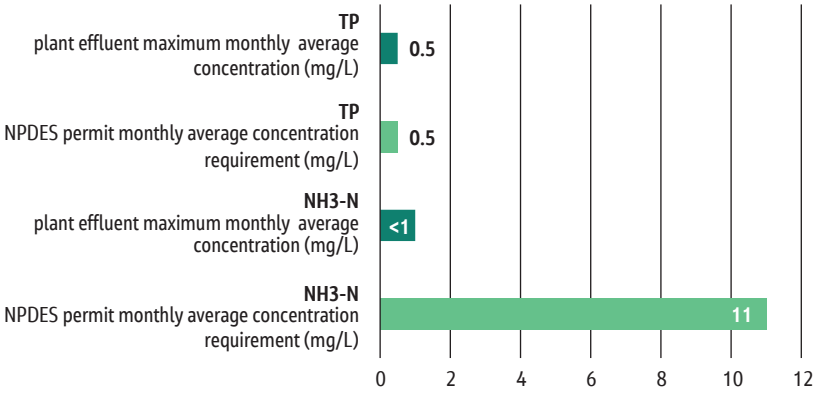


Exhibit 8

2021-2022 plant effluent minimum DO concentration versus NPDES permit requirement

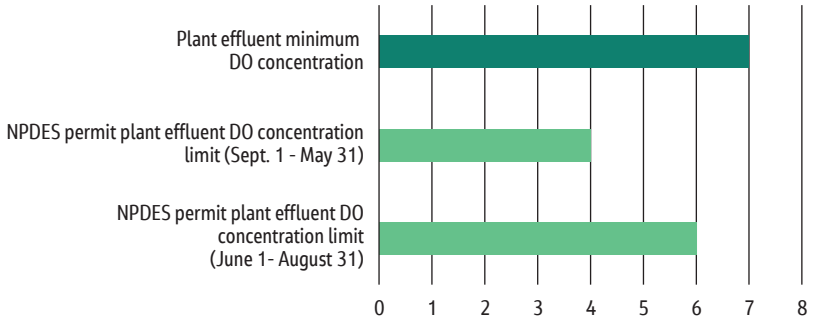
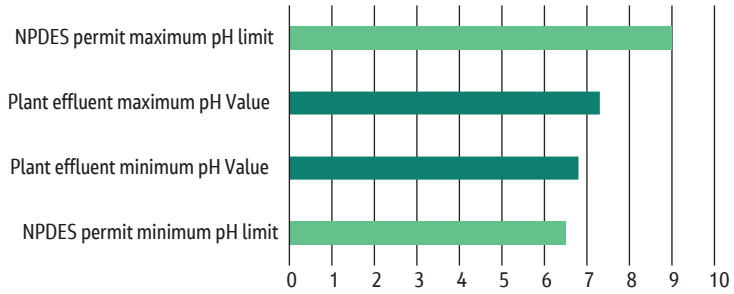


Exhibit 9

2021-2022 plant effluent maximum and minimum pH values versus NPDES permit limits



Operations and maintenance

Exhibit 10
2021-2022 plant effluent maximum 7-day fecal coliform geomean versus NPDES permit effluent requirement

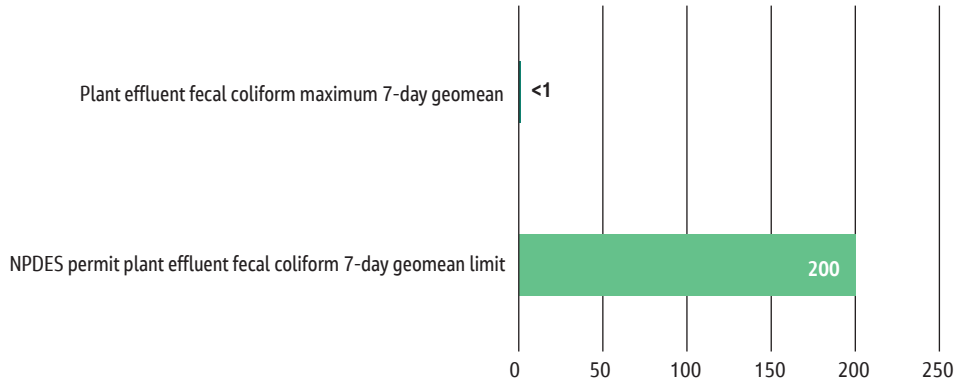


Exhibit 11
2021-2022 plant effluent maximum mercury concentration versus NPDES permit mercury concentration requirement

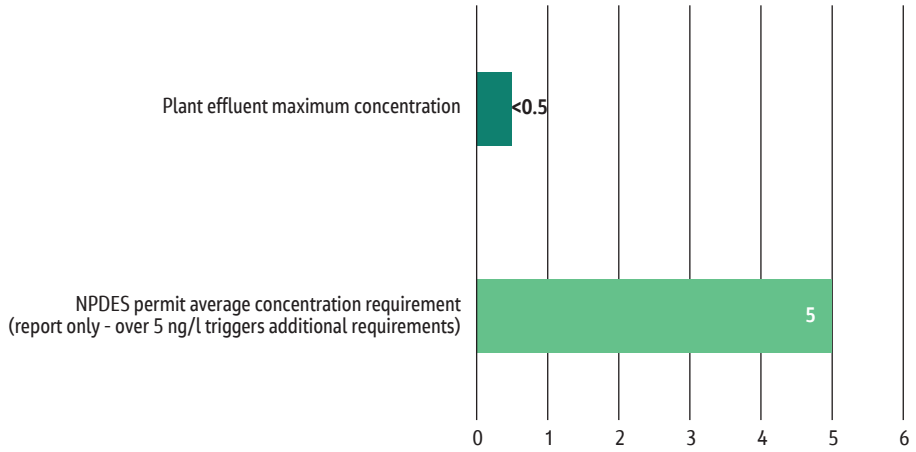
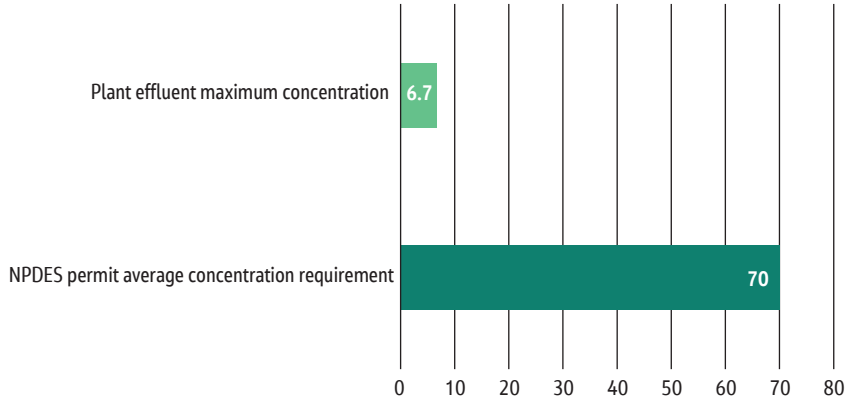
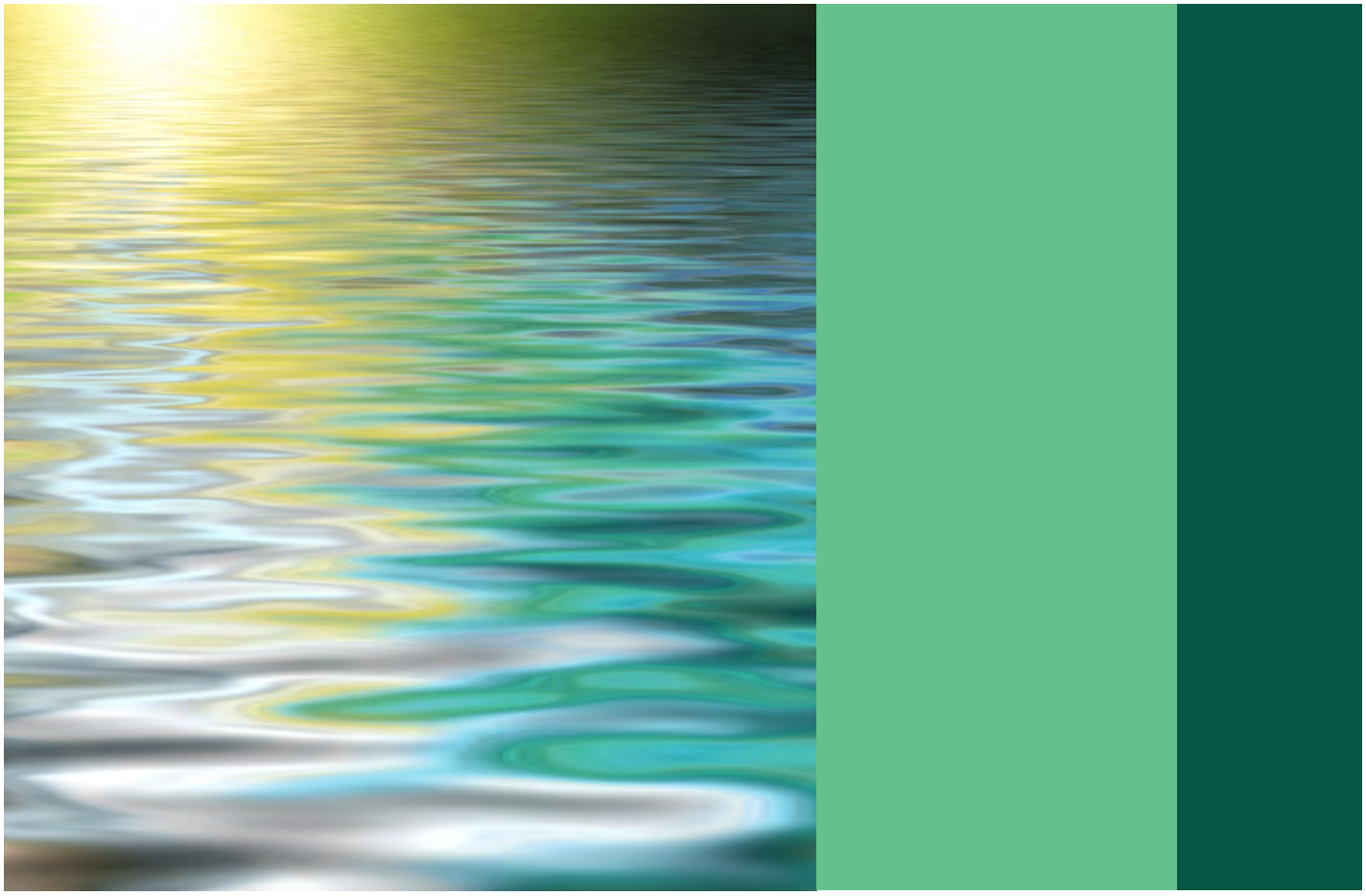


