TRAVERSE CITY

Stormwater Asset Management Plan

May 2017

OHM

Advancing Communities®

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Acronyms

AMP – Asset Management Plan or Program

BMP – Best Management Practice

BRE – Business Risk Exposure

CIP – Capital Improvement Plan

CMMS – Computerized Management and Maintenance System

CoF – Consequence of Failure

ERU – Equivalent Residential Unit

GIS – Geographic Information Systems

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

SAG – Stormwater Advisory Group

SAW – Stormwater Asset Management and Wastewater Grant

TSS – Total Suspended Solids

Executive Summary

The stormwater infrastructure system of Traverse City was built as the City developed. That infrastructure collects and conveys the water from rainfall so that private property is protected from flooding. Recognizing the importance of this stormwater system in protecting property from damage, maintaining property values, and maintaining the water quality in Boardman Lake, the Boardman River, and Grand Traverse Bay, Traverse City initiated a comprehensive assessment of its stormwater infrastructure.

This Asset Management Plan summarizes this assessment and includes key recommendations for future funding levels and alternatives for funding mechanisms. This document was prepared using grant funding from the State of Michigan 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 stormwater collection system using the latest available hardware and software.
- Survey key system components to augment the City's existing GIS database and to make it easier for future generations to access infrastructure data with greater ease.
- Add information for sewer material type, age, and depth to the GIS database.
- Physically evaluate the structural condition of all publicly-owned system components, including storm sewer pipes, manholes, catch basins, and outfalls. Store the data in the City's GIS database.
- Analyze the flow capacity of the City's storm sewer pipes and identify where pipes should be enlarged to minimize flood potential to a reasonable level.
- Identify other capital improvements that will allow the City to reduce annual flow volumes and pollutant loadings to Boardman Lake and Grand Traverse Bay.
- Identify long-term operations and maintenance strategies to maintain a reasonable structural condition into perpetuity, including:
    - Regularly-scheduled sewer inspection (televising), similar to what is done for wastewater infrastructure
    - Repair and rehabilitation to address structural problems resulting from aging infrastructure
- Provide recommendations on developing a sustainable funding source for stormwater, similar to that of enterprise funds that already exist for the City's water and wastewater systems.


Figure 1: Manhole Deposits


Figure 2: Beach Erosion


Figure 3: Storm Sewer Defects


Figure 4: Street Flooding

The City of Traverse City has a significant funding gap for their stormwater system. The needs identified in this Asset Management Plan exceed available local funding under the City's current budget framework. This is largely due to the following:

- The City of Traverse City, like the vast majority of Michigan communities, has no dedicated funding source for stormwater infrastructure. Unlike water and wastewater systems which have fee-based programs to fund the operation and maintenance of infrastructure, stormwater has no clear path to dedicated funding, largely due to judicial precedent which exposes communities to unnecessary legal risk when they attempt to establish stormwater enterprise funds.

- As communities like Traverse City have developed and aged, the buried infrastructure is deteriorating (see Figures 1-4 for photos of known problems). 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 which could result in the following:

  - Increased threat of property damage and loss due to flooding
  - Increased potential for impassable roadways during heavy rainfall events
  - Increased pollutant loading to Boardman Lake and Grand Traverse Bay
  - Increased frequency of beach erosion and beach closures due to health concerns

- This Asset Management Plan recommends a ***dedicated funding source*** be established to ***collect annual revenues of $2.02 million*** to meet the identified needs in this document. This funding mechanism will likely be required into perpetuity and may need to be adjusted if the City changes its expectations for Level of Service or if other priorities change. The key components of the recommended stormwater program are listed below:

Table 1: Proposed Stormwater Program

Items	Annual Cost	
Catch Basin Replacement Program (Inspection/Cleaning)	$	100,000
Sewer Rehabilitation and Repairs	$	310,000
Manhole Replacement Program (Repairs/Inspection/Cleaning)	$	90,000
Storm Sewer Replacement (Hydraulics)	$	315,000
Infiltration BMPs (Volume and Pollutant Control)	$	350,000
Sweeping and Leaf Collection	$	285,000
Sewer System Inspection and Cleaning	$	160,000
End of Pipe Treatment	$	70,000
Boardman River Wall Maintenance	$	65,000
Open Channel and Culvert Maintenance	$	75,000
Stormwater Utility Bill (City-owned facilities)	$	50,000
Administrative Costs and New Personnel	$	150,000
Total	**$**	**2,020,000**

I. Introduction

In December 2013, the City of Traverse City applied for a Stormwater, Asset Management, and Wastewater (SAW) grant from the Michigan Department of Environmental Quality (MDEQ) in order to develop an Asset Management Program or Plan (AMP) for the City's stormwater system. This grant money also required a City matching contribution. 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 developed by the City's Stormwater Advisory Group (SAG):

Enhance the safety, health, and quality of life for the people of Traverse City through the effective management and maintenance of its stormwater infrastructure.

B. Team

The team leaders listed in Figure 5 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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Figure 5: 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, inlets, 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. Appendix A lays out edits made by the City and OHM Advisors during the completion of the AMP.

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 stormwater asset.

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:

- Characteristics of the System: An age, material, and size distribution of the infrastructure was identified.
- Size, elevations, and slopes of sewer system: The City hired a surveyor to measure elevations for storm sewer manhole rims. Subsequently, manhole depths were measured by City staff to determine sewer invert elevations and pipe sizes. This information was entered into the City's GIS and used for the hydraulic modeling effort.
- 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 storm 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 stormwater collection system was sampled to get a reliable assessment of the overall structural condition of the entire system. See Appendix B for illustrations of the City's stormwater 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 6. 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 B contains maps to illustrate the condition of the assets inspected as part of this AMP.

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 Ratings 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

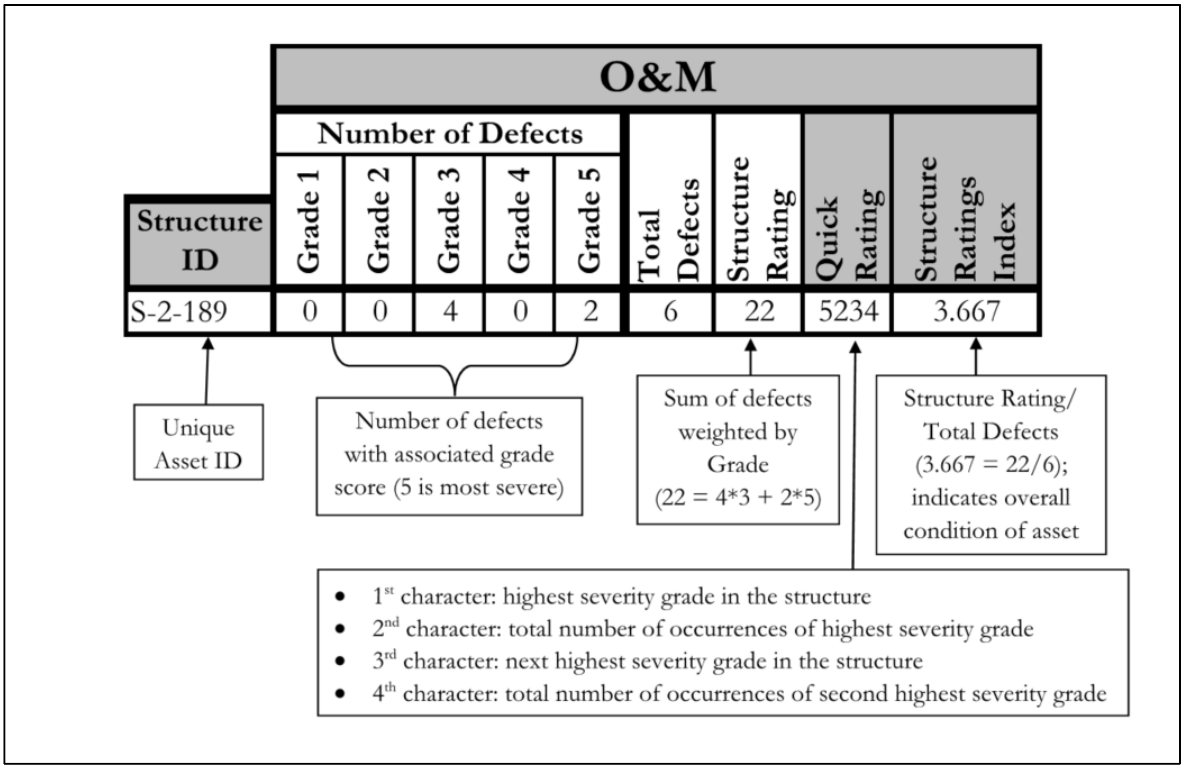


Figure 6: NASSCO Metrics

B. Manholes

There are approximately 1,220 manhole structures in the City's stormwater collection system, as listed in the GIS. As part of the SAW effort, a detailed condition assessment was performed on about 630 manholes, or just over 50% of the total inventory. Figure 7 shows a distribution of the manhole infrastructure based on infrastructure age. The average age of the manholes in the system is approximately 55 years with nearly 70% of the system installed between 1940 and 1970.

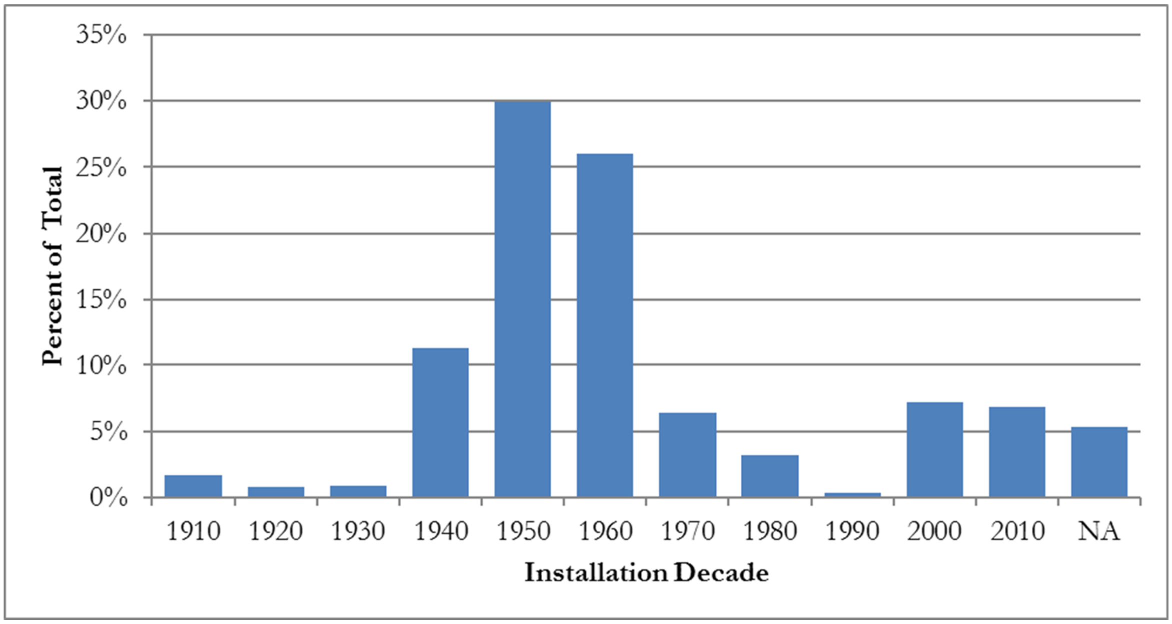


Figure 7: Distribution of Storm Manholes Based on Installation Date

Figure 8 and Figure 9 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 1.8 and average O&M rating of 0.9. Figure 10 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.

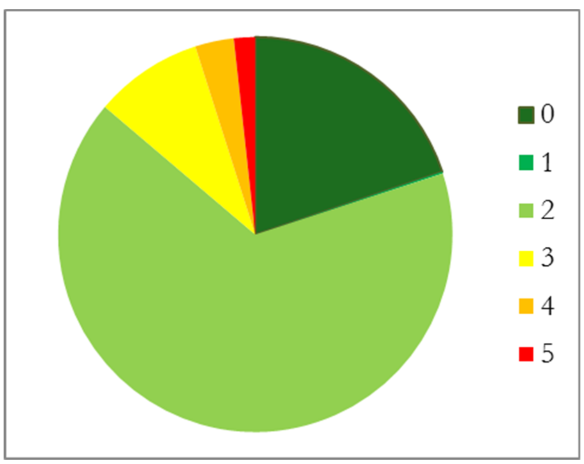


Figure 8: Storm Manhole Structural Ratings

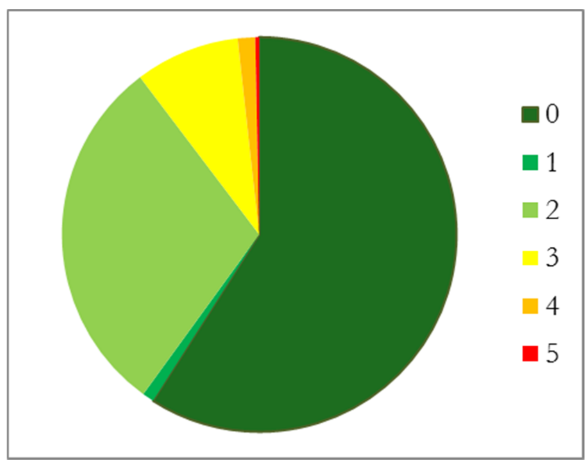


Figure 9: Storm Manhole O&M Ratings

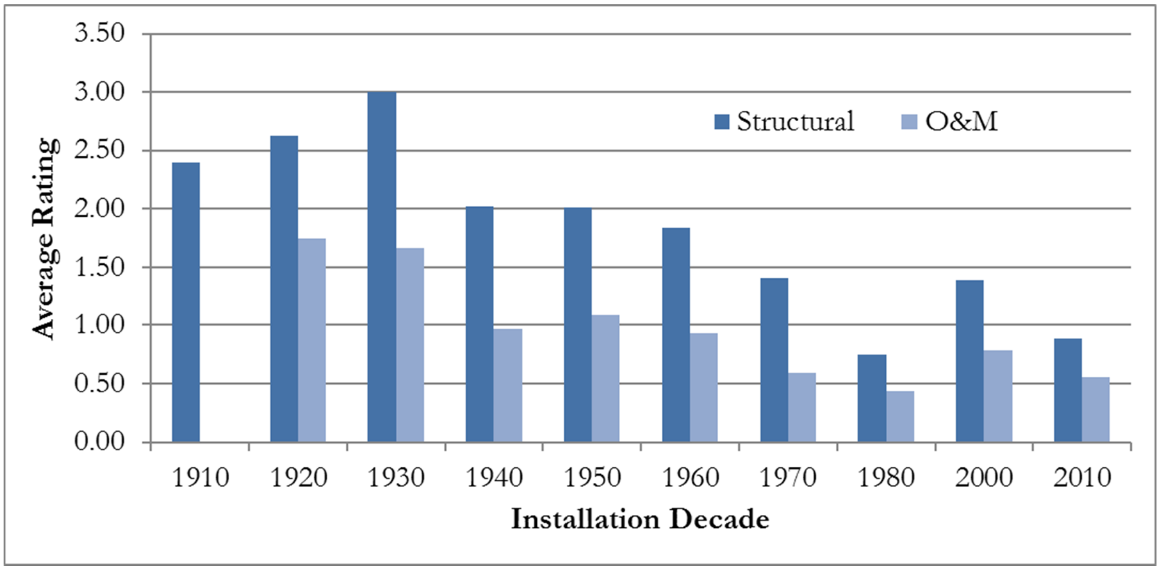


Figure 10: Average Storm Manhole Condition Ratings Indices by Installation Decade

* 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 11 and Figure 12 provide additional details of the distribution of scores in each decade. In general, the structural and O&M condition is worse for older manholes.

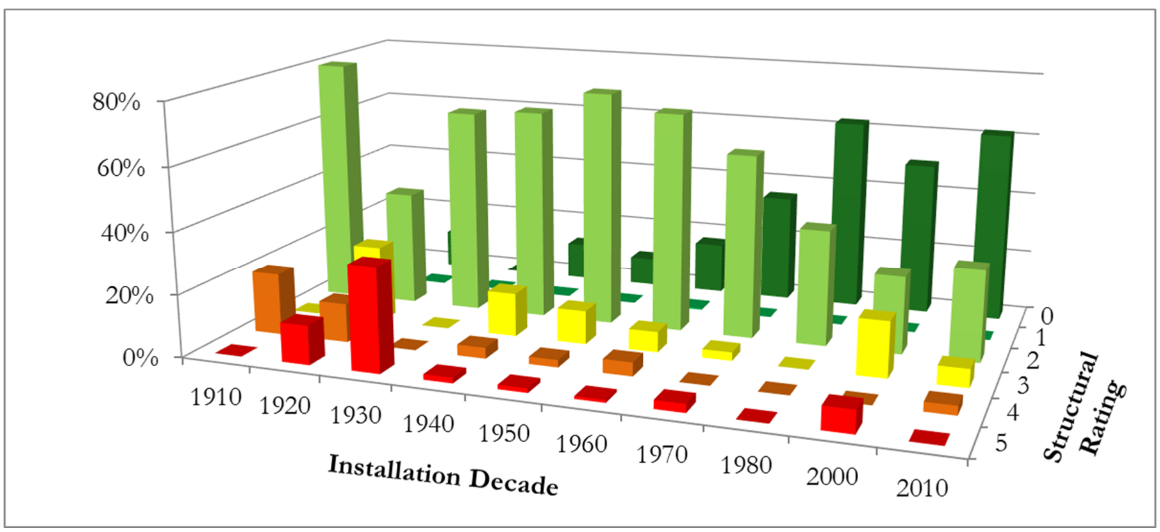


Figure 11: Storm Manhole Structural Ratings Indices by Decade

* Some asset condition data (for components newer than 1993) were available from previous City inspections that were performed separate from the SAW Grant effort.

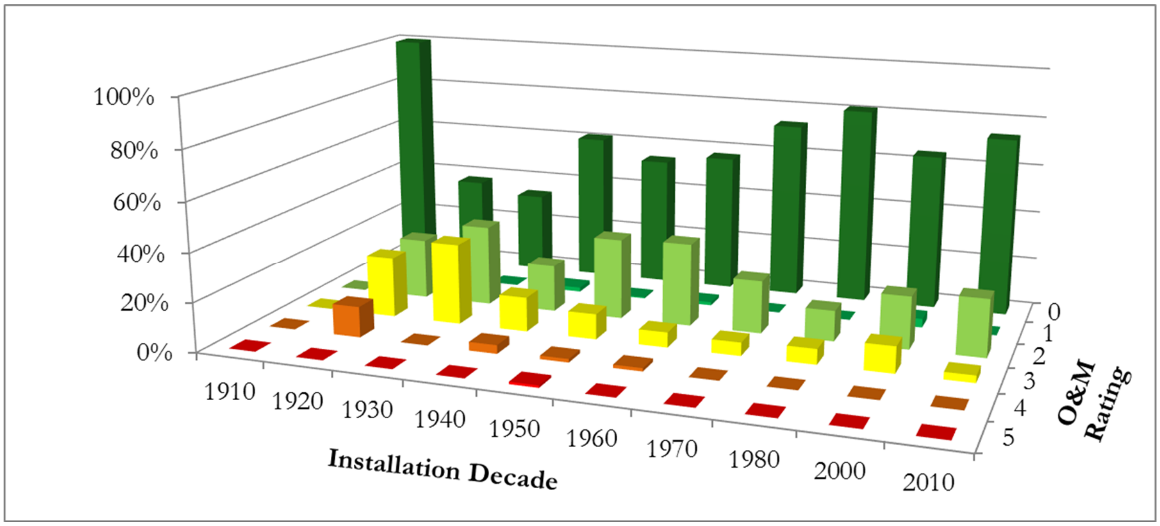


Figure 12: Storm Manhole O&M Ratings Indices by Decade

* 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 13, 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 or pipe connection issues and inner wall cracking. Pipe connection failures are usually caused by the connecting pipes shifting, which causes the grout at the connection to deteriorate over time. The interior wall cracking appeared to be typical, expected deterioration.
- O&M manhole issues were predominantly driven by infiltration and deposits. Infiltration is induced by cracks on the manhole walls, which provide inlets for rain, groundwater, and soil to infiltrate into the manholes through these cracks. Deposits occur when soil and other debris build up in a structure without regular cleaning/flushing.

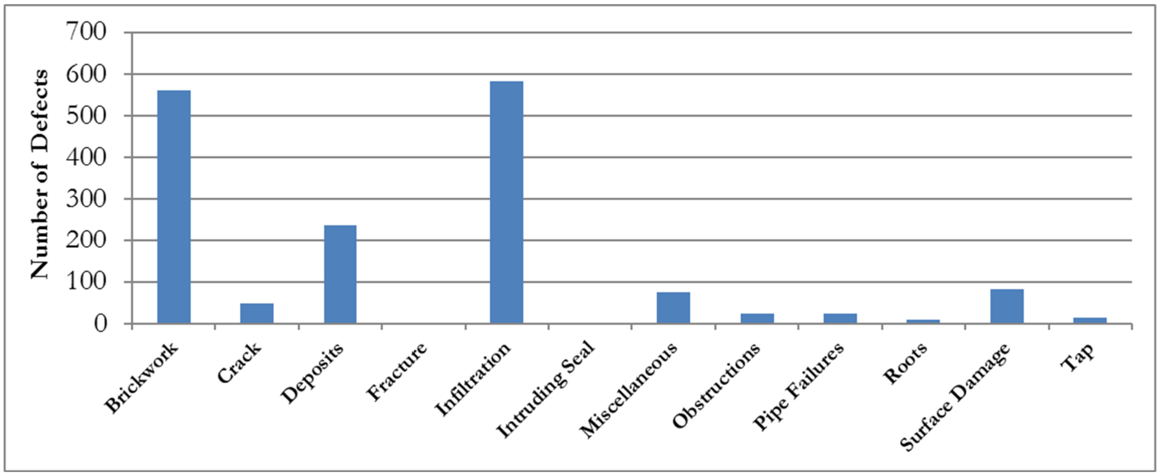


Figure 13: Storm Manhole Defects

C. Storm Sewer

There are approximately 65 miles of storm sewer pipe in the City's stormwater collection system, as listed in the GIS. The average age of the system is 55 years with nearly 70% of the system installed between 1940 and 1970. Figure 14, Figure 15, and Figure 16 summarize the storm sewer collection system inventory in terms of age, material, and diameter. The majority of the system consists of reinforced concrete pipe.

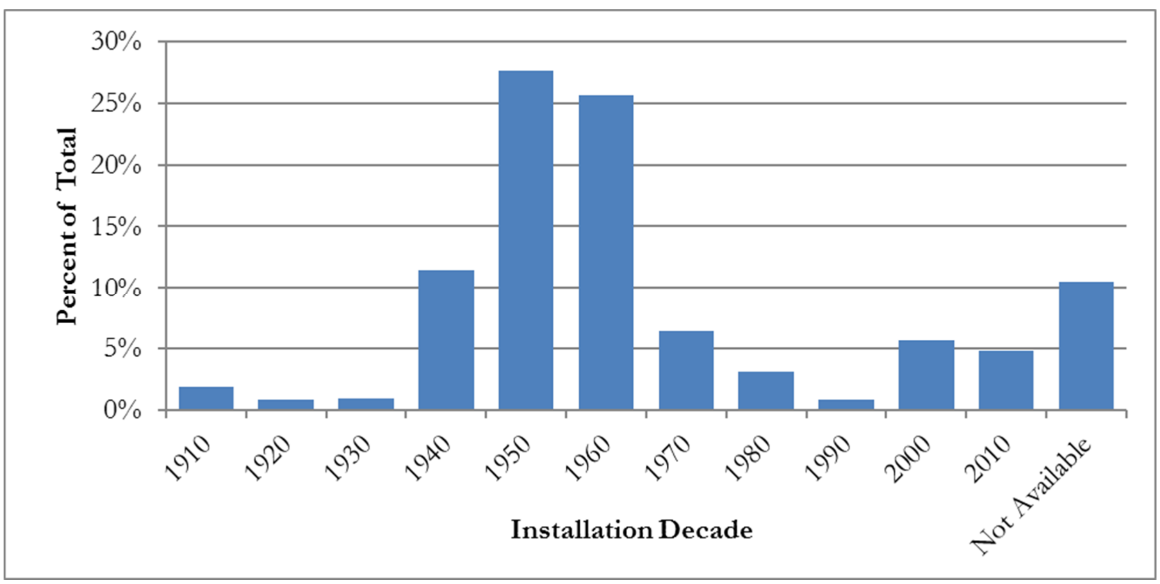


Figure 14: Storm Sewer Installation Inventory

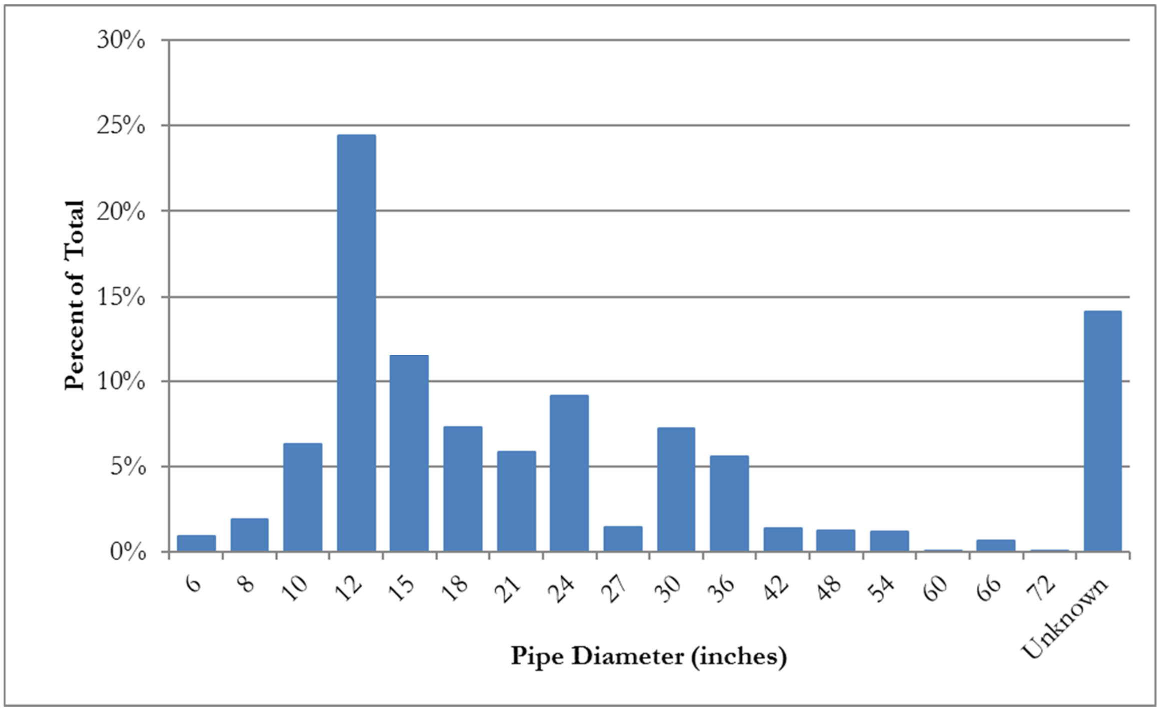


Figure 15: Storm Sewer Diameter Inventory

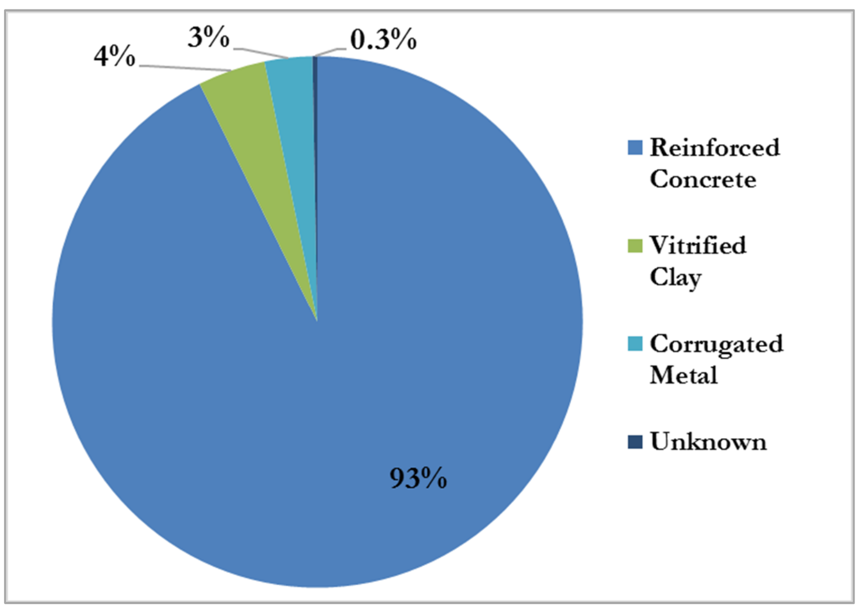


Figure 16: Storm Sewer Material Inventory

As part of the SAW effort, a condition assessment was performed on approximately 40 miles of pipe, or about 60% of the system. The inspected portion of the system had an average Overall (structural and O&M) rating of 2.0, indicating that the majority of the system is in good condition. The average structural rating is 1.7, and the overall O&M rating being 1.9. Figures 16 and 17 show a breakdown of Overall PACP Ratings.

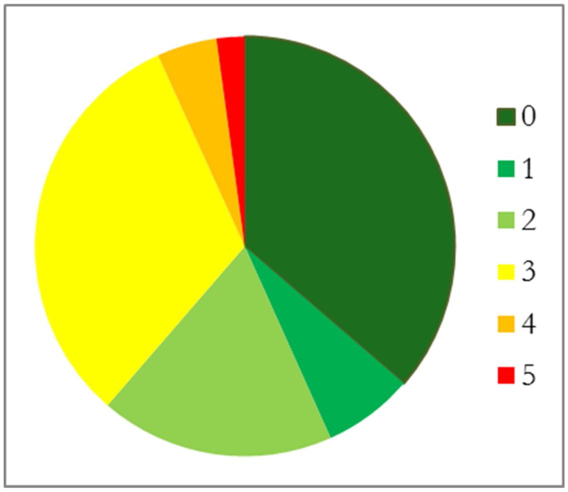


Figure 17: Storm Sewer Structural Ratings

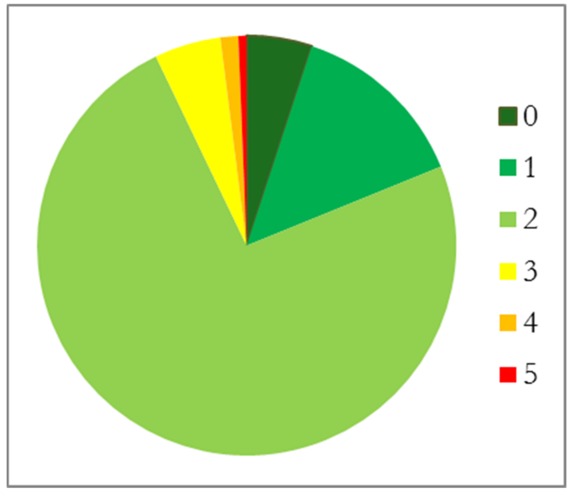


Figure 18: Storm Sewer O&M Ratings

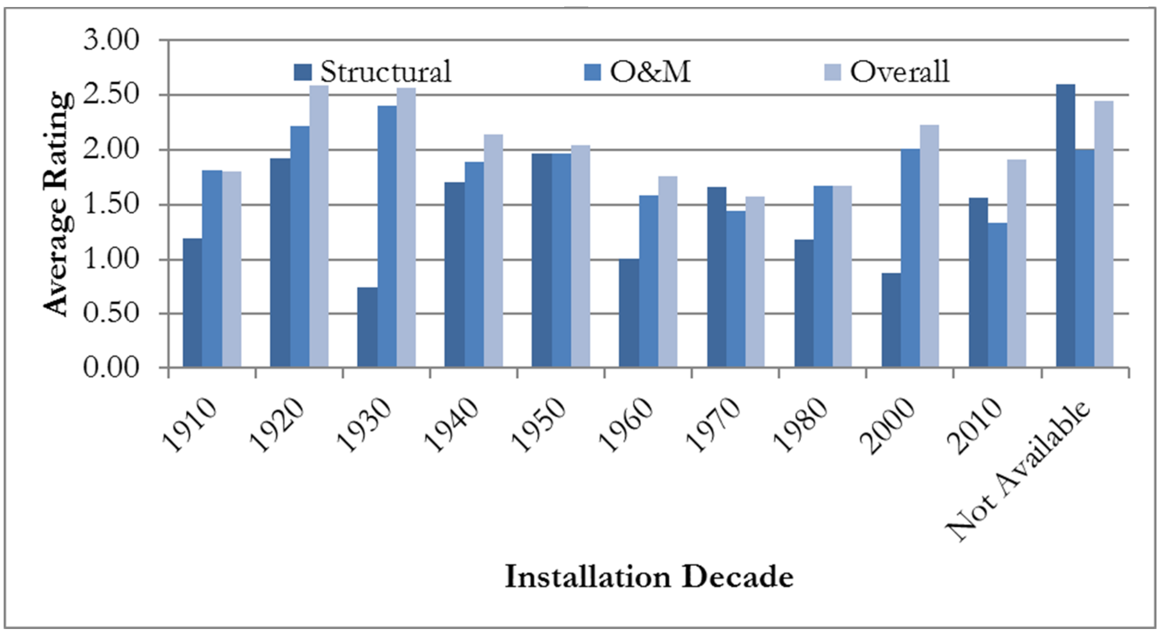


Figure 19: Average Storm Sewer Condition Ratings Indices by Installation Decade

* Some asset condition data (for components newer than 1993) were available from previous City inspections that were performed separate from the SAW Grant effort.

