Stormwater Management Plan

City of Silver Bay, MN

Amended June 2023

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Certification

Stormwater Management Plan

For

City of Silver Bay, MN

BMI Project No. 0U1.128340

Amended June 2023

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

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Date: 06/20/2023

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This stormwater management plan was developed with funds from the Minnesota Clean Water Fund and federal award NA20NOS4190088 from the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce provided to the Minnesota Department of Natural Resources (DNR) for Minnesota's Lake Superior Coastal Program.

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I. Executive Summary

This report provides the City of Silver Bay with a guide for stormwater activities in the City and will serve as a tool to protect, preserve, and enhance its water resources. Periodic amendments to the plan will likely occur so that the plan remains current with the rules and regulations of the governing agencies, is updated with city and county public improvement planning, is modified as funding opportunities change with constructed practices, and evolves with Lake County Soil and Water Conservation District project planning. The goals of this Stormwater Management Plan include the following.

1. Assess current drainage infrastructure through hydraulic modeling.
2. Identify stormwater quantity and quality improvement projects.
3. Develop preliminary infrastructure installations necessary to minimize impacts to its critical waterbodies.
4. Develop anticipated project costs and identify funding opportunities.

The plan investigates the potential for improvements to the City's stormwater infrastructure and best management practices (BMPs) focused on improving the water quality of the City's water resources including Lake Superior. Bolton & Menk, Inc. partnered with Lake County Soil and Water Conservation District (Lake SWCD), and the City of Silver Bay, to prepare this plan.

Locations for several different types of BMPs were identified and modeled for water quality improvements and preliminary cost estimates were prepared for each BMP. The BMP cost estimates were compared to the expected pollutant removal levels to generate a cost benefit assessment. Potential BMP locations were identified through discussions with the City of Silver Bay and Lake SWCD, making use of aerial photography, light detection and ranging (LiDAR), as-built drawings, and survey data. Recommended strategies were proposed based on the environmental, economic, and social benefits to the City.

This report describes the strategies, results, and economic benefits for treating stormwater runoff to the City of Silver Bay critical waterbodies but does not provide a full feasibility report for the BMPs that are proposed. Additional information and analysis are required before implementation can be considered.

The following BMPs are proposed to improve stormwater infrastructure and water quality of the City's natural resources:

Proposed BMP Type	Proposed BMP Location	Anticipated Costs
Hydrodynamic Separator and Debris Separating Baffle Box	Associated with City and Lake County Roadway Projects	$35,100 - $93,200
Shopping Center Culvert Replacement	City Properties	$443,600 – $964,000
Adams Blvd Culvert Replacement	City Properties	$133,420
Perimeter Ditch Maintenance Access and Rehabilitation	City / Private Properties	$80,120
East Branch Beaver River - Residential Development Study	City Properties	$30,000-$50,000

II. Introduction

A. History

The City of Silver Bay is located in Lake County, 56 miles northeast of Duluth, MN on Highway 61. The City occupies an area of 8.06 square miles and has a population of approximately 1,900 residents. The major natural surface water features of Silver Bay are Lake Superior and the surface waters that drain to Lake Superior, including Bean and Bear Lake, the East Branch Beaver River, and Williams Creek. Refer to **Figure 1** for a general location map.

The City of Silver Bay was originally built in 1956 by the Reserve Mining Company for the employees of the newly built taconite processing plant. Houses and infrastructure went up quickly to house the approximately 3500 workers and families. The taconite processing plant operated over the next 30 years, until it ultimately closed in 1986. Once closed, the population declined as workers left for employment elsewhere. At present, Taconite continues to be processed at the Northshore Mining facility in Silver Bay when the mine in Babbitt, MN is open. The City is host to an abundance of outdoor recreational activities and tourism related businesses including shops, restaurants, and hotels. The City not only borders Tettegouche State Park, Superior National Forest, and Lake Superior, but is host to its own natural resources including Black Beach, picnic and camping areas, Silver Bay Marina, numerous trails, lakes, rivers, and streams. The City is passionate about the preservation and management of its natural resources, continuing to be stewards for Lake Superior and the surrounding watershed.

B. Project Background

Silver Bay faces many challenges that come with a community that was built in the 1950's including aging infrastructure, flooding, erosion, and water quality. Through coordination with the City of Silver Bay, and the Lake County SWCD, critical water quality improvement projects have been identified to help improve the water quality of the City's valuable water resources. This stormwater management plan will outline the critical water resources, propose water quality improvement projects, and aid in prioritizing projects aligned with the City's future improvement projects and funding opportunities. It will also provide a framework for future funding with numerous potential project partners.

C. Past Studies

The Silver Bay Stormwater Management Plan is predicated on numerous studies that have addressed project planning, identification of pollutant sources, and natural resource protection.

i. Silver Bay Comprehensive Plan (Adopted December 2015): Tourism, cultural, recreation, and natural resources outlines the goals and action steps to ensure the protection and preservation of key environmental resources that have a crucial role in Silver Bay's economy and culture.

ii. Silver Bay Comprehensive Plan (2007): Outlines background information including demographics, transportation, public works, housing, recreation, land use and zoning, and community and economic development.