Exhibit 12
2021-2022 plant effluent maximum copper concentration versus NPDES permit copper concentration requirement



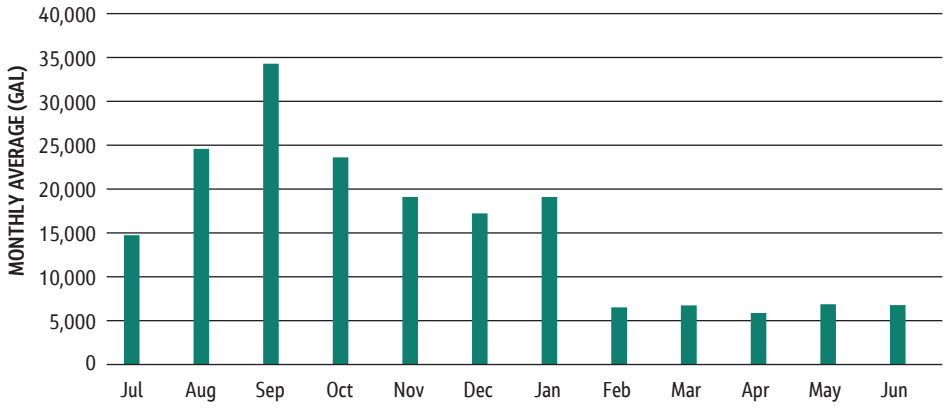


Water reuse curbs use of City water in treatment process

Exhibit 13 shows the average City water usage for each month relative to the reuse water upgrade. Reuse water, colloquially known as W3, is the facility-produced effluent water that is recycled back into various plant processes. Two of these processes, our solids concentrators, are the largest water users within our entire plant, and now only use reused water. Jacobs completed an out-of-scope project in late 2021 to restore and expand use of reuse water to make this possible.

Exhibit 13

City water usage



28 mg per year is equivalent to approximately 6.5 days worth of influent flow treated at the TCRWWTP.

Laboratory quality assurance and quality control

Quality assurance (QA) and quality control (QC) programs are important at all levels of laboratory operations. All results must be valid, representative, comparable and of known precision and accuracy to be of value. The laboratory adheres to Jacobs' established and well-documented QA program, which meets the requirements of the NPDES permit. This enables us to provide reliable, legally defensible results and to make decisions to protect public health and enhance the environment.

Expanding sample collection for novel analytes and data

Jacobs' laboratory expanded our sample collection procedures and data analyses to include perfluoroalkyl and polyfluoroalkyl substances (PFAS) sampling in influent, effluent and biosolids. These compounds are persistent in the environment and on many common surfaces, which makes clean sample collection of utmost importance in generation of quality data. Jacobs established site-specific procedures for sampling in complex situations, which are consistent with guidance from Environment, Great Lakes, and Energy (EGLE) and the U.S. EPA. Jacobs also continued to collect samples used to track COVID-19 trends in the homogenized influent, which provides a snapshot of infection rates in the community.

Maintaining quality laboratory assets

Jacobs' laboratory maintains state-of-the-art equipment that must meet stringent regulatory requirements. Laboratory equipment is regularly maintained by Jacobs staff and is serviced annually by certified technicians.

Industrial Pretreatment Program

The IPP is a core element of the NPDES aimed to protect water resources and municipal biosolids from industrial pollutants. This program places responsibility for the oversight of industrial facilities on the Publicly Owned Treatment Works (POTW). It also ensures that the POTW has legal authority to set and enforce requirements for all commercial users to protect the sewer collection system and POTW. Jacobs administers the IPP for the City.

The City also serves as the Control Authority for six connected townships, establishing consistent discharge regulations for all sewered users in the connected region. Additionally, the City serves as the control authority for the Grand Traverse Regional Septage Treatment Facility (GTRSTF), which receives trucked waste from both in and out of the county.

The IPP is responsible for inventory of the commercial and industrial users in this wide service area, ensuring all proper regulations are followed, conducting inspections and sampling of permitted users and conducting investigations into emerging pollutants and disruption to the collection system (usually grease obstructions).

Highlights the past year include:

- Identified and permitted a previously unidentified industry subject to federal categorical regulations
- Revised and re-issued industrial discharge permits for two significant industrial users (SIUs)
- Participated in a periodic, two-day on-site program review by EGLE
- Completed the periodic industrial user survey and generated a database with contact and facility information for 1,162 commercial sewer users
- Conducted all required inspections and sampling events for all six permitted SIUs
- Identified and mitigated two direct sources and two indirect sources of PFAS contamination to the POTW as part of EGLE's IPP PFAS Initiative
- Conducted additional sampling of the collection system and conducted industrial inspections as part of the PFAS Initiative
- Performed an audit of trucked waste to the POTW to ensure no industrial process wastes were entering the GTRSTF, including facility inspections and sampling
- Addressed pollutant violations from SIUs and non-permitted industrial users and worked alongside industry to better understand permit requirements

Regulatory compliance

Regulatory compliance keeps **Traverse City** ahead of new regulations, builds positive relationships with regulators and benefits the City when it is time for permit renewal and other regulatory interactions—we received regulatory compliance support from Director of Environmental Compliance Jeff Heroux and Compliance Manager Mary Ann Rouse.

From October 1, 2021-September 30, 2022, we had zero permit limit exceedances, pulling 1,352 samples for a compliance rate of 100%.

Our compliance rate for this reporting period was 100%.

Maintenance/asset management

Preventive versus corrective maintenance focus on prevention, documentation

Jacobs is committed to protecting Traverse City's facilities and equipment by practicing routine preventive maintenance (PM). Corrective maintenance (CM) does occur when equipment repairs are needed, but our principal emphasis is on PM and predictive maintenance (PdM). Jacobs maintains your assets with the goal of minimizing unplanned and emergency repairs.

By performing and tracking daily, weekly, monthly and annual PM on all equipment, we have sustained operations with minimal to no interruption. Our approach keeps the various treatment systems in the best condition possible, preventing premature wear and deterioration and avoiding unnecessary costs.