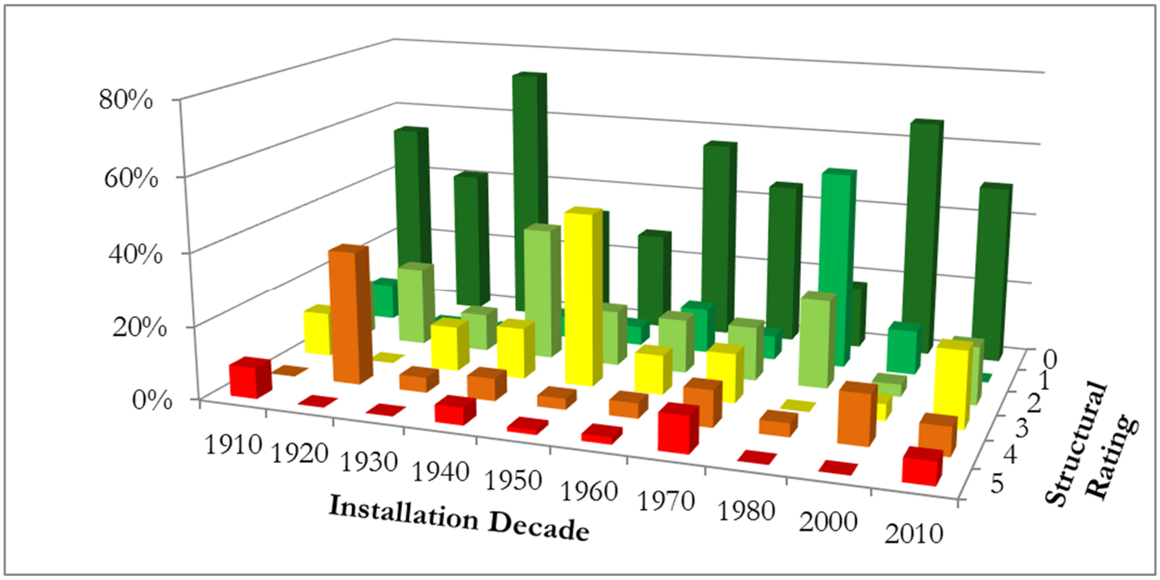


Figure 20: Breakdown of Storm Sewer Pipe Structural Scores by Decade

* Some asset condition data (for components newer than 1993) were available from previous City inspections that were performed separate from the SAW Grant effort.

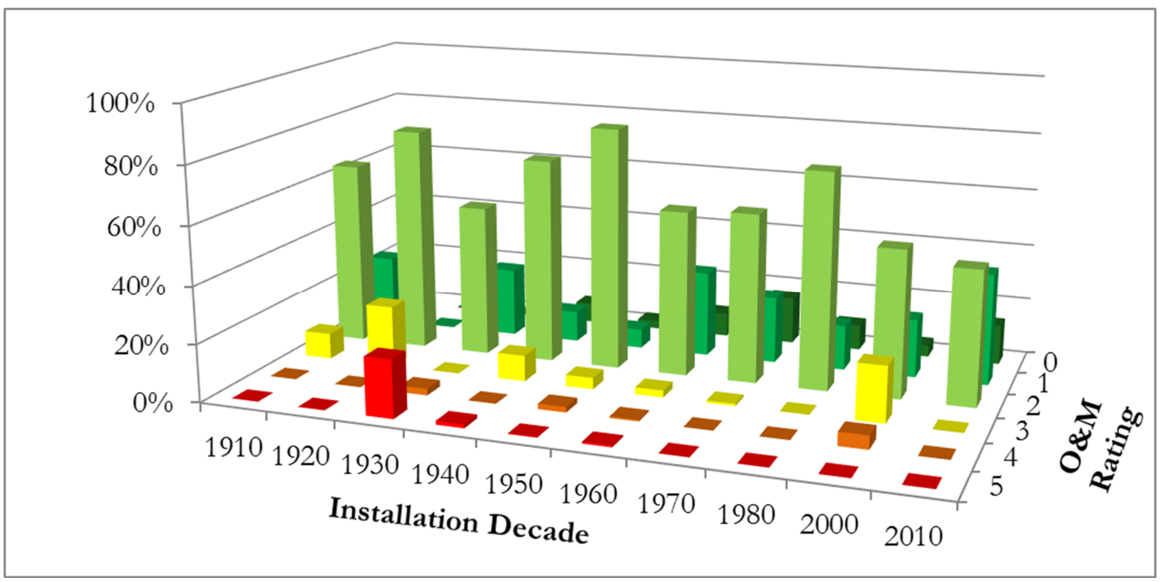


Figure 21: Breakdown of Storm Sewer Pipe O&M Scores by Decade

* 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 14 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 35% of the inspected system. Extrapolating this to the entire stormwater collection system yields roughly 23 miles of storm 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	15.6	24.8	38%
1	2.8	4.5	7%
2	4.9	7.7	12%
3	3.8	6.0	9%
4	10.1	16.0	24%
5	4.1	6.5	10%

Table 4: Footage of Sewer System Structural Defects by Pipe Diameter

Diameter	0	1	2	3	4	5	Total
8	24			573	320	146	1,063
10	541	140	2,994	4,310	3,384	2,717	14,085
12	1,424	1,797	9,246	10,453	6,181	5,807	35,858
15	511	1,347	7,594	4,916	7,874	4,861	27,103
18	1,589	739	5,645	2,848	5,545	2,625	18,992
21	44	1,243	6,508	4,324	5,827	1,650	19,595
24	314	1,134	7,526	3,324	5,302	5,694	23,294
27	675	323	1,693		425	1,038	4,153
30	1,499	767	3,069	822	49,799	2,539	58,495
36	680	151	4,128	2,172	1,072	837	9,040
42	190	538	890		1,461	886	3,966
48			536	219			755
54	49		692			256	997
66			438				438
Total (ft)	**7,542**	**8,177**	**50,958**	**33,961**	**87,191**	**29,057**	**217,836**
Total (mi)	**15.6**	**2.8**	**4.9**	**3.8**	**10.1**	**4.1**	**41.2**

The most predominant structural defects as observed in the storm system are surface damage and cracks or fractures; the most common O&M defects in the surveyed system are soil/dirt/rock deposits, infiltration, and root intrusion. Figure 22 depicts the type and number of defects reported in the inspected portion of the stormwater collection system.

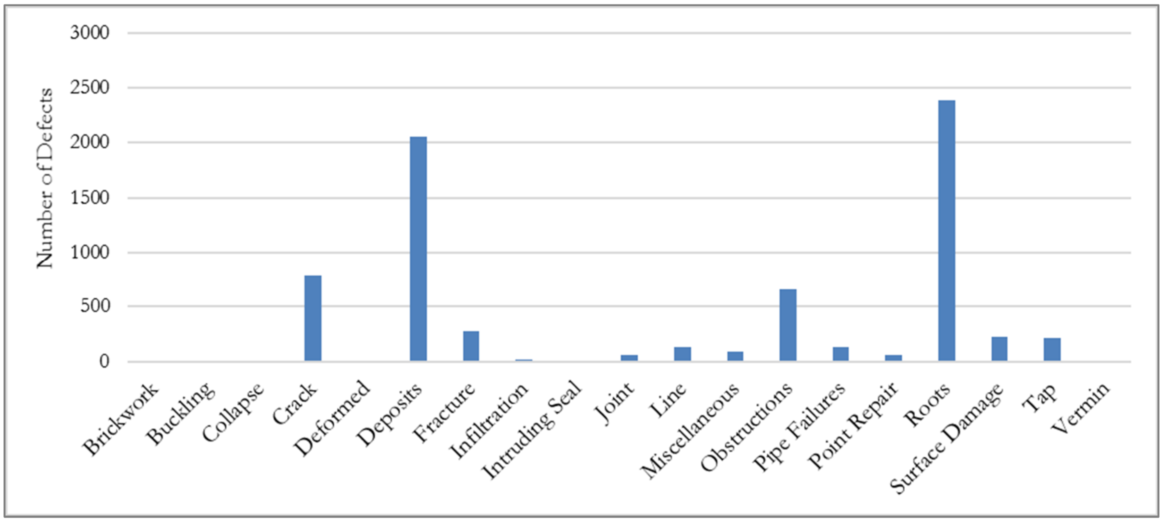


Figure 22: Storm Sewer Defects

D. Catch Basins

There are approximately 2,400 catch basins in the City's stormwater collection system. Roughly 1,450 catch basins (around 60% of the total) were performed by OHM Advisors and City staff throughout the City. The collected data included, but were not limited to, the location, size, type, condition, and material of the catch basin components. The catch basin sample included in this analysis is a representative sample of the system and is appropriate for extrapolating conditions to the entire system.

Because the defect coding system in NASSCO's MACP is very detailed and meant for the evaluation of larger diameter structures, the catch basin were assessed with a simplified methodology. This method was determined to be acceptable due to catch basins being much smaller structures that generally get replaced during road construction projects before their service life expires. The simplified rating utilizes a 0 to 5 scale based on NASSCO's code matrix in an effort to maintain consistency with the other asset evaluations that were performed as a part of this project. Similar

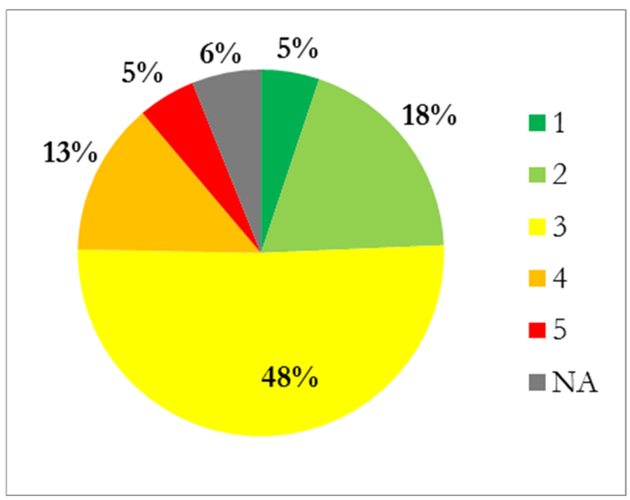


Figure 23: Catch Basin Condition Assessment Distribution

to NASSCO's Ratings Indices, the higher the overall structure rating, the worse the condition of the catch basin.

The condition ratings of the assessed catch basins in shown in Table 5. A map of condition ratings is available in Figure B-13 in Appendix B. There were 154 inventoried catch basins with a rating of either 4 or 5, seven of which were deemed to be in need of repair. Catch basins are generally repaired and replaced during road projects. 84 of the catch basins (around 6%) could not be given a condition rating due to the structure being full of water, full of debris, or unable to be opened. The inspection data is incorporated in the City's CMMS and will be updated as the City performs inspections in the future.

Table 5: Summary of Catch Basin Inspections

Rating	OHM Inspections	City Inspections	Total Inspections	Percent of System Total
0	0	79	79	5.4%
1	1	70	71	4.9%
2	70	194	264	18.1%
3	333	369	702	48.2%
4	39	147	186	12.8%
5	6	64	70	4.8%
Not Available	51	33	84	5.8%
Total	**500**	**956**	**1456**	**-**

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 forecast, 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 that may cause flooding damage and require 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 storm sewer infrastructure, which will be required for system components that are aging beyond their useful service lives.

Figure 24 shows the approximated structural deterioration curve for the stormwater infrastructure based on this single assessment and should be revised using future condition assessments. The deterioration curve assumes an average system-wide useful life of 120 years. As suggested by this curve, the average condition of the City's stormwater infrastructure would be expected to degrade from its current rating of 1.7 to reach a rating of 5 in approximately 45 years if no repair and rehabilitation programs were implemented. In addition, the rate of deterioration of the existing infrastructure is likely going to increase, underlining the importance of field inspection in the upcoming years.

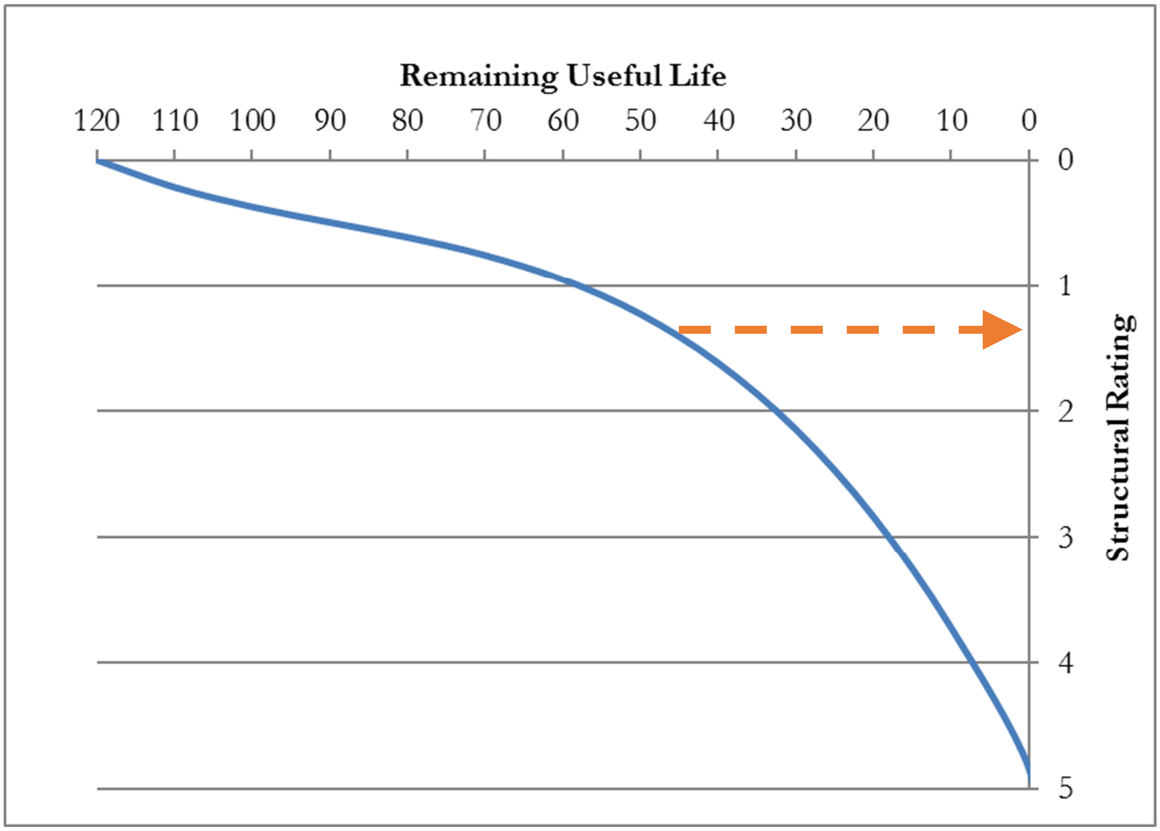


Figure 24: System Deterioration Profile

The longevity of Traverse City's stormwater 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 (Figure 25). 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 25 and Figure 26, 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 stormwater system is rapidly aging with some pipes and manholes installed as early as 1914. With dedicated funding to proactively maintain and rehabilitate the system, the current structural condition can be sustained as shown in Figure 26.

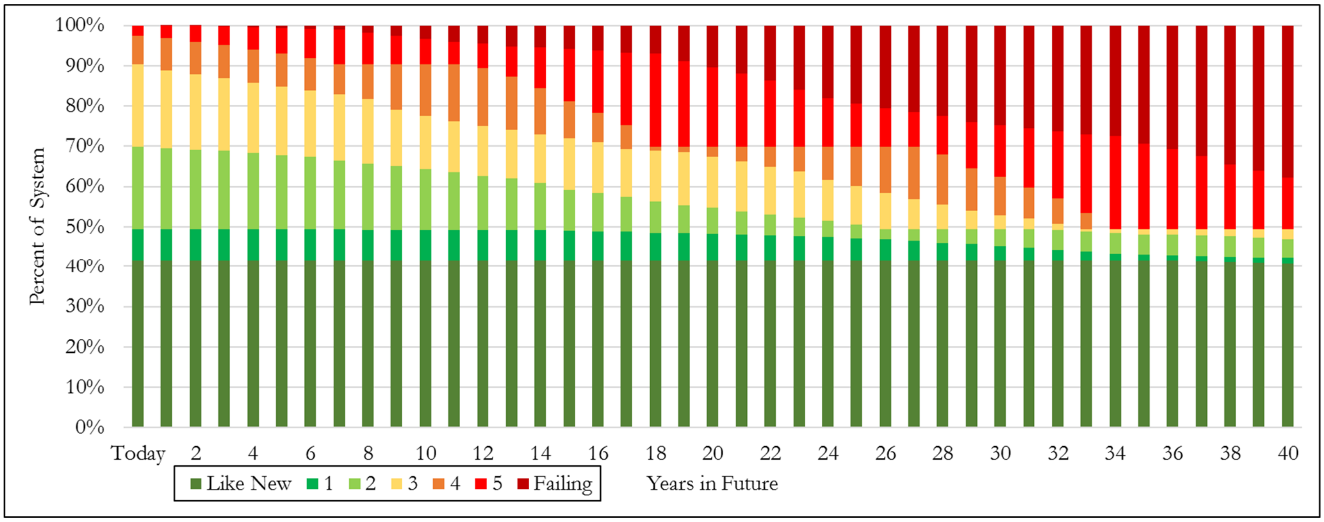


Figure 25: Structural Deterioration Under Existing Funding Level

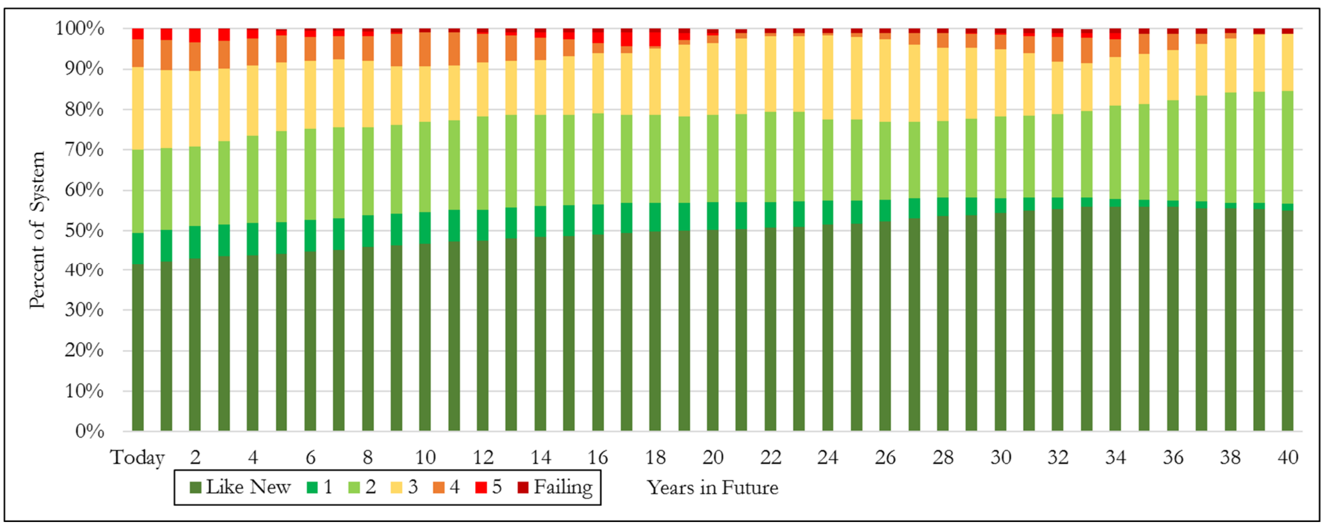


Figure 26: Maintaining Current Structural Condition Under Proposed New Funding Level

IV. Hydrologic and Hydraulic Modeling

The hydrologic/hydraulic modeling program XP-SWMM 2016 was used to estimate peak flow rates and determine the hydraulic capacity of Traverse City's stormwater collection system. The larger (trunk) storm sewers were modeled during this effort. While these only represent a small percentage of the total system, they drive the performance of the remainder of the system. Detailed information regarding the model and results are available in Appendix C.

The model was developed from existing Geographic Information System (GIS) data maintained by the City of Traverse City's GIS department as well as data publicly available on the State of Michigan GIS portal (GIS Open Data). Given the spatial extent of the computer model and the reliance on community wide data sets, as well as the lack of data available outside of city limits, the computer model should be considered a planning level tool suitable for generating system wide recommendations related to general quantities and areas of green infrastructure to be implemented. It was not calibrated with actual storm water flow data from measured conveyance in pipes during storm events. Thus, the results should be further analyzed during implementation of any proposed improvements.

The stormwater model revealed that some of the City's sewers are too small to provide a reasonable level of service. Although immediate replacement is not recommended, this Asset Management Plan identifies opportunities to replace these sewers as street replacement projects are implemented.

An *Existing Conditions* model was developed to simulate the collection system under existing (2016) land use conditions. The key findings of the *Existing Conditions* model are discussed below. A *Proposed Conditions* model was developed to simulate the impacts of recommended hydraulic improvements and infiltration Best Management Practices (BMPs). The primary purpose of this effort was to identify storm sewers system wide that should be replaced during future road projects so as to provide an adequate level of protection against flooding. Additionally, the BMP recommendations will enhance water quality and significantly reduce the volume of stormwater discharged to Grand Traverse Bay along Rose Street and Boardman Lake along Hannah Avenue. These identified sewers are reflected in the Capital Improvement Plan (CIP) component of the cost summary. These recommendations may be adjusted by the City to reflect actual Level of Service needs in specific neighborhoods.

The Existing Conditions model was used to identify the storm sewers and bridges/culverts within the City that are undersized. The analysis was performed for both the 5-year and 10-year recurrence interval storm events. In general, both the 5-year and 10-year events resulted in predicted hydraulic surcharge and roadway inundation in multiple areas.

- **Undersized Storm Sewers -** Storm sewers were defined as undersized where the Existing Conditions model predicted the hydraulic grade line to exceed the ground surface during the time of peak flow, indicating flooding potential under the 5-year peak flow conditions.

- **Undersized Bridges/Culverts -** In our analysis, culverts and bridges from Seventh Street to the Boardman River were analyzed under existing conditions for the 5-, 10-, and 100-year recurrence interval storm events.

Both the 5-year and 10-year design storms are the most commonly used by communities for establishing design criteria for storm sewer sizing, and either are appropriate for Traverse City. Given the need for hydraulic improvements in the stormwater collection system under both the 5-year and 10-year event criteria, the 5-year storm is recommended as the design event on which to base future storm sewer improvements for the following reasons:

The 5-year recurrence interval storm, along with the 10-year storm, is a commonly-used design criteria for municipal stormwater Level of Service and provides a reasonable level of protection against system surcharging. The magnitude of system improvements will be smaller and more reasonable under the 5-year recurrence interval standard.

Beyond the goal to convey wet weather flows to the outfalls, a key concern in Traverse City is the quality of stormwater that reaches Boardman Lake and Grand Traverse Bay. Stormwater volume and quality are directly linked because volume reduction (via infiltration) reduces the total pollutant loading to surface water bodies. Water quality was a Level of Service component desired by the SAG. Therefore, the hydrologic/hydraulic model was used to analyze a Green Infrastructure Scenario for the Rose Street and Hannah Avenue sewersheds to quantify potential runoff volume and pollutant reduction through the implementation of infiltration BMPs within the right-of-way. The CIP costs include a provision for infiltration BMPs to be installed as streets and sewers are replaced.

This Asset Management Plan recommends a balanced approach between sewer enlargement and infiltration BMPs. This addresses two issues: flood control and stormwater quality.

Recommendations for storm sewer capital improvements are provided for the following key reasons:

- Provide the City with an inventory of recommended sewer size increases to be used to replace aging sewers or when roadway replacements are implemented. This is a key component of this AMP, and is necessary to help define the full cost of operating the City's stormwater infrastructure for the next several decades.

- Provide the City with a cost estimate for the recommended sewer size increase and the addition of infiltration BMPs to mitigate the impacts of increasing pipe size.

- Provide a reasonable Level of Service to protect the residents, visitors, and business owners in Traverse City. Although the predicted flooding is brief, any surcharging above the surface creates an undue burden on motorists, adjacent parcels, and increases the likelihood of property loss and unwanted erosion at or near the bay.

- Prepare the City for the need to adapt to changing climate patterns. In Michigan, the average annual precipitation has increased by 5 to 10 percent and during intense rainfall events precipitation has increased about 35 percent, according to the Environmental Protection Agency (EPA). Planning for larger storm sewers will make it easier for the City to adapt and maintain an adequate Level of Service for future generations.

V. Level of Service

Level of Service for a stormwater system is traditionally defined as the storm magnitude (i.e. annual exceedance interval) that the collection system can convey without causing surface flooding that may negatively impact residents, businesses, and institutions. This is often referred to in terms of inches of rainfall or annual recurrence interval, such as the 10-year storm (also known as the 10% storm, as it has a one-in-ten chance of being exceeded in any given year).

For the analysis of the stormwater collection system flow capacity, the 5-year and 10-year recurrence interval events were used, as they are the most common levels of protection for municipal stormwater collection systems. ***The 5-year recurrence interval storm event was chosen as the baseline Level of Service for storm sewer flow capacity, due to the hydraulic model results showing a disproportionately large fraction of the system that would be identified as undersized under the 10-year recurrence interval criteria. The 10-year storm can be used for individual scenarios should the City deem it necessary to provide an additional level of flood protection in critical areas.***

Meeting the City's long-term needs requires that:

1. **The system remains clean, structurally sound, and clear of obstructions**
2. **The system is large enough to prevent excessive flooding**
3. **The system controls the amount of pollutants reaching Grand Traverse Bay**

The SAG reviewed various flood control Level of Service scenarios. Based on feedback, some temporary flooding may be permissible within the street area, provided that the duration is relatively short, the maximum depth does not interfere with traffic, and there is no property damage. The following criteria were developed for desired flood control Level of Service:

- A maximum flooding depth of six inches on roadways will not negatively impact emergency response times
- The maximum duration of roadway flooding shall be 30 minutes for primary emergency routes (ADT>5,000)
- The maximum duration of roadway flooding shall be 60 minutes for non-emergency routes (ADT between 2,000 and 5,000)
- The maximum duration of roadway flooding shall be 6 hours for low volume residential street (ADT<2,000)

Figures B-14 and B-15 in Appendix B illustrate the hydraulically-deficient sewers with flood durations and peak flood depths. These figures can be used to prioritize which sewers should be upsized to accommodate the flood control Level of Service. As shown in Figures B-14 and B-15, there are storm sewers that meet the flood control Level of Service criteria but would still result in surface flooding during the 5-year and/or 10-year storm. Although these sewers are not a high priority for upsizing, the City should consider their replacement when they coincide with street reconstruction projects. The cost estimates in this document reflect the assumption that the City will replace these sewers in conjunction with roadway projects.

Other key components of the Level of Service have emerged due to increased attention to Asset Management Planning, stormwater quality, and environmental sustainability. These components are as follows:

- Minimum water quality standards at the system outfalls, including maximum concentrations of known pollutants such as Nitrogen, Phosphorus, Total Suspended Solids (TSS), heavy metals, and E. coli (bacteria). Given the importance of the water quality in Grand Traverse Bay, this Level of Service is of utmost importance in Traverse City and was reinforced during the Stormwater Advisory Group (SAG) process. <u>***A reasonable goal for water quality would be to establish a maximum desired TSS concentration of 80 mg/L***</u> (80 parts per million) at the City's outfalls. This is consistent with new MDEQ guidelines for water quality in communities with NPDES stormwater permits.

- 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 <u>***before***</u> 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 storm sewer televising (inspection) program and an annual repair and rehabilitation program to maintain an average structural condition equal to that observed in 2016.***</u>

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 D and F.

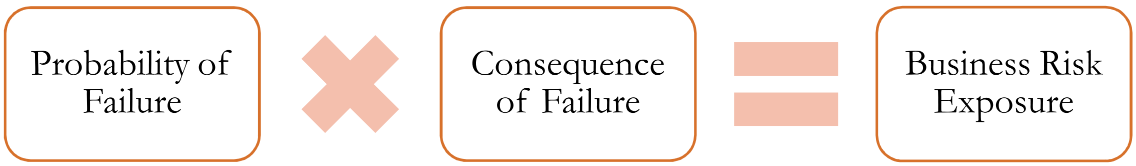


Figure 27: BRE Equation

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 6.

Table 6: 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 7. Details in how the factors were scaled is available in Appendix D.

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 7: 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 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 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 28. 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.

Probability of Failure

Consequence 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 28: BRE Prioritization Matrix

A detailed CIP that incorporates BRE and upcoming road projects for a three year planning period is available in Appendix F. The identified funding needed to address the stormwater sewer CIP is $625,000, which includes expenditures for sewer rehabilitation and repair and sewer enlargement to meet hydraulic needs. $90,000 per year is needed to address the stormwater manholes. Since the stormwater infrastructure is currently underfunded, implementing the CIP is contingent upon the City establishing a dedicated funding source for stormwater.

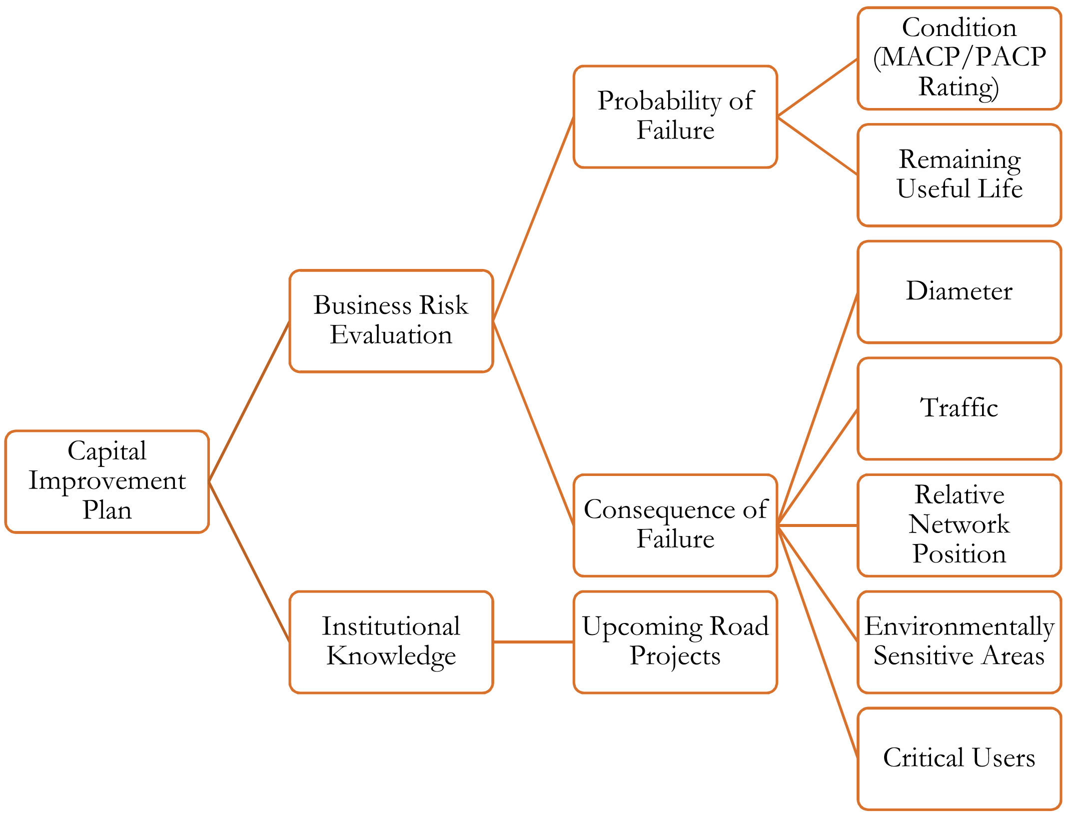


Figure 29: CIP and Risk Flow Chart

VII. Revenue Structure

A Stormwater Advisory Group (SAG) was formed in 2015 and met four times to discuss the prospect of long term funding for the City's stormwater system. There is currently no dedicated funding source for Traverse City's stormwater system, unlike water and wastewater systems. A Funding Feasibility Study with revenue analysis developed as part of this AMP is available in Appendix E.

The total spent annually by the City for all stormwater-related activities is approximately $750,000, with $360,000 dedicated from the general fund and additional funding from streets budget if available. Those activities are summarized below:

- Sweep streets to help reduce the amount of dirt that washes into the storm sewer.
- Clean catch basins and curb inlets annually to remove dirt and debris before it gets into local waterways.
- Pick up leaves on streets to keep stormwater inlets from clogging and roadways and property from flooding.
- Install and maintain end-of-pipe stormwater filters and treatment systems to reduce the pollution that reaches Grand Traverse Bay.
- As City streets budget allows, repair and replace storm sewers during road reconstruction projects.

Existing problems were identified during the inventory and inspection of the stormwater system, combined with interviews with key City public works staff to identify known physical and budgetary problems. Key issues are noted below:

- The average age of the City's storm sewer system is 60 years; approximately 15% of the sewer system requires repair or replacement.
- To avoid unnecessary escalation of costs, protection of private property, and ensure protection of the local waterways from pollution, more investment must be made in the existing storm sewer system. This includes more attention to proactive maintenance and ongoing repairs.
- Currently, investment in the storm sewer system can be described as piecemeal and minimal. Investment is primarily driven by funding available from miscellaneous budgets, i.e. there is no systematic, institutionalized mechanism in place that is fiscally sustainable.

A. Funding Mechanism

Providing adequate, quality service requires both a plan for strategic investment in new and existing infrastructure and a fiscally sustainable means to support that investment. This requires a systemic approach to reviewing the structural condition of the stormwater infrastructure on a perpetual basis and upgrading the system to maintain an adequate level of service to address both flood prevention and water quality. This is the purpose of an Asset Management Plan.

There are two ways cities in Michigan can fund services: taxes and fees. The table below juxtaposes these two options and their relative implications. It was prepared to aid dialogue within the City and with its citizens in choosing a path forward.

Table 8: Comparison of Stormwater Funding Strategies

Strategy/Decision	Positive Implications	Negative Implications
Continue Existing Program	Avoid controversy associated with any new fees or taxes.	Legacy costs will accrue, project costs will be higher than necessary, service will decline, flooding may occur, and local waterways will be subject to more pollution.
Adequately invest using Tax Revenues	The City will satisfy its short term stormwater infrastructure needs through adequate funding.	Unfair to both residents and businesses. In the longer term, may be another draw on the General Fund due to limitations by Headlee, Proposal A, and state cuts in revenue sharing. Other services may suffer. Future priorities may shift and tax revenues would be diverted away from stormwater.
Adequately invest using an Enterprise Fund (Stormwater Utility)	The City will satisfy its stormwater infrastructure needs. Investments benefiting individual businesses and residents will be much fairer and more likely to be sustained over the long run. Flooding will be less likely and water quality will improve.	Could result in protest from sectors currently receiving benefits at no cost, i.e. tax-exempt properties. Some risk of utility fee being challenged as a violation of the State Constitution.