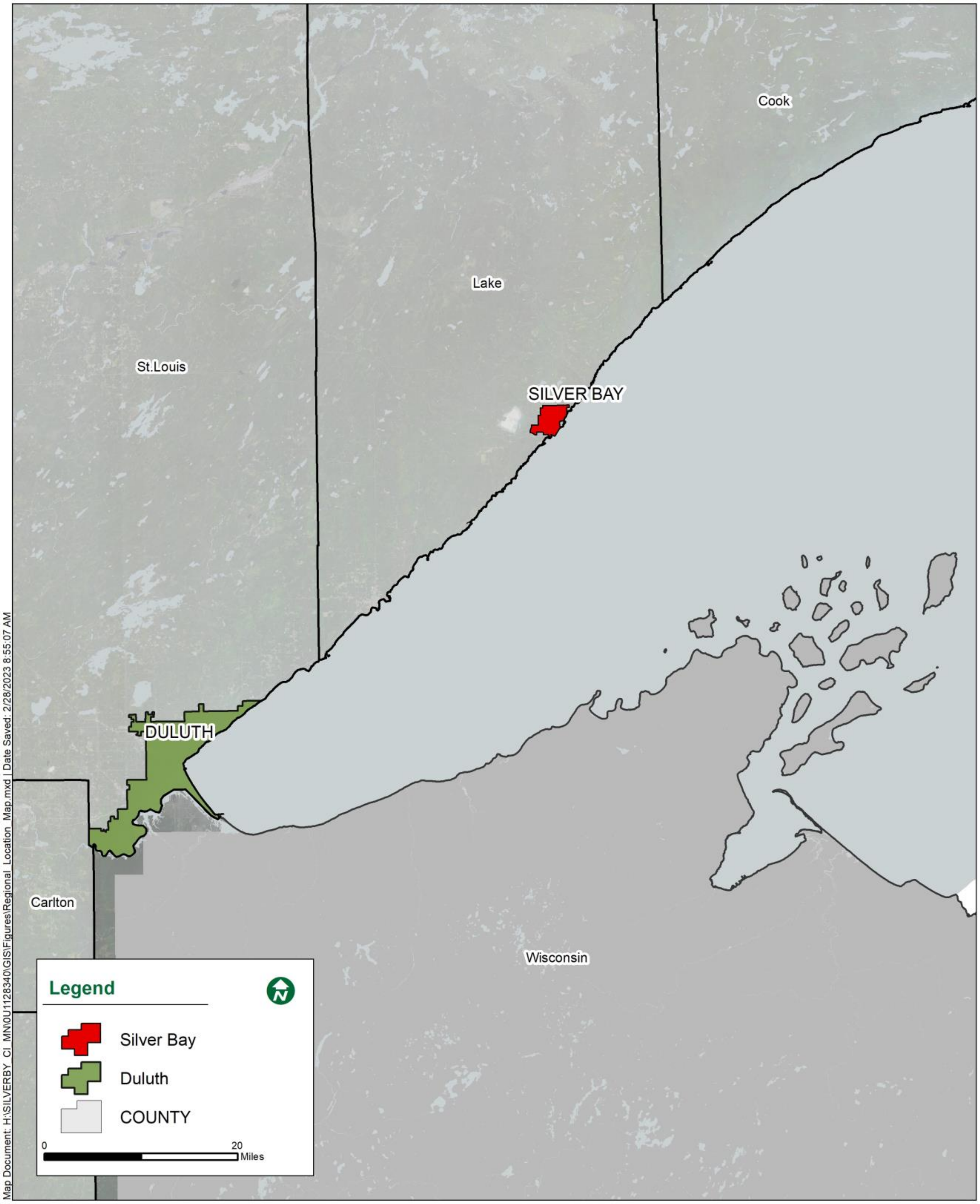

Figure 1: Regional Location Map

D. City Development, Permitting, and Regulations

The City of Silver Bay has specific ordinances for zoning and development that discuss the governing regulations associated with specific land use activities. The zoning ordinance defines building setbacks, minimum and maximum lot size, development densities, primary structure heights, and maximum impervious surface coverage. All these requirements have the potential to affect drainage. Therefore, it is appropriate to consider the potential impacts to the local water resources.

This section of the SWMP presents a synopsis of the current agency requirements while acknowledging the existence of other requirements that may be applicable. Many of these agency requirements are focused on wetland resources. However, recent programs at the state level involve nonpoint source pollution control. Although Silver Bay has a separate storm sewer system, it currently is not regulated as an MS4.

The City is committed to the preservation and enhancement of its wetlands and water resources through compliance with local, state, and federal wetland and nonpoint source pollution regulations.

1. MPCA NPDES Construction Stormwater Permit Program

The USACE implements provisions of Section 404 of the Clean Water Act with guidance from the EPA through a permitting process. The Section 404 permit also requires a Section 401 water quality certification before it is valid. The EPA has given Section 401 certification authority to the MPCA.

The powers and duties of this Minnesota state agency include:

- Fulfilling mandates from the EPA, particularly in regard to the Clean Water Act.
- Administration of the NPDES construction stormwater permit program.
- Administration of the NPDES industrial site discharge permit program.
- Development of Total Maximum Daily Loads (TMDLs) for water bodies and watercourses in Minnesota (often in conjunction with other agencies or joint powers organizations such as watersheds).

The NPDES program and the TMDL program regulate nonpoint source pollution. These two programs affect stormwater management and address water quality impacts from watershed activities.

Generally, Phase II of the NPDES program regulates communities less than 100,000 people that are within “urbanized” areas. NPDES Phase II addresses three areas of stormwater management:

- Construction site activity
- Industrial site activity

Surface waters listed as impaired on the Proposed TMDL (303(d)) impaired waters list have been developed by MPCA. Broadly, the TMDL process identifies the sources and relative load contributions of all inputs to a water body for a given pollutant. Through this process, pollutant reduction strategies can be developed to allow a water body to meet its designated use. Specifically, a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet its designated use, and an allocation of that amount to the pollutant's sources. This calculation must also include a Margin Of Safety (MOS).