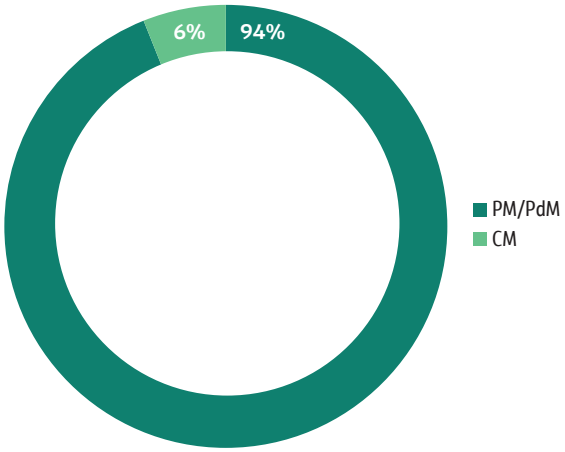
Continued efforts in the TCRWWTP maintenance program are based around these three basic goals:

- Eliminate equipment downtime
- Extend the usable life of an asset
- Reduce the amount of reactive/corrective work

Industry best practices show that 80 percent of maintenance activities should be PM, and CM should account for 20 percent or less of all maintenance activities.

In the past year, our team completed 4,591 maintenance records at the TCRWWTP, documenting tasks in our computerized maintenance management system (CMMS). Our team completed 4,313 PM/PdM work orders and 278 CM work orders with 94 percent being PdM or PM versus 6 percent CM. This PM/CM ratio exceeds the industry standard 80/20 ratio as shown in Exhibit 14.

Exhibit 14
TCRWWTP PM/PdM versus CM



The total time to conduct a PdM/PM task averaged 1 hour and 11 minutes compared to the labor hours to complete a CM task, which averaged 3 hours and 55 minutes. These statistics reinforce our emphasis on proactive preventative maintenance to enhance equipment reliability and reduce unplanned maintenance cost to the City.

Traverse City trusts Jacobs to care for wastewater utility assets owned by the citizens. The management of these assets is vital to our role as your O&M provider, so we take care to catalogue each piece of equipment, analyze every task associated with its care, schedule routine maintenance and thoroughly document both routine and CM.

Maintenance/asset management

Maintenance highlights

August 2021

The City contracted an arc flash and overcurrent device coordination study on lift stations to enhance workplace safety and ensure the optimal functionality of electrical components. Based on OSHA requirements, the arc flash study established hazard ratings for the electrical components at the facility and lift stations with the use of the standards developed by the NFPA referred to as NFPA 70E, Standard for Electrical Safety in the Workplace. These established ratings are used to determine the proper level of PPE required while working on or near these electrical components. All local disconnects and power sources were labeled with their hazard rating and associated PPE requirement. The coordination study consisted of inspecting the plant's overcurrent devices for proper sizing and operation. The study was recommended by Traverse City Light and Power after their inspection of the main switch gear at the facility revealed that the sizing of the overcurrent devices was not coordinated in an optimal manner to ensure continuity of line power to the facility, protection against equipment damage or abatement of possible safety hazards

Arc flash analysis.

October 2021

Replaced aeration blower #1 regaining equipment redundancy with two operable blowers in service and replaced the failed north aeration basin isolation gate valve.

North aeration gate valve replacement .

October 2021

Coast Guard pump replacement.

Aeration blower replacement.

November 2021

Replaced Birchwood lift station isolation valves.

Birchwood lift station isolation valves.

December 2021

Assisted City with watermain break that occurred near the WWTP by setting up a bypass pump to pump accumulated drinking water from the excavation site to one of the WWTP primary settling tanks until the leaking pipe could be isolated.

Assisted City with water main break.

January 2022

Coordinated replacement of main plant power supply transfer switch. The large blue trailers are two portable generators that were put in place to ensure continuity of power and thus reduce the operational and compliance vulnerabilities related to performing this repair.

Main plant power supply transfer switch replacement.

Replacement of main plant power supply transfer switch.

February 2022

Renovated front office at no cost to the City and reapproached how to repair the ferric chloride storage tank completing the repair safely for less than $1,000 estimated a cost of $10,000.

Front office renevation.

Ferric chloride tank repair.

Ferric chloride tank repair.

May 2022

Performed three-year asset condition assessment (Appendix A).

Safety

Jacobs' focus on safety and worker well-being—known as BeyondZero™—empowers our people to create and sustain a positive, safe and healthy work environment for themselves and colleagues. This mindset extends to the community. It also mirrors our respect for the environment in the tools and solutions we employ to contribute to sound business practices.

For Traverse City, this means we identify and anticipate the effects of a disruptive event or trend and work to minimize adverse impacts. Our team is adaptable, which lends itself to learning and in turn thriving. Our safety program emphasizes keeping pace with training and certifications.

During this reporting period, our Jacobs site team completed 110 hours of Jacobs safety training.

With help from Regional Safety Professional JD Verbrugge and our onsite Safety Champion and Lead Mechanic Shane Wyatt, we continue a strong safety culture at the facility, striving to maintain zero recordable incidents and promoting safety amongst our staff, our families and everyone who comes onsite. Our safety culture is supported by top company leadership and proactively implemented by everyone at onsite.

Some of our day-to-day expectations include a Culture of Caring safety moment at every onsite meeting (this is an opportunity to share lessons learned or other caring message) and ensuring everyone understands they have stop-work authority (if they see or feel a situation is unsafe, they know they can stop the work, fix the issue and complete the work in the safest manner possible).

Your onsite Jacobs team has worked more than 1,070 days without a recordable safety incident.

2021-2022 safety accomplishments

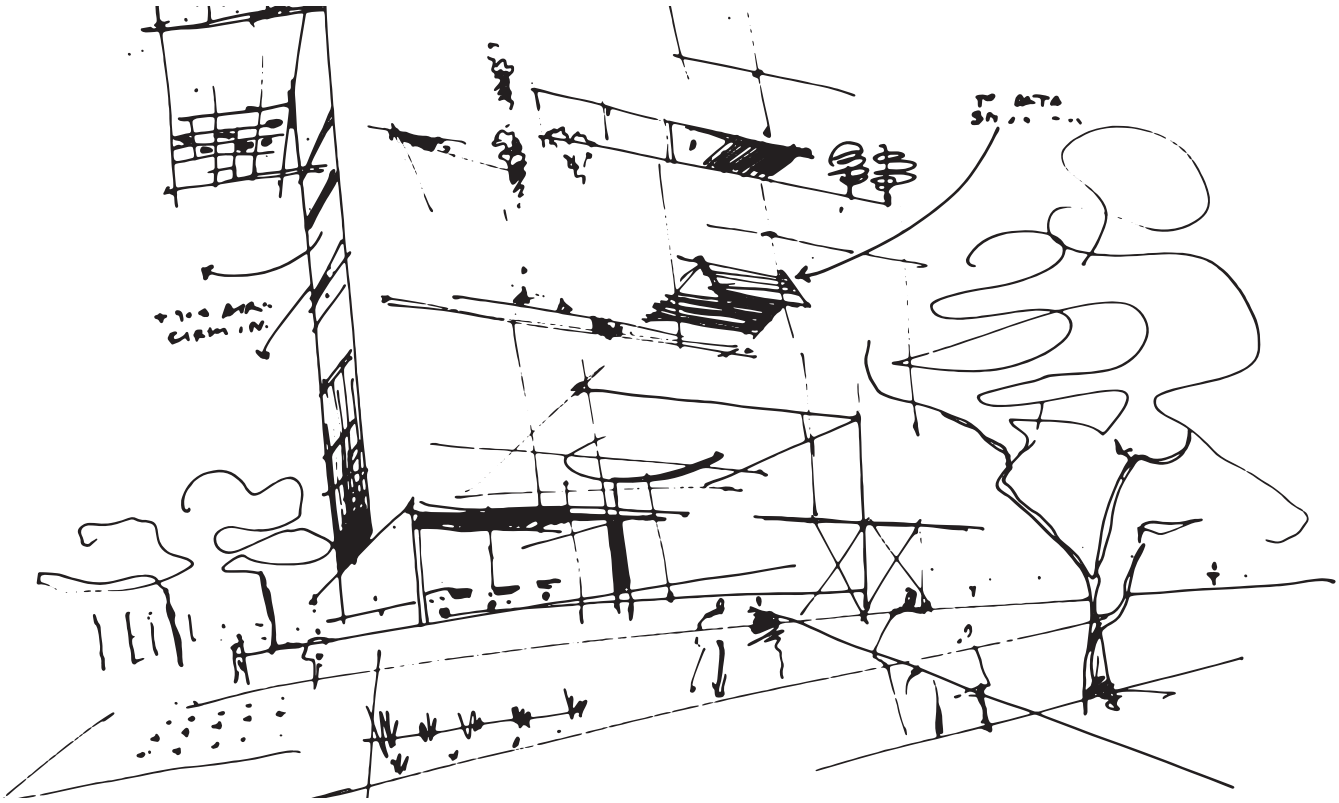
For nearly three years, our team has worked without any recordable safety incidents. This is a testament to our tried-and-true safety protocols as well as our individual diligence to keep ourselves and each other safe.