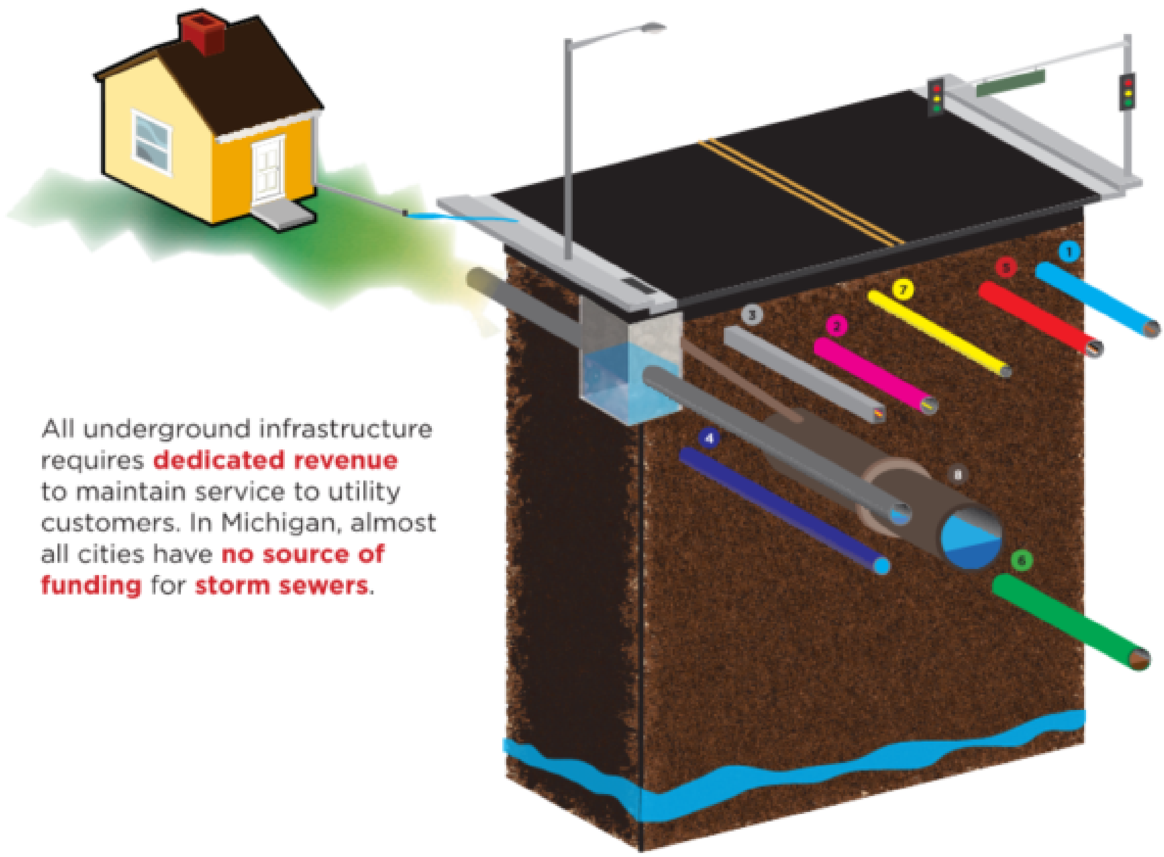
Another option could include a combination of both taxes and fees. However, if any fee is established for stormwater, it would be ideal to allow the fee to cover all cost components of the stormwater infrastructure, as is consistent with the fee mechanisms for other infrastructure, such as water and wastewater.

B. Guiding Principles

There are several ideologies that guided the SAG in their recommendation of a fiscally sustainable financing mechanism. Debate and discussion on how best to move forward will be most productive if it begins with a set of principles to benchmark the merits of ideas put forth in the process. The SAG suggested the following four principles:

1. When estimating the amount of revenue needed and the amount to be charged, the math will always include the cost of four things: capital, operation, maintenance, and replacement. These represent the true short and long term costs of infrastructure service. Any weak link in this chain seriously compromises reliability.
2. The City will not rely on federal or state government to subsidize local utility services. That approach is unsustainable because the subsidies may not be adequate, Traverse City may not get them, and subsidies aren't guaranteed to be received in perpetuity.
3. The City will earn and maintain the public trust by choosing a funding strategy that is both fair and transparent regarding:
    a. How costs are calculated
    b. How charges are allocated to customers.
4. Meeting public expectations to optimize costs and be fair means we need to make sure the actions of various City departments (i.e. public works, planning, engineering, finance, etc.) have the same end goal. That means a commitment to collaboration and partnerships. Therefore, decisions about how much, where, and when to invest will be made on a systematic basis considering:
    a. Cost
    b. Benefits
    c. Alignment with other City programs
    d. Contribution to quality of life and public safety
    e. Alignment with services provided by others

Figure 30 illustrates the different underground utilities in Traverse City. The charges are representative of typical single family homes in Michigan and comparable to average utility rates in Traverse City. With the exception of stormwater, each of the utilities has a dedicated revenue source. The key recommendation from the SAG is to pursue the development of a stormwater rate ordinance and utility. This recommendation comes from the desire to have a fair and equitable charge for services.



	UTILITY	OWNER	REVENUE SOURCE	TYPICAL CHARGE
1	CABLE	CHARTER CABLE	USER FEE	$175
2	TELEPHONE	AT&T	USER FEE	$25
3	FIBER OPTIC	LIGHTSPEED	USER FEE	$49
4	WATER	CITY WATER UTILITY	USER FEE	$35
5	ELECTRICITY	TRAVERSE CITY LIGHT & POWER	USER FEE	$80
6	SANITARY	CITY SEWER UTILITY	USER FEE	$40
7	GAS	DTE	USER FEE	$120
8	**STORM SEWER**	CITY	NONE	NA

Figure 30: Underground Utilities and Funding Sources

C. Current and Proposed Investment

The City has currently allocated $360,000 per year to stormwater activities. These are mostly costs linked to keeping the system clean, including leaf pickup, street sweeping, and catch basin cleaning. Any additional costs, such as repair or replacement of catch basins, and structural repair or replacement of manholes and sewers, are generally taken from the City's streets budget. This creates unnecessary strain on the streets budget, as that money is needed to repair and replace the City's roadways. This further underscores the need for a dedicated funding source for stormwater assets.

The inventory and condition assessment completed for this AMP include several new O&M and CIP costs that are crucial to meeting the City's goals of effective management and maintenance of stormwater infrastructure. As shown in Table 9, there is a substantial funding gap of $1.66 million between the $2.02 million proposed annually and the $360,000 currently allocated to stormwater in the City's current budget. Additional funding is now associated with the stormwater component of roadway projects and is coming from road budgets. If a stormwater utility were enacted, the funds should be diverted back to roadway repairs.

Proposed Budget Items	Annual Cost
O&M Expenditures	
Sewer Rehabilitation and Repairs	$310,000
Manhole Replacement Program (Repairs/Inspection/Cleaning)	$90,000
Sweeping and Leaf Collection	$285,000
Sewer System Inspection and Cleaning	$160,000
Boardman River Wall Maintenance	$65,000
Open Channel and Culvert Maintenance	$75,000
Administrative Costs and New Personnel	$150,000
Stormwater Utility Bill (City-owned facilities)	$50,000
O&M Subtotal	**$1,185,000**
CIP Expenditures	
Catch Basin Replacement Program (Inspection/Cleaning)	$100,000
Storm Sewer Replacement (Hydraulics)	$315,000
Infiltration BMPs (Volume and Pollutant Control)	$350,000
End of Pipe Treatment	$70,000
CIP Subtotal	**$835,000**
Annual Total	**$2,020,000**
Existing Stormwater Budget	**$360,000**
Funding Gap	**$1,660,000**

Table 9: Proposed Investment Needs

Many of the O&M related items must occur annually to maintain and prolong the life of aging infrastructure while the CIP items are generally projected for a 20- to 30-year timeframe so as to avoid excessive annual budgets. For example, sewer size increases and infiltration BMPs should be programmed to coincide with planned roadway replacement projects as they occur, likely over a 30-year period.

D. Preliminary Rate Model

An analysis of existing land use and magnitude of impervious areas within individual parcels was used to evaluate how a stormwater billing program might impact typical property owners. This process utilized an existing City GIS database showing the size and location of impervious areas on all parcels. An Equivalent Residential Unit (ERU) was determined from the median impervious area measured on residential parcels within Traverse City.

For Traverse City, the ERU was determined to be approximately 1,915 square feet of impervious area, including rooftops, driveways, patios, etc. This calculation can be applied to all parcels to determine the approximate number of ERUs (or billing units) within the City. Based on our preliminary review of the total imperious area within City limits, as well as the number of single-family residential parcels, our estimate of the number of billing units in the City is about 34,600.

Based on the recommended stormwater program, a stormwater utility would result in modest fees, impacting the typical residential property with a fee that would likely range from $6 to $7 per month. Fees would be more equitable than taxes.

Of the 34,000-35,000 estimated stormwater billing units in the City, approximately 86% of these units are associated with non-residential customers (e.g. commercial, industrial, institutional), while residential customers would be responsible for the remaining 14%. This excludes the airport property, which has retention basins onsite and does not have a stormwater outlet to the City's system.

Based on preliminary data, the City can generate approximately $415,000 for every one dollar per month charged to an ERU. In other words, a monthly charge of about $6 per ERU (median residential parcel) would close the stormwater infrastructure funding gap referenced in this document. A monthly charge of $7 per ERU should generate enough revenue to fully fund the $2.02 million recommended stormwater program.

E. Fee vs. Tax

In order to fully explore the viability and fairness of a stormwater utility fee, it is necessary to compare it to property tax revenues to see how it would impact a typical customer. Because the City has many tax-exempt properties with large impervious surfaces, those properties would be subsidized if the City's stormwater program were funded through a tax millage. Table 10 summarizes the difference in monthly costs for various residential scenarios between an ERU-based user fee and a tax, based on the most recent Equalization Report and an assumed 2.0 Mil tax to generate an equivalent revenue to the stormwater utility.

Table 10: Fee vs. Tax Summary

Typical Monthly Fee * / **	Stormwater Utility	Property Tax (Millage)
R-1b parcel (typical property)	$6-$7	$16
R-1a parcel (larger property)	$12-$14	$20
Median Taxable Income Property	$6-$7	$16
Newly-purchased median home ($265k)	$6-$7	$23

* *Stormwater Utility Fee estimate: 34,600 City-wide ERUs (billing units), airport excluded (no stormwater outlet)*
** *Property tax based on need for ~2.0 Mils, applied to taxable values in the 2016 Equalization Report for Grand Traverse County*

Using property taxes to collect the recommended revenues in this report will result in significantly higher costs to the residents of Traverse City, as compared to a utility fee. The primary reason for this difference is that the residential customers, who are not tax-exempt, would subsidize numerous tax-exempt property owners throughout the City. As all property owners, tax-exempt and non-tax-exempt, depend on the City's stormwater system, the property tax represents an unfair distribution of costs.

VIII. On-Going Data Management

A fully utilized AMP will improve the City's stormwater system for the City's future generations. Figure 31 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. This data management process will aid in the tracking and use of data to cost-effectively manage the City's stormwater 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 31: 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. 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: Data Management and Editing

Appendix A: Data Management and Editing

Traverse City's stormwater 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 stormwater GIS database with OHM Advisors in early 2015. That database served as a reference for OHM throughout the course of the project. A screenshot of the database's contents can be seen in Figure A-1.

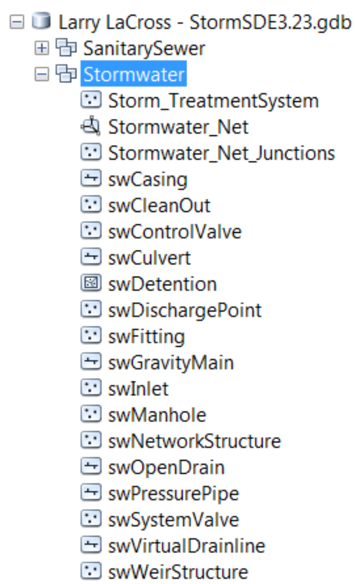


Figure A-1: Stormwater Geodatabase Contents

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 linking 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 integrate 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 stormwater system moving forward; especially if the City implements a funding source for the stormwater 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 stormwater gravity mains is available in Figure A-2.

OBJECTID *	FACILITYID	INSTALLDATE	MATERIAL	DIAMETER	MAINSHAPE	LINEDYEAR	LINERTYPE	DOWNELEV	UPELEV	SLOPE	FROMMH	TOMH	EN
1	STP-1	7/7/1972	Reinforced Concrete	10"	<Null>	<Null>	<Null>	607.630005	608.429993	0.4	STM-010028	STM-010029	
2	STP-2	7/7/1972	Reinforced Concrete	12"	Circular	<Null>	<Null>	605.97998	607.549988	0.4	STM-010029	STM-010030	
3	STP-3	7/7/1972	Reinforced Concrete	10"	Circular	<Null>	<Null>	605.830017	606.630005	0.4	STM-010036	STM-010030	
4	STP-4	7/7/1972	Reinforced Concrete	12"	<Null>	<Null>	<Null>	603.799988	605.830017	0.44	STM-010030	STM-010007	
5	STP-5	<Null>	Reinforced Concrete	21"	Circular	<Null>	<Null>	603.18	603.81	0.36	STM-010007	STM-010008	
6	STP-6	<Null>	Reinforced Concrete	15"	Circular	<Null>	<Null>	604.859985	606.27002	0.4	STM-010035	STM-010006	
7	STP-7	<Null>	Reinforced Concrete	12"	Circular	<Null>	<Null>	606.130005	608.22998	0.28	STM-010031	STM-010003	
8	STP-8	<Null>	Reinforced Concrete	12"	Circular	<Null>	<Null>	606.5	607.289978	0.32	STM-010034	STM-010035	
9	STP-9	<Null>	Unknown	12"	<Null>	<Null>	<Null>	608.88	609.39	0.30605	STM-010001	STM-010002	
10	STP-10	<Null>	Reinforced Concrete	12"	Circular	<Null>	<Null>	608.27002	608.880005	0.32	STM-010002	STM-010003	
11	STP-11	<Null>	Reinforced Concrete	18"	Circular	<Null>	<Null>	607	608.22998	0.28	STM-010003	STM-010004	
12	STP-12	<Null>	Reinforced Concrete	12"	Circular	<Null>	<Null>	607.25	603.309998	0.26	STM-010032	STM-010004	
13	STP-13	<Null>	Reinforced Concrete	12"	Circular	<Null>	<Null>	608.48999	609.02002	0.26	STM-010033	STM-010004	
14	STP-14	<Null>	Reinforced Concrete	21"	Circular	<Null>	<Null>	605.869995	606.799988	0.27838	STM-010004	STM-010005	
15	STP-15	<Null>	Reinforced Concrete	21"	Circular	<Null>	<Null>	604.460022	605.669983	0.28	STM-010005	STM-010006	
16	STP-16	<Null>	Reinforced Concrete	12"	<Null>	<Null>	<Null>	609.29	610.02	0.25	STM-021035	STM-021033	
17	STP-17	<Null>	Reinforced Concrete	12"	Circular	<Null>	<Null>	608	609.29	0.4	STM-021033	STM-021012	
18	STP-18	5/31/1960	Reinforced Concrete	30"	Circular	<Null>	<Null>	605.530029	606.26001	0.172958	STM-021014	STM-021017	
19	STP-19	5/31/1960	Reinforced Concrete	30"	Circular	<Null>	<Null>	605.169983	605.530029	0.174144	STM-021017	STM-021020	
20	STP-20	5/27/1960	Reinforced Concrete	30"	Circular	<Null>	<Null>	604.590027	605.169983	0.175862	STM-021020	STM-021022	
21	STP-21	5/27/1960	Reinforced Concrete	30"	Circular	<Null>	<Null>	603.969971	604.590027	0.184999	STM-021022	STM-021025	
22	STP-22	5/27/1960	Reinforced Concrete	30"	Circular	<Null>	<Null>	602.26001	603.969971	0.701428	STM-021025	STM-021026	
23	STP-23	5/27/1960	Reinforced Concrete	30"	Circular	<Null>	<Null>	600.77002	602.26001	0.663707	STM-021026	STM-021027	
24	STP-24	5/26/1960	Reinforced Concrete	36"	Circular	<Null>	<Null>	599.409973	600.77002	0.318305	STM-021027	STM-021030	
25	STP-25	5/26/1960	Reinforced Concrete	30"	Circular	<Null>	<Null>	590.059998	599.409973	2.166038	STM-021030	STM-021037	
26	STP-26	<Null>	Unknown	12"	<Null>	<Null>	<Null>	610.4	610.91	0.3	STM-021034	STM-021032	
27	STP-27	<Null>	Unknown	12"	<Null>	<Null>	<Null>	612.25	612.73999	0.22	STM-021029	STM-021030	
28	STP-28	<Null>	Unknown	12"	<Null>	<Null>	<Null>	611.48999	612.25	1	STM-021030	STM-021031	
29	STP-29	<Null>	Unknown	12"	<Null>	<Null>	<Null>	610.400024	611.48999	0.37	STM-021031	STM-021032	
30	STP-30	<Null>	Reinforced Concrete	12"	<Null>	<Null>	<Null>	609.29	610.06	0.3	STM-021032	STM-021033	
31	STP-31	10/7/1967	Reinforced Concrete	36"	Circular	<Null>	<Null>	608.79	609.38	0.18	STM-020032	STM-020033	
32	STP-32	10/7/1967	Reinforced Concrete	36"	Circular	<Null>	<Null>	608.35	608.79	0.18	STM-020033	STM-020034	
33	STP-33	10/5/1967	Reinforced Concrete	36"	Circular	<Null>	<Null>	608.22	608.35	0.17	STM-020034	STM-020035	
34	STP-34	10/5/1967	Reinforced Concrete	42"	Circular	<Null>	<Null>	607.15	607.66	0.17	STM-020036	STM-020019	

1 (of 3801)

Figure A-2: Stormwater 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 650 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 October 8, 2015 in a Microsoft Excel document named "Final Manhole Inspection Tables_SW.xlsx." This table can also can be found on the external hard drive associated with the stormwater 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 30.6 miles of sewer, which is over half of the City's collection system (additional sewer was inspected by Terra, but after the AMP analysis was completed; the City will incorporate that data into GIS and Lucity for future use). Terra provided the City with the inspection videos, reports, and three database files named "Sonar PACP.mdb", "Traverse City GranitePACP.mdb", and "Traverse City PACP.mdb". The City shared those files with OHM Advisors on March 17, 2016 for compilation and analysis.

In addition to the data collected by Terra, City staff also performed pipe inspections in accordance with NASSCO's Pipeline Assessment Certification Program (PACP) on 6.9 miles of sewer. Two database files called "StormPACPTESTtoOHM2017.5.2.mdb" and "StormPACPTESTtoOHM2017.5.4.mdb" were delivered to OHM on May 4, 2017. Because these databases were delivered so close to the project deadline, no deterioration forecasting or reviews were performed on these inspections. However, the data was added to the final tables and maps in Appendix A.

OHM Advisors returned the compiled data 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 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_SW.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. Catch Basin Data

OHM Advisors performed catch basin evaluations on 500 of the City's structures located on the east side of the City. OHM compiled the catch basin evaluation information in a tabular format that is consistent with the rest of the condition data deliverables. This file was an Excel document named "Final Catch Basin Inspection Tables.xlsx", which was delivered to the City on November 11, 2016. The final tables and the associated photographs can also be found on the external hard drive. The City performed an additional 1,000 evaluations which were integrated directly into Lucity by City staff.

F. Criticality Factors

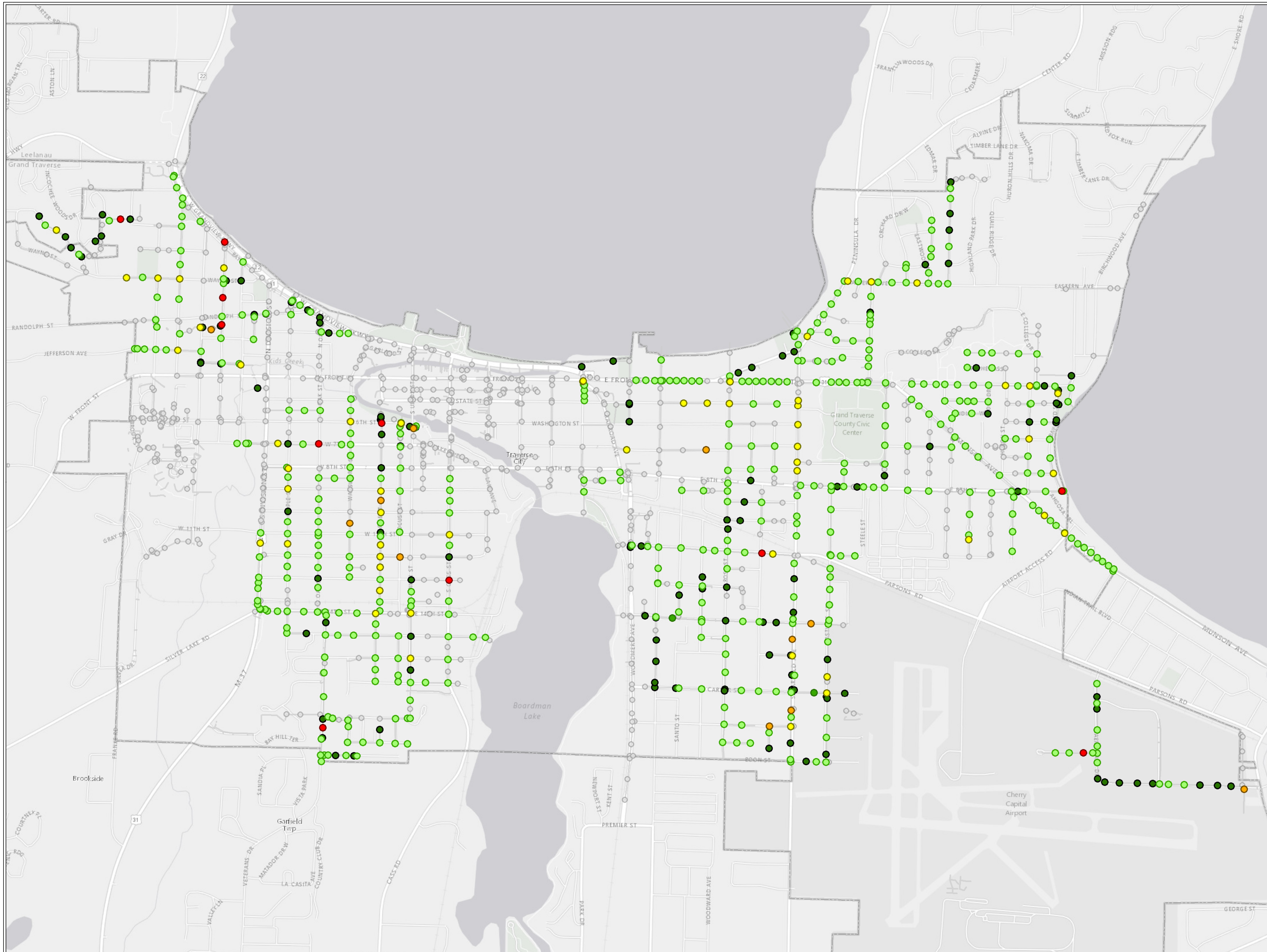
The criticality factors were created using the "StormSDE3.23.gdb" geodatabase. A new attribute field was created for each criticality factor, which was populated for all manhole and pipe segment features. Please refer to Appendix D for further details on factors and how the criticality matrix was developed. 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.

G. 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 stormwater 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. Having a dedicated funding source for the stormwater system will help guarantee a continued investment in this database, which in turn will help guarantee adequate system repairs in the long term.

Appendix B: Condition and Level of Service Maps



Traverse City SAW

MACP Structural Index Ratings

Traverse City, MI

Figure B-1

Stormwater Manholes

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 Value
- Stormwater Gravity Main
- Traverse City

0 1,800 3,600
Feet

1" = 1,800'

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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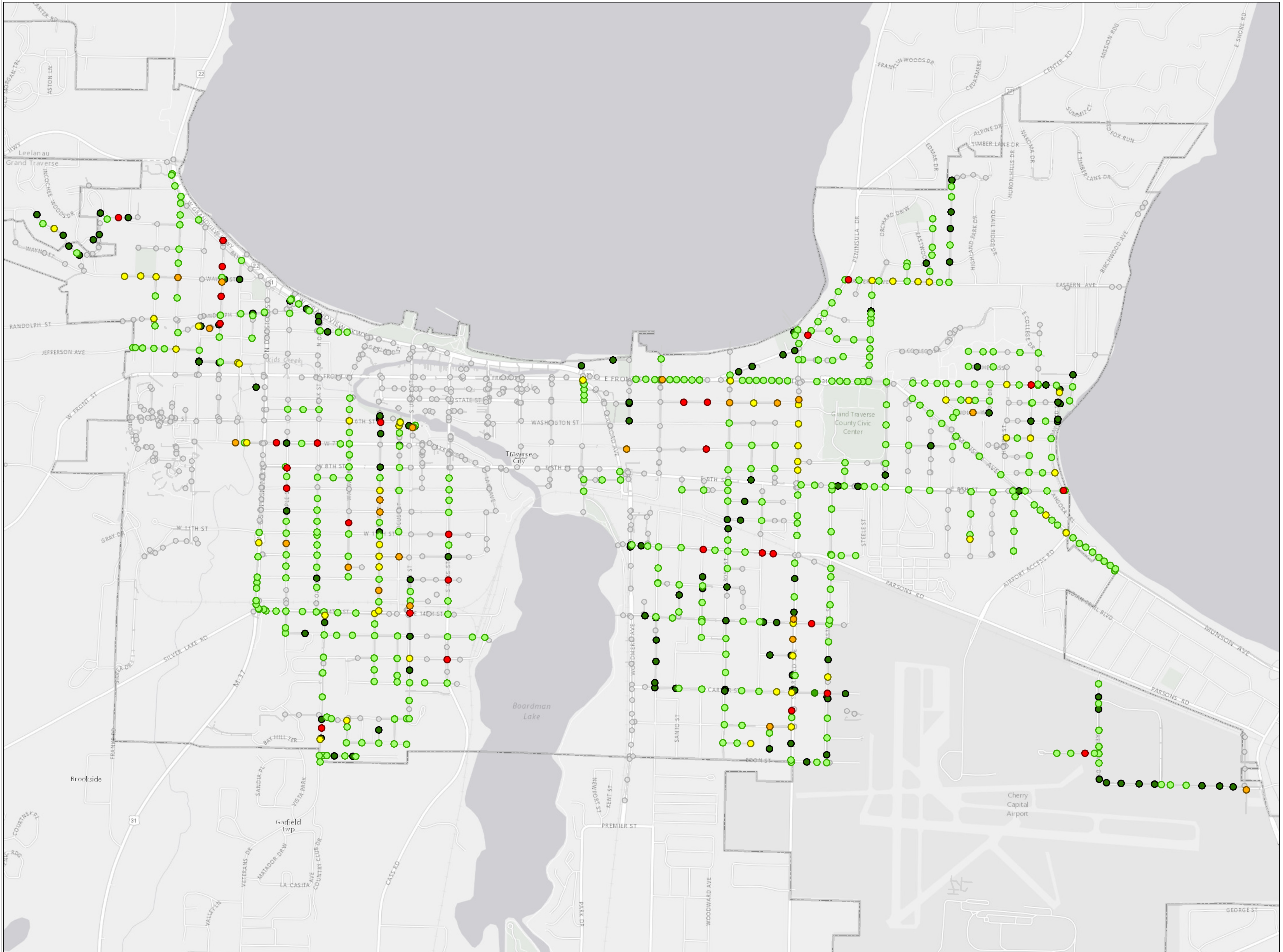
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-1 MACP Structural Index Ratings.mxd

Traverse City SAW
MACP Highest Rated Structural Defects

Traverse City, MI

Figure B-2



Stormwater Manholes

Structural Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Stormwater Gravity Main
- Traverse City

0 1,800 3,600
Feet

1" = 1,800'

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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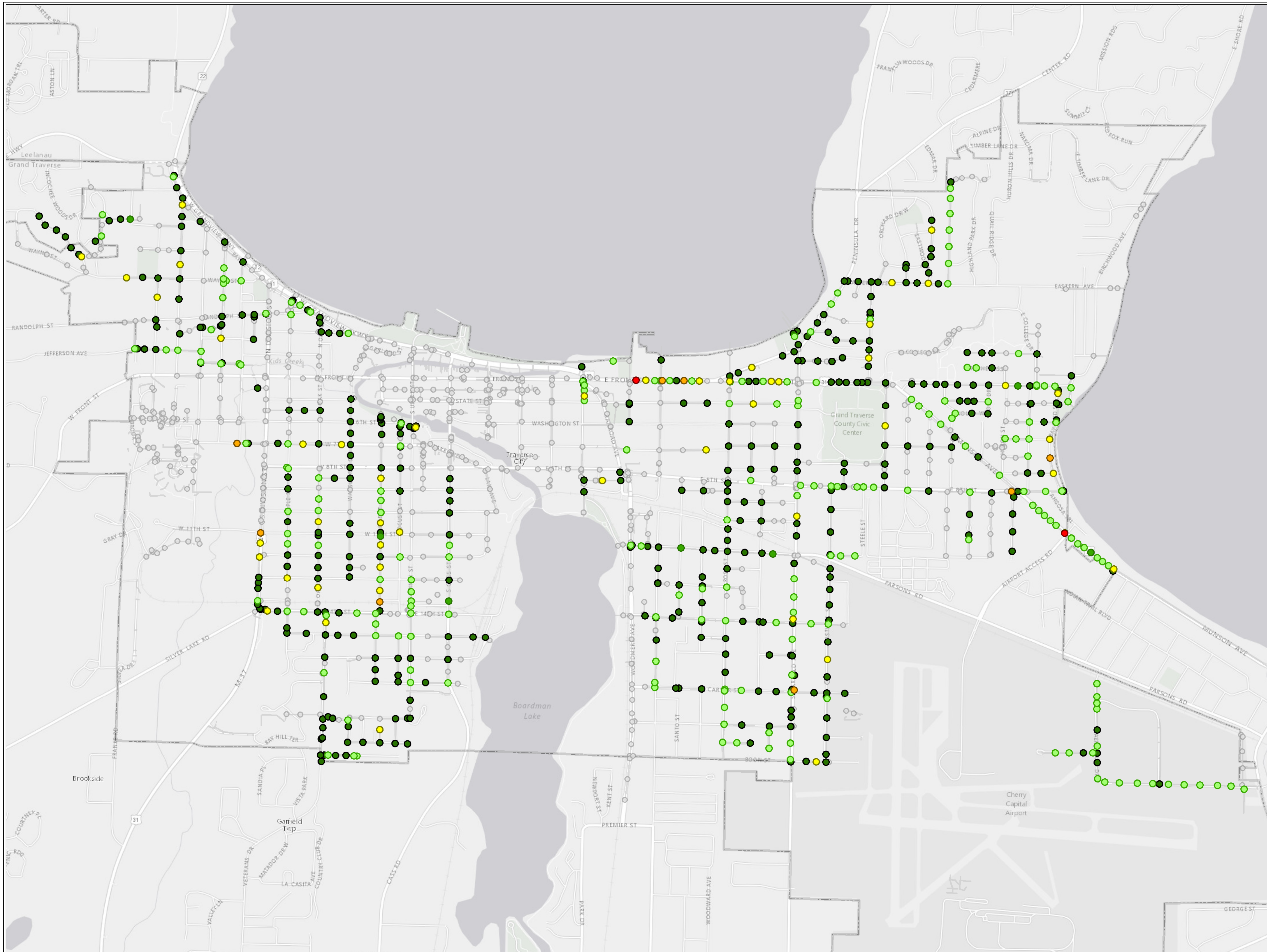

Traverse City SAW

MACP O&M Index Ratings

Traverse City, MI

Figure B-3

Stormwater Manholes

O&M 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 Value
- Stormwater Gravity Main
- Traverse City

0 1,800 3,600
Feet

1" = 1,800'

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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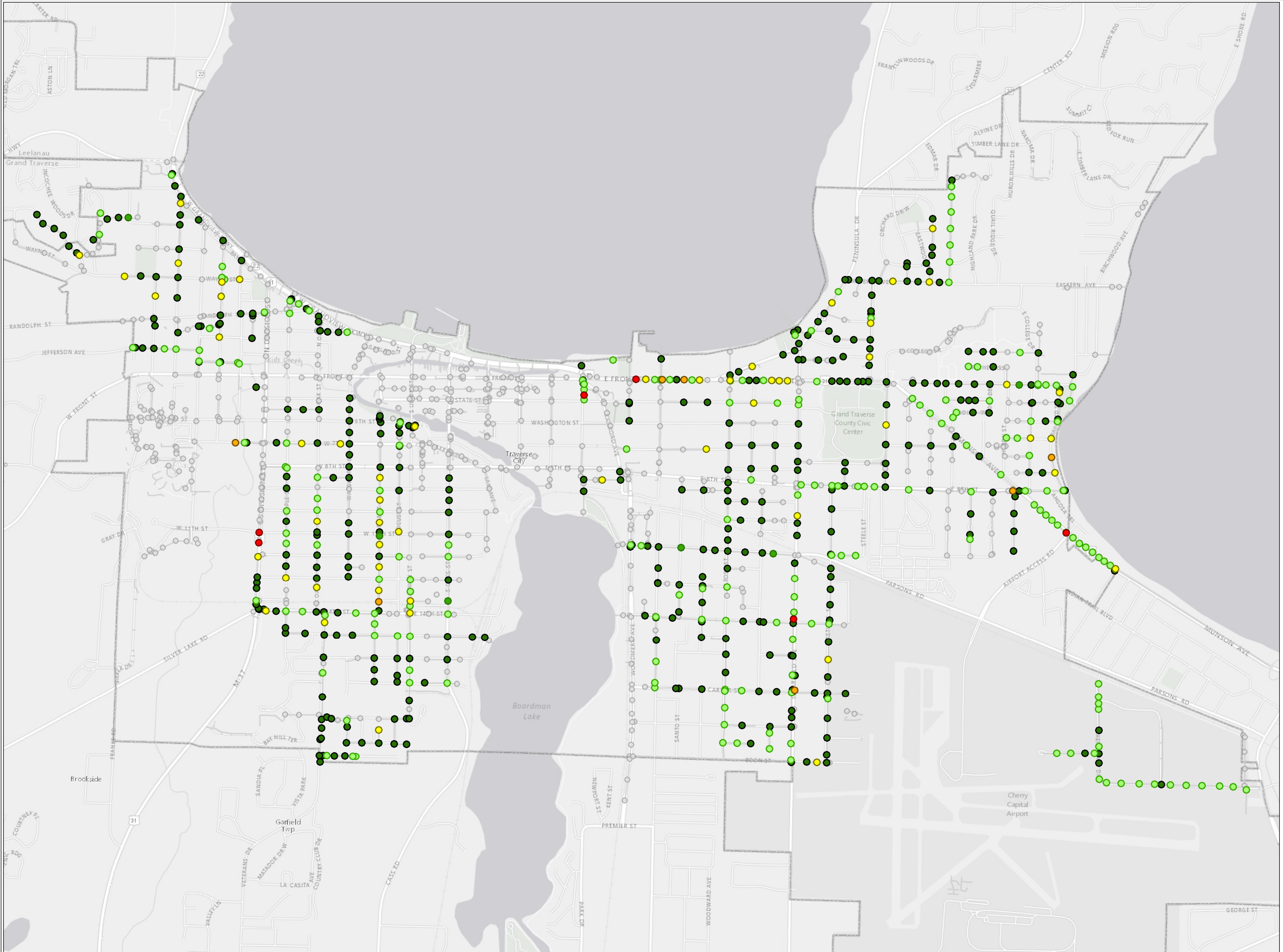
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-3 MACP O&M Index Ratings.mxd