2. North Shore Management Plan

The purpose of the North Shore Management Plan is to define strategies for environmental protection and orderly growth along the North Shore of Lake Superior. The Plan provides guidelines for stormwater quality and quantity best management practices that, when used, prevent or reduce pollution of water. https://northshoremanagementboard.files.wordpress.com/2021/10/nsmb.document.full_.pdf

3. Minnesota Department of Natural Resources (DNR)

The DNR has regulatory authority over the lakes, wetlands and watercourses in the Protected Waters Inventory. Public Waters are defined within Minnesota Statutes 103G.005 Subdivision 15. Wetlands in the public waters inventory are generally those Types 3, 4, and 5 wetlands in excess of 10 acres in rural areas or in excess of 2.5 acres in municipalities and incorporated areas. Watercourses in the inventory generally include natural streams and altered watercourses with total drainage areas exceeding two square miles and designated trout streams.

Other powers and duties of the Minnesota DNR within the City include:

<u>Floodplain Management</u>

The Minnesota DNR offers assistance to local floodplain administrators. Communities use their floodplain ordinance in conjunction with FEMA-approved maps to guide land use decisions. The DNR assists local communities by providing general regulatory assistance.

<u>Management of the Flood Hazard Mitigation program</u>

The program's purpose is to provide technical and financial assistance to local governmental units for conducting flood damage reduction studies and for planning and implementing flood damage reduction measures. Eligible projects include: flood damage reduction studies for planning and implementing structural and non-structural measures including: acquisition of structures in the flood plain, relocations, flood-proofing, development of flood warning systems, public education, flood plain restorations, dams, dikes, levees, flood bypass channels, flood storage structures, water level control structures and other related activities. FEMA floods maps do not yet exist for Lake County.

<u>Shoreland Management</u>

Minnesota's Shoreland Management Program guides land development along Minnesota's lakes and rivers to protect their ecological, recreational, and economic values. The state shoreland rules (MR 6120.2500 - 6120.3900) establish minimum standards to protect habitat and water quality and preserve property values. These standards are implemented through local shoreland ordinances. Anyone who owns land along a lake or river should contact their city with questions about the standards and permit requirements that apply to their property. The DNR's role is to ensure that local shoreland ordinances comply with the state shoreland rules and to provide technical assistance and oversight to these local governments.

4. U.S. Army Corps of Engineers (USACE)

   The Corps' regulatory program includes Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. Under Section 10, a Corps permit is required to do any work in, over or under a 'Navigable Water of the U.S.' Waterbodies have been designated as 'Navigable Waters of the U.S.' based on their past, present or potential use for transportation for interstate commerce. Under Section 404, a Corps permit is required for the discharge of dredged or fill material into waters of the U.S. Many waterbodies and wetlands in the nation are waters of the U.S. and are subject to the Corps' Section 404 regulatory authority.

5. Board of Water and Soil Resources (BWSR)

   The local and regional wetland rules are governed by the Wetland Conservation Act (WCA). The WCA, passed in 1991, extends protection to all wetlands unless they fall under one of the exemptions of the WCA. The WCA follows a "no net loss" policy. The wetlands covered under the WCA must not be drained or filled, wholly or partially, unless replaced by restoring or creating wetland of at least equal public value under an approved replacement plan. Replacement ratio is typically 2:1 (2 acres created for every 1 acre filled) for wetland impacts.

   A designated Local Government Unit (LGU) is responsible for making exemption and no-loss determinations and approving replacement plans.

   The powers and duties of this Minnesota state agency also include:

   - Coordination of water and soil resources planning among counties, watersheds, and local units of government.
   - Facilitation of communication among state agencies in cooperation with the Environmental Quality Board.
   - Approval of watershed management plans.

6. State and Federal Jurisdictional Boundaries for Public Wetlands and Waters

   Wetlands are delineated in accordance with the Federal guidelines. The USACE and the BWSR regulate wetlands as defined by a jurisdictional delineation. For wetlands that fall under the MnDNR jurisdiction, the Ordinary High Water Level (OHW) determines the boundary of MnDNR jurisdiction. The OHW is established by the MnDNR.

7. Agency Stormwater Publications

   Best Management Practices (BMPs) are techniques, methods, and measures that prevent or reduce water pollution from stormwater runoff. These practices may include regulations, structural features, and operation/maintenance procedures. The City of Silver Bay will adopt the MPCA's Minnesota Storm Water Manual as the standard reference to storm water BMPs.

E. Data Sources, Hydraulic Modeling and Analysis

The City of Silver Bay has an archive of as-built record plans that include public utilities, zoning, and development information. In addition, Soil and Water Conservation District Technical Service Area 3 (TSA3) conducted a survey to cover data gaps regarding storm sewer structure elevations and pipe sizes.

The as-built record plans were coupled with the survey collected by TSA3 to develop a regional hydraulic model of the storm sewer system. This model was used to identify problem areas related to storm sewer capacity and open channel flow. LiDAR surface topography was also utilized to develop accurate drainage delineations to the corresponding storm sewer inlet and open channel locations.

Innovyze's XPSWMM software was used to create a regional model of the City, incorporating Atlas 14[1] rainfall depths and MSE 3 rainfall distributions. The increase in rainfall depth and intensity shown in Atlas 14 consequently increases runoff rates and volumes above those given by the previous generation of design precipitation data. This results in higher design flows and volumes within the city's trunk storm sewer system model.