When safety meets technology

The onsite Jacobs team is applying technological advances when it comes to job planning and safety. Jacobs has implemented a system called ionCity. This new data management system engages our team members and is used as a safety platform to conduct electronic pre-task plans (e-PTPs), weekly safety inspections, facility and vehicle inspections, BeyondZero Observations and near-miss reporting for review. ionCity also can be used for planning by helping our site teams keep track of their deliverables, create work orders, keep track of maintenance and financial information and measure key performance indicators (KPIs). With this technology we can keep our people safe by identifying hazards prior to each job task and plan more efficiently.

BeyondZero℠

BeyondZero is about keeping our people safe. That means not getting injured, not allowing others to be injured and not allowing unsafe practices, behaviors or conditions to exist. It's about creating a culture of caring by actively engaging and involving employees and influencing their beliefs and behaviors.



Sustainability

Jacobs' vision is to be a recognized leader in sustainable operations and maintenance, and our mission is to collaborate and learn together to leave a more sustainable footprint our clients and communities. Our award-winning program leverages the passion and ingenuity of our people to develop site-specific sustainability goals to lessen our footprint and that of our client. At the TCRWWTP, we work to do our part for the environment locally and globally.

During this reporting period, our team established several sustainability goals to pursue, including:	Pursuit of these goals resulted in the following outcomes:
Optimizing operation of the renovated digester #3 to reduce energy usage and costs	Using the more-efficient linear mixer has reduced run time of the electrical recirculation pump while maintaining more effective mixing and operation. Energy use has decreased by at least five percent while digester efficacy has improved.
Conducting oil analysis to reduce frequency of routine oil changes in equipment	A total of 96 percent of oil samples sent for analysis this contract year indicated that the oil quality was still satisfactory and did not require a change. This avoided unnecessary oil changes and saved at least 20 gallons of oil.
Instituting process control changes to increase phosphorus removal efficiency and reduce chemical usage	Adding a new ortho-phosphate analysis improved data and allowed more-efficient control of the ferric chloride feed system. This helps avoid swings in effluent phosphorous concentrations and substantially reduces ferric chloride use for chemical precipitation of phosphorous.
Replacing existing fluorescent lighting with LED retrofits and new panels	Installing new LED units in the gravity belt concentrator (GBC) thickening building and retrofitting of the old units to reinstall with compatible LED bulbs.

Sustainability stats of note

Our team recycled:

- **1,500** pounds of mixed recyclables
- **110** pounds of exam gloves
- **2,220** pounds of scrap metal
- **150** pounds of batteries
- **345** gallons of oil

Other activities conducted as part of Jacobs commitment to sustainability included:

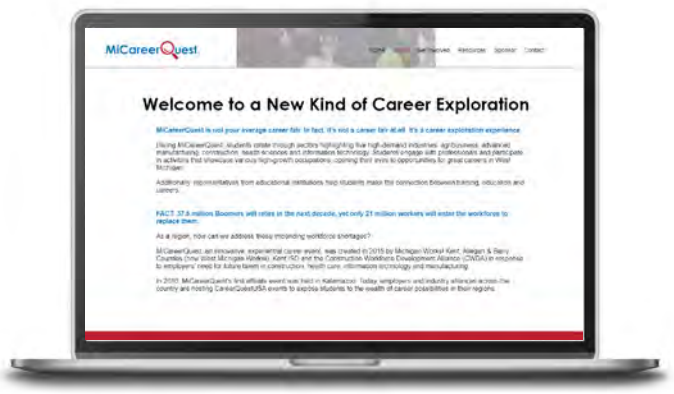
- Participating in the Grand Traverse County Conservation District Earth Day Tree Planting event
- Recycling 2,000 pounds of used electronics to Bay Area Recycling for Charities
- Performing trash pickups at neighboring Hull Park and along the TART Trail

Community involvement

At Jacobs, being active within the communities in which we work and live is integral to us. We've been a part of the Traverse City community for more than three decades; participating in community events brings us a sense of belonging. Additionally, we know the importance of aligning our various projects with the City Commission Strategic Priorities involving climate, economic development and water systems.

During 2021-2022, we're thrilled to report that we participated in the following community service events and activities:

- Volunteered planting trees on Earth Day at the Brown Bridge Quiet Area. Event hosted by Grand Traverse Conservation District.
- Held a public open house at TCRWWTP and held four plant tours. With each tour, we discussed wastewater biology (including a live viewing of microorganisms), displayed an informative poster discussing grease and what to do with it and set up a membrane module with a description of how it works. This was the first time we held an open house like this, and we plan to make it an annual event thanks to the overwhelming positive feedback we received.
- Volunteered at the Paddle Antrim event (since 2016)
- Take time each month to pick up trash along the TART trail that runs along the southern fence of the facility and at Hull Park (adjacent to the plant on the west side), which is a new service we provided this year.
- Donated to the following nonprofits that share our passion for improving and protecting the environment through endeavors and commitment to water conservation and resources management:
  - Paddle Antrim
  - Inland Seas
  - Grand Traverse Bay Watershed
- Worked with MiSTEM: Joshua Lycka spent an evening hosting MiSTEM teachers at the plant where he presented on wastewater and applicable careers, performed laboratory test and provided a tour. In the coming year we plan to submit career profiles, conduct tours and assist with MiCareer Quest.



Paddle Antrim's mission is to protect our water resources by using paddle sports to connect people to our waterways. Through stewardship, education, improved water trail access and promotion of our waterways we will increase water resource protection and enhance the economic vitality of the region.

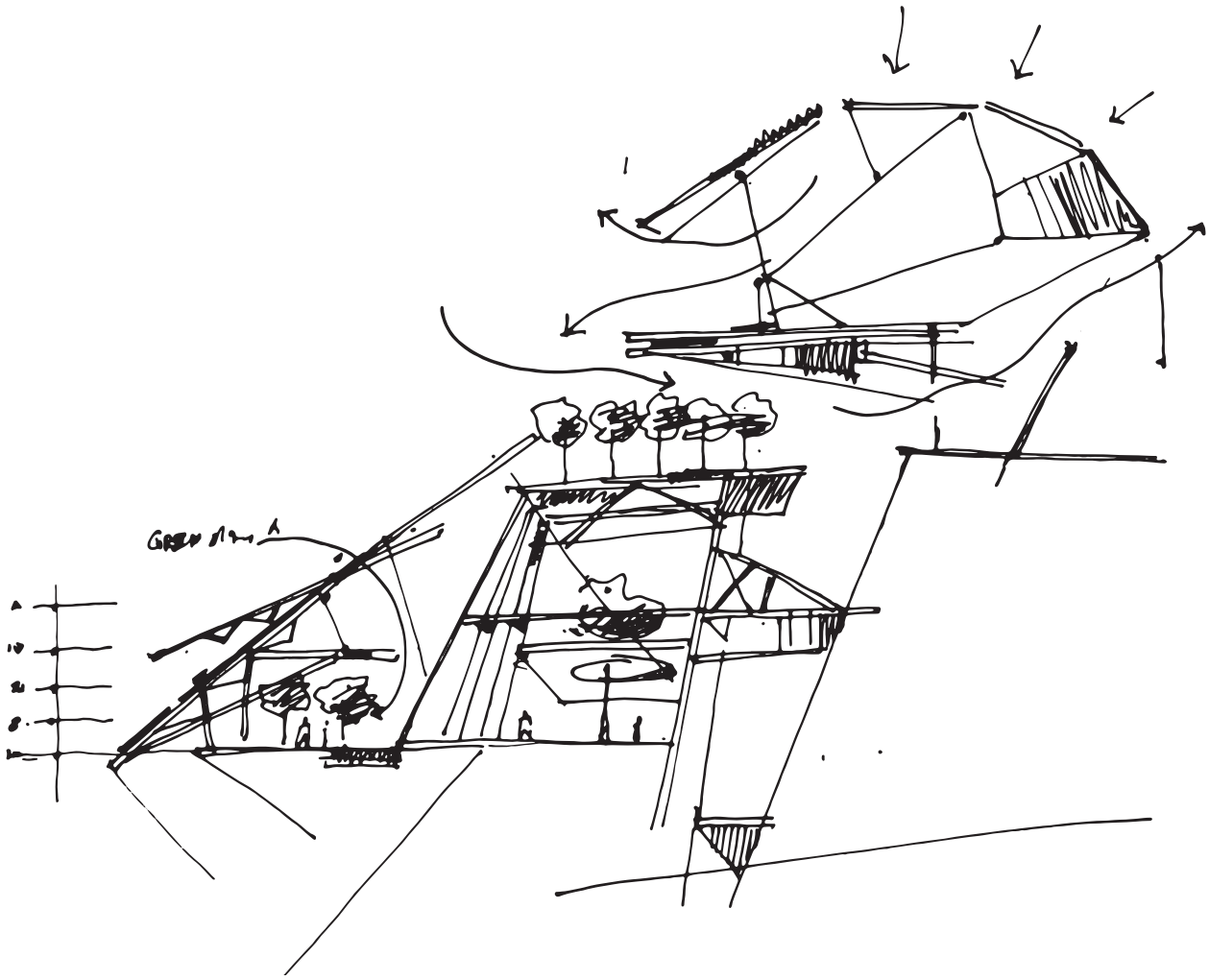
ISEA's mission is to inspire a lifetime of Great Lakes curiosity, stewardship and passion in people of all ages.