Traverse City SAW

MACP Highest Rated O&M Defects

Traverse City, MI

Figure B-4



Stormwater Manholes

O&M Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Stormwater Gravity Main
- Traverse City

0 1,800 3,600
Feet

1" = 1,800'

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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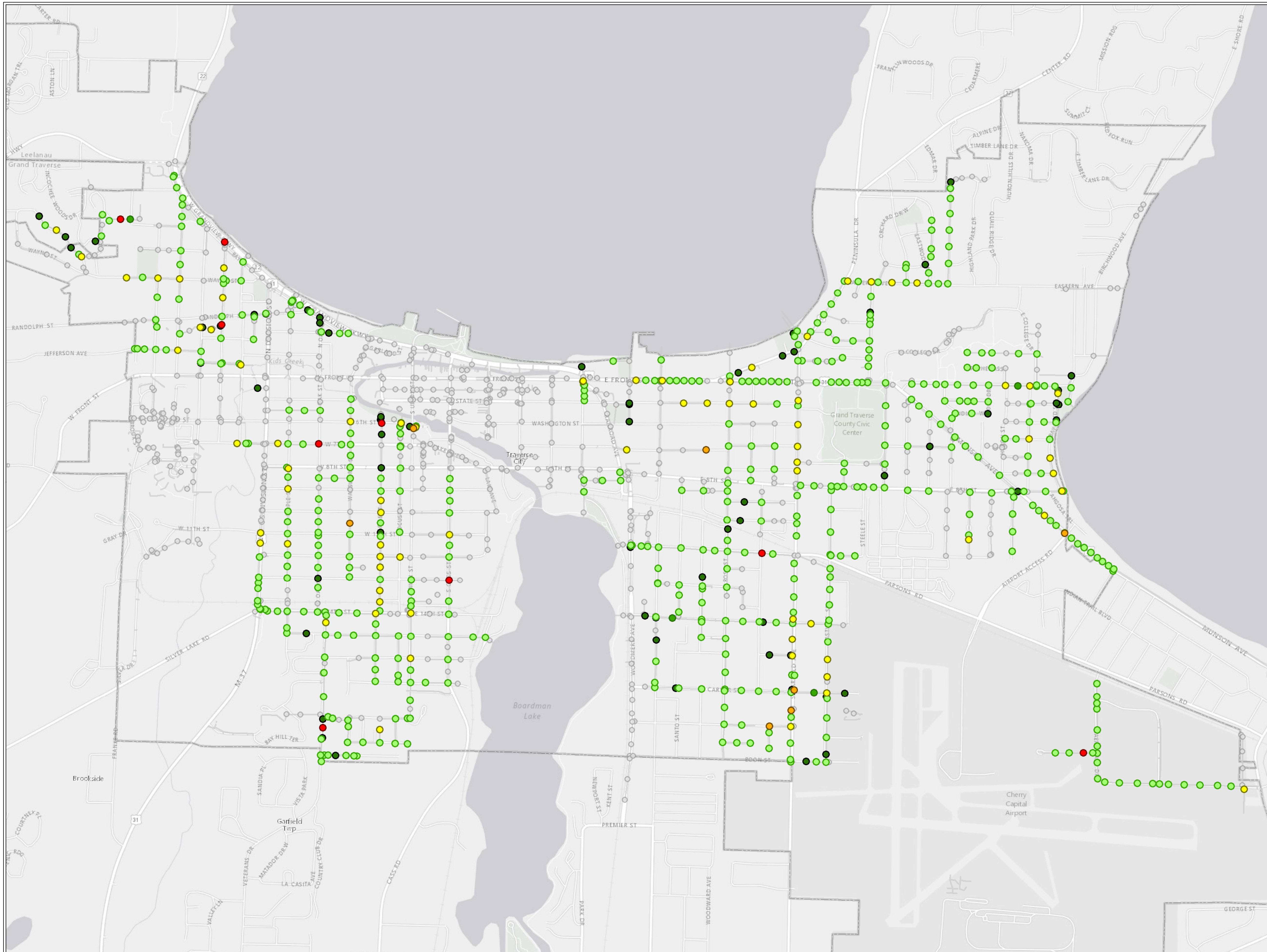
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-4 MACP Highest Rated O&M Defects.mxd



Traverse City SAW
MACP Overall Index Ratings

Traverse City, MI

Figure B-5

Stormwater 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 Value
- Stormwater Gravity Main
- Traverse City

0 1,800 3,600
Feet

1" = 1,800'

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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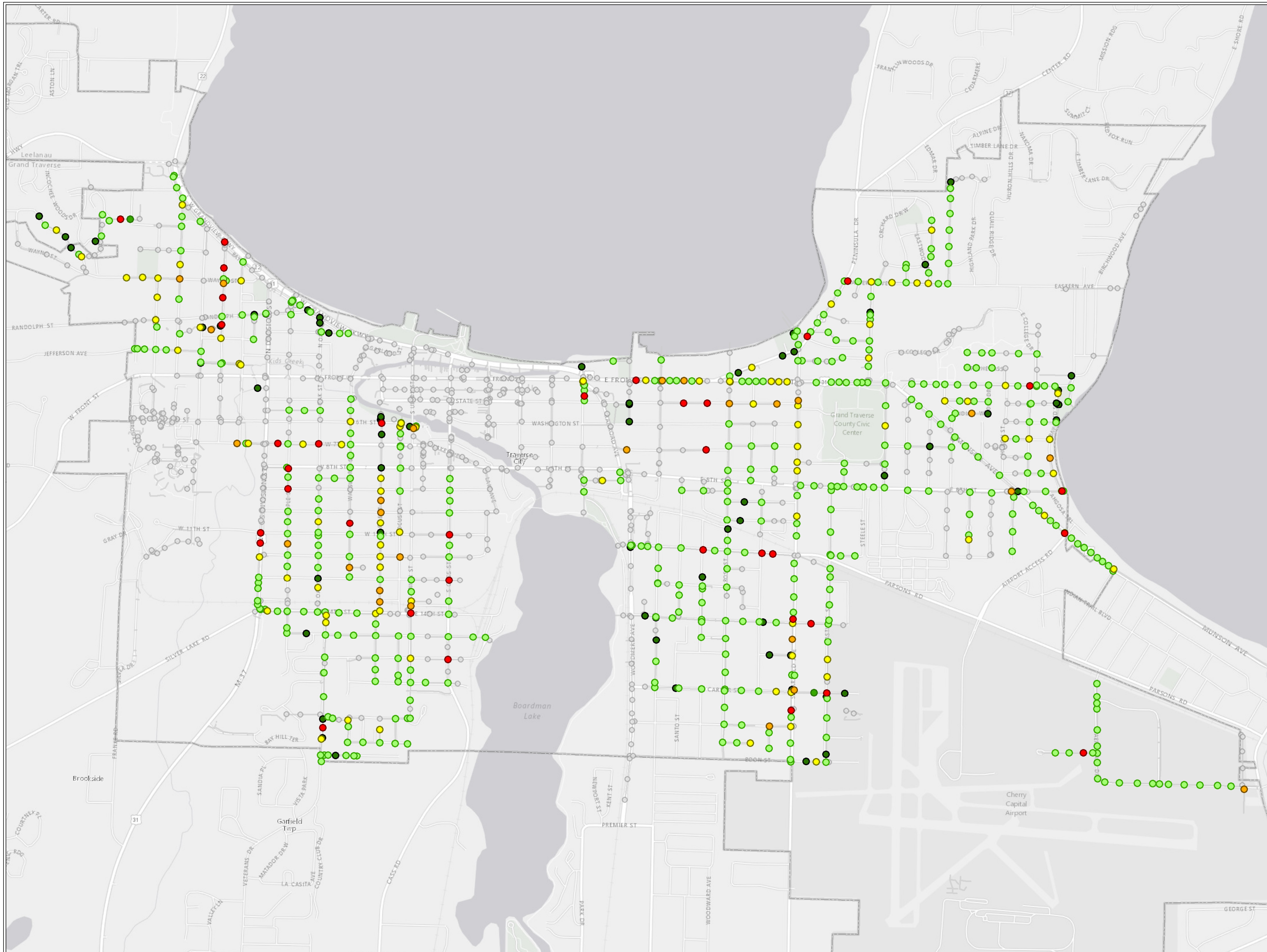
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-5 MACP Overall Index Ratings.mxd



Traverse City SAW

MACP Highest Rated Overall Defects

Traverse City, MI

Figure B-6

Stormwater Manholes

Overall Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Stormwater Gravity Main
- Traverse City

0 1,800 3,600
Feet

1" = 1,800'

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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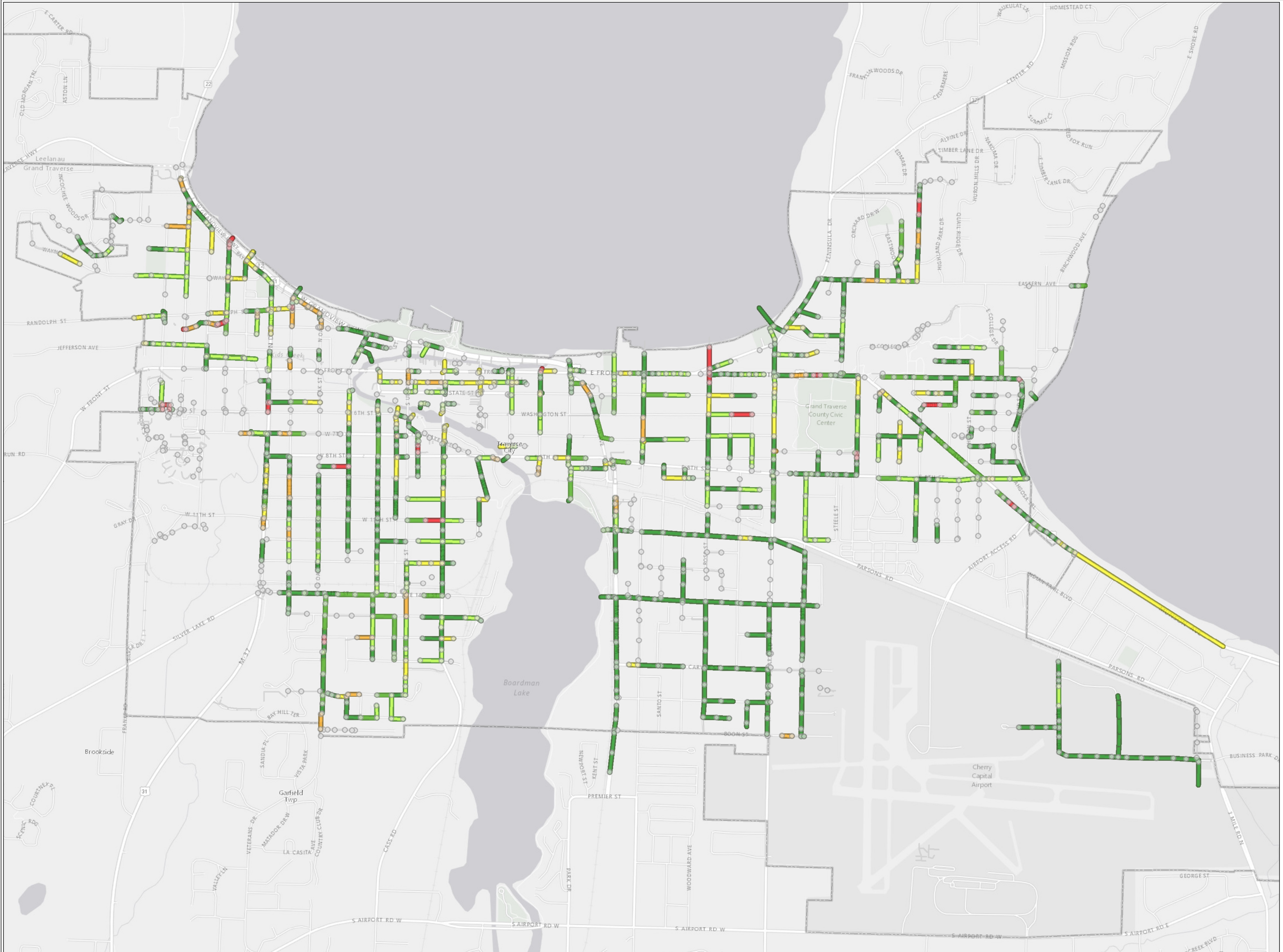
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-6 MACP Highest Rated Overall Defects.mxd



Traverse City SAW
PACP Structural Index Ratings

Traverse City, MI

Figure B-7

Stormwater Manholes

Stormwater Gravity Main

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 1,900 3,800
Feet

1" = 1,900'

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 26, 2017

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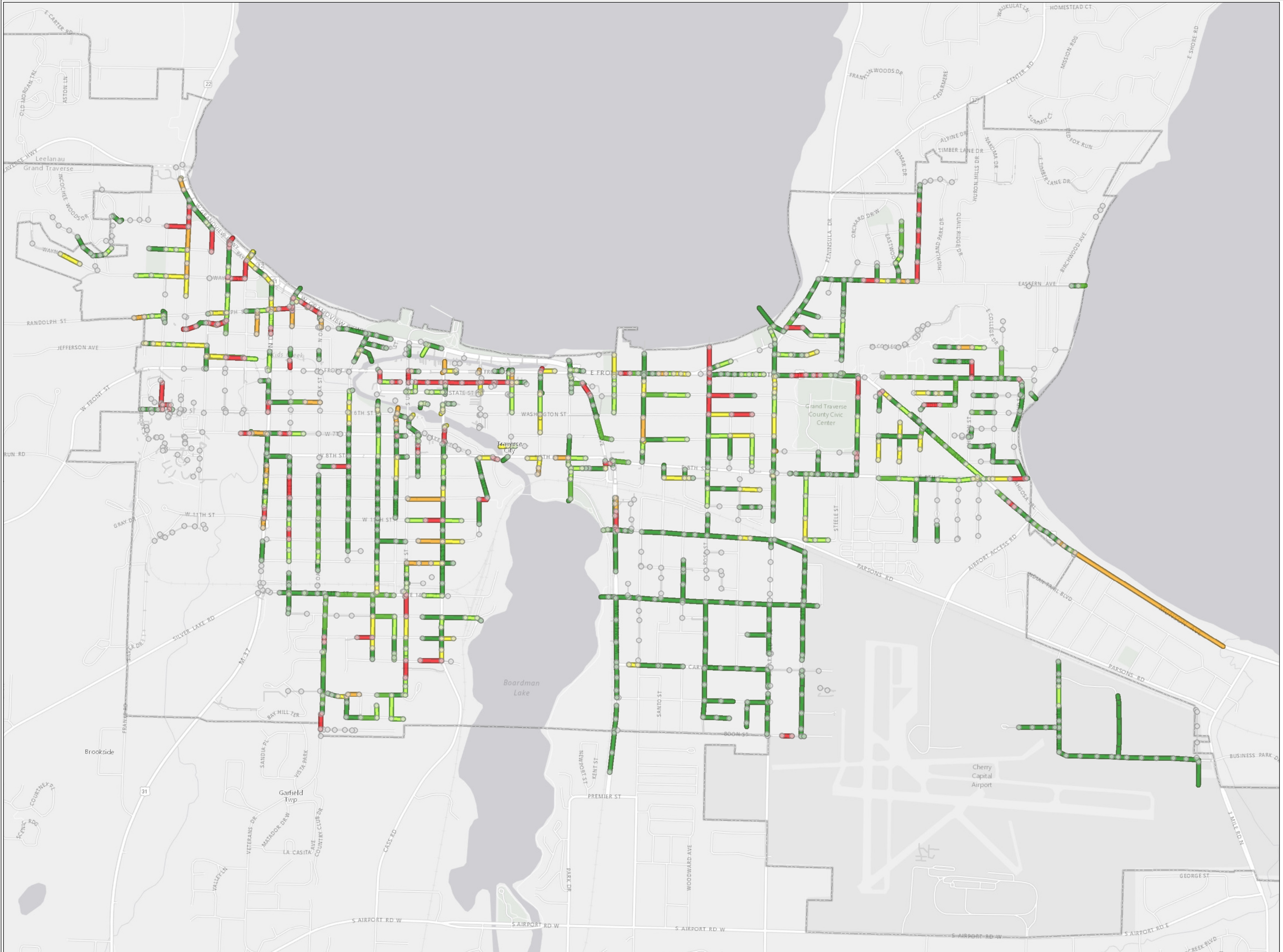

Traverse City SAW

PACP Highest Rated Structural Defects

Traverse City, MI

Figure B-8

Stormwater Manholes

Stormwater Gravity Main

Structural Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Traverse City

0 1,800 3,600
Feet

1" = 1,800'

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 26, 2017

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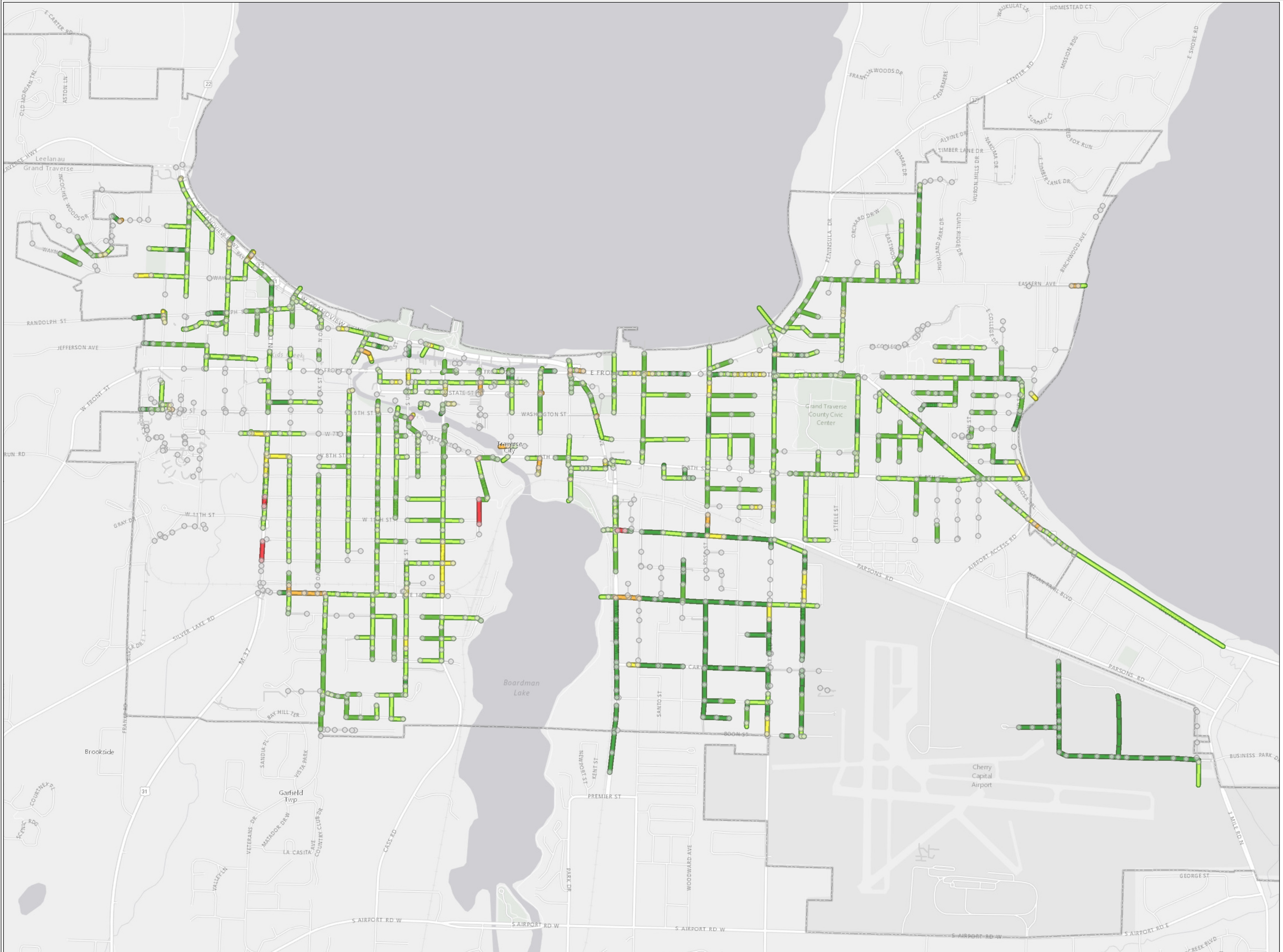
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-8 PACP Highest Rated Structural Defects.mxd



Traverse City SAW

PACP O&M Index Ratings

Traverse City, MI

Figure B-9

Stormwater Manholes

Stormwater Gravity Main

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 Value
- Traverse City

0 1,900 3,800
Feet

1" = 1,900'

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 26, 2017

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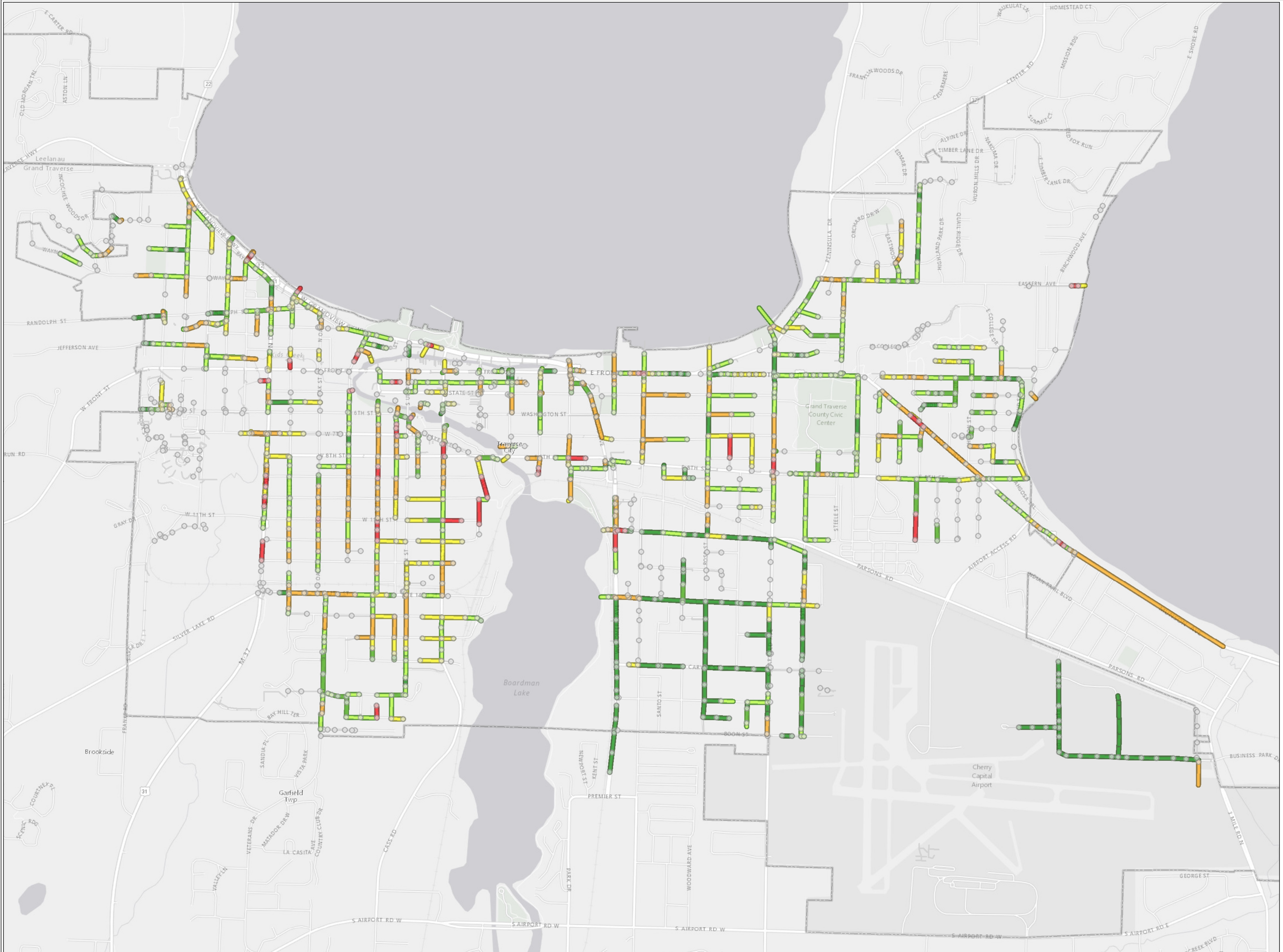


Traverse City SAW

PACP Highest Rated O&M Defects

Traverse City, MI

Figure B-10

Stormwater Manholes

Stormwater Gravity Main

O&M Highest Rated Defect

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Traverse City

0 1,900 3,800
Feet

1" = 1,900'

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

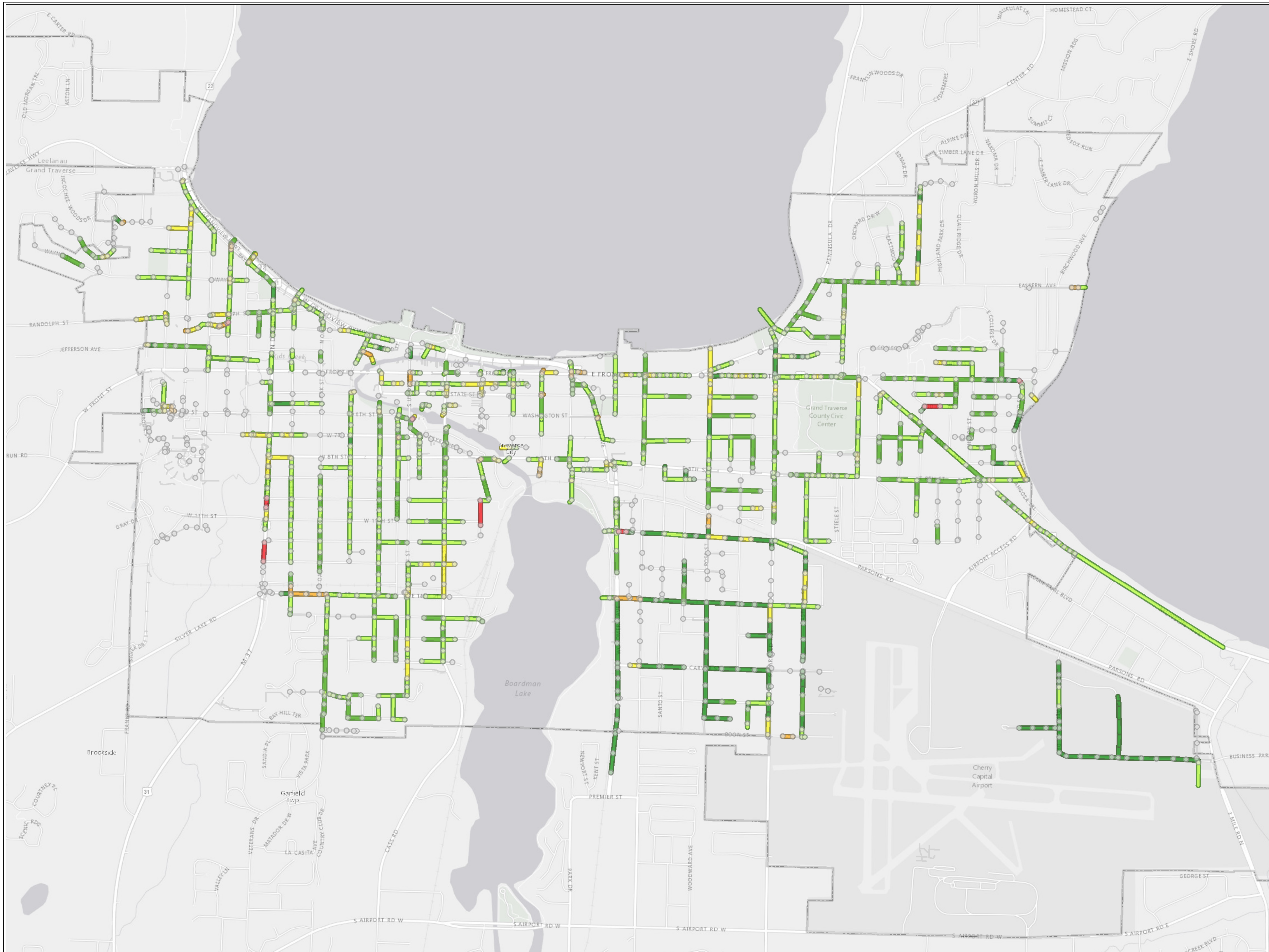
Map Published: May 26, 2017

Traverse City SAW

PACP Overall Index Ratings

Traverse City, MI

Figure B-11



Stormwater Manholes

Stormwater Gravity Main

Overall 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 Value
- Traverse City

0 1,900 3,800

Feet

1" = 1,900'

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 26, 2017

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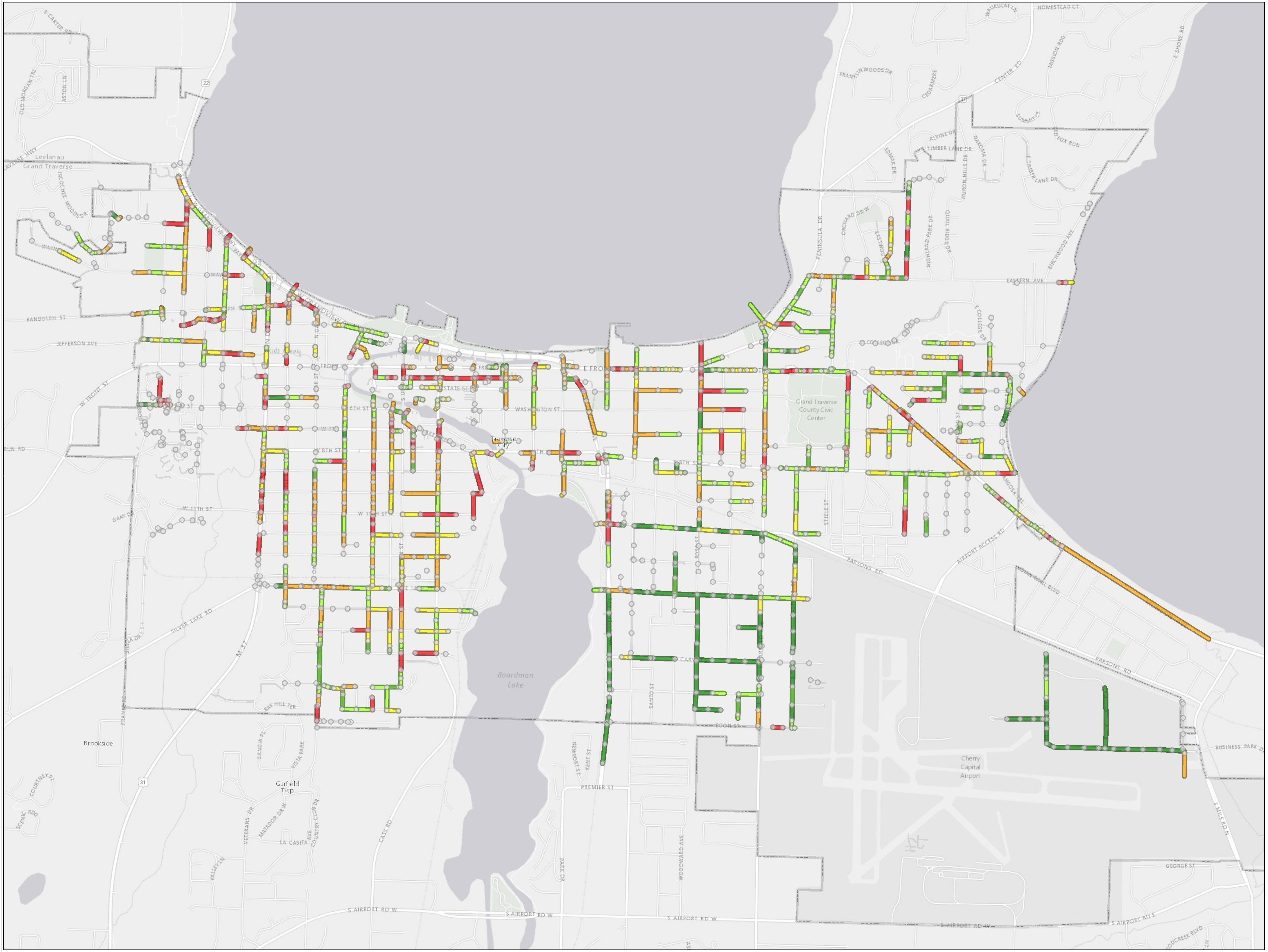

Traverse City SAW

PACP Highest Rated Overall Defects

Traverse City, MI

Figure B-12

Stormwater Manholes

Stormwater Gravity Main

Overall Highest Rated Defects

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Traverse City

0 — 1,900 — 3,800 Feet

1" = 1,900'

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.