The water quality pollutant removal efficiency for the proposed BMP's (Best Management Practices) were calculated using a variety of water quality software based on the specific need, including the Sizing of Hydrodynamic Separators and Manholes (SHSAM), and Minimal Impact Design Standards (MIDS).

F. Goals & Objectives

The primary concerns regarding the Silver Bay storm sewer system included aging infrastructure, water quality, maintenance access, and conveyance capacities of pipes, culverts, and open ditch systems. The goals and objectives of the Stormwater Management Plan for the City of Silver Bay are as follows:

1. Develop an understanding of the existing storm sewer infrastructure through the compiling of as-built record plans and additional storm sewer infrastructure survey data.
2. Develop a regional hydraulic model updated with Atlas 14 rainfall depths and MSE 3 rainfall distribution.
3. Utilize the regional hydraulic model to identify critical problem areas.
4. Identify critical infrastructure maintenance needs and propose solutions.
5. Propose water quality improvements.
6. Define project costs and identify potential funding.

[1] https://hdsc.nws.noaa.gov/hdsc/pfds/docs/NA14Vol2.pdf

III. Existing Conditions

A. Key Surface Waters

Surface water management is a strong component of the City's overall approach to protecting and preserving the community's natural resources. The City of Silver Bay recognizes the value and impact that surface water can have on the quality of life in the community. Surface water management also includes the infrastructure designed and constructed to collect, convey, store, treat, control and protect surface water resources. The following key surface waters are listed on the MNDNR Public Waters Inventory.

Figure 2 illustrates the Public Water Inventory within Silver Bay.

1. Lake Superior

   Lake Superior is the most notable public water with the City of Silver Bay. The City is committed to protecting this valuable resource and adheres to the goals of the North Shore Management Plan. Lake Superior is listed as impaired by the Minnesota Pollution Control Agency for mercury in fish, and Polychlorinated biphenyls in fish tissue. These impairments are considered non-construction related.

2. Beaver River, East Branch

   The East Branch Beaver River drains roughly 50 square miles of primarily forested land. Notable upstream water bodies that drain into the East Branch Beaver River include Lax Lake, Bear Lake, and Bean Lake. Most of the river basin lies outside of the City Limits of Silver Bay, but a small segment of the river flows through the Silver Bay Golf Course. The East Branch discharges to the main branch Beaver River just south of the City limits at a point about 1 mile upstream from where the Beaver River flows into Lake Superior. The river is identified by the MNDNR as a designated trout stream. The main branch of the Beaver River is listed as impaired by the Minnesota Pollution Control Agency for pH, turbidity, and mercury in fish.

3. Williams Creek, Bean Lake, Bear Lake, and Unnamed Creek

   Williams Creek, Bean Lake, Bear Lake, and Unnamed creek are listed on the MNDNR Public Water Inventory. The Bean and Bear Lake are identified by the MNDNR as a designated trout lake, and the unnamed creek is identified as a designated trout stream. The watershed includes 1.71 acres of forested land use. The surface waters drain into the East Branch Beaver River. Williams Creek is located on the northeast border of Silver Bay and drains roughly 430 acres of primarily forested land.

B. Soils

The soils information in this plan is from the United States Department of Agriculture Natural Resources Conservation Service (NRCS) Soil Survey of Lake County. The soils maps in the report are general and intended for broad planning purposes. The soils of Silver Bay are shown in **Figure 3**. Soil Types within the City consist primarily of Urban Land-Cuttre complex, 0 to 8 percent slopes, very rocky (11.5%), Mesaba, stony-barto, stony-Rock outcrop complex, 15 to 35 percent slopes (10.1%), and Mesaba, stony-Giese, rubbly-Barto, stony complex, 0 to 18 percent slopes (8.7%).

The drainage nature of the soils is important for determining the surface water runoff from a given area. If the soil is well drained, a significant portion of the precipitation will be infiltrated into the ground, whereas if a soil is very poorly drained, most of the precipitation will flow from the site of impact.

The Hydrologic Soil Group (HSG) defines a soil's propensity to generate runoff for a given rainfall event. Four HSG groups are identified: A, B, C, D. HSG A soils have the lowest potential to generate runoff and typically consist of sandy and gravely soils. HSG D soils have the highest potential to generate runoff and typically consist of muck, peaty muck, and tight clay soils. The associations found within the Silver Bay study area primarily fall into HSG D, indicating a high to very high potential to generate runoff.

Hydric soils are those characteristic soils found in wetland areas. A wetland must possess three technical criteria in order for it to be identified as a wetland. These three are: 1) hydrophytic vegetation, 2) hydric soils, and 3) wetland hydrology. The definition of a hydric soil is: "a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part."

C. Wetlands

The wetland information in this section is taken from the National Wetland Inventory (NWI). Silver Bay is limited in the number of wetlands present on the NWI within City limits. This is likely due to the resolution of the NWI maps. Instead, the city is characterized by poorly drained soils, smaller depression storage areas, and steep slopes that direct runoff to nearby creeks and lakes. The poorly drained soils trap water in smaller depressions that wouldn't otherwise show up on the NWI mapping. Therefore, the NWI is not a comprehensive view of the city's wetland systems. During preliminary design, it would be prudent to conduct a cursory review of potential wetlands and ensure wetland delineations are conducted prior to final design.

The Minnesota Department of Natural Resources identifies the different wetland types as Lakes, ponds, stormwater ponds, Freshwater Emergent Wetland, and freshwater shrub wetland. Most of the wetlands are classified as Freshwater Forested/Shrub Wetland and Freshwater Emergent Wetland. **Figure 4** illustrates the NWI wetlands that are present within Silver Bay.