Grand Traverse Bay Watershed is a non-profit for the public's waterways. Grand Traverse Bay and all its waterways make our area truly unique and admired. As a local non-profit, The Watershed Center is passionate about safeguarding the beautiful waters of Grand Traverse Bay and our inland lakes and streams for all to enjoy. Guided by research and data, our scientists and policy experts are leading the discussion on water protection and restoration in our region.

Paddle Antrim.

Tree planting.

Paddle Antrim.



Financial overview

Exhibit 15 shows the TCRWWTP financial overview, including annual limit, percent rebatable, percent invoiceable, expenses, difference and (rebate)/invoice.

Exhibit 15
2021-2022 summary financial report

	Annual limit	Percent rebatable	Percent invoiceable	Expenses	Difference	(Rebate)/Invoice
Repairs	$125,000.00	100%	100%	$169,211.26	$44,211.26	$44,211.26
Ferric	$117,369.00	100%	100%	$134,654.18	$17,285.18	$17,285.18
Elec	$461,004.00	100%	100%	$448,431.16	($12,572.84)	($12,572.84)
Total	$703,373.00			$752,296.60		$48,923.60

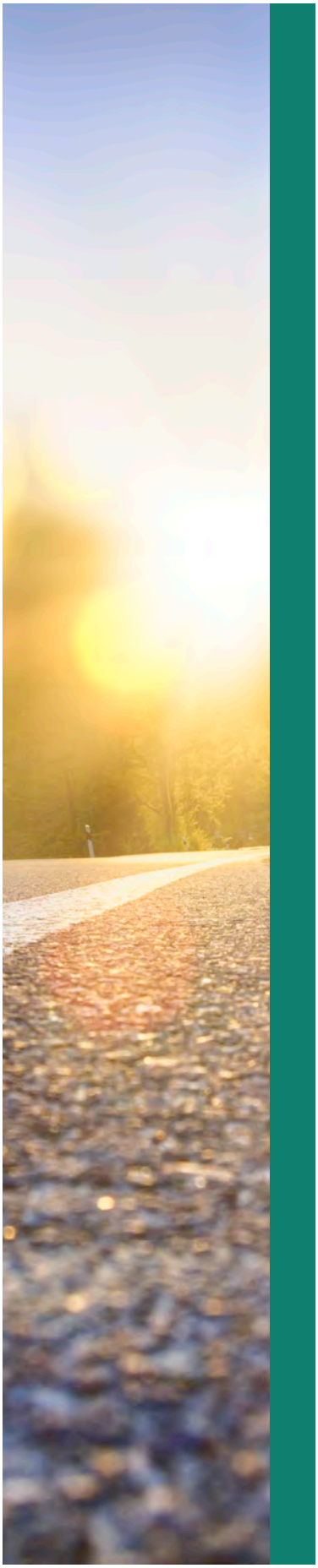
Looking forward

Jacobs and Traverse City have worked together to advance overall operations, make repairs to key equipment and plan for additional improvements to business systems and utility assets. For 2023, our team is working hard to align our site goals and various projects with the City Commission Strategic Priorities. Our plans looking ahead include:

- Potential rooftop solar array and battery storage facility
- Hosting the second-annual Innovation Workshop (tentatively scheduled for September 2023, and we're working with the City to define topics)
- Optimizing biological phosphorous removal to reduce chemical consumption; Jacobs will be sampling in early summer 2023 to calibrate our plant model to support optimization
- Increasing community involvement efforts, specifically building on last year's inaugural public open house
- Participating in a new program to monitor several communicable diseases in addition to COVID-19 and sharing data publicly —through an online dashboard— with local public health officials and the National Wastewater Surveillance System (NWSS)
- Performing a TCRWWTP digester gas reuse study and presenting this study at our second annual Innovation Workshop

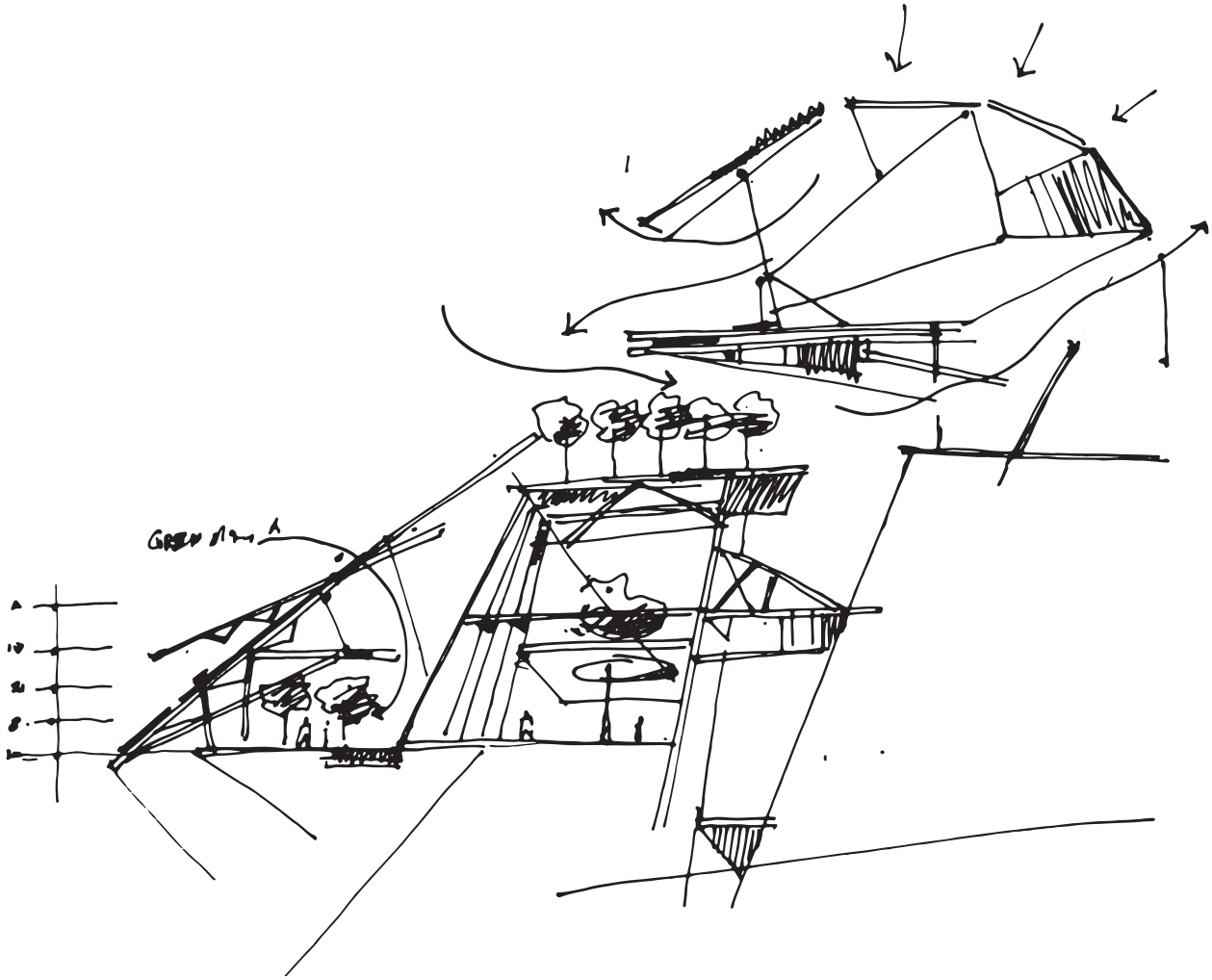
The Jacobs team is proud to serve Traverse City as your O&M partner.