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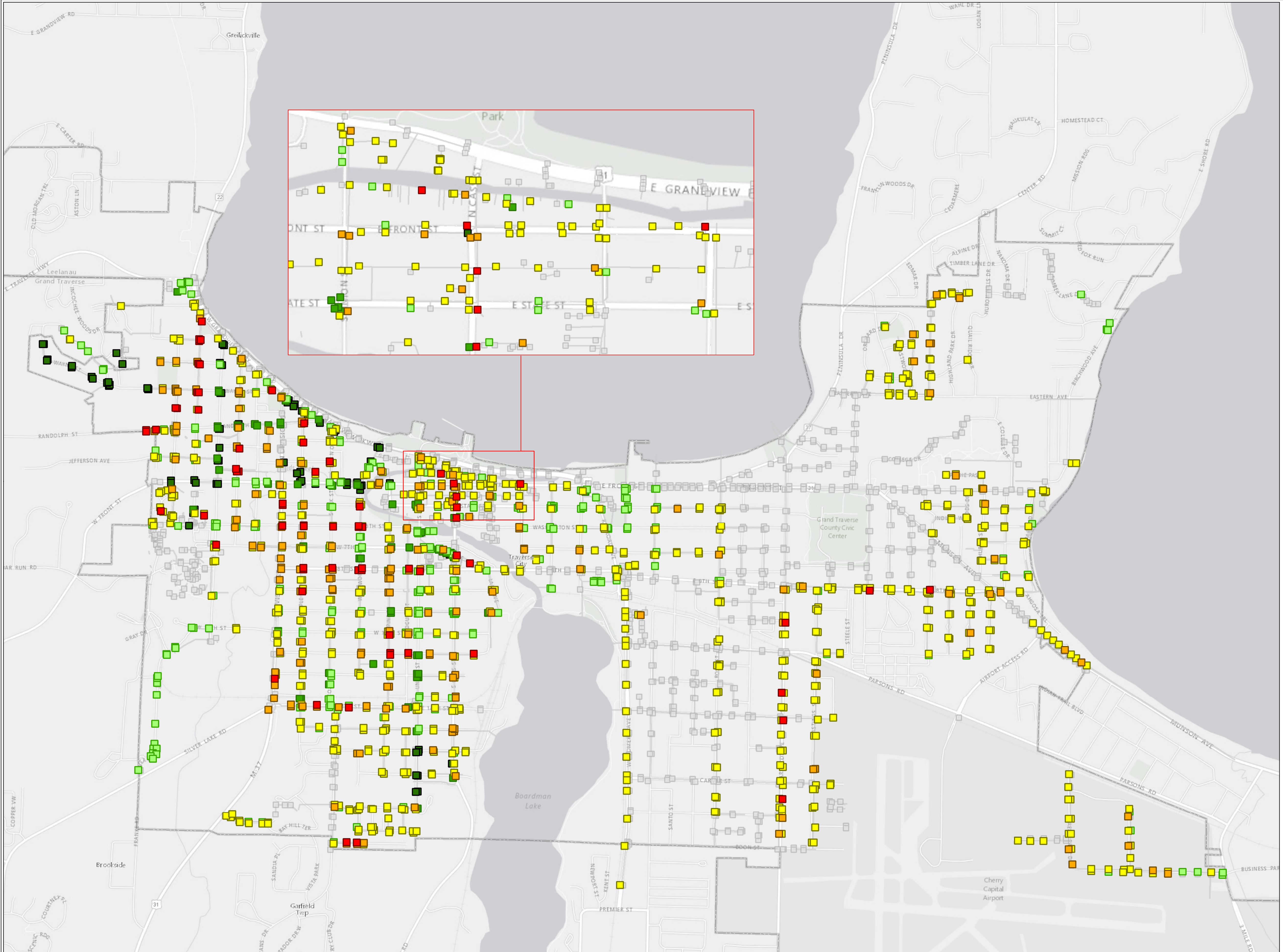
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-12 PACP Highest Rated Overall Defects.mxd

Traverse City SAW

Catch Basin Condition Ratings

Traverse City, MI

Figure B-13



Stormwater Catch Basins

Overall Structure Rating

- 0
- 1
- 2
- 3
- 4
- 5
- No Associated Value
- Stormwater Gravity Main
- Traverse City

0 1,900 3,800 Feet

1" = 1,900'

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.

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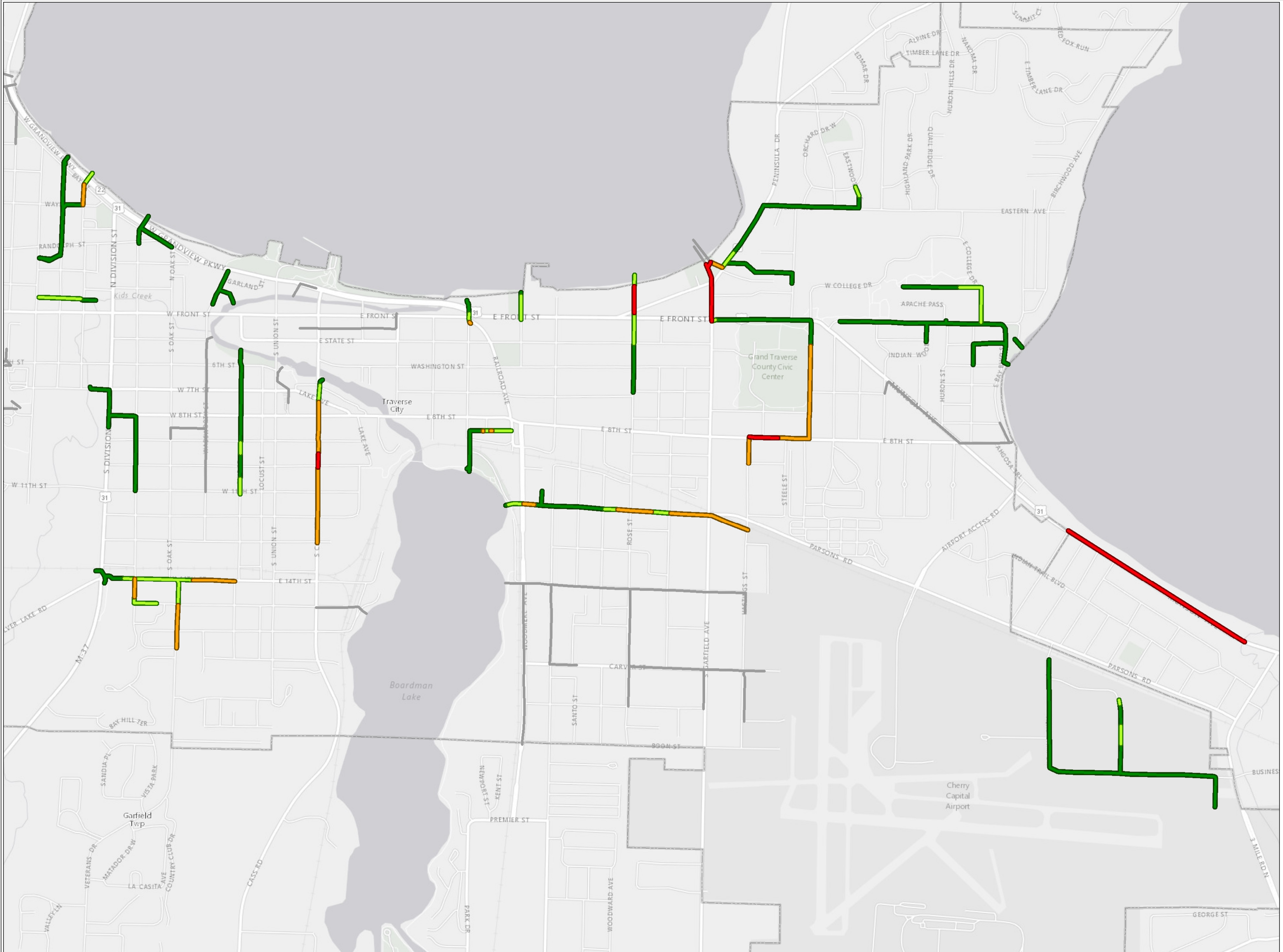
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-13 Catch Basin Condition Ratings.mxd



Traverse City SAW

20% Chance Storm
(5-yr Recurrence Interval)

Duration of Roadway Flooding

Traverse City, MI

Figure B-14

Duration of Roadway Flooding

20% Chance Storm - 5yr Recurrence Interval

- x < 15 minutes
- 15 =< x < 30 minutes
- 30 =< x < 60 minutes
- x >= 60 minutes
- Modeled Stormwater Segments
- 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.

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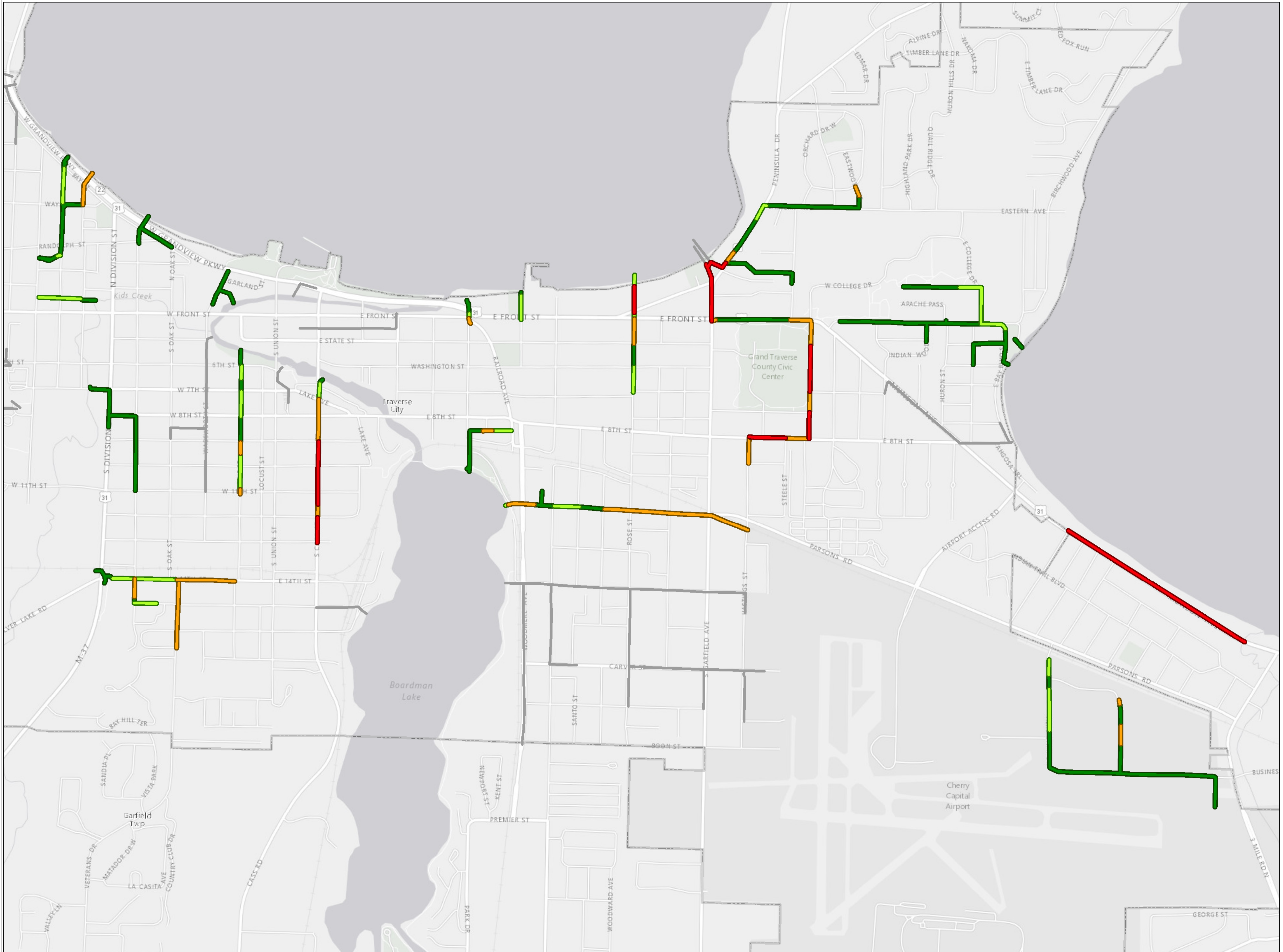
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-14 20% Chance Storm Duration of Roadway Flooding.mxd



Traverse City SAW

10% Chance Storm
(10-yr Recurrence Interval)

Duration of Roadway Flooding

Traverse City, MI

Figure B-15

Duration of Roadway Flooding

10% Chance Storm - 10yr Recurrence Interval

- x < 15 minutes
- 15 =< x < 30 minutes
- 30 =< x < 60 minutes
- x >= 60 minutes
- Modeled Stormwater Segments
- Traverse City

0 1,600 3,200
Feet

1" = 1,600'

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P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20170427 Traverse City Stormwater MACP and PACP Figs\Figure A-15 10% Chance Storm Duration of Roadway Flooding.mxd

Appendix C: Modeling Study

Appendix C: Modeling Study

A. Introduction

The hydrologic/hydraulic modeling program XP-SWMM 2016 was used to estimate peak flow rates and determine the hydraulic capacity of Traverse City's stormwater collection system. XP-SWMM is a physically-based storm event simulation program capable of simulating runoff from various land uses and soil types, combining sub-basin hydrographs, and routing flow through storage (detention ponds and/or surface flooding) and conveyance elements (sewers, open drainage channels, and roadway flow that occurs when the sewer system is surcharged).

XP-SWMM integrates the hydrologic analysis with the hydraulic analysis, so any stormwater storage resulting from detention ponds or surface flooding/ponding is taken into account in peak flow computations. Peak flows from the hydrologic analysis were used to compute a hydraulic grade line (HGL) for each section of evaluated sewer pipe and open drainage channels.

An *Existing Conditions* XP-SWMM model was developed to simulate the collection system under existing (2016) land use conditions. The key findings of the *Existing Conditions* XP-SWMM model are discussed in this section. A *Proposed Conditions* XP-SWMM model was developed to simulate the impacts of recommended hydraulic improvements and infiltration Best Management Practices (BMPs). Sections L and M include a discussion of the *Existing Conditions* and *Proposed Conditions* modeling, respectively.

B. 2007 Stormwater Management Report

Traverse City completed an analysis of its stormwater collection system in 2007. The objectives of that study were to determine system capacity through hydrologic and hydraulic modeling, delineate drainage area boundaries, review the condition of outfalls and other drainage components, and identify water quality projects that could be constructed to protect the Grand Traverse Bay from stormwater pollutants. Appendix C-A, Figure C-A-1, illustrates the 2007 delineated drainage areas.

The 2007 report used the Soil Conservation Service (SCS) Curve Number method to approximate runoff volumes and peak flows. The Curve Number method uses an Initial Abstraction that effectively eliminates any runoff for the first portion of the storm. Drainage areas, such as **Area "CM"** from the 2007 study, has an aggregate Curve Number of 70. In this scenario the first ~1 inch of rainfall is part of the Initial Abstraction and does not become runoff. Although this type of analysis was appropriate to serve the needs of the 2007 study, it can underestimate runoff for smaller storms, such as the 2-year and 5-year storm, where the first inch of rainfall is a significant part of the storm.

XP-SWMM was used for our analysis since it predicts smaller storm event runoff for urban areas more accurately than SCS Curve Number methodology. Also, the SWMM Runoff method is ideal to model the impacts of Green Infrastructure retrofits, such as bioretention, on peak flows and total runoff volumes. This provides an ideal foundation on which to calculate pollutant reduction and other water quality benefits.

Since modeling stormwater quality requires the consideration of more frequent (lower magnitude) storm events, such as the 1-inch storm and 2-year storm, the SWMM Runoff method is recommended. Fortunately, the SWMM Runoff method can be scaled up to model larger storm events, including but not limited to the 10-year, 50-year, and 100-year recurrence interval storms. It should be noted that the XP-SWMM modeling of less frequent (i.e. 5-year / 10-year) events yielded, in several cases, higher peak flows as compared to the 2007 results. This is likely due to the inclusion of directly-connected impervious surfaces, such as roadways, parking lots, and driveways, which immediately contribute stormwater runoff to the collection system.

C. Scalability of Model

The XP-SWMM model can easily be expanded in the future, at the City's discretion, to include additional storm sewers that aren't yet modeled and to verify the impacts of future land development on the existing system. Potential uses for model expansion include:

- Modeling the impacts of infiltration BMPs on peak flows and flow volumes.
- Quantifying the buildup, wash-off, and transport of common pollutants in stormwater to identify the need for future BMPs.
- Determining peak flows and flow volumes to design new end-of-pipe stormwater treatment BMPs and optimize the maintenance of existing BMPs.
- Modeling actual rainfall events to compare to observed conditions (model calibration and/or validation).

D. Level of Service

Level of Service for a stormwater system is traditionally defined as the storm magnitude (i.e. annual exceedance interval) that the collection system can convey without causing surface flooding that may negatively impact residents, businesses, and institutions. This is often referred to in terms of inches of rainfall or annual recurrence interval, such as the 10-year storm (also known as the 10% storm, as it has a one-in-ten chance of being exceeded in any given year).

The City's current stormwater ordinance (Chapter 1068: Ground-Water Protection and Storm-Water Runoff Control) does not mention a specific level of protection for its collection system. For this analysis, the 5-year and 10-year recurrence interval events were used, as they are the most common levels of protection for municipal stormwater collection systems.

Other key components of the Level of Service have emerged due to increased attention to Asset Management Planning, stormwater quality, and environmental sustainability. These components are as follows:

- Minimum water quality standards at the system outfalls, including maximum concentrations of known pollutants such as Nitrogen, Phosphorus, Total Suspended Solids, heavy metals, and E. coli (bacteria). Given the importance of the water quality in Grand Traverse Bay, this Level of Service is of utmost importance in Traverse City.
  - Although the City's stormwater system is not yet regulated by the MDEQ, water quality is still a local priority, and should therefore be considered a key objective of future system improvements.
- Regular cleaning and maintenance of the collection system to prevent backups due to clogged sewers.

E. Hydraulics: Drainage Channel and Storm Sewer Parameters

Channel cross sections were added to the model to represent Kids Creek, as this drainage channel represents a major component of the City's drainage system. Kids Creek was added to the model by digitizing the GIS Digital Elevation Model (DEM) and using the 1-foot contours developed in 2015. Surveyed cross sections were also available from cross-sectional survey performed on the main channel of Kids Creek in early 2016 as part of the SAW Stormwater Management Plan Grant. Channel cross sections were spaced roughly between 50 to 100 feet and included additional cross sections near bridges and culverts. The cross sections include low-lying or flat areas outside of the defined channel. This was done in order to more accurately model the floodplain during low-probability (i.e. 50-year / 100-year) storms, allowing the flow which overtops the banks of the channel to spread over adjacent areas.

The channel roughness factor (Manning's *n*), was estimated based on the 2011 Flood Insurance Study for Kids Creek as listed in the following table.

Table C-1: Manning's *n* values for Kids Creek (FEMA, 2011)

Stream	Channel *n*	Overbank *n*
Kids Creek	0.03-0.04	0.035-0.055

Bridge and culvert dimensions were based on field survey. Entrance and exit loss coefficients were estimated based on hydraulic charts for bridges and culverts available from the Federal Highway Administration (FHWA).

The hydraulic characteristics of Kids Creek, as represented in the XP-SWMM model, reflect downstream boundary conditions for each modeled storm sewer that discharges to Kids Creek. This adds confidence to the hydraulic model for sewers tributary to Kids Creek.

F. Hydrology – Kids Creek Watershed

In order to represent the peak flows in Kids Creek for design events, it was necessary to create an inflow hydrograph reflecting areas upstream of the City. To determine the appropriate peak flow rates for design events (5-year and 10-year for the local sewer system), we researched previous studies of Kids Creek, including:

- FEMA Flood Insurance Study (last updated in 2011)
- MDEQ Peak Discharge Requests (available on the MDEQ website)
- 2010 MDEQ Report entitled *Kids Creek Watershed Hydrologic Study*

Based on the data provided in the above resources, the following peak flows were selected for the Kids Creek hydrograph at Seventh Street (illustrated in Figure C-1), reflecting areas upstream of the City.

- 5-year peak flow: 240 cfs
- 10-year peak flow: 265 cfs
- 100-year peak flow: 700 cfs

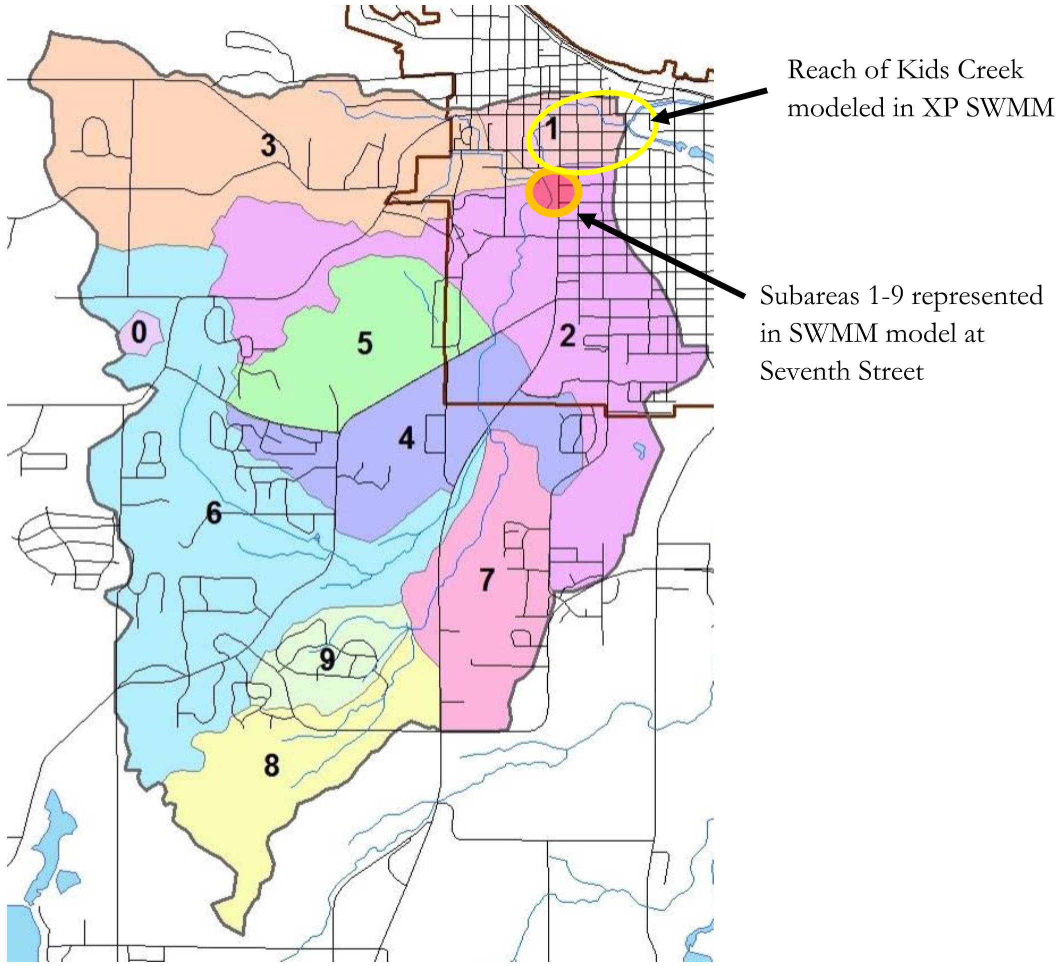

Figure C-1: Kids Creek Watershed

Source: Kids Creek Subwatershed Action Plan – The Watershed Center of Grand Traverse Bay, 2013

A SWMM runoff hydrograph was created to mimic the Kids Creek peak flows, with key parameters (i.e. impervious area percentage, width, slope, and saturated soil conductivity) adjusted so the 5-year, 10-year and 100-year peak flows matched those listed above. These hydrographs were developed for a SCS Type II 24-hour rainfall so the peak flow timing would match well to the runoff hydrographs calculated within the City (which were also calculated using the same rainfall distribution). The upstream flow hydrographs were combined with the urban areas within the City limits to predict the peak flows and flow levels within Kids Creek.

The drainage area for Kids Creek is roughly 7.5 square miles. ***For this size drainage area, the FEMA- and MDEQ-reported flow rates seem fairly low, especially since Kids Creek is known for flooding during smaller storm events (i.e. 2-year and 5-year)***. This could be due to the fact that many FEMA floodplain maps are based on older land use conditions (the FEMA calculations are from a 1973 hydrologic study) or the historical rainfall data no longer holds true.

The 2011 FEMA profiles for Kids Creek are provided in Appendix C-A, Figure C-A-2. The profiles illustrate the hydraulic grade line (HGL) predicted by FEMA for the 100-year storm and callouts for the HGL predicted by the XP-SWMM model.

During the 100-year storm event, flood attenuation occurs through Kids Creek. Upstream of the City, the predicted 100-year storm peak flow rate is 700 cfs and through flood attenuation the XP-SWMM model predicts a peak flow rate at the confluence with the Boardman River of 432 cfs. According to the FEMA Flood Insurance Study (2011), the peak discharge at the Boardman River is 331 cfs. The lower peak flow at the Boardman River confirms that flood attenuation is occurring through the reach of Kids Creek within the City's boundaries. The potential reasons for the difference in peaks flows (452 cfs vs. 331 cfs) are as follows:

- The XP-SWMM model includes flow inputs from urban drainage areas immediately tributary to Kids Creek. This will likely increase the peak flow estimate in Kids Creek.
- The XP-SWMM model has more accurate topographic information along the reach of Kids Creek within the City which increases our confidence in flood attenuation.

G. Hydrology- Sub-basin Parameters

The 6.5 square mile study area for the City's stormwater collection system, limited to areas draining to City-owned storm sewers, was subdivided into 161 individual sub-basins to quantify the stormwater runoff contribution from individual portions of the watershed. Figure C-2 shows the sub-basins created based on the existing 2007 delineated basins. Sub-basin delineation was confirmed using 1-foot contours (2015) created by OHM using the Digital Elevation Model (DEM) provided by Grand Traverse County. The sub-basin boundaries in the 2007 stormwater report were generally accurate; only minor modifications were necessary to reflect 2015 topography.

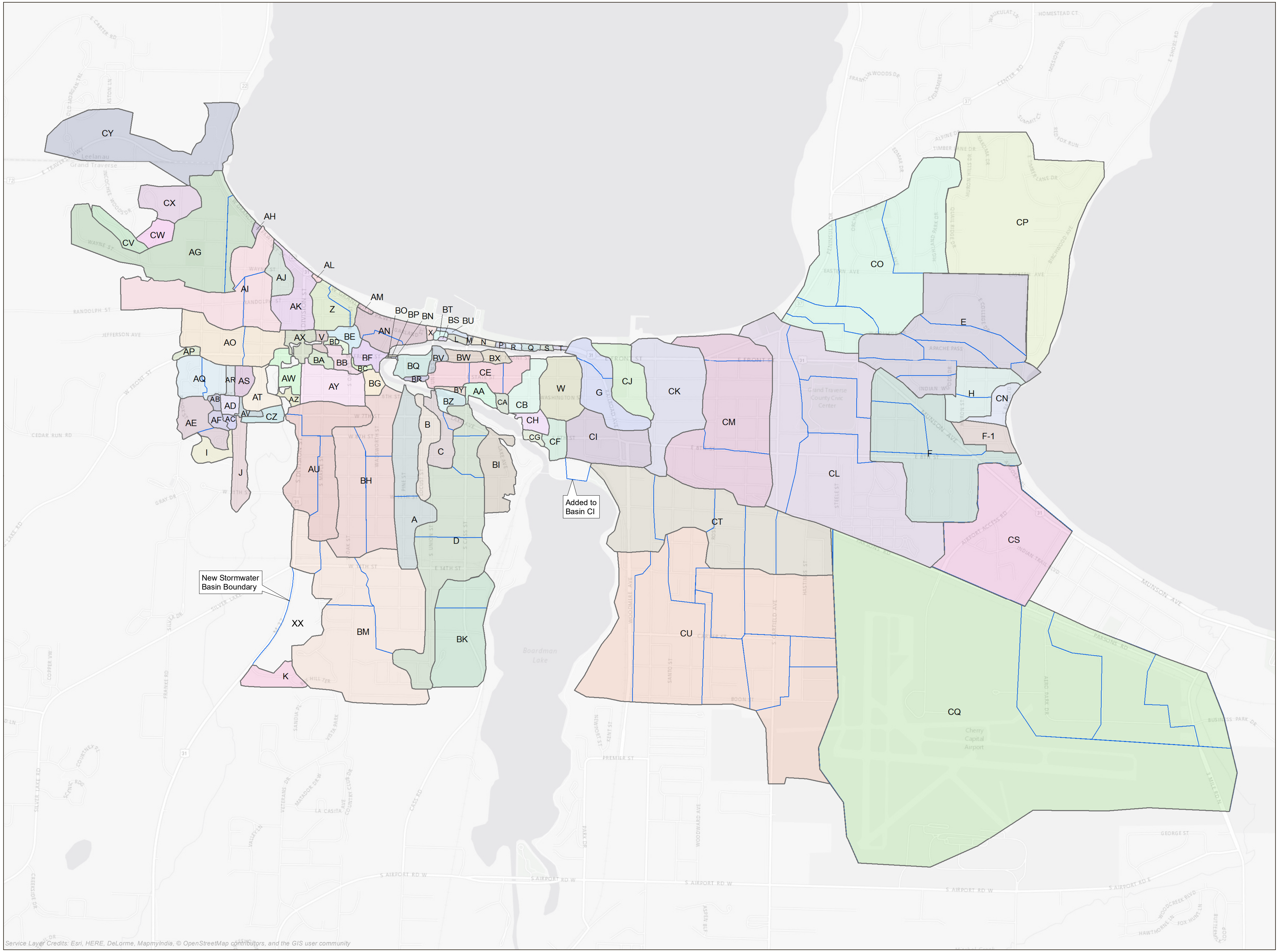

Figure C-2
Edited Stormwater Basins

Traverse City, MI

2007 Stormwater Basin Boundary

Edited 2007 Stormwater Basin Boundary

0 2,000 4,000
Feet

1" = 2,000'

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The majority of the City has soils classified as Type A. Given the abundance of well-drained (sandy) soils in the City, confirmed by our analysis of the USDA/NRCS online soils maps, all subbasisns were assigned a saturated soil conductivity (infiltration) rate reflective of sandy soils (1 inch/hr). Although this infiltration rate is lower than what the USDA/NRCS data would suggest for native sandy soils, the presence of compacted topsoil in urban areas reduces the effective infiltration rate due to compacted organic and loamy material mixed with the native sands.

The Green Ampt methodology was used to model infiltration for pervious areas. This is a standard tool to model the impacts of infiltration and depends on multiple variables to define the pervious surface and how quickly rainfall can soak into the soil so it does not become runoff. Variables used in the Traverse City model are as follows:

- Average Capillary Suction: 4 inches (typical for sandy soils)
- Initial Moisture Deficit: 0.34 (typical for sandy soils)
- Saturated Hydraulic Conductivity: 1.0 inch/hour (reflects limiting topsoil layer)

H. Design Storms and Peak Flow Estimation

Design storms were used to predict peak flows throughout the watershed under existing conditions and to model proposed improvements. Peak flow rates were evaluated using the 1-, 2-, 5-, 10-, and 100-year recurrence interval events. The rainfall depths are based on the National Oceanic and Atmospheric Administration's (NOAA) Precipitation Frequency Data Server (PFDS), also known as NOAA Atlas 14. These values supersede previous rainfall depth/frequency tables, TP-40 and Bulletin 71, both of which are based on older rainfall statistics. The 24-hour rainfall distribution used is the SCS Type II, which is the most commonly used rainfall distribution in Michigan by local, county, and state regulatory agencies to estimate peak flows for design events.

Table C-2: Design Storm Rainfall Depths in Traverse City (NOAA Atlas 14)

Recurrence Interval	24-hour Rainfall (inches)
1-year	2.05
2-year	2.31
5-year	2.79
10-year	3.25
100-year	5.27

The rainfall depths for smaller storm events from TP-40 are slightly below the rainfall depths compared to NOAA Atlas 14. However, for the 100-year recurrence interval storm event, the NOAA Atlas 14 24-hour rainfall depths are approximately 20 percent higher than TP-40.

In addition to looking at design storms (which are based on a synthetic rainfall distribution), OHM modeled the September 5, 2014 event using XP-SWMM. The most intense part of this storm, which occurred during the early morning hours, ***roughly approximates a 10-year recurrence interval storm***, as measured against 30-minute and 60-minute rainfall durations. Since this storm is recent and reflects an actual storm in Traverse City, it is a useful benchmark against which to measure the effectiveness of the storm sewer system.

The modeled peak flows from the September 5, 2014 storm were compared to the 5-year and 10-year design storm peak flows. The modeled peak flows from the September 5, 2014 storm were nearly identical to those from the 10-year / 24-hour duration design storm. The model also predicted the same level of hydraulic surcharge and street flooding for the September 5, 2014 storm than was predicted for the 10-year storm. This was confirmed through flooding photos of various neighborhoods provided by City staff. Table C-3 lists the peak flow comparison for two representative sewersheds, Rose Street and Hannah Avenue.

Table C-3: Peak Flow Comparison: Design Storm vs. September 5, 2014 Event

Rose Street Outfall: Peak Flow Rates (cfs)			
	5-year	**10-year**	**September 5, 2014**
Pipe	59.7	60.6	60.8
Roadway	95.6	134.7	142.9
Total	155.3	195.3	203.7

Hannah Avenue Outfall: Peak Flow Rates (cfs)			
	5-year	**10-year**	**September 5, 2014**
Pipe	99.0	100.9	101.0
Roadway	29.1	45.5	46.0
Total	128.2	146.4	147.0

Table C-3 reveals that the Rose Street outfall can convey approximately one third of the peak flow reaching Grand Traverse Bay for the 10-year event. The remaining flow is conveyed overland, primarily along the street.