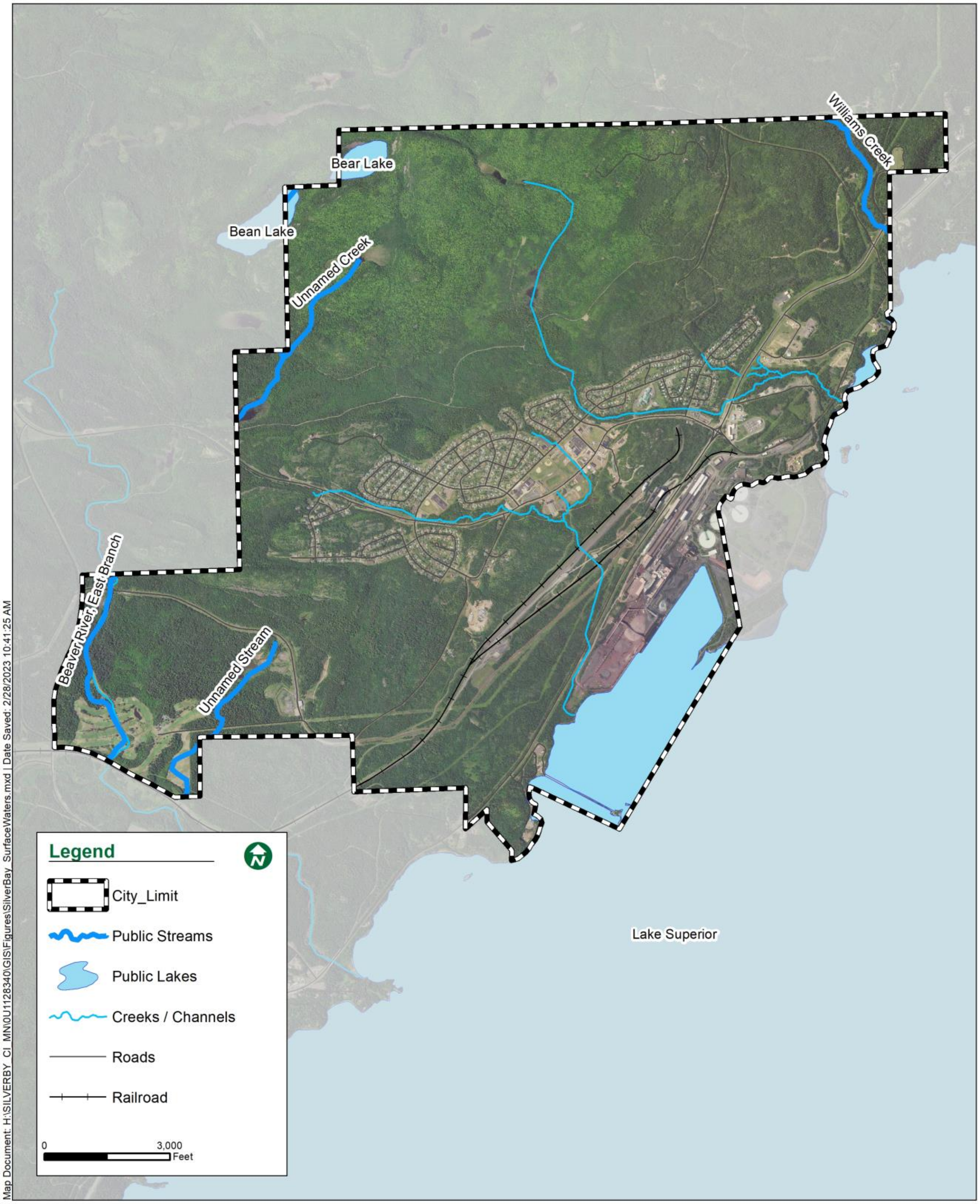

Figure 2: Public Waters Inventory

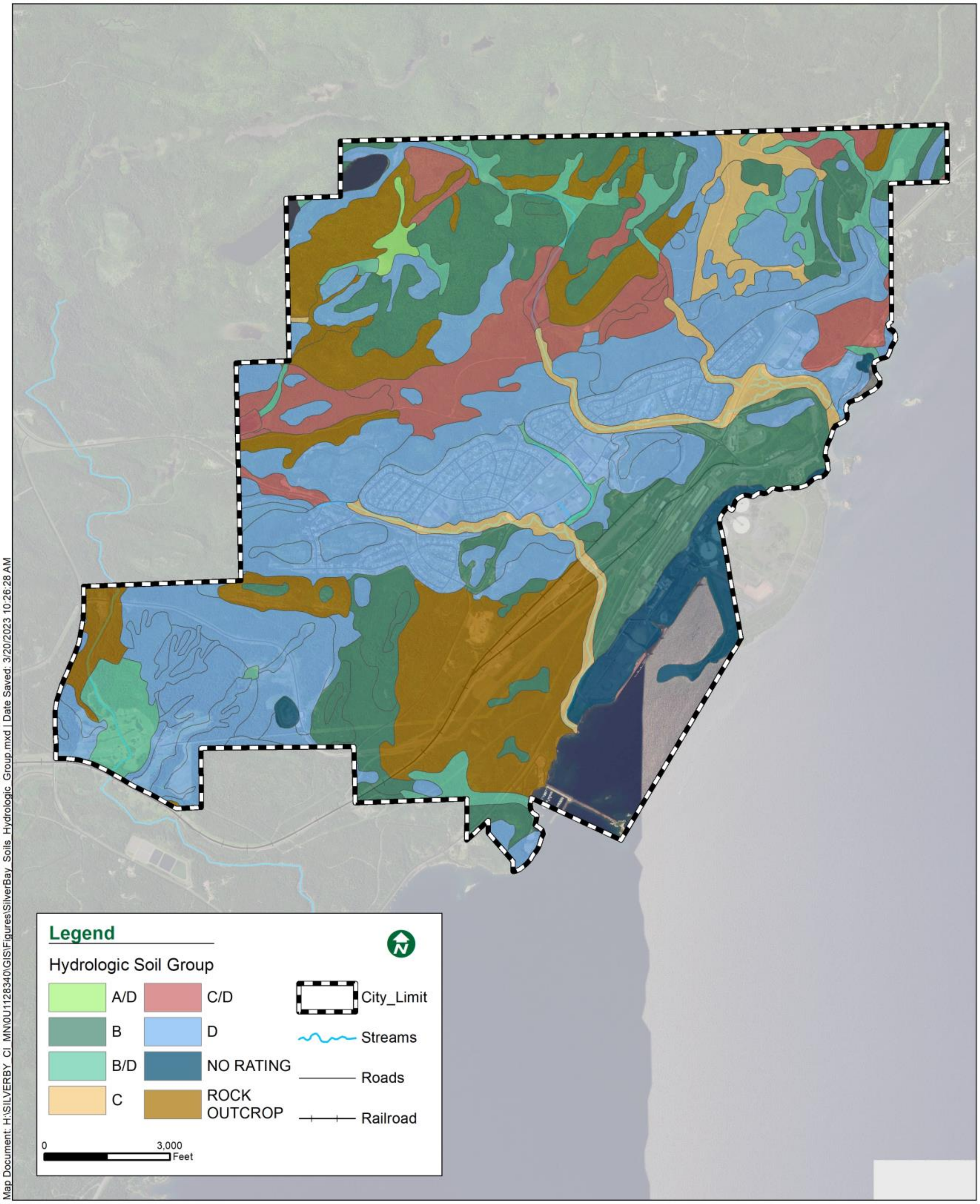

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Figure 3: Soils Map

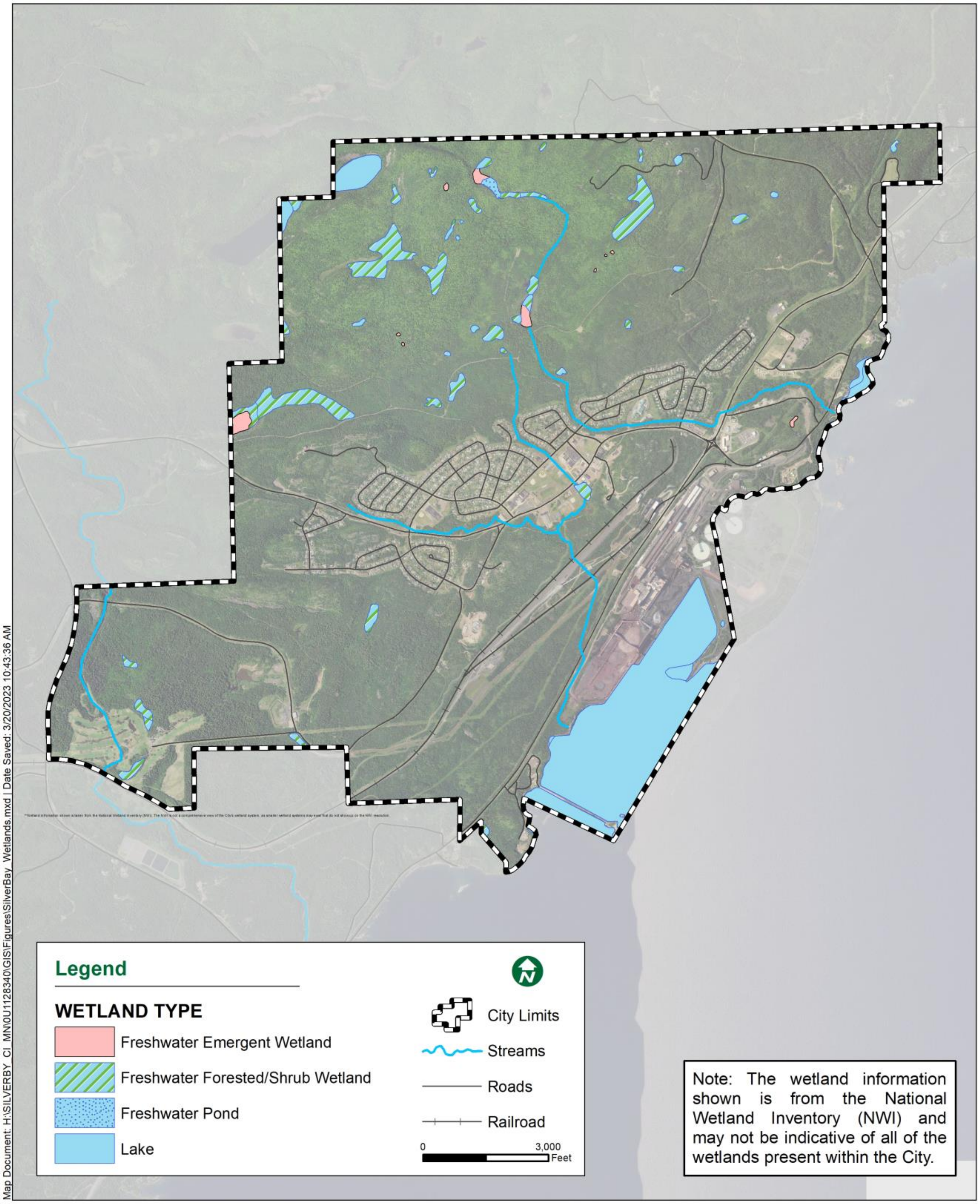

Figure 4: Wetlands Map

D. Stormwater Runoff and Hydraulic Modeling

Stormwater runoff is defined as the portion of precipitation which flows over the ground surface during, and for a short time after, a storm. The quantity of runoff is dependent on the following:

- Rainfall depth and intensity of the storm event
- Amount of antecedent rainfall
- Length of the storm
- Type of surface upon which the rain falls (i.e. soils, land cover, impervious surfaces)
- Slope of the ground surface

The National Oceanic and Atmospheric Administration (NOAA) has been studying trends in the rainfall data to develop statistical hypothetical rainfall event. The most recent study, called ATLAS 14, provides precipitation frequency estimates for the Midwest, including Minnesota. Over the last few decades, records and projected trends have indicated that we will see more precipitation and higher intensity rainfall events. Climate change has affected weather patterns, resulting in greater precipitation amounts and higher intensity storms. **Table 1** lists the depth, duration and frequency of design storms represented by ATLAS 14.

Atlas 14		
Recurrence Interval (Years)	Duration (Hours)	Rainfall (Inches)
1-yr	24	2.26
2-yr	24	2.60
5-yr	24	3.22
10-yr	24	3.79
100-yr	24	6.17

Source: NOAA's National Weather Service (PFDS)

Table 1: Atlas 14 Design Storms

Innovyze's XPSWMM software was utilized to create a regional hydrology and hydraulics model of the City, incorporating Atlas 14 rainfall depths and MSE 3 rainfall distributions which simulates a more intense rainfall during the design storm. The increase in rainfall depth and intensity consequently increase the design runoff rates and volumes needing to be collected and conveyed within the city's trunk storm sewer system.

The stormwater drainage infrastructure was populated in the model using information collected from multiple sources including the following:

- Survey (Utilizing GPS equipment)
    - Storm sewer pipe sizes, invert elevations, and pipe material.
    - Cross sections of open channel ditches and natural channels.

- As-built Records
    - The City had a collection of as-built records dating back to the inception of the City in 1950. In some cases, the as-built records were compared to the survey information to confirm that accuracy of the information.
- LiDAR (Light Detection and Ranging)
    - In lieu of survey or as-built records, LiDAR is used to determine surface elevations of infrastructure, ditches, or natural channels.

The resolution of the model included all of the main storm sewer trunk lines, perimeter ditches, and select natural channels. Storm sewer inlets and catch basin leads were not included in the modeling. The resolution of the model was chosen to gain a general understanding of the capacity of stormwater collection and conveyance systems within the City of Silver Bay. By analyzing the entire system, the City will be able to prioritize critical infrastructure in need of maintenance and identify systemic flooding or capacity issues.

Drainage areas and the time of concentrations were determined utilizing LiDAR. Each subbasin was populated with its total area, land use type, curve number, and time of concentration. Time of concentration was determined based on subbasin area, slopes, and land cover to accurately represent the natural conditions.

E. Existing Storm Sewer System and Modeling Results

The City of Silver Bay was originally constructed in the 1950's and early 1960's by the Reserve Mining Company for the employees of the newly built taconite processing plant. As with any community built in the 1950's, the City is currently faced with aging infrastructure that, in some cases, is approaching 70 years old. Silver Bay has been working in conjunction with Lake County to maintain and replace their infrastructure to meet the current demands. The most recent Lake County projects include the reconstruction of Horn Blvd, Penn Avenue, and Outer Drive.

The stormwater runoff that is captured by the City's storm sewer system discharges into Lake Superior at two primary locations. The first location is located approximately 1000-feet north of the Silver Bay Marina. The second location is located at Black Beach Park. The stormwater is routed to each discharge location by way of an open channel stream. The City's storm sewer system outlets into the open channels at locations along Penn Boulevard, Davis Drive, and Outer Drive. **Figure 5** shows the City's drainage divide and the two primary discharge locations into Lake Superior.

Much of the storm sewer in Silver Bay in constructed of corrugated metal pipe (CMP). Corrugated metal pipe has a design life of ranging from 40-75 years. There are many factors that affect the life expectancy of a corrugated metal pipe including abrasion, environment, and material.[2] Abrasion has the potential to cause early failure in the inverts of a drainage pipe due to abrasive flows combined with flow velocities. The environment surrounding the pipe, including the soils chemistry and water pH can cause early failure due to corrosion.

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[2] https://www.conteches.com/pipe-article/article/31/2-common-questions-when-it-comes-to-relining-with-cmp