We will continue to work with you to achieve optimum performance and value from all essential water infrastructure, while bringing you a world of knowledge and resources. We look forward to moving our partnership forward as we support the community, public health and environment.



Aligning Jacobs' and TCRWWTP's priorities with that of the Traverse City Commissions

Project	Result	Traverse City Commission strategic priority alignment
Clean digesters and perform condition assessments on digesters 4 and 5 CIP# 1175	Treatment process reliability and future planning	Water Systems and Economic Development
Engineering evaluation of 3 lift stations CIP# 967	Treatment process reliability and future planning	Water Systems and Economic Development
Gravity Belt Concentrator Refurbishment CIP #1236	Treatment process reliability and future planning	Water Systems and Economic Development
Treatment Plant SCADA and PLC Upgrade CIP#970	Treatment process reliability and future planning	Water Systems and Economic Development
Structural Condition Assessment – Various locations of the facility CIP#1169	Treatment process reliability and future planning	Water Systems and Economic Development
Upgrade of boiler controls and install of gas metering equipment CIP# 1077 and 1037	Optimizing digester gas usage	Climate and Water Systems
West Fine Screen Refurbishment – CIP# 1237	Maintaining process reliability and planning for the future	Water Systems and Economic Development
CWSRF Upgrade CIP# 904. Headworks and UV system upgrade	Restoring process reliability for the future.	Water Systems and Economic Development
Analyzing wastewater for diseases through participation in the Wastewater SCAN program	Supporting public health and public health officials	Water Systems and Economic Development
Conducting biological phosphorus removal sampling for plant modeling	Identifying treatment process hurdles inhibiting biological phosphorus removal to reduce chemical consumption and cost	Climate, Water Systems and Economic Development
Rooftop solar project	Reduce electrical consumption by 10%	Climate and Economic Development



Appendix A

Traverse City Regional Wastewater Treatment Plant
and Lift Station Condition Assessment Report

Traverse City Regional Wastewater Treatment Plant and Lift Station Condition Assessment Report

2022

Prepared for

City of Traverse City

Introduction

As the first step in the Asset Management (AM) process all the Assets were reviewed and imported into Jacob's ACES Condition Assessment Program. After the Database had been populated there where a total of 843 assets identified of which 831 were able to be assessed. The remaining assets could not be assessed due to operational constraints and were deemed not critical.

Condition Assessment and risk data was entered into Jacobs Asset Condition Evaluation System (ACES) using the pre-existing Risk Matrices from the 2017 Assessment which assigned levels of Consequence and likelihood of Failure to each of the Facilities process areas.

Contents

Acronyms and Abbreviations

ACES®	Asset Condition Evaluation System
AMP	Asset Management Plan
CMMS	Computerized Maintenance Management System
COF	Consequence of Failure
IIMM	International Infrastructure Management Manual
LOF	Likelihood of Failure
TCRWWTP	Traverse City Regional Waste Water Treatment Plant

Condition Assessment Process

Jacobs 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's necessary to group together the assets that display similar characteristics. 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 broken down into more specific categories. In the case of pumps for example, grouping is done based on the specific type of pump, such as centrifugal pumps and vertical turbine pumps. Jacobs identified a list of critical assets both by using the registry from the legacy ACES program as well as an updated list of assets from our Computerized Maintenance Management Software.

Exhibit 1 contains a complete list of the asset types used to evaluate the assets within the Wastewater Plant and Lift Stations.

Exhibit 1 Asset Types

Asset Types	
Tag ID	**Description**
ACTUATOR-FOLDER	ACTUATOR
BLOWER-FOLDER	BLOWER
CLARIFIER-FOLDER	CLARIFIER
CLARIFIER-SKIMMER	CLARIFIER SKIMMER
COMPRESSOR-AIR	AIR COMPRESSOR
COMPERSSOR-DRYER-AIR	AIR DRYER
CONVEYOR-FOLDER	CONVEYOR
DEWATERING-GBT	DEWATERING GRAVITY BELT THICKENER
DIGESTER	DIGESTER
ELEC-MCC	MOTOR CONTROL CENTER
ELEC-PANEL CONTROL	CONTROL PANEL
ELEC-SOFT-START	SOFT START
ELEC-VFD	VARIABLE FREQUENCY DRIVE
FILTER-MEMBRANE	MEMBRANE FILTER
GEN-EM	EMERGENCY DIESEL GENERATOR
GRIT-CLASSIFIER	GRIT CLASSIFIER
HVAC-BOILER	HOT WATER BOILER
HVAC-FAN-EX	EXHAUST FAN
HVAC-FAN-SUPPLY	SUPPLY FAN
HVAC-HEATER-ELEC	ELECTRIC HEATER
HVAC-HEAT-ECHANGER	HEAT EXCHANGER
HVAC-UNIT	HEATING VENTILATION AIR CONDITION UNIT
INST-CONTROL-T	INTRUMENT CONTROLLER
INST-DETECTOR-GAS	GAS DETECTOR
INST-LIT	LEVEL INDICATING TRANSMITTER
INST-LVL-ULTRASONIC	ULTRASONIC LEVEL TRANSMITTER

Asset Types (cont.)	
Tag ID	**Description**
INST-PLC	PROGRAMABLE LOGIC CONTROLLER
INST-SAMPLER	SAMPLER
INST-SENSOR	SENSOR
INST-TRANSDUCER	PRESSURE TRANSDUCER
INST-UPS	UNIVERSAL POWER SUPPLY
INST-XMITTER	TRANSMITTER
MIXER-FOLDER	MIXER
MIXER-SUB	SUBMERSABLE MIXER
MOTOR-ACH	AC HORIZONTAL MOTOR
MOTOR-FOLDER	MOTOR
MTR-FM-MAG	MAGNETIC FLOW METER
MTR-WATER	WATER METER
PANEL-LIGHTING	LIGHTING PANEL
PT-GEARBOX	GEARBOX
PUMP-CTH	CENTRIFICAL HORIZONTAL PUMP
PUMP-CTV	CENTRIFICAL VERTICAL PUMP
PUMP-DIA-AIR	AIR DIAPHRAGM PUMP
PUMP-DPS	DRY PIT SUBMERSABLE PUMP
PUMP-GRINDER	GRINDER PUMP
PUMP-HB	HOT WATER BOOSTER PUMP
PUMP-M	METERING PUMP
PUMP-PC	PROGRESSIVE CAVITY PUMP
PUMPC-SCREW	SCREW PUMP
PUMP-SUB	SUBMERSABLE PUMP
PUMP-SUMP	SUMP PUMP
PUMP-VAC	VACUUM PUMP
SAFETY-ALARM-FIRE	FIRE ALARM
SCREEN	SCREEN
SCREEN-WASHER	DEWATERING SCREEN
STRUCT-BLDGS-CONCTRETE-BRICK	STRUCTURES AND BUILDINGS
STRUCT-DOOR	DOOR
SYSTEM-ELECTRICAL	ELECTRICAL SYSTEM
TANK-BASIN	BASIN
TANK-FOLDER	TANK
TOOL-BRIDGE-CRANE	BRIDGE CRANE
TOOL-HOIST-EL	OVERHEAD HOIST
VEHICLES-CRANE	OVERHEAD CRANE
VLV-ARV	AIR RELEASE VALVE
VLV-B	BALL VALVE
VLV-BFP	BACK FLOW PREVENTER
VLV-BFV	BUTTERFLY VALVE
VLV-CK	CHECK VALVE
VLV-FOLDER	VALVE
VLV-PLUG	PLUG VALVE
VLV-SLUICE-SLIDE	SLUICE GATE
WET-WELL	WET WELL

Using a database of questions and answers developed by Jacobs, to assess similar assets for hundreds of clients, the plant staff and maintenance professionals developed a set of questions and answers for each asset type in **Exhibit 1**. The answers to each question have scores between one and five, with one being the best condition and five being the worst condition. The overall condition score of each asset is a culmination of the individual score given to the answer to each question. To provide a more accurate overall risk score, we adjust for the fact that not all questions have the same level of impact in determining the condition of an asset by weighting the importance of each question. For example, a greater weight is given to answers for a question pertaining to how a valve functions (whether it opens and closes smoothly), than to a question about the condition of the coating on the valve. To further ensure the highest level of accuracy in assessing the condition of an asset, the questions where measurements can be compared to known standards are considered overriding questions. The score for an overriding question is set up such that no matter what the scores of the other questions, the overall score for the asset can never be less than the score for the overriding question. Examples of measurements that provide greater insight into the condition of an asset are: the measured insulation resistance of a motor, or the peak vibration reading of a motor bearing. **Appendix A** contains a complete list of all the asset type questions, answer sets with question weightings, and overriding questions.