I. Hydraulic Model

Per the SAW Grant application scope, the hydraulic model was limited to storm sewers with a diameter equal to or larger than 24 inches. In some sewersheds where hydraulic deficiencies were noted in early model runs, the model was expanded to include smaller storm sewers in order to determine flooding potential in nearby areas.

XP-SWMM includes a hydraulic flow routing model for both open channel and closed conduits. Selected nodes in the hydraulic model receive hydrograph input by interface file from an upstream block (e.g., the Runoff Block) and/or by direct user input. The model performs dynamic routing of stormwater flows throughout the major storm drainage system to the outfall points of the receiving drainage system.

The outfall points were each assigned boundary conditions to reflect higher-than normal water levels in Boardman Lake and Grand Traverse Bay. FEMA Flood Insurance Study (FEMA, 2011) data were used to establish these boundary conditions. For all sewer systems discharging into Grand Traverse Bay and Boardman Lake, the 10-year recurrence interval peak water level was used. Although this is a conservative value, the higher water levels used as a boundary condition did not have a significant impact on hydraulic surcharging within the City's collection system, as the majority of the system is located above the range of potential water levels in Boardman Lake and Grand Traverse Bay.

The modeled storm sewers were based on 2015-2016 survey data of rims and invert elevations. Friction coefficients reflect typical values for the respective pipe materials. In all cases, the sewers were assumed to be unobstructed and flowing freely.

J. Model Calibration

Although there was not a budget for calibrating the storm sewer hydrologic and hydraulic models, the September 5, 2014 rainfall event was used as an initial calibration storm. Based on photographic evidence of surface flooding during this event, it appears that the XP-SWMM hydraulic model accurately represented the magnitude of surface flooding at key locations where flooding was predicted. Furthermore, interviews of City staff and business owners (through the Stormwater Advisory Group process) revealed that the flood-prone areas predicted by the model were generally consistent with locations where surface flooding was known to be an issue.

However, photographs and interviews do not provide enough data to prove the accuracy of the hydrologic and hydraulic models. As such, the model calibration process should be finalized through the installation of long-term flow meters and rain gages in key locations of interest. These flow meters should include pressure transducers to as to measure hydraulic surcharge and they should be in place for at least two years (longer if no significant rain events are measured). Having the data from this metering program will allow the City to:

- Better understand the peak flows and flow volumes resulting from more frequent storms (i.e. 1-inch, or 90% event) for the sizing of future stormwater treatment BMPs
- Increase confidence in the runoff potential from larger, less frequent rainfall events for flood control purposes and to maintain an adequate Level of Service.

K. Stormwater Detention

For the majority of modeled areas, detention ponds of significant size do not exist. The only exception was the 14th Street sewershed in the southwest corner of the City. However, since the 14th Street corridor is being modeled in more detail as part of a separate project, OHM did not model the stormwater detention in this area.

L. Dual Drainage and Flood Storage

The XP-SWMM model allows for a dual drainage scenario, under which runoff can be conveyed by the storm sewer pipes and the roadway at the same time. This scenario is useful when modeling areas where surcharging is predicted, which occurs in several areas of Traverse City during the 5-year and 10-year recurrence interval storm events. When the hydraulic grade line exceeds the street level, the flow is routed along the street to the next intersection, at which it can either re-enter the storm sewer or continue flowing on the surface.

As XP-SWMM routes this flow, the peak flow is attenuated (reduced) due to the additional roadway storage volume. This scenario is a better match to actual physical conditions and it helps to prevent an over-estimation of peak flows in the system.

M. Existing Conditions: Key Findings

The Existing Conditions model was used to identify the storm sewers and bridges/culverts within the watershed that are undersized. The analysis was performed for both the 5-year and 10-year recurrence interval storm events. In general, both the 5-year and 10-year events resulted in predicted hydraulic surcharge and roadway inundation in multiple areas.

1. Undersized Storm Sewers

Storm sewers were defined as undersized where the Existing Conditions model predicted the hydraulic grade line to exceed the ground surface during the time of peak flow, indicating flooding potential under the 5-year peak flow conditions.

Figure C-3 illustrates the locations of all sewers modeled as part of this study. Predicted undersized storm sewer during the 5-year peak flow conditions are highlighted in Figure C-4.

Figure C-3
Stormwater Modeled Segments

Traverse City, MI

Modeled Stormwater Segment

0 2,000 4,000
Feet

1" = 2,000'

Source: Data provided by Traverse City, MI. OHM Advisors does not warrant the accuracy of the data and/or the map. This document is intended to depict the approximate location of the mapped features within the Community and all use is strictly at the user's own risk.

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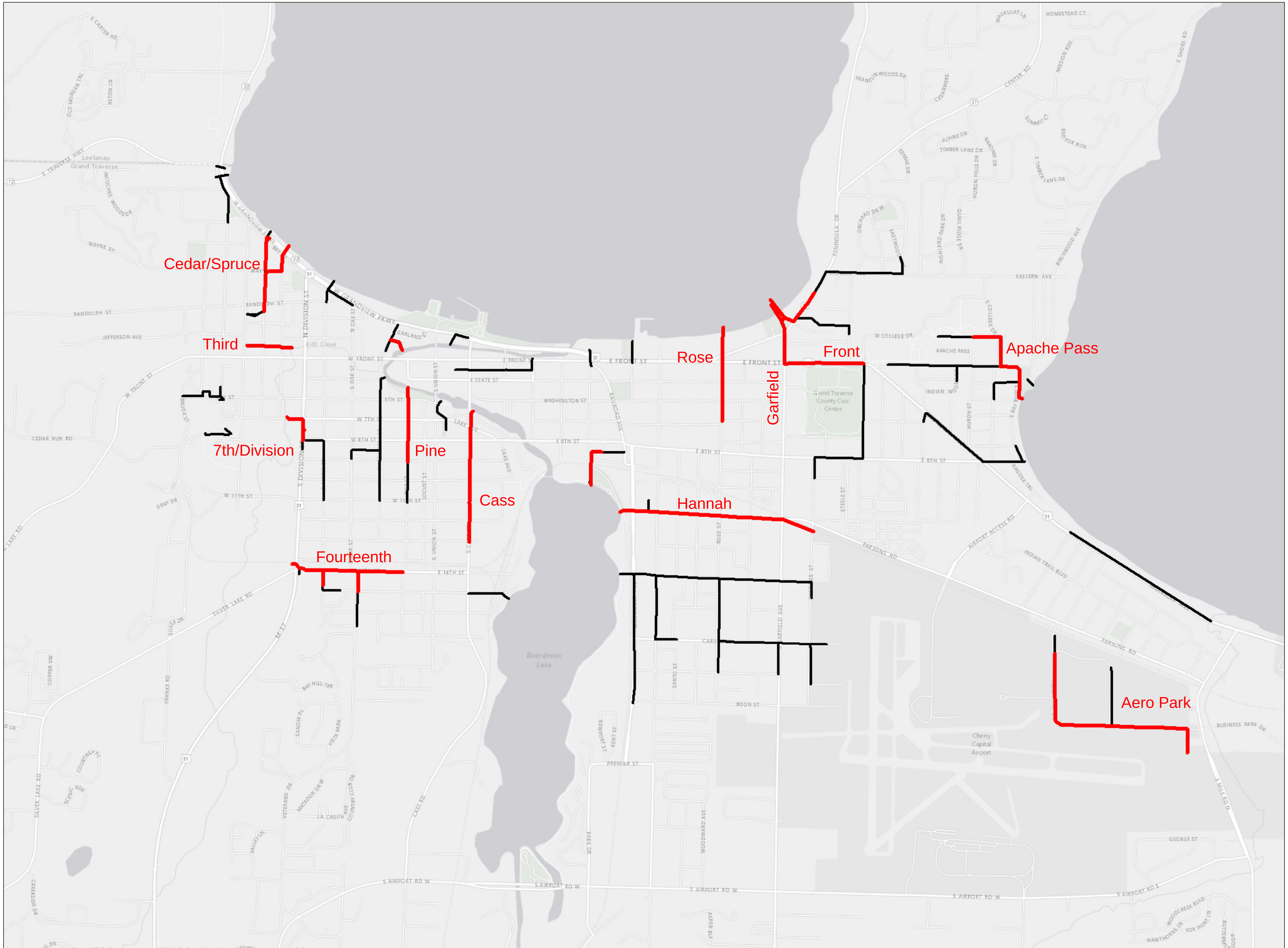

Figure C-4
Stormwater Undersized Segments

Traverse City, MI

Undersized Stormwater Segment

Modeled Stormwater Segment

0 2,000 4,000
Feet

1" = 2,000'

Source: Data provided by Traverse City, MI. 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.

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The analysis shows that the predicted flooding would be brief (less than 15-30 minutes in most cases).

The importance of avoiding surface flooding can be demonstrated by Figure C-5, where the Cass Street sewer is predicted to surcharge and cause flooding on 12th Street, adjacent to the Cone Drive facility. Although this flooding is brief, the rising waters are close to entering nearby businesses. Cone Drive representatives have confirmed that flooding is a routine problem for them.

Figure C-5: Street Flooding on 12th Street (near Cone Drive)

The following locations are predicted to have storm sewer that is unable to convey peak flows without surcharging to the surface resulting from the 5-year recurrence interval storm event:

- ***Rose:*** From Webster Street to Bay
- ***Hannah:*** From Garfield Avenue to Boardman Lake
- ***Aero Park:*** From Parsons Road to North Three Mile Road
- ***Apache Pass:*** College Drive to Front St to East Bay Boulevard
- ***Peninsula Drive***: Southwest on Peninsula Drive to outlet at Bryant Park
- ***Front Street/Garfield Avenue:*** From East Front Street at Fair Street to South Garfield Avenue, from Garfield Avenue to Peninsula Drive to the Bay
- ***Wastewater Treatment Plant:*** South of Eighth Street to Boardman Lake
- ***Cass Street:*** From Twelfth Street to Boardman River
- ***Spruce and Cedar:*** On Spruce Street from Randolph Street to Bay and Cedar Street from Wayne Street to the Bay

- ***Hall Street:*** Southwest of Garland Street to Boardman River
- ***Pine Street:*** From Ninth Street to Boardman River
- ***Fourteenth Street:*** From Pine Street to Kids Creek (past Division Street)
- ***Seventh and Division Street:*** On Division Street from Eighth Street and Seventh Street and on Seventh Street from Division Street to Kids Creek
- ***Third Street:*** From Elmwood Avenue to Cedar Street and outlet to Kids Creek

The city has verified, through flooding photographs, that several of the above locations have undersized storm sewers. Photographs were provided to us for 12^{th} Street (near Cone Drive), Cedar Street, and Rose Street (see Appendix C-B for photographs)

2. <u>Undersized Bridges/Culverts</u>

In our analysis, culverts and bridges were analyzed under existing conditions for the 5-, 10-, and 100-year recurrence interval storm events. Table C-4 provides a summary of bridges and culverts along Kids Creek (organized upstream to downstream).

Table C-4: Bridge/Culvert Summary

Location	Length (ft)	Width (ft)	Height (ft)	Crossing Type	Structure Type	Structure Shape	Material
7th Street	100	7.8	5.5	Bridge	Wingwall 10-30 Degree	Square/ Rectangle	Concrete
6th Street	83.3	17.9	4.5	Bridge	Headwall	Open Bottom Square/ Rectangle	Concrete
S. Cedar Street	59.9	6.6	4.9	Culvert(s)	Projecting	Round	Corrugated Metal
S. Cedar Street	58.6	6	4.1	Culvert(s)	Projecting	Ellipse	Corrugated Metal
W. Front Street	156.5	18.8	8	Culvert(s)	Projecting	Open Bottom Arch	Corrugated Metal
Division	150.9	7.9	5.8	Bridge	Wingwall 10-30 Degree	Open Bottom Square/ Rectangle	Concrete
Maple Street	84.6	8	6.3	Bridge	Headwall	Open Bottom Square/ Rectangle	Concrete
W. Front Street	162.8	14.1	7.7	Bridge	Wingwall 10-30 Degree	Open Bottom Arch	Corrugated Metal
Wadsworth Street	198.4	12.4	6	Bridge	Wingwall 10-30 Degree	Square/ Rectangle	Concrete

Table C-5: Culvert/Bridge Model Results

	5-year		10-year		100-year	
Conduit Location	**Roadway Overtopping**	**Peak Flow (cfs)**	**Roadway Overtopping**	**Peak Flow (cfs)**	**Roadway Overtopping**	**Peak Flow (cfs)**
7th Street	No	237	No	263	No	385
6th Street	No	265	No	293	Yes	657
S. Cedar Street	No	261	Yes	289	Yes	350
S. Cedar Street	Yes	239	Yes	244	Yes	254
W. Front Street	No	242	No	269	No	481
Division Street	No	247	No	273	No	461
Maple	No	246	No	271	No	458
W. Front Street	No	241	No	267	No	453
Wadsworth Street	No	241	No	266	No	452

Through the main channel of Kids Creek, the following bridges and culverts have hydraulic deficiencies as detailed below:

- ***6th Street:*** The culvert at this location is not hydraulically sufficient to convey the 100-year recurrence interval storm event. This is confirmed by the 2011 FEMA Study. The HGL, according to the model, is slightly over a foot above the roadway, which is similar to the FEMA Study.
- ***South Cedar Street:*** The culverts at this location are approximately 40% filled with sediment. The culverts are not hydraulically sufficient to convey the 10 or 100-year recurrence interval storm events.
- ***South Cedar Street:*** The culverts at this location are approximately 66% filled with sediment. The culverts are not hydraulically sufficient to convey the 5, 10 or 100-year recurrence interval storm events.

For both culverts along Cedar Street, the 2011 FEMA Study confirms that during the 100-year recurrence interval storm event, the hydraulic grade line (HGL) is just at or above the roadway. For the 10-year recurrence interval storm event, the HGL for the FEMA Study illustrates that the flow can be conveyed through the culverts unlike the XP-SWMM model. This difference between the 10-year HGL is most likely do to the percentage of sediment modeled. (See Appendix C-A for the FEMA HGL)

N. Proposed Conditions

Both the 5-year and 10-year design storms are the most commonly used by communities for establishing design criteria for storm sewer sizing, and either are appropriate for Traverse City.

Given the need for hydraulic improvements in the stormwater collection system under both the 5-year and 10-year event criteria, the 5-year storm is recommended as the design event on which to base future storm sewer improvements for the following reasons:

- The 5-year recurrence interval storm, along with the 10-year storm, is a commonly-used design criteria for municipal stormwater systems and provides a reasonable level of protection against system surcharging.
- The magnitude of system improvements will be smaller and more reasonable under the 5-year recurrence interval standard.

A proposed hydraulic model was developed to identify the sizes and locations of sewers necessary to convey peak flows from the 5-year / 24-hour recurrence interval storm event. Under this scenario, there is a 20% chance in any given year that the referenced storm sewers would surcharge at or above the ground surface elevations. The proposed model was limited to the hydraulic component of the model only; sewer sizes were increased to the diameter necessary to safely convey flows during the 5-year event without surcharge to the surface. This modeling exercise was intended to reveal the magnitude of the pipe diameter increase necessary at specific locations. These recommendations may be adjusted by the City in the future to accommodate varying expectations for Levels of Service in specific neighborhoods.

Beyond the goal to convey wet weather flows to the outfalls, a key concern in Traverse City is the volume of stormwater that reaches Boardman Lake and Grand Traverse Bay. Therefore, we analyzed a Green Infrastructure Scenario for the Rose Street and Hannah Avenue sewersheds to quantify potential runoff volume reduction through the implementation of infiltration Best Management Practices (BMPs) within the right-of-way (see Figures C-6 and C-7).

To most effectively reduce the runoff volume reduction through BMPs is to design the green infrastructure with the following recommended parameters:

- Near Catch basins
- Width of 10-12 feet
- Depth of 1 foot

To achieve the width of 10-12 feet within the right-of-way, sections of the street can be narrowed to a minimum of 24 feet. Figure C-8 and C-9 are examples of green street BMPs within residential areas within the right-of-way.

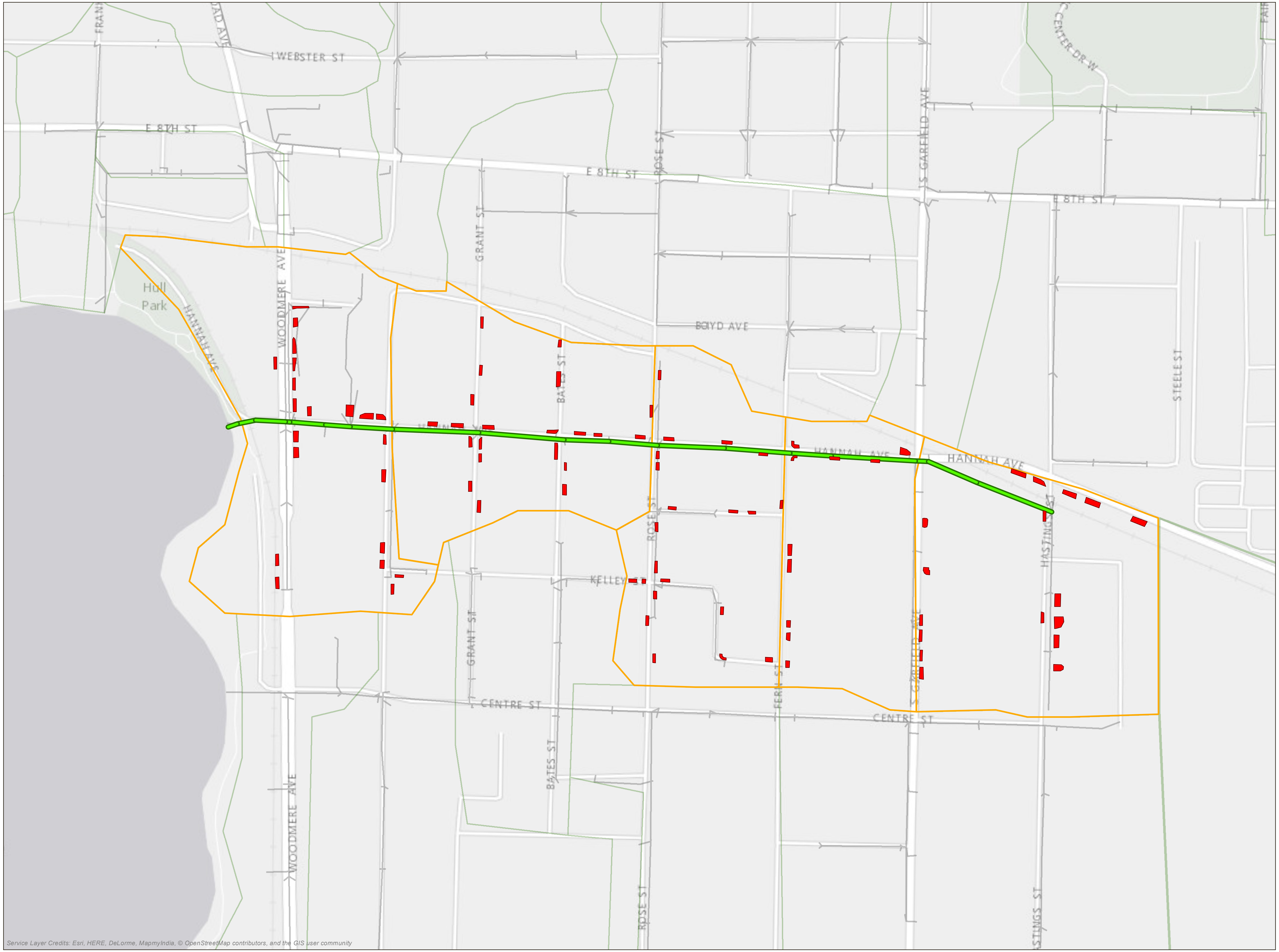

Figure C-6
Hannah Watershed
Potential BMP Locations

Traverse City, MI

- Green Infrastructure
- Hannah Ave Stormwater Pipes
- Hannah Basin
- Other Stormwater Basin
- Stormwater Gravity Main

0 400 800
Feet

1" = 400'

Source: Data provided by Traverse City, MI. 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: September 21, 2016

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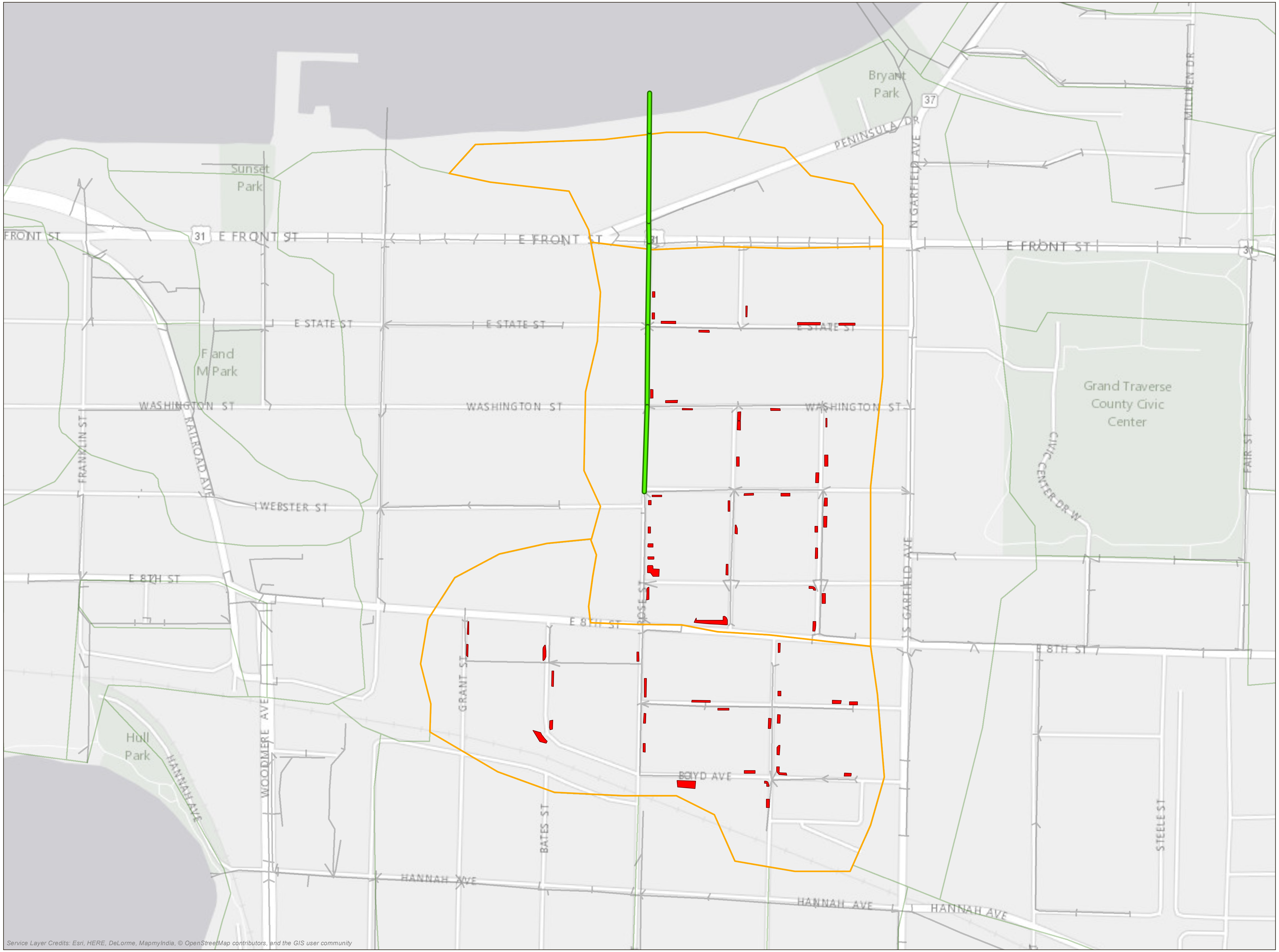

Figure C-7
Rose Watershed Potential BMP Locations

Traverse City, MI

- Green Infrastructure
- Rose Street Stormwater Pipes
- Rose Basin
- Other Stormwater Basin
- Stormwater Gravity Main

0 400 800 Feet

1" = 400'

Source: Data provided by Traverse City, MI. 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.

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Figure C-8 and C-9: Example of BMPs within right-of-way

Recommendations for storm sewer improvements are provided for the following key reasons:

- Provide the City with an inventory of recommended sewer size increases to be used to replace aging sewers or when roadway replacements are implemented. This is a key component of the SAW Asset Management Plan, and is necessary to help define the full cost of operating the City's stormwater infrastructure for the next several decades.
- Provide the City with a cost estimate for the recommended sewer size increase and the addition of infiltration BMPs to mitigate the impacts of increasing pipe size. Table C-6 provides the cost of sewer replacement both with and without infiltration BMPs, as well

as the cost of the infiltration BMPs. Based on our preliminary modeling effort, it was assumed that approximately 2% of the impervious area would need to be converted to green infrastructure in order to maximize the benefit of infiltration BMPs.

- Provide a reasonable Level of Service to protect the residents, visitors, and business owners in Traverse City. Although the predicted flooding is brief, any surcharging above the surface creates an undue burden on motorists, adjacent parcels, and increases the likelihood of property loss and unwanted erosion at or near the bay.

- Prepare the City for the need to adapt to changing climate patterns. In Michigan, the average intensity of rainfall events has been rising and is predicted to rise significantly in the next 50 years. Planning for larger storm sewers will make it easier for the City to adapt and maintain an adequate Level of Service for future generations.

Although the Green Infrastructure Scenario demonstrates the potential to significantly reduce runoff volumes and pollution to Grand Traverse Bay, it does not entirely eliminate the need to replace undersized storm sewers. Green Infrastructure typically addresses more frequent storms (i.e. 1 inch of rain), where storm sewers are evaluated under the conditions of a 5-year event, where runoff volumes and peak flows are much higher.

Table C-6: Cost Estimate for Undersized Storm Sewer Locations

Location	**Cost of Sewer Replacement (no infiltration BMPs)**	**Cost of Sewer Replacement (with infiltration BMPs)**	**Cost of Infiltration BMPs**
Rose	$970,000	$830,000	$1,040,000
Hannah	$1,450,000	$1,230,000	$1,300,000
Aero Park	$2,440,000	$2,070,000	$1,310,000
Apache Pass	$900,000	$770,000	$910,000
Peninsula Drive	$630,000	$530,000	$1,030,000
Garfield	$1,340,000	$1,140,000	$860,000
Wastewater Treatment Plant	$260,000	$220,000	$400,000
Cass Street	$1,140,000	$970,000	$940,000
Spruce and Cedar	$670,000	$570,000	$700,000
Hall Street	$110,000	$100,000	$240,000
Pine Street	$510,000	$440,000	$380,000
Fourteenth Street	$1,060,000	$900,000	$1,210,000
Seventh and Division Street	$240,000	$210,000	$510,000
Third Street	$250,000	$210,000	$310,000
Bay Street	$60,000	$50,000	$170,000
Total	**$12,030,000**	**$10,240,000**	**$11,310,000**

The costs in Table 6 reveals that there is a significant need for capital improvements to the storm sewer system in order to provide a reasonable level of protection against surface flooding. Adding Green Infrastructure (infiltration BMPs) to the list of capital projects is not critical but is recommended in order enhance water quality in Grand Traverse Bay. As demonstrated in Table C-6, adding infiltration BMPs will not significantly reduce the cost of storm sewer replacement. However, the impact on water quality will be significant with the implementation of infiltration BMPs. Table C-7 includes a summary of key water quality benefits that can be realized through infiltration BMPs, based on our modeling in the Rose and Hannah subwatersheds.

Table C-7: Rose and Hannah Summary of Contaminants Reduced

Rose			
Contaminant	**1-year (lbs/year)**	**2-year (lbs/year)**	**Annual (lbs/year)**
Suspended Solids	404	413	329
Phosphorus	2	2	2
Nitrogen	15	15	12
Lead	0	0	0
Zinc	1	1	1
Copper	0	0	0

Hannah			
Contaminant	**1-year (lb/year**	**2-year (lbs/year)**	**Annual (lbs/year)**
Suspended Solids	615	631	435
Phosphorus	3	3	2
Nitrogen	23	23	16
Lead	0	0	0
Zinc	1	1	1
Copper	0	0	0

The costs defined in Table C-6 will be integrated in the Stormwater Asset Management Plan over a long (20 year) timeframe. This helps to reduce the annual cost to the City while effectively planning for the inevitable replacement of storm sewers as road replacement occurs. Although replacing undersized storm sewers is not necessarily a priority that requires immediate attention, the City should use these recommendations as a road map to take advantage of strategic utility enhancements when road projects provide the opportunity to replace storm sewers.

Appendix C-A: Maps

Figures

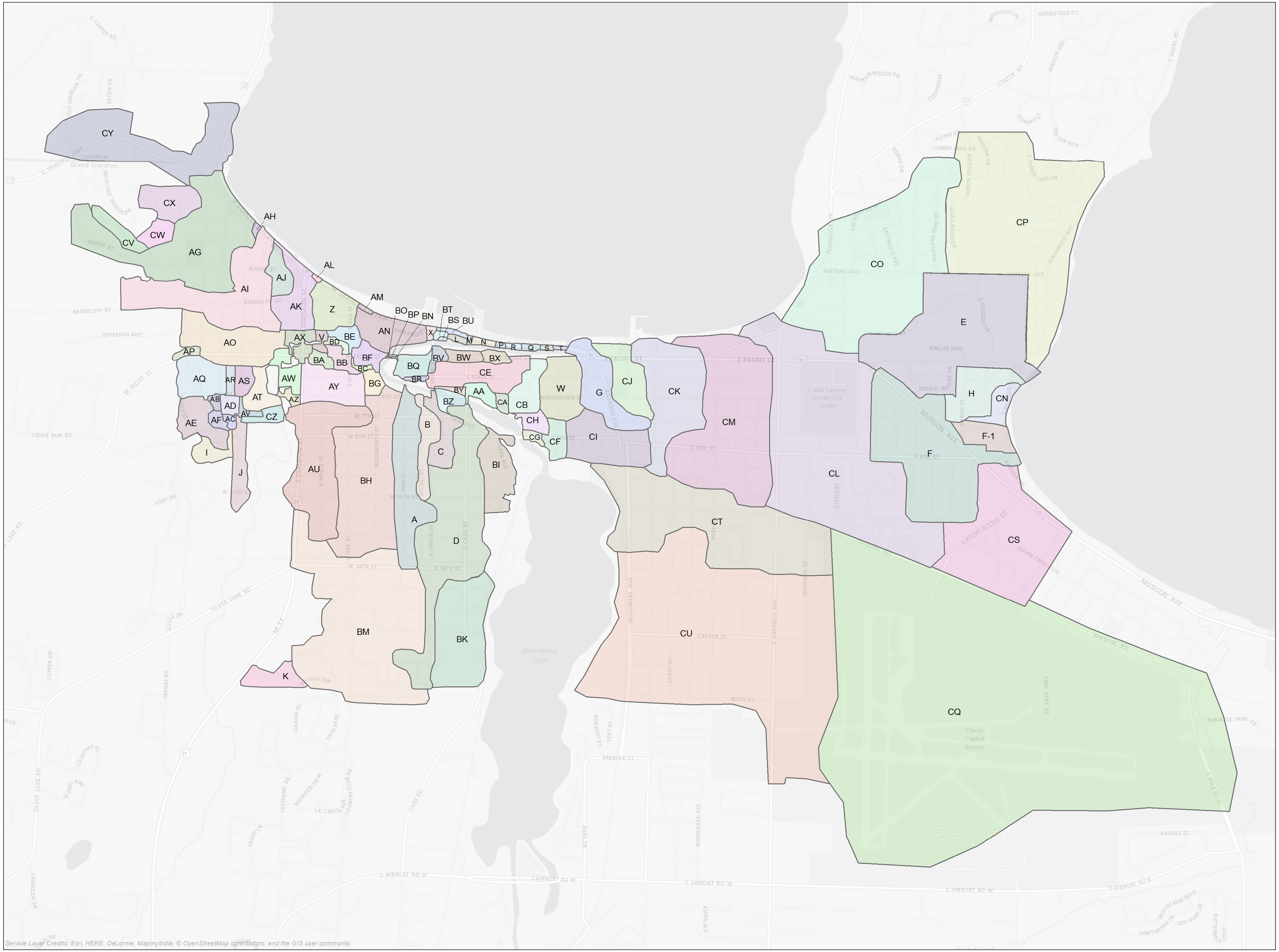

Figure C-A-1

2007 Stormwater Basins

Traverse City, MI

2007 Stormwater Basin Boundary

0 2,000 4,000 Feet

1" = 2,000'

Source: Data provided by Traverse City, MI. 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.