To facilitate the evaluation of assets, the overall asset scores are grouped into ranges and assigned a condition category. **Exhibit 2** shows the range of overall asset scores that make up each condition category. To identify the current condition of an asset, experienced Jacobs' maintenance specialists answer the asset type questions for each critical asset, using both measured and observed data. Observed data includes 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 taken under load, thermal imaging and insulation resistance.

To be accurately evaluated, assets must be operating under normal 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.

Exhibit 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 **Exhibit 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 asset's remaining service life.

Exhibit 3 Condition Category Description

Condition Category	Description	Estimated Percentage 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 (PdM) 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 percent 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

Risk-Based Condition Assessment

Jacobs performs risk-based condition assessments. 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 failure, there are additional risk factors that can more accurately help us define the best repair and replacement strategy. Understanding the risk of assets failing helps to make better use of the results of a condition assessment, prioritizing 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. Using a relative risk ranking concept is a proven industry standard for managing infrastructure assets effectively.

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 facility 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:

Total Risk = Consequence x Likelihood

Sections 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 TCRWWTP and Lift Stations 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.

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 a system's ability to meet its established level of service. 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 system. 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 CMMS to prioritize work orders based on the condition of the asset. This works well for routine preventative maintenance (PM) or PdM work orders (WOs). 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. **Exhibit 4** shows the consequence of failure matrix, which was developed with Jacobs in conjunction with the City of Traverse City and utilized for the TCRWWTP 2017 Condition Assessment and the 2022 Assessment. It lists the level of service categories and the range of consequences (negligible to severe) with scores (1-10).

Exhibit 4 Consequence of Failure Matrix

Consequence of Failure (COF)					
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.

Likelihood of Failure

To score the likelihood of an asset failing, a matrix was developed and approved for use by the in the same workshop prior to the 2017 Condition Assessment, in the same manner the consequence of failure scores was developed. The result is presented in **Exhibit 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 "negligible" to "very likely" with scores 1 to10 respectively. 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. Changing the COF usually requires a redesign of a process or complete change to the assets or systems in use. However, likelihood of failure (LOF) can be changed more easily by rebuilding an asset, improving maintenance procedures or by the successful application of predictive technologies. These are all things that can be done without the need for major asset replacements or plant redesigns.

Exhibit 5 Likelihood of Failure Matrix

Likelihood of Failure						
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 Unscheduled 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.

Using the COF and LOF matrices, Jacobs' staff assigned a risk score to each one of the facility's process areas. Total Risk is calculated by multiplying Consequence of Failure by Likelihood of Failure refer to **Exhibit 6**.

Exhibit 6 Process Area Risk Scores by Total Risk

	Consequence of Failure (COF)					Likelihood of Failure (LOF)						
	Public Confidence	Safety of Public and Employees	Regulatory Compliance	System Delivery	Financial Impact	Physical Condition	O and M Protocols	Performance	Reliability	Consequence of Failure (COF)	Likelihood of Failure (LOF)	Total Risk
ACES Unit Process	**25%**	**25%**	**20%**	**20%**	**10%**	**60%**	**20%**	**10%**	**10%**			
Digestion	10	10	7	4	10	1.56	5	5	5	8.2	3.3	27
Fine Screens	1	1	1	4	10	2.01	5	1	1	2.5	3.1	7.7
Grit Removal	1	1	1	1	4	3.02	5	1	1	1.3	4.5	5.8
Laboratory	1	1	4	1	1	2.13	1	1	1	1.6	3.2	5.1
Membrane Filtration	10	7	7	4	10	1.39	3	1	10	7.4	2.8	20.7
Odor Control	4	7	1	7	7	1.8	3	1	1	5	2.3	11.6
Preliminary Treatment	1	4	1	1	10	1.6	3	1	1	2.6	2.2	5.9
Primary Treatment	10	7	7	10	10	2.46	3	1	7	8.6	6.8	33.37
Secondary Treatment	1	1	1	10	10	1.87	5	5	3	3.7	3.6	13.26
Solids Handling	7	7	1	10	4	1.92	5	1	10	6.1	3.8	23.65
UV Disinfection	4	1	10	4	4	1.35	5	7	5	4.4	3.6	16.02
Structures and Support	1	1	1	4	4	1.67	3	1	3	1.9	2.5	4.75
Bay St LS	4	1	7	4	4	2.41	5	1	1	3.6	4.7	17.3
Birchwood LS	4	4	4	4	4	1.68	5	1	1	4	2.5	10.08
Clinch Park LS	7	4	7	1	1	1.8	5	1	3	4.4	3	13.35
Coast Guard LS	4	1	4	4	4	1.87	5	1	7	4.4	2.8	12.46
Front St LS	10	7	7	4	10	1.92	5	1	1	7.4	2.9	22.15
Hull Park LS	7	4	4	4	1	1.7	5	1	1	4.4	3	13.35
Riverine LS	7	1	4	7	4	1.6	5	1	1	4.6	2.5	11.7
TBA LS	7	4	4	4	4	1.6	5	1	5	4.7	2.8	13.7
Woodmere LS	4	4	4	4	4	1.69	5	1	5	4	2.9	11.68

Exhibit 7 shows the ranking of Process Area Total Risk using the assumption that all the assets were in new or like new condition. The purpose of this exhibit is to show where risk exists within the TCRWWTP's process areas without considering the physical condition of the assets. Total Risk is calculated by multiplying the Consequence of Failure (COF) by the Likelihood of Failure (LOF)