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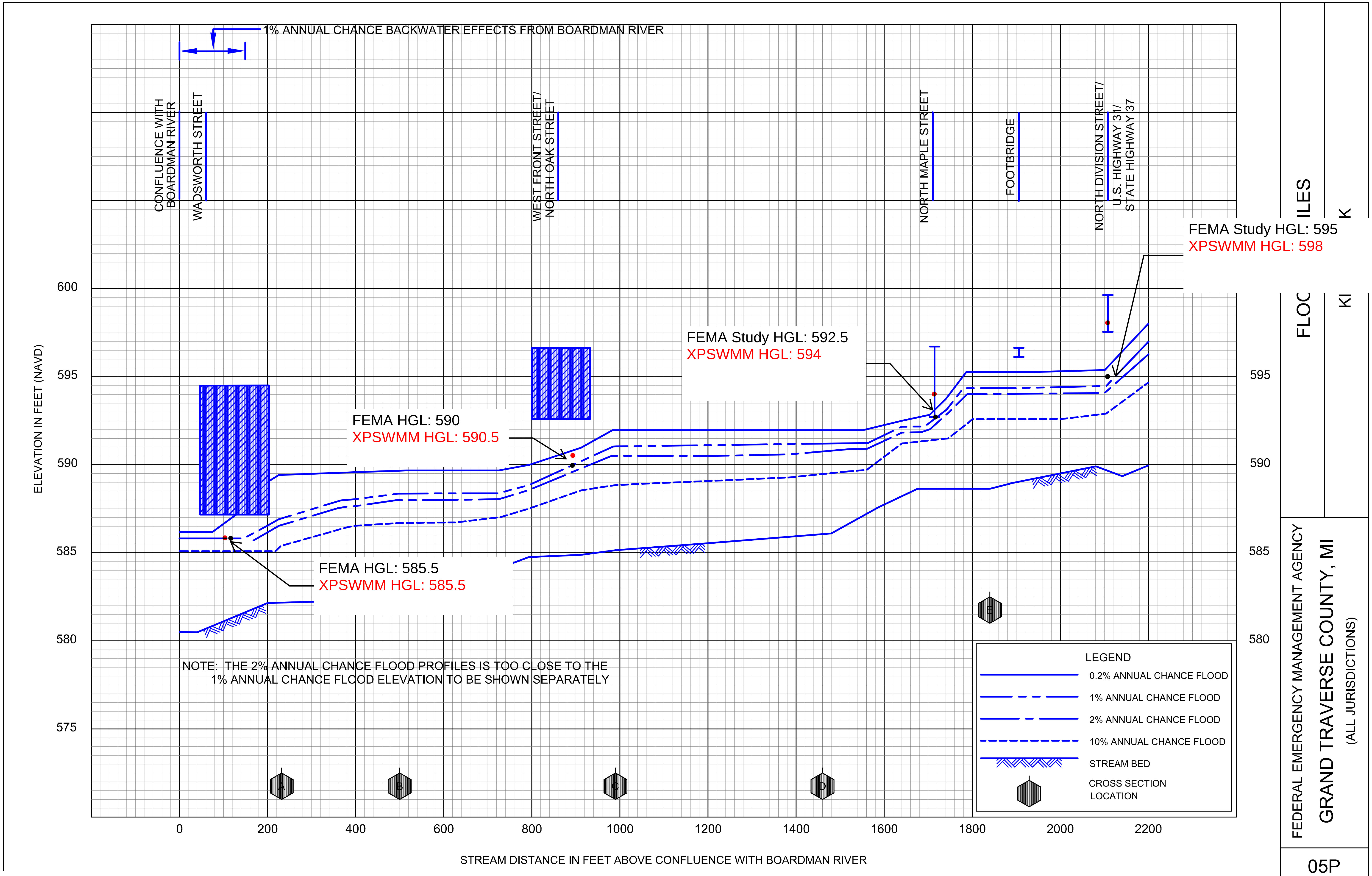

Figure C-A-2: FEMA Flood Profiles- Official vs. Hydraulic (SWMM) Model

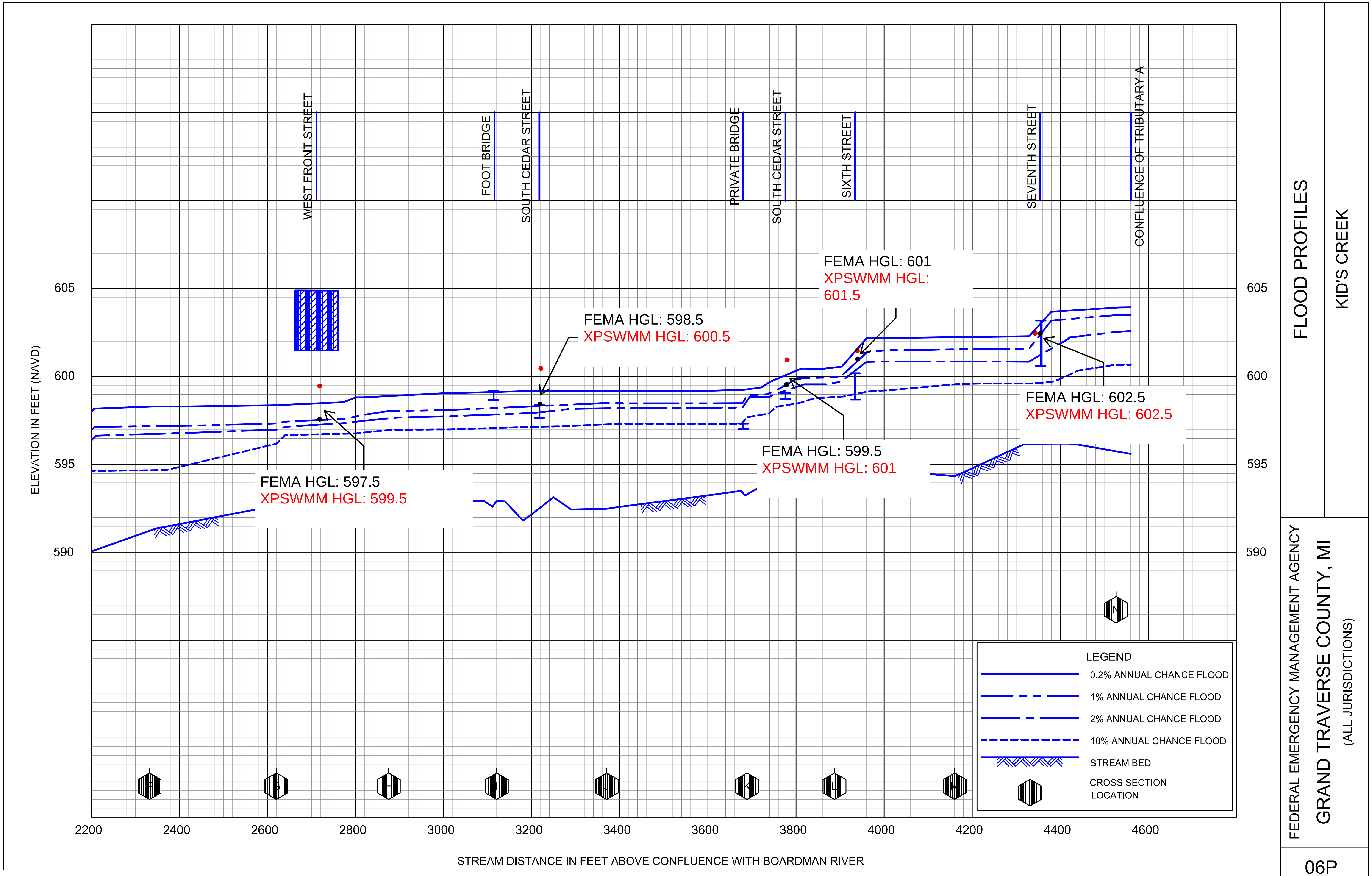

Figure C-A-2: FEMA Flood Profiles- Official vs. Hydraulic (SWMM) Model

Appendix C-B: Flooding Validation

Figures

Figure C-B-1

Flooding Validation Photo
12^{th} Street (Cone Drive)
09-08-2015

Traverse City, MI

Modeled Stormwater Segment
Undersized Stormwater Segment
Stormwater Gravity Main

0 200 400
Feet

1" = 200'

Source: Data provided by Bing Maps and Traverse City, MI. 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.

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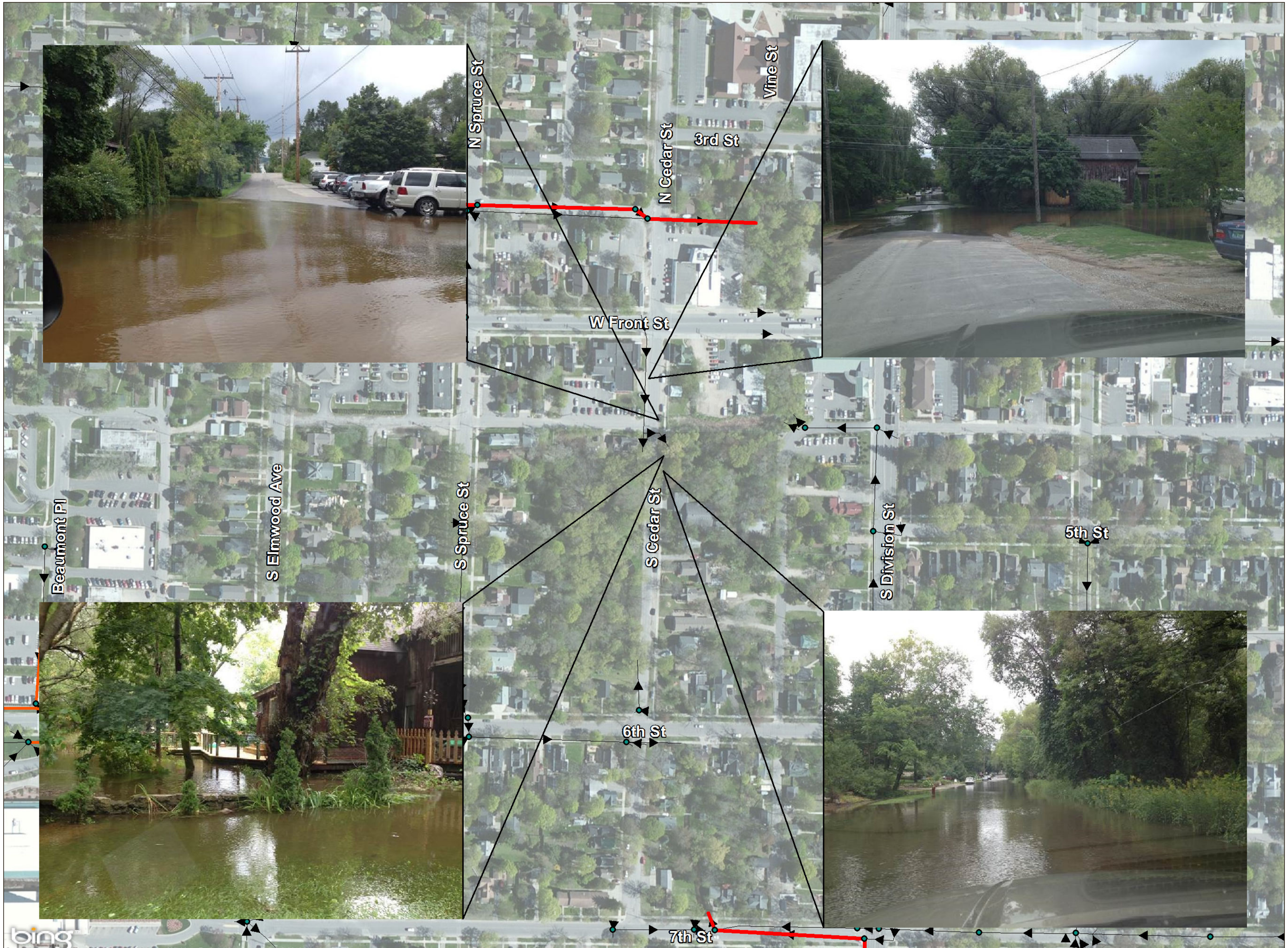

Figure C-B-2

Flooding Validation Photos

Cedar Street

09-05-2014

Traverse City, MI

Modeled Stormwater Segment

Undersized Stormwater Segment

Stormwater Gravity Main

0 200 400

Feet

1" = 200'

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P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\20160830 Traverse City Stormwater Basins with Pictures - Copy.mxd

Figure C-B-3

Flooding Validation Photos
Rose Street
09-15-2015

Traverse City, MI

Modeled Stormwater Segment
Undersized Stormwater Segment
Stormwater Gravity Main

0 200 400
Feet

1" = 200'

Source: Data provided by Bing Maps and Traverse City, MI. 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: November 14, 2016

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Appendix D: Criticality and Risk

Appendix D: Criticality and Risk

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).

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 D-1.

Table D-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 D-4. 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 D-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 D-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 D-3. The final CoF is then computed by taking a weighted average of the CoF Community Impacts as depicted in Figure D-2. 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 3. 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.

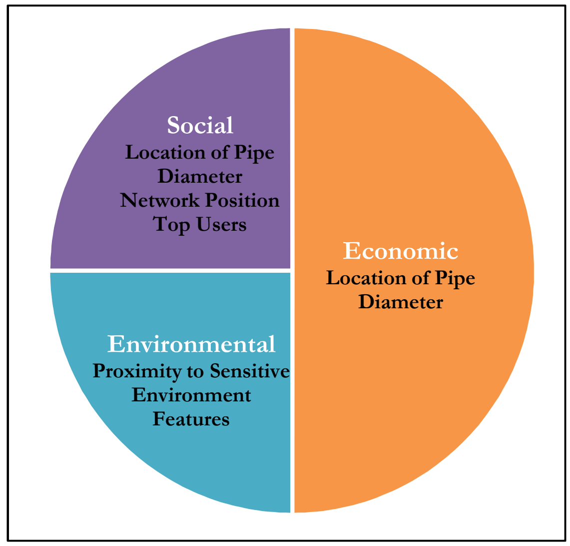

Figure D-1: CoF Community Impacts

Location of Pipe: 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 D-4 is an example of the rating scale used for the Location of Pipe factor.

Table D-2: 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 D-5, below, is a guide to help scale Relative Network Position of Pipe.

Table D-3: CoF Factor: Relative Network Position of Pipe

Rating Scale	Description
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 service 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 D-6 summarizes the rating scale.

Table D-4: 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 evaluates 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 D-7 summarizes the rating scale.

Table D-5: CoF Factor: Diameter

Rating Scale	Description
1	Less than 12 in
2	$\geq$ 15 in - < 20 in
3	$\geq$ 24 in - < 30 in
4	$\geq$ 36 in - < 48 in
5	$\geq$ 54 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 D-8 summarizes the rating scale.

Table D-8: CoF Factor: Sensitive Features

Rating Scale	Description
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 D-9.

Table D-9: PASER Scale

PASER Rating	Pavement Condition
9-10	Excellent
7-8	Good
5-6	Fair
3-4	Poor
1-2	Failed
NA	Data Not Available

Appendix E: Funding Feasibility Study

Executive Summary

Recognizing the importance of this stormwater system in protecting property from damage, maintaining property values, and preserving the water quality in Boardman Lake, the Boardman River, and Grand Traverse Bay, Traverse City initiated a comprehensive assessment of its stormwater infrastructure.

This is an Executive Summary of the Funding Feasibility Study, a key component of the Stormwater Asset Management Plan. This document is intended to be a tool that the City's elected officials and staff can use to guide decisions related to the creation of a stormwater enterprise fund.

To understand the need for a dedicated funding source for stormwater, it is important to understand and define the existing funding gap. That can be accomplished by reviewing what is currently being done and comparing that to what is recommended in the Asset Management Plan.

What does Traverse City currently do to manage Stormwater?

- Sweep streets to help reduce the amount of dirt that washes into the storm sewer.
- Clean catch basins and curb inlets annually to remove dirt and debris before it gets into local waterways.
- Pick up leaves on streets to keep stormwater inlets from clogging and roadways and property from flooding.
- Install and maintain end-of-pipe stormwater filters and treatment systems to reduce the pollution that reaches Grand Traverse Bay.
- As City streets budget allows, repair and replace storm sewers during road reconstruction projects.

The total spent annually by the City for all stormwater-related activities is approximately $750,000, with variable funding from the streets budget and $360,000 from general fund.

What problems were identified?

Existing problems were identified through a City-wide inspection of the stormwater system, combined with interviews with key City staff to identify known physical and budgetary problems. Key issues are noted below:

- The average age of the City's storm sewer system is 60 years and approximately 15% of the sewer system requires repair or replacement.
- To avoid unnecessary escalation of costs, protection of private property, and ensure protection of the local waterways from pollution, more investment must be made in the existing storm sewer system. This includes more attention to proactive maintenance and ongoing repairs.

- Currently, investment in the storm sewer system can be described as piecemeal and minimal. Investment is primarily driven by funding available from miscellaneous budgets, i.e. there is no systematic, institutionalised mechanism in place that is fiscally sustainable.

Providing adequate, quality service requires both a plan for strategic investment in new and existing infrastructure and a fiscally sustainable means to support that investment. This requires a systemic approach to reviewing the structural condition of the stormwater infrastructure on a perpetual basis and upgrading the system to maintain an adequate level of service to address both flood prevention and water quality. This is the purpose of an Asset Management Plan.

What does Traverse City need to do to protect property and sustain water quality?

- Fix the identified structural problems before they become critical and costs escalate.
- Replace or rehabilitate system components that are aging beyond their service lives.
- Inspect and clean the storm sewer system on a regular basis.
- Replace undersized sewers to prevent street flooding and property damage.
- Reduce the volume and rate of rainfall runoff in ways that enhance stormwater quality, reduce long term costs, extend the life of 'grey' (traditional) infrastructure (AND support tourism in Traverse City through enhanced water quality along the City's beaches).
- Facilitate and incentivize the use of green infrastructure, such as infiltration and filtration.
- Recognize the value added of making green infrastructure an "on the book asset" in the stormwater system.
- Encourage (through local policy) improved management of stormwater as properties redevelop, such as stormwater infiltration and/or filtration.
- Install stormwater infiltration zones during road reconstruction projects to reduce runoff volumes.
- Continue preventative maintenance (street sweeping, inlet/catch basin cleaning).
- Construct and maintain new end-of-pipe treatment systems.
- Maintain and repair eroded drainage channels, culverts, and bridges.
- Maintain and repair the sheet pile wall along the Boardman River.

Recognizing that investment options must be more widely vetted by city leaders and with the public, these principles are best met by funding the Stormwater Asset Management Plan in the same manner as with sanitary sewer services: through the establishment and use of a utility-based enterprise fund.

I. Introduction

In December 2013, the City of Traverse City applied for a Stormwater, Asset Management, and Wastewater (SAW) grant from the Michigan Department of Environmental Quality (MDEQ) in order to develop an Asset Management Program or Plan (AMP) for the City's stormwater system. Since sustainable infrastructure funding is a key element of an AMP, the exploration of a funding mechanism for the City's stormwater system was included in the grant scope. The purpose of this Funding Feasibility Study is to provide a comprehensive review of Traverse City's existing stormwater program, and an evaluation of how a stormwater utility could be implemented to create a consistent and dedicated source of funding.

This study was supported by an MDEQ SAW grant to develop a sustainable, dedicated funding source for Traverse City's stormwater system and define the existing funding gap.

A. Stormwater Advisory Group

A Stormwater Advisory Group (SAG) was established to engage a wide cross-section of local stakeholders to learn about, discuss, and make informed recommendations to the City Commission regarding management and funding of the City's stormwater infrastructure. The SAG met four times between January and July 2016. An overview of the meeting attendees and key topics is available in Table E-1. The following mission statement was developed by the SAG:

Enhance the safety, health, and quality of life for the people of Traverse City through the effective management and maintenance of its stormwater infrastructure.

Table E-1: Summary of Stormwater Advisory Group Meetings

SAG Meeting	Attendees:	Key Topics
#1 1/12/16	City Commissioners: Carruthers and Werner Munson: Stephen Tongue Cone Drive: Jack Cramer Catt Development: Ron Parker Resident Representative: John Williams Watershed Center: Crissman/Andrews/Erickson City Public Works Staff City Manager OHM Staff	• Stormwater 101 • Funding of water and wastewater infrastructure • Value of the City's stormwater assets • Current stormwater budget
#2 2/9/16	City Commissioners: Carruthers and Werner Munson: Robert Van Rees Holiday Inn: Charlie Robles Catt Development: Ron Parker Northwest Michigan College: Hans Van Sumeren Resident Representative: John Williams Watershed Center: Crissman/Andrews/Erickson City Public Works Staff City Manager OHM Staff	• Mission Statement for stormwater • Stormwater pollution • Reactive vs. proactive maintenance • Prioritization exercise
#3 4/5/16	City Commissioners: Carruthers and Werner Munson: Stephen Tongue Holiday Inn: Charlie Robles Northwest Michigan College: Hans Van Sumeren Resident Representative: John Williams Watershed Center: Crissman/Andrews/Erickson City Public Works Staff City Manager OHM Staff, including Chuck Hersey (PSC, Inc.)	• Overview of age/condition of assets • Projected cost to maintain system • Early discussion of funding strategy
#4 7/12/16	City Commissioners: Carruthers and Werner Cone Drive: Jack Cramer Munson: ABSENT Holiday Inn: ABSENT Northwest Michigan College: ABSENT Resident Representative: ABSENT Watershed Center: Crissman/Andrews City Public Works Staff City Manager OHM Staff, including Chuck Hersey (PSC, Inc.)	• Summary of materials presented to date • Results of deterioration forecast for manholes and sewers • Results of storm sewer modeling • Impact of stormwater infiltration on flow volumes and water quality • Updated cost estimates to maintain system • Presentation of taxes vs. fees (impacts on typical property owners)
Note: Two churches were invited and encouraged to send representatives (St. Francis and Central United Methodist). Despite multiple attempts to contact leadership at both churches, neither sent representatives to the SAG meetings. Also invited but did not attend any of the meetings: Paul Thwing (TCAPS) and Carmen Stephens (Hagerty Insurance).		

B. SAG Guiding Principles

There were four core principles that the SAG considered when selecting a fiscally sustainable financing mechanism. Debate and discussion on how best to move forward will be most productive if it begins with a set of principles to benchmark the merits of ideas put forth in the process. These principles are:

1. When estimating the amount of revenue needed and the amount to be charged, the math will ALWAYS include the cost of four things: *capital*, *operation*, *maintenance*, and *replacement*. These represent the true short- and long-term costs of infrastructure service. Any weak link in this chain seriously compromises reliability.
2. Traverse City will not rely on federal or state government to subsidize local utility services. That approach is unsustainable because the subsidies may not be adequate, Traverse City may not get them, and subsidies are not guaranteed to be received in perpetuity.
3. To earn and maintain the public trust, a funding strategy must be both fair and transparent regarding how costs are calculated and how charges are allocated to customers.
4. Meeting public expectations to optimize costs and be fair means the actions of various City departments (i.e. public works, planning, engineering, finance, etc.) have the same end goal. That means a commitment to collaboration and partnerships. Therefore, decisions about how much, where, and when to invest will be made on a systematic basis considering:
    - Cost
    - Benefits
    - Alignment with other City programs
    - Contribution to quality of life and public safety
    - Alignment with services provided by others

Recognizing that investment options must be more widely vetted by city leaders and with the public, the SAG found that these principles are best met by funding the stormwater system in the same manner as with sanitary sewer services: through the establishment and use of a utility-based enterprise fund.

C. Stormwater Utilities

A Stormwater Utility provides a dedicated funding source for a Stormwater system. In Traverse City, the stormwater system includes storms sewers, catch basins, manholes, detention ponds, open channels, green infrastructure or other Best Management Practices (BMPs), end-of-pipe treatment, and any other part of the infrastructure that impacts the conveyance or treatment of stormwater.

Currently, most communities in Michigan continue to fund stormwater-related activities through General Funds, supplemented by street/road funding. However, the stormwater system tends to be the first to be "cut off" from General Funds when priorities change and funds are diverted to other programs. Stormwater infrastructure suffers when priorities are shifted, and stormwater systems become obsolete and/or ineffective as they exist without an adequate source of funding.

According to the most recent annual Stormwater Utility Survey from Western Kentucky University (Campbell, Dymond, et. al., 2016), there are over 1,600 cities in the United States with a stormwater utility (i.e. enterprise fund for stormwater infrastructure). However, only eight cities in Michigan have stormwater utilities while our neighbor to the south, Ohio, has over 100 cities with stormwater utilities and Wisconsin has over 120 cities with stormwater utilities. The lack of stormwater utilities in Michigan is primarily due to judicial precedent stemming from the following two cases:

- Bolt v Lansing, Michigan Supreme Court (1998)
- Jackson County v City of Jackson, Michigan Court of Appeals (2013)

These cases deemed the stormwater fee an "illegal tax" and a violation of the Headlee Amendment.

II. Current and Proposed Program

The City's stormwater infrastructure is aging and in need of significant improvements. The City's Stormwater AMP has revealed significant structural, maintenance, and hydraulic capacity issues.

A. Current Services

The City has currently allocates about $360,000 per year from the General Fund to stormwater related activities. These are mostly costs linked to keeping the system clean, including leaf pickup, street sweeping, and catch basin cleaning. Any additional costs, such as repair or replacement of catch basins, and structural repair or replacement of manholes and sewers, are generally taken from the City's streets budget. This creates unnecessary strain on the streets budget, as that money is needed to repair and replace the City's roadways. Currently, investment in the storm sewer system can be described as piecemeal and minimal. To date, investment is not driven by needs. Investment is primarily driven by funding available from miscellaneous budgets; there is no systematic, institutionalized mechanism in place that is fiscally sustainable.

The City's Stormwater AMP has revealed significant structural, maintenance, and hydraulic capacity issues. The current funding gap is approximately $1.66 million per year.

B. Stormwater System Needs

The inventory and condition assessment completed for the City's Stormwater AMP include several new O&M (Operation and Maintenance) activities and capital costs that are crucial to meeting the City's goals of effective, proactive management and maintenance of its stormwater infrastructure. More investment is necessary to prevent costly emergency repair, to protect private property, and to protect the local waterways and Grand Traverse Bay from pollution. This includes more attention to proactive maintenance and implementing a systematic repair/rehabilitation program. Providing an adequate, quality service requires both a plan for strategic investment in new infrastructure and a fiscally sustainable means to support that investment.

The recommended O&M activities must occur annually to maintain and prolong the life of aging infrastructure as well as control pollution to the bay; they are also critical to maintain a focused and cost-efficient approach to system repair.

The capital improvement plan (CIP) identifies items that are generally projected for a 20- to 30-year timeframe to avoid excessive annual budgets. For example, sewer size increases and infiltration BMPs should be programmed to coincide with planned roadway replacement projects as they occur, likely over a 30-year period.

As shown in Table E-2, there is a substantial funding gap of $1.66M. This is the difference between the $2.02M proposed annual budget and the $360,000 currently allocated to stormwater from the general fund. Details on the needs and annual costs for each component are summarized in the following sections.

Table E-2: Proposed Stormwater Budget

Proposed Budget Items		Annual Cost
O&M Expenditures		
	Sewer Rehabilitation and Repair	$310,000
	Manhole Rehabilitation and Repair	$90,000
	Sweeping and Leaf Collection	$285,000
	Sewer system televising, cleaning	$160,000
	Boardman River Wall Maintenance	$65,000
	Open Channel/Culvert Maintenance	$75,000
	Personnel / Administrative Costs	$150,000
	Stormwater Utility Bill (City-owned facilities)	$50,000
	O&M Subtotal	**$1,185,000**
CIP Expenditures		
	Catch Basin Replacement Program	$100,000
	Sewer Replacement (Hydraulics)	$315,000
	Stormwater Volume Control BMPs	$350,000
	End of Pipe Treatment	$70,000
	CIP Subtotal	**$835,000**
	Annual Total	**$2,020,000**
	Existing Stormwater Budget	**$360,000**
	Funding Gap	**$1,660,000**

1. Storm Sewers

There are approximately 65 miles of storm sewers with an average age of 60 years. Annual costs for storm sewers total $785,000 and include:

- $160,000 - Inspect and clean the majority (approximately 80%) of the storm sewer system on a 20-year cycle. Inspect and clean known problems areas (approximately 20% of the system) on a 5-year cycle.

- $310,000 - Fix the identified structural problems before they become critical and costs escalate. Replace/rehabilitate system components that are aging beyond their service lives during road projects.

- $315,000 - Replace undersized sewers to prevent street flooding and property damage. These sewers should be replaced as the streets they are under are scheduled for reconstruction, so as to minimize the replacement cost.

2. <u>Manholes</u>

There are approximately 1,200 storm manholes with an average age of 60 years. Annual costs for manholes total $90,000 and include:

- $15,000 - Inspect and clean system on a 20-year cycle (approximately 60 per year).
- $15,000 - Fix the identified structural problems before they become critical and costs escalate.
- $45,000 - Replace/rehabilitate system components that are aging beyond their service lives during road projects (approximately 20 per year).
- $15,000 – Long term maintenance to replace manhole lids or chimneys.

3. <u>Catch Basins</u>

There are approximately 2,400 storm drain inlets or catch basins in the City. Annual costs for catch basins total $100,000 and include:

- $30,000 - Inspect and clean system on a 20-year cycle (approximately 120 per year).
- $70,000 - Replace/rehabilitate system components that are aging beyond their service lives during road projects (approximately 60 per year). This is based on the assumption that a typical catch basin will be replaced, on average, about once every 40 years (about the same frequency as road reconstruction).

4. Treatment and volume control BMPs

Today, there are approximately 35 stormwater treatment BMPs in the City ranging from outlet covers to advanced filtration systems. Given the abundance of sandy soils in Traverse City, there is an opportunity to reduce annual runoff volume and pollutant loading to the bay. Based on feedback received during the SAG process, a key Level of Service goal was established: ***reduce runoff volume through infrastructure enhancements***. This goal can be achieved through targeted installation of infiltration BMPs as roadways are replaced. Annual costs for BMPs total $425,000 and include:

- $30,000 – Cleaning existing BMPs twice per year
- $15,000 – Depreciation or recovery costs for replacement of existing BMPs after 50 year life
- $25,000 – Installation of 5 new end-of-pipe treatment BMPs in a 10-year cycle (one $50,000 BMP installed every two years)
- $350,000 – Installation of distributed volume control BMPs, including rain gardens, bioretention areas, and/or underground exfiltration sewers. These projects would be scheduled to occur alongside roadway projects so as to minimize costs.

5. Additional Costs

There are several additional costs related to preventative maintenance and increased personnel costs. Annual costs for additional services total $625,000 and include:

- $75,000 – Maintain and repair open drainage channels and culvert/bridges, primarily along Kids Creek (see the Stormwater Management Plan for additional details on Kids Creek recommendations)
- $65,000 – Maintain and repair the sheet pile wall along the Boardman River
- $285,000 – Continue preventative maintenance, specifically street sweeping and leaf collection, to keep debris and pollutants out of the stormwater system (according to City records, these activities remove ***850-900 tons of dirt and debris per year*** that would otherwise find its way to Grand Traverse Bay)
- $90,000 – Additional personnel costs to oversee stormwater-related projects
- $60,000 - Annual costs for GIS software, aerial photography, and stormwater billing administrative efforts
- $50,000 – Stormwater utility bill for City owned properties

III. Preliminary Rate Analysis

The calculations described in this section reflect the anticipated best practices for stormwater utilities that have been outlined in House Bill 4100 (HB4100), *Stormwater Utility Act*, which was introduced in the Michigan Legislature in January 2017. At the time this document was prepared, the outcome of HB4100 was not yet known. However, should the bill become law, it will be important to develop a funding mechanism that is equitable and representative of the impact of each property on the stormwater collection system.

The rate analysis in this document focuses on impervious area as the key metric for determining the impact on the stormwater system. Parcels with more impervious surfaces (i.e. rooftops, parking lots, driveways, etc.) discharge higher volumes of stormwater runoff. This, in turn, increases the demand on the system of pipes, manholes, and culverts.

A crucial component of this study is to determine how a stormwater user fee would be distributed among the City's property owners: residents, business owners, and key ratepayers such as industries or large facilities. This includes the development of a preliminary rate model for determining revenue potential and approximate fee distribution among zoning districts and property types.

A. ERU Methodology

An analysis of existing land use and magnitude of impervious areas for individual parcels was used to evaluate how a stormwater billing program might impact typical property owners. This process utilized the City's existing GIS database that contained the size and location of impervious areas on all parcels, including rooftops, driveways, patios, etc. An Equivalent Residential Unit (ERU) was determined from the median impervious area measured on a sample of typical residential parcels within Traverse City.

For Traverse City, the ERU was determined to be approximately 1,915 square feet of impervious area per single-family residential parcel. This was based on a total of 116 randomly-selected R-1b parcels (the most common single-family residential parcel type). R-1a parcels were also sampled, and it was found that the impervious coverage of R-1a parcels was roughly double that of R-1b parcels. As such, we recommend that the City consider two separate billing classifications for the two primary single-family residential zoning districts. In this scenario, an R-1b parcel would be treated as a *single* ERU. An R-1a parcel would be treated as *two* ERUs.

A monthly charge of $6-$7 per ERU should generate enough revenue to fully fund the $2.02 million recommended stormwater program

The ERU factor can be applied to non-residential parcels to determine the approximate number of ERUs (or billing units) within the City as shown in Table E-3. Based on a preliminary review of the total imperious area within City limits, as well as the number of single-family residential parcels, the estimated of the number of billing units in the City is about 34,600. The impervious area analysis was performed using available impervious area layers from the City's GIS database. The impervious data layer has some errors and should not be relied on as a final product that can be used to establish final ERU counts. Prior to establishing a stormwater billing database, the impervious areas will need to be refined to eliminate errors so as to guarantee an accurate and equitable billing structure.

Table E-3: Billing Units by Zoning Classification

Zoning Classification	Number of Parcels	Impervious Area (sq. ft)	Number of ERUs	Percent of Total ERUs
Non-Residential	1,196	41,542,771	21,693	63%
R-1a Residential	728	3,426,453	1,456	4%
R-1b Residential	3,349	9,480,845	3,349	10%
Multi-Family	823	15,514,583	8,102	23%
Total	**6,096**	**69,964,652**	**34,600**	**100%**

Of the 34,000-35,000 estimated stormwater billing units in the City, approximately 86% of these units are associated with non-residential customers (e.g. commercial, industrial, institutional), while residential customers would be responsible for the remaining 14%. This excludes the airport property, which has retention basins onsite and does not have a stormwater outlet to the City's system.

When planning for stormwater utility revenues, it is prudent to assume that some revenue losses will occur due to delinquent accounts (usually about 2% of total revenue) and stormwater credits that property owners would apply for (usually at least 5% of revenues; see next section for details on credits). When selecting an appropriate fee, these revenue losses should be anticipated. As such, the recommendations in this report include a fee range which should cover the potential losses described above.

Based on preliminary data, the City can generate approximately $415,000 annually for every one dollar per month charged to an ERU (closer to $385,000 annually for every dollar charged when taking into account typical revenue losses described above). In other words, a monthly charge of about $6 per ERU (median residential parcel) would close the stormwater infrastructure funding gap referenced in this document. A monthly charge of $7 per ERU should generate enough revenue to fully fund the $2.02 million recommended stormwater program. As such, a monthly fee of $6-$7 per ERU is recommended for Traverse City.

The top 20 non-residential rate payers are shown in Table E-4. The number of billing units (ERUs) is based on the total impervious area divided by the ERU area of 1,915 square feet. This allows for an equitable billing for non-residential properties that takes into account the additional runoff volume as compared to a typical residential customer.