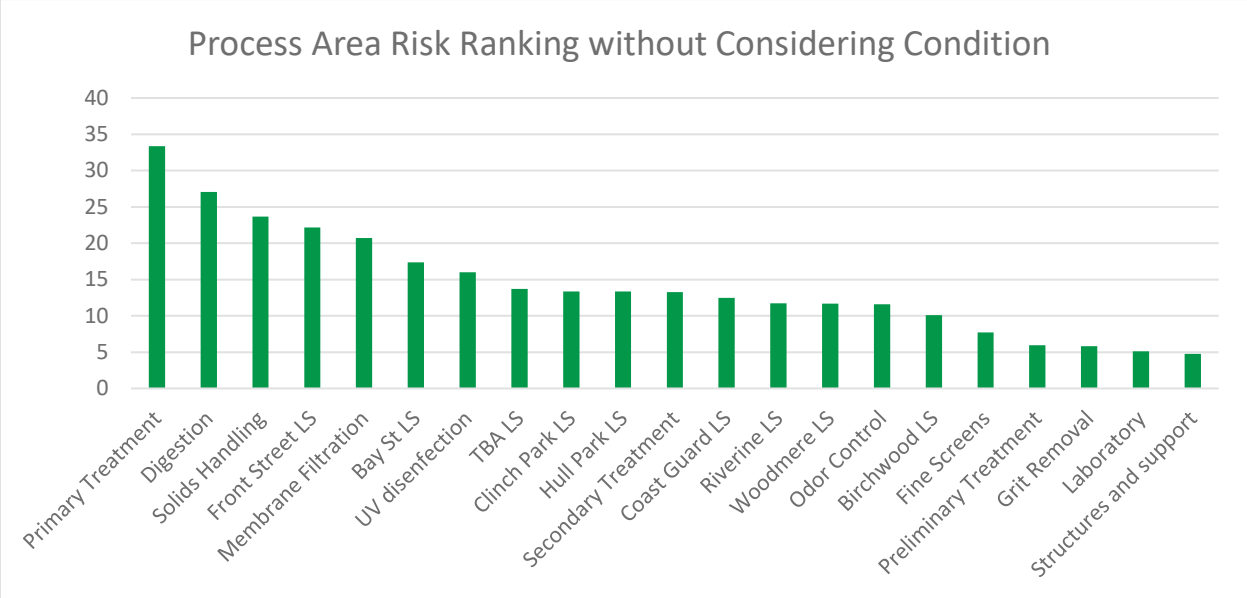
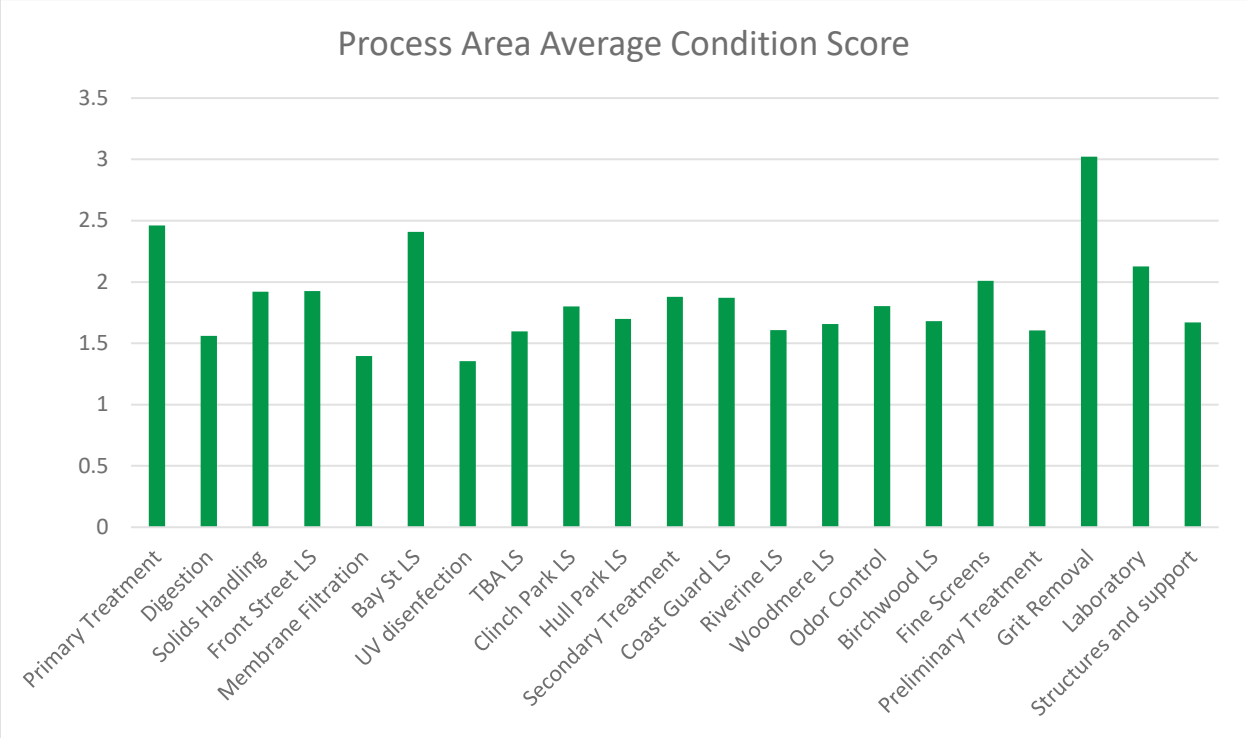


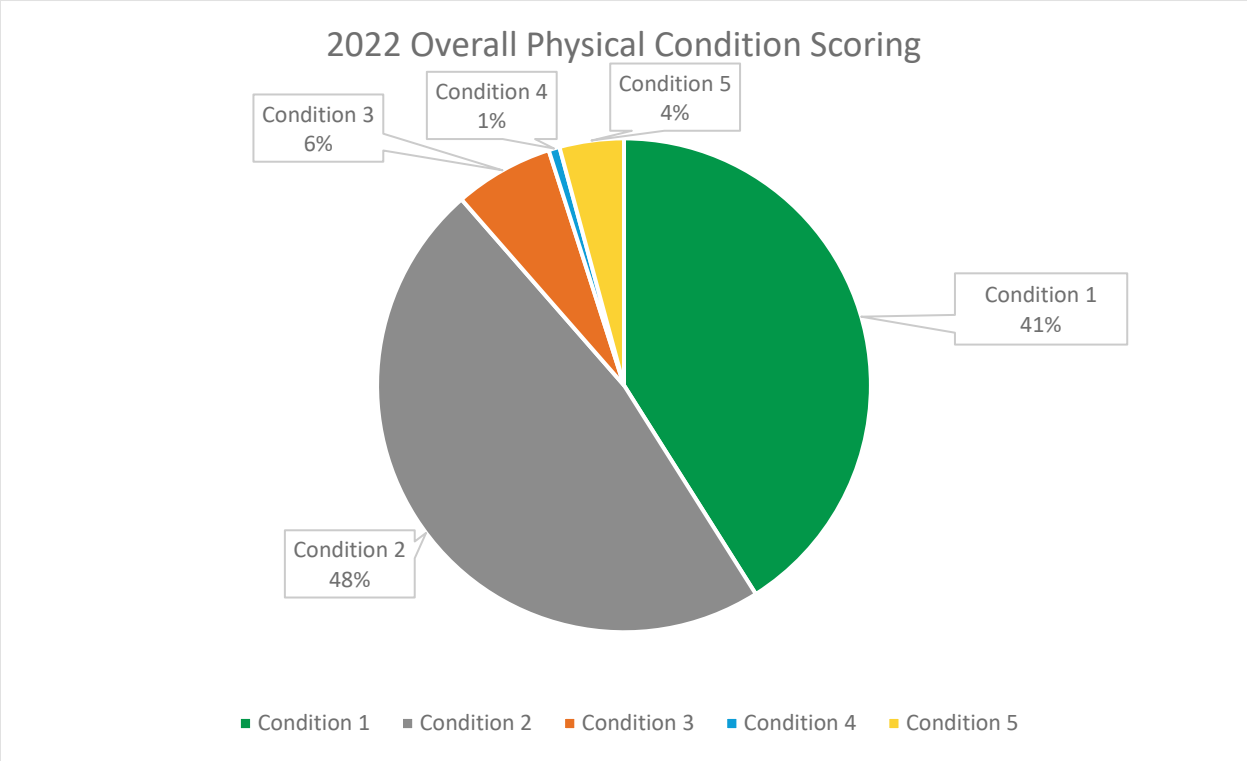
Exhibit 8 displays the average condition score for each of the TCRWWTP's Process Areas. A detailed report of each asset's condition score can be found in **Appendix C.**



Condition Assessment Findings

A summary of the overall condition of the assets within TCRWWTP and Lift Stations can be found in **Exhibit 8**. (Refer to **Exhibit 3** for explanations of each condition score). The results indicate that 736 (89 percent) of the 831 assessed assets have a condition score of two or less, indicating they are in "very good" to "good" condition. 95 (15 percent) assets identified received a condition score of three or greater, indicating they would require maintenance in the near future. The below pie chart shown in **Exhibit 9** illustrates these findings.

Exhibit 9



A report detailing the assessment of each asset, including comments from the assessment team and pictures of concerns identified can be found in **Appendix B.**

Summary

The overall condition of the assets within Traverse City Waste Water Treatment Plant and associated Lift Stations show to be in "good" to "very good" condition. A large majority of the assets that scored a 3 or greater, indicating they are in need of maintenance or not functional, are in the facility's Primary Treatment and Grit Removal Process Areas. These process areas are in one of the older portions of the facility and are currently part of the City's 2023-2024 Headworks and Primary Treatment CIP, which will address a large portion of the aging equipment.

Company values

We do things right.
We always act with integrity — taking responsibility for our work, caring for our people and staying focused on safety and sustainability. We make investments in our clients, people and communities, so we can grow together.

We challenge the accepted.
We know that to create a better future, we must ask tough questions. We always stay curious and are not afraid to try new things.

We aim higher.
We do not settle — always looking beyond to raise the bar and deliver with excellence. We are committed to our clients by bringing innovative solutions that lead to profitable growth and shared success.

We live inclusion.
We put people at the heart of our business. We have an unparalleled focus on inclusion with a diverse team of visionaries, thinkers and doers. We embrace all perspectives, collaborating to make a positive impact.

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