Table E-4: Top 20 Non-Residential Key Rate Payers

Owner Name	Impervious Area (sq. ft.)	Percent Impervious	Number of ERUs	Percent of Total ERUs
City of Traverse City	1,850,959	11%	967	2.79%
Northwestern Michigan College	1,717,737	23%	897	2.59%
Munson Medical Center	1,413,963	47%	738	2.13%
TCAPS	1,327,476	33%	693	2.00%
Grand Traverse County	784,821	26%	410	1.18%
United States Government	718,371	21%	375	1.08%
TBA Intermediate School	537,005	55%	280	0.81%
Toms Food Market, Inc.	458,071	83%	239	0.69%
Lancz, Harry & Claire	456,450	68%	238	0.69%
East Bay Plaza, LLC	308,313	88%	161	0.47%
Oleson Foundation	297,490	82%	155	0.45%
Cone Drive Operations, Inc.	267,363	58%	140	0.40%
Bay Hill I	266,287	36%	139	0.40%
Diocese of Gaylord	248,879	68%	130	0.38%
Lear Operations Corp	204,451	19%	107	0.31%
C & U Properties, Inc.	200,366	74%	105	0.30%
Consumers Energy	197,983	28%	103	0.30%
Meijer, Inc.	194,518	29%	102	0.29%
Marsh Brothers Holding	191,932	85%	100	0.29%
Alcotec Wire Corp	186,823	71%	98	0.28%

To determine the potential range in fees for the predicted key ratepayers from Table 4, multiply the number of ERUs for each ratepayer by $6-$7 per month. For the Munson Medical Center (738 ERUs), the likely monthly fee would be approximately $4,430 to $5,170.

For the vast majority of customers, the stormwater utility fee is the lowest of all utility fees, including water, sewer, electric, gas, cable, data, and phone.

B. Stormwater Credits

In order to develop a stormwater utility that is compliant with HB4100 (Stormwater Utility Act), it will be necessary to create a system of credits to allow customers to reduce their stormwater utility bills when they implement onsite controls to limit the peak runoff, reduce runoff volume, or reduce the concentration of stormwater pollutants. These controls may consist of detention ponds, infiltration BMPs, green roofs, stormwater filters, etc. A credit program would allow the property owners to apply for a credit by demonstrating the impact of their onsite controls (typically prepared by a Professional Engineer). Receiving the stormwater utility credit would be contingent upon perpetual maintenance of the stormwater controls so they continue to function as originally intended.

Although credits are not intended to eliminate the fee for any parcel, they typically provide a reduction in the monthly bill; usually ranging from 10% to 50%, depending on the number of stormwater controls implemented and the total impact on stormwater runoff volume (higher credits typically require a more significant investment in stormwater controls).

If any property owner can demonstrate that they do not discharge any stormwater to the City's stormwater infrastructure, they can and should have their fee waived. This scenario can occur for properties that are on the edge of the City that discharge outside the City's boundary. This may also apply to properties that discharge directly to Grand Traverse Bay.

C. Property Tax Comparison

In order to fully explore the viability and fairness of a stormwater utility fee, it is necessary to compare it to property tax revenues to see how it would impact a typical customer. Because the City has many tax-exempt properties with large impervious surfaces, those properties would be subsidized if the City's stormwater program were funded through a tax millage. Table E-5 summarizes the difference in monthly costs for various residential scenarios between an ERU-based user fee and a tax, based on the most recent Equalization Report and an assumed 2.0 Mil tax to generate an equivalent revenue for the stormwater utility.

Using property taxes to collect the recommended revenues will create an imbalance between actual system demand and user cost and result in significantly higher costs to the residents of Traverse City, as compared to a utility fee.

Table E-5: Typical Monthly Fee for Residents

Typical Monthly Fee * / **	Stormwater Utility	Property Tax (Millage)
R-1b parcel (typical property)	\$6-\$7	\$16
R-1a parcel (larger property)	\$12-\$14	\$20
Median Taxable Income Property	\$6-\$7	\$16
Newly-purchased median home (\$265k)	\$6-\$7	\$23

** Stormwater Utility Fee estimate: 34,600 City-wide ERUs (billing units), airport excluded (no stormwater outlet)*
*** Property tax based on need for ~2.0 Mils, applied to taxable values in the 2016 Equalization Report for Grand Traverse County*

Using property taxes to collect the recommended revenues in this report will result in significantly higher costs to the residents of Traverse City, as compared to a utility fee. The primary reason for this difference is that the residential customers, who are not tax-exempt, would subsidize numerous tax-exempt property owners throughout the City. As all property owners, tax-exempt and non-tax-exempt, depend on the City's stormwater system, the property tax scenario would create an imbalance between actual system demand and user cost.

D. Legality of Stormwater Utilities

In the Supreme Court case *Bolt v. City of Lansing,* the City of Lansing's stormwater utility was found to be an illegal tax, based on the Headlee Amendment. The Michigan Supreme Court ruled that the stormwater service charge imposed by Lansing was unconstitutional and void on the basis that it was a tax for which voter approval was required and not a valid use fee. The Court established three "tests" to distinguish fees and taxes:

1. The fee serves a regulatory purpose rather than revenue-raising purpose
2. The fee is proportional to services rendered
3. The fee is voluntary so property owners can refuse or limit their use of the stormwater system.

HB4100 (Stormwater Utility Act) will serve to provide a roadmap that communities can use to establish a "Bolt-Compliant" stormwater utility that stands up to the three tests above. The recommendations in this study are consistent with the language in HB4100. Furthermore, the City's efforts to complete an Asset Management Plan for its stormwater system will provide the necessary documentation that will allow it to move forward in a manner that satisfies the steps outlined in HB4100.

IV. Recommendations and Next Steps

The City of Traverse City should pursue the development of a stormwater utility through a rate ordinance approved by the City Commission. This is necessary to maintain an adequate Level of Service in the City's stormwater system and addresses the funding gap identified in the City's Asset Management Plan. The rate ordinance should be based on the billing methodology outlined in this memorandum and should include a stormwater credit program.

The next steps toward implementation include:

- Complete and submit the SAW Asset Management Plan and Stormwater Management Plan (to be delivered at the end of April 2017).
- Develop a draft Stormwater Credit Manual, defining the fee reductions possible through on-site stormwater management by property owners.
- Refine and complete the rate model using the following information:
    - Final recommended stormwater budget
    - Estimated revenue reductions due to delinquent bills and stormwater credits
    - Desired fund balance needs (using a 10-year cash flow analysis)
- Develop a Master Account File for stormwater billing. This will be based on the ERU coverage and a final measurement of impervious surfaces on all parcels (using the latest GIS aerial photography).
- Coordinate with key ratepayers and let them know about the pending stormwater bill. Provide information on stormwater credits and encourage them to apply for credits if they are eligible.
- Draft and pass a rate ordinance for a stormwater enterprise fund.
- Integrate the Master Account File with the City's existing billing system for water/sewer.
- Develop a FAQ page on the City's website that highlights the new stormwater utility bill and what it will be used for (reference the Asset Management Plan).
- Send out the first stormwater utility bills (anticipate additional support in the first few months for questions and resolution of any billing disputes).

Appendix F: Capital Improvement Plan

Appendix F: 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-1. The PoF and CoF score for each asset assessed are illustrated in Appendix F-A. The stormwater assets in Traverse City were given high, medium or low priority based on their BRE shown in Figure F-1.

Probability of Failure

Consequence 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-1: BRE Prioritization Matrix

The City has currently allocated about $360,000 per year to stormwater activities, although some additional funding does come from the Streets budget for specific projects. The identified funding needed to address the stormwater sewer CIP is $625,000, which includes expenditures for sewer rehabilitation and repair and sewer enlargement to meet hydraulic needs. $90,000 per year is needed to address the stormwater manholes. Since the stormwater infrastructure is currently underfunded, the CIP is contingent upon the City establishing a dedicated funding source for stormwater. If a stormwater utility (or similar funding source) is created, the City will be able to adequately manage the continued aging and degradation of their stormwater infrastructure without a loss in the level of service.

This CIP includes a detailed project table for an initial a three (3) year planning period, with the first projects reflecting those with the highest BRE score. 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 Tables F-1 through F-4. 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 stormwater infrastructure before beginning the CIP design process.

It was assumed that the annual investment in the CIP would ramp up between Years 1-3, given that it will take some time to establish a new funding source and to be fully-engaged in a CIP program.

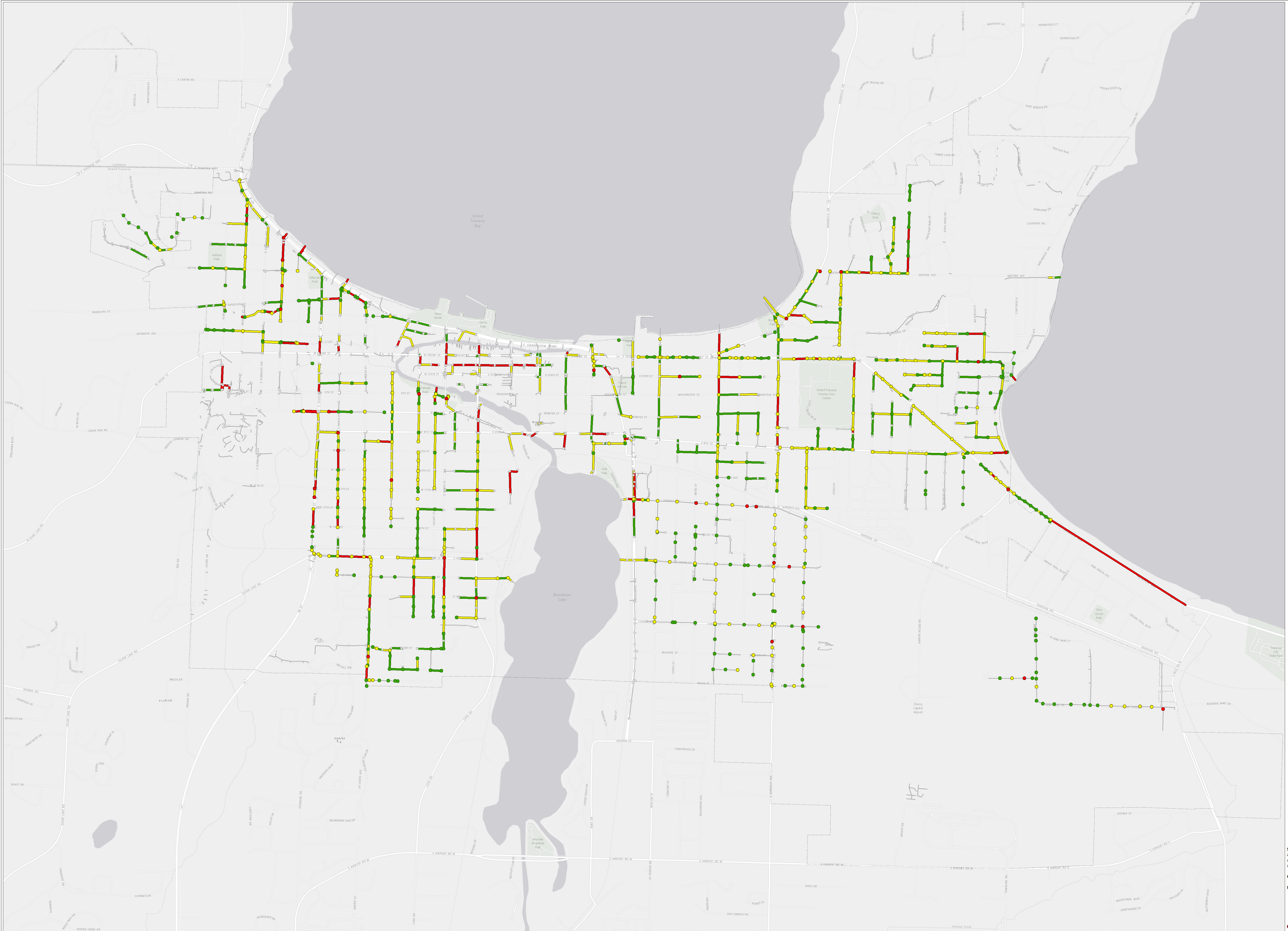

Figure F-2
Business Risk

Traverse City, MI

N
W E
S

0 900 1,800 2,700
Feet
1" = 900'

Stormwater Manholes
- No Associated Value

Business Risk
- Low Priority (1-4)
- Medium Priority (5-9)
- High Priority (10-25)

Stormwater Gravity Main
- 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: April 18, 2017

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Table F-1: Capital Improvement Projects for Year 1 (FY2018/2019)

Facility ID	Diameter (in)	Proposed Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
STP-1038	36		318	4	4	16	Heavy Cleaning	$5,000	7th street
STP-1281	24		23	3	5	15	Cleaning	$200	Rivers Edge Drive
STP-1875	18		252	3	5	15	Cutting and Grouting	$17,000	Garfield Avenue
STP-382	24		93	3	5	15	Heavy Cleaning	$2,000	Grandview Outlet
STP-466	30		230	3	5	15	Heavy Cleaning	$4,000	Third Street
STP-306	24		103	3	5	15	Full Liner	$22,000	Spruce Street
STP-1033	10		173	3	5	15	Remove and Replace	$22,000	7th street
STP-1475	36	54	172	3	5	15	Remove and Upsize	$109,000	Hannah Avenue
STP-1679	30		601	3	5	15	Spot Liner(s)	$28,000	Wellington Street
STP-1037	36		39	4	3	12	Cleaning	$1,000	7th street
STP-1863	12		295	3	4	12	Cutting and Grouting	$12,000	Garfield Avenue
STP-3339	18		362	2	6	12	Heavy Cleaning	$5,000	Woodmere Avenue
STP-3337	36	60	150	3	4	12	Remove and Upsize	$95,000	Hannah Avenue
STP-1039	15		304	3	4	12	Spot Liner(s)	$7,000	7th street
STP-1809	12		420	2	5	10	Cutting and Grouting	$17,000	Garfield Avenue
STP-1483	12		213	2	5	10	Full Liner	$15,000	Hannah Avenue
STP-465	15		384	2	5	10	Monitor Closely, Spot Liner(s)	$7,000	Third Street
STP-949	15		206	2	5	10	Spot Liner(s)	$7,000	7th Street
STP-1491	12		383	2	5	10	Spot Liner(s)	$6,000	Woodmere Avenue
STP-302	24		387	2	5	10	Monitor Closely, Spot Liner(s)	$12,000	Spruce Street
							Estimated Total CIP Cost*	**$393,200**	

** Year 1 cost is lower than recommended CIP budget due to assumption that full CIP program will ramp up over a 3-year period*

Table 2: Capital Improvement Projects for Year 2 (FY2019/2020)

Facility ID	Diameter (in)	Proposed Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
STP-528	30	66	450	3	5	15	Remove and Upsize	$473,000	Rose Street
STP-527	30	54	101	3	5	15	Remove and Upsize	$64,000	Rose Street
STP-376	15		268	2	5	10	Full Liner	$29,000	Randolph Street
STP-375	24		44	2	5	10	Spot Liner(s)	$12,000	Randolph Street
							Estimated Total CIP Cost*	**$578,000**	

** Year 2 cost is lower than recommended CIP budget due to assumption that full CIP program will ramp up over a 3-year period*

In the fiscal year of 2019/2020, Randolph Street from Division Street to Bay Street will be under construction to address the sanitary sewer and water main. Storm sewer pipes that are along this reach have been incorporated into the CIP for that fiscal year. The Rose Street sewer was shown to be significantly undersized (hydraulic model) and is recommended for replacement; repairing this sewer only is not advised, at it would fail to address the hydraulic deficiency at this location.

Table F-3: Capital Improvement Projects for Year 3 (FY2020/2021)

Facility ID	Diameter (in)	Proposed Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
STP-1256	54		256	3	5	15	Spot Liner(s)	$59,000	Alleyway between Front and State
STP-664	42		99	3	5	15	Spot Liner(s)	$21,000	6th Street
STP-665	42		141	3	5	15	Spot Liner(s)	$42,000	6th Street
STP-2934	42		105	3	5	15	Spot Liner(s)	$21,000	6th Street
STP-1155	18		233	3	5	15	Full Liner	$31,000	Union Street
STP-1252	30		332	2	6	12	Full Liner	$89,000	Alleyway between Front and State
STP-1258	36		256	2	6	12	Full Liner	$81,000	Alleyway between Front and State
STP-1181	24		276	2	6	12	Heavy Cleaning	$4,000	Alleyway between Front and State
STP-3086	15		175	2	6	12	Remove and Replace	$28,000	Alleyway between Front and State
STP-1157	12		244	2	5	10	Heavy Cleaning	$3,000	Union Street
STP-1250	30		341	2	5	10	Lateral Cutting	$700	Alleyway between Front and State
STP-1147	18		203	2	5	10	Spot Liner(s)	$9,000	Pine Street
STP-1199	15		192	3	4	12	Monitor Closely, Spot Liner(s)	$7,000	Cass Street
STP-328	24		39	3	5	15	Cleaning	$300	Cedar outlet
STP-329	24		24	2	5	10	Cleaning	$200	Cedar outlet
STP-290	24		243	3	4	12	Spot Liner(s)	$56,000	Cedar outlet
STP-799	36		131	3	4	12	Cleaning	$2,000	14th Street
STP-798	42	48	3134	3	4	12	Heavy Cleaning	$6,000	14th Street
STP-794	42	48	271	3	4	12	Heavy Cleaning	$5,000	14th Street
STP-216	24		218	2	6	12	Spot Liner(s)	$56,000	Monroe Street

Facility ID	Diameter (in)	Proposed Diameter (in)	Length (ft)	CoF	PoF	BRE	Project	Planning-Level Cost	Street Name
STP-215	24		192	2	5	10	Monitor Closely, Spot Liner(s)	$12,000	Monroe Street
STP-910	12		274	3	4	12	Cleaning	$2,000	Division Street
STP-1635	12		126	3	4	12	Cleaning	$700	8th Street
STP-265	24		192	2	6	12	Monitor Closely, Spot Liner(s)	$23,000	Spruce Street
STP-3093	24		158	2	5	10	Monitor Closely, Spot Liner(s)	$23,000	Spruce Street
STP-279	24		58	2	5	10	Spot Liner(s)	$12,000	Spruce Street
STP-1900	24		318	2	6	12	Spot Liner(s)	$12,000	8th Street
STP-919	8		146	2	6	12	Spot Liner(s), Cutting and Grouting	$8,000	Maple Street
STP-888	12		200	2	5	10	Full Liner	$14,000	Division Street
							Estimated Total Cost	**$627,900**	

Table F-4: Manhole Capital Improvement Projects Year 1 (FY2018/2019)

Facility ID	CoF	PoF	BRE	Project	Planning-Level Cost
STM-019019	4	4	16	Minor Point Repair, Root Treatment	$300
STM-021014	3	5	15	Monitor Closely, Replace Chimney	$2,000
STM-028017	3	5	15	Replace Chimney	$2,000
STM-147021	3	5	15	Replace Chimney	$2,000
STM-020065	3	5	15	Chimney Liner	$400
STM-147028	3	5	15	Major Point Repair	$300
STM-031007	3	4	12	Minor Point Repair, Major Point Repair	$400
STM-021010	2	5	10	Replace Chimney	$2,000
STM-004013	2	5	10	Minor Point Repairs	$200
STM-004016	2	5	10	Sewer Cleaning/Vactoring, Major Point Repair, Wall Liner	$3,300
STM-021009	2	5	10	Monitor Closely, Replace Chimney	$2,000
STM-004011	2	5	10	Replace Chimney	$1,800
STM-115010	2	5	10	Replace Chimney	$1,500
STM-028020	2	5	10	Replace Chimney	$2,000
STM-076034	2	5	10	Replace Chimney	$2,000
STM-016010	2	5	10	Minor Point Repairs, Chimney Liner	$600
STM-145016	2	5	10	Sewer Cleaning/Vactoring, Major Point Repair	$800
STM-076008	2	5	10	Monitor Closely, Replace Chimney	$2,000
STM-035028	2	5	10	Minor Point Repair, Replace Chimney	$2,100
STM-033019	2	5	10	Replace Chimney	$2,000
STM-117004	2	5	10	Monitor Closely, Replace Chimney	$2,000
STM-028012	2	5	10	Sewer Cleaning/Vactoring, Full Manhole Liner	$3,500
STM-009017	2	5	10	Monitor Closely, Replace Chimney	$2,000
STM-036014	2	5	10	Sewer Cleaning/Vactoring, Chimney Liner	$900
STM-020009	2	5	10	Minor Point Repair, Major Point Repair	$400
STM-020031	2	5	10	Sewer Cleaning/Vactoring, Replace Chimney	$2,500
STM-021024	2	5	10	Sewer Cleaning/Vactoring, Replace Chimney	$2,500
STM-076010	2	5	10	Sewer Cleaning/Vactoring, Replace Chimney	$2,500
STM-076027	2	5	10	Sewer Cleaning/Vactoring, Chimney Liner	$900
STM-076026	2	5	10	Sewer Cleaning/Vactoring, Chimney Liner	$900
STM-019022	2	5	10	Minor Point Repairs	$200
				Estimated Total Cost*	**$48,000**

** Year 1 cost is lower than recommended CIP budget due to assumption that full CIP program will ramp up over a 3-year period*

The first year of the manhole capital projects addresses all of the manholes with a high BRE score (10 or higher). The planning level cost to address these capital projects is below the annual $90,000. This is to allow the City to ramp up the CIP program. Manholes with medium priority should be addressed in year two (2) of the CIP, which is estimated to cost $45,000.

Figure 3 shows the capital improvement projects per year for the three year period.

Continuing the Asset Management Plan Beyond 2017

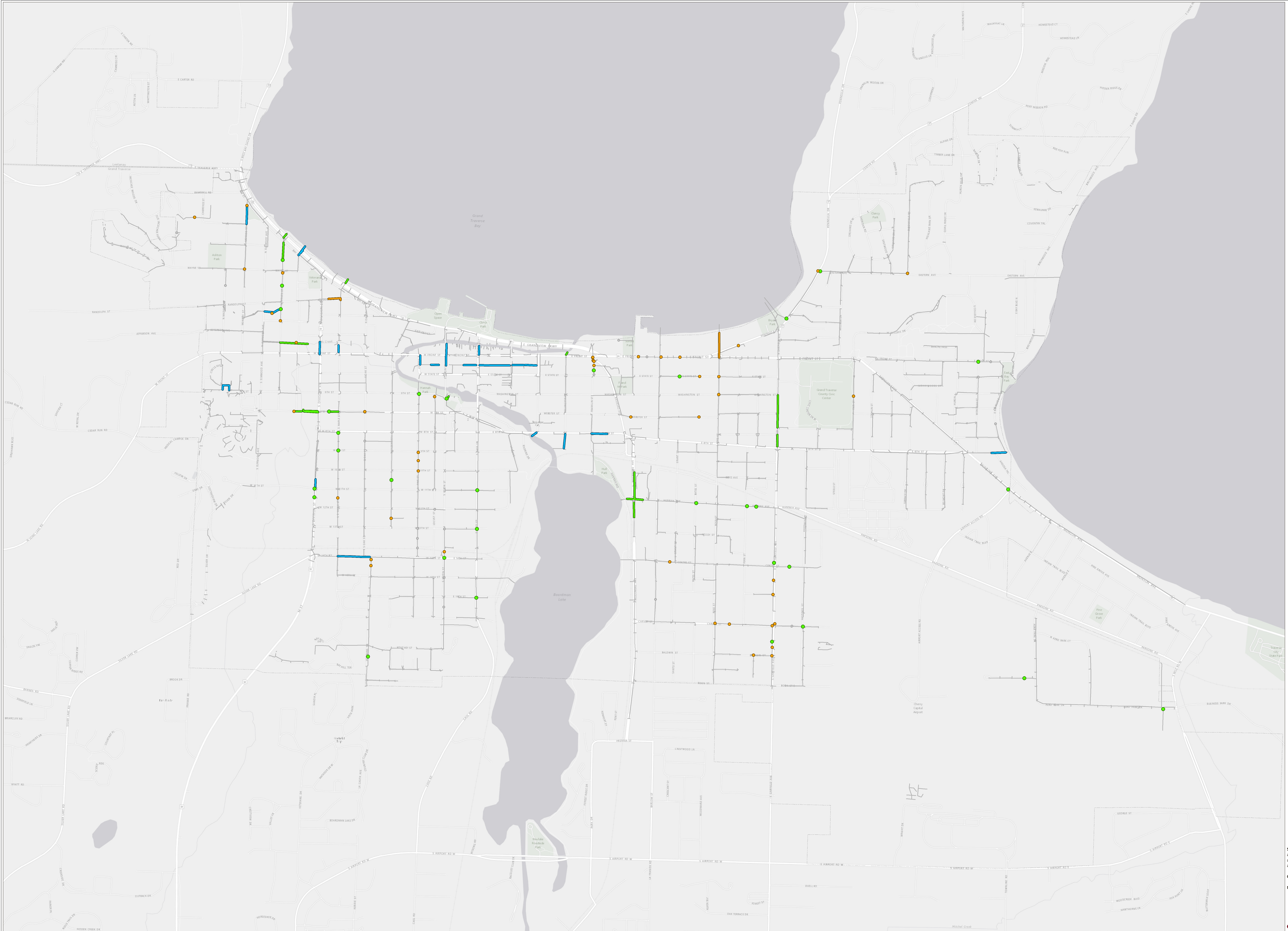
As the capital and rehabilitation projects are completed for both the storm sewer pipes and manholes, ***the City stormwater geodatabase must be continuously updated*** to reflect the changing conditions. For example, the PoF variable, which indicates structural condition, must be reset after a pipe 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.

Figure F-3
CIP Yearly Projects

Traverse City, MI



Stormwater Manholes

No Associated Value

CIP Year

Year 1

Year 2

Stormwater Gravity Main

No Associated Value

CIP Year

Year 1

Year 2

Year 3

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: April 21, 2017

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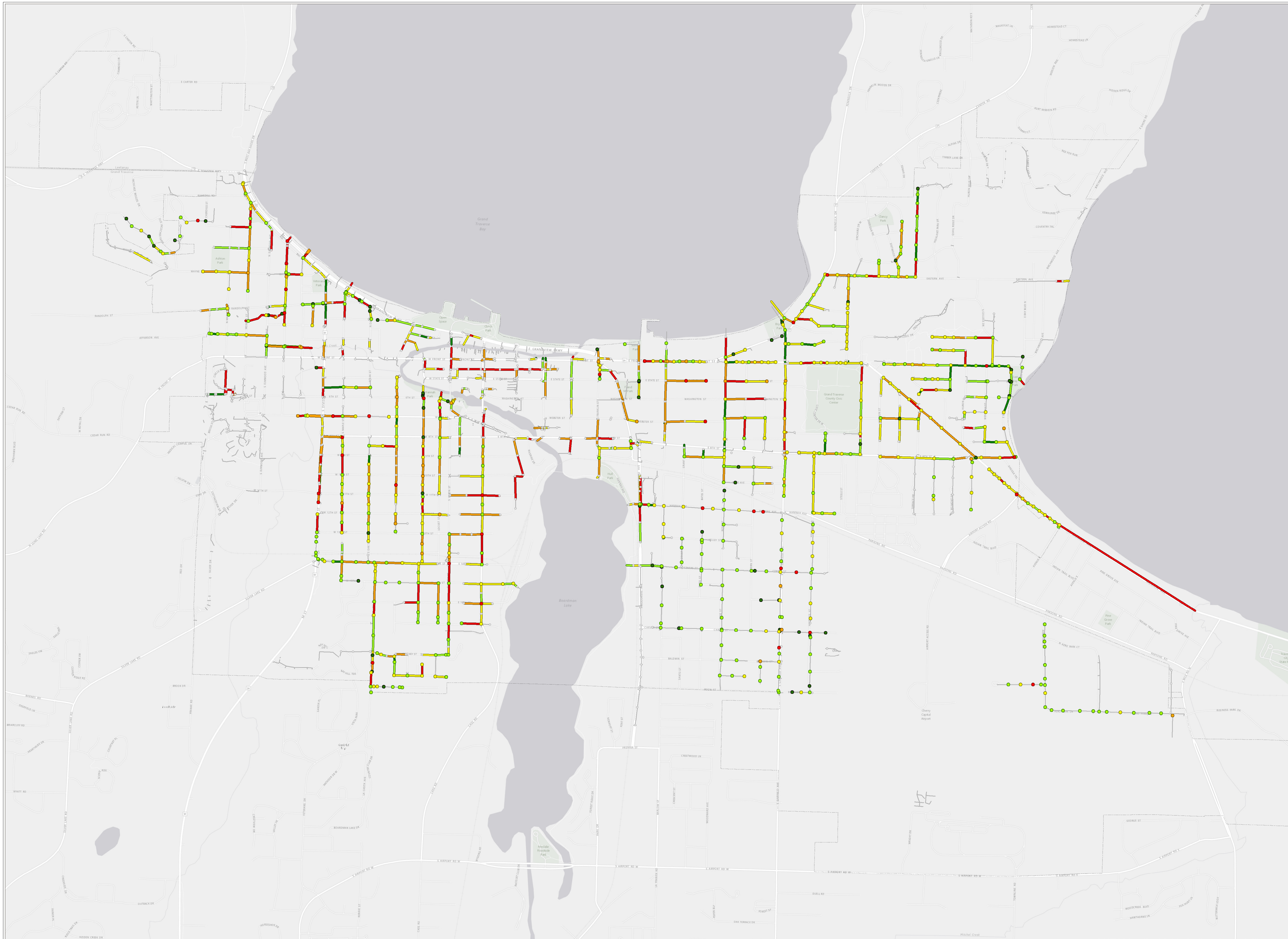
P:\1000_1999\1006140011_Traverse City SAW Stormwater_GIS\ArcLayouts\CIP Maps\20170418 CIP yearly projects.mxd

Appendix F-A: Maps

Figures

Figure F-A 1: Probability of Failure

Traverse City, MI



Stormwater Manholes

No Associated Value

Probability of Failure

- 1
- 2
- 3
- 4
- 5

Stormwater Gravity Main

No Associated Value

Probability of Failure

- 1
- 2
- 3
- 4
- 5

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: April 18, 2017

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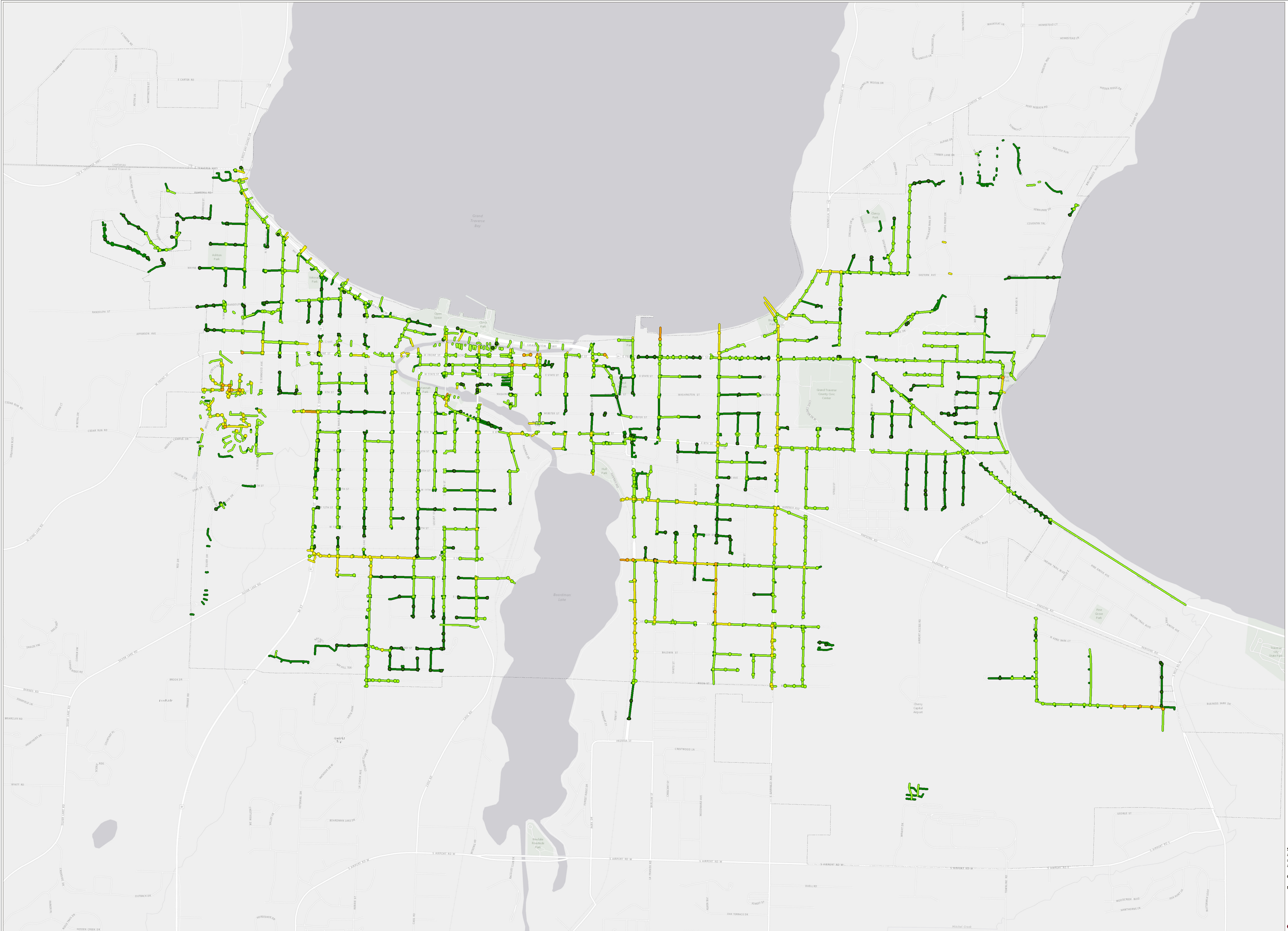

Figure F-A 2: Consequence of Failure

Traverse City, MI

N
W E
S

0 900 1,800 2,700
Feet

1" = 900'

Stormwater Manholes

No Associated Value

Consequence of Failure

1
2
3
4

Stormwater Gravity Main

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.

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