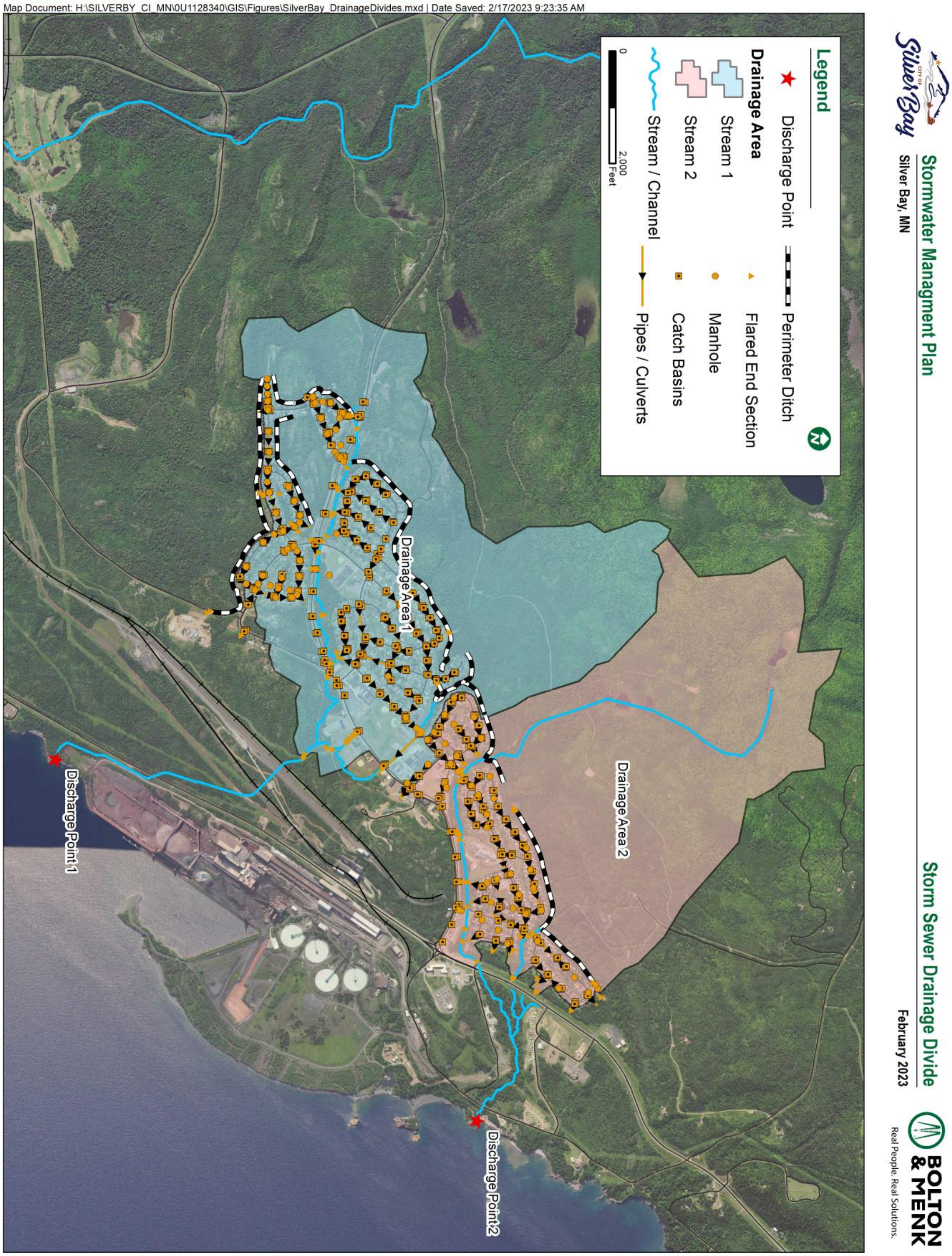


Figure 5: Storm Sewer Drainage Divide

Lastly, corrugated metal pipe is usually constructed using steel or aluminum. The type of metal and type of coating applied to the metal, commonly galvanized and aluminum coated, can have a direct effect on the longevity of the material and its resistance to abrasion and corrosion.

Each community has its own requirements for their storm sewer design capacity. Design capacity typically corresponds to stormwater flow that is operating under open channel conditions, or is operating slightly under pressure, but at no point does the flow exceed the rim of any catch basin or manhole structure. In other words, the design capacity is the rainfall event that the storm sewer conveys before there is water above the height of a storm sewer structure. It is common practice for new developments to design their storm sewer to have capacity to convey a 5-yr or 10-yr design storm event. For the City of Silver Bay, this would correspond to a 3.22-inch and 3.79-inch rainfall event in a 24-hour period, respectively.

The most recent Atlas 14 Study have indicated that we will see more precipitation and higher intensity rainfall events based on the last few decades of rainfall records. The Atlas 14 design rainfall depths for the 1-year, 2-year, 5-year and 10-year event are similar to the values given by US Weather Bureau in TP-40 published in 1961. However, the 6.17 inch design rainfall depth for the Atlas 14 100-year event has now increased over 1 inch from the TP-40 design value of 5.1 inches. As Silver Bay continues to maintain, improve and replace its storm sewer system, it is important to consider the larger Atlas 14 rainfall events as a form of resilience planning.

The existing storm sewer system was evaluated for the 2-yr, 5-yr, 10-yr, and 100-yr rainfall event utilizing Atlas 14 rainfall projections and an MSE3 rainfall distribution. **Figure 6** outlines the modeling extents within Silver Bay, and **Figures 7 – 9** illustrate the conveyance capacity of the storm sewer system as they relate to each design rainfall event. Each of the 4 colors shown indicate the rainfall event in which stormwater exceeds the rim (surface) of the structure, also known as surcharging.

It is important the system be analyzed as a whole during public improvement projects to ensure adequate system conveyance. The following results represent the existing storm sewer system.

Much of the existing storm sewer system is over capacity during the 10-year event, with surcharging observed in 58% of the storm sewer system. The 5-yr rainfall events result in approximately 46% of the storm sewer system showing surcharging conditions, while only 29% of the system is over capacity in the 2-year event. **Table 2** below summarizes the hydraulic capacity of the existing storm sewer system.

Existing Storm Sewer	
Design Recurrence Interval (Years)	Percent of Pipes Meeting Design Standard
2-yr	71%
5-yr	54%
10-yr	42%

Table 2: Existing Storm Sewer System Hydraulic Capacity

Stormwater Management Plan
Silver Bay, MN

Modeling Extents
January 2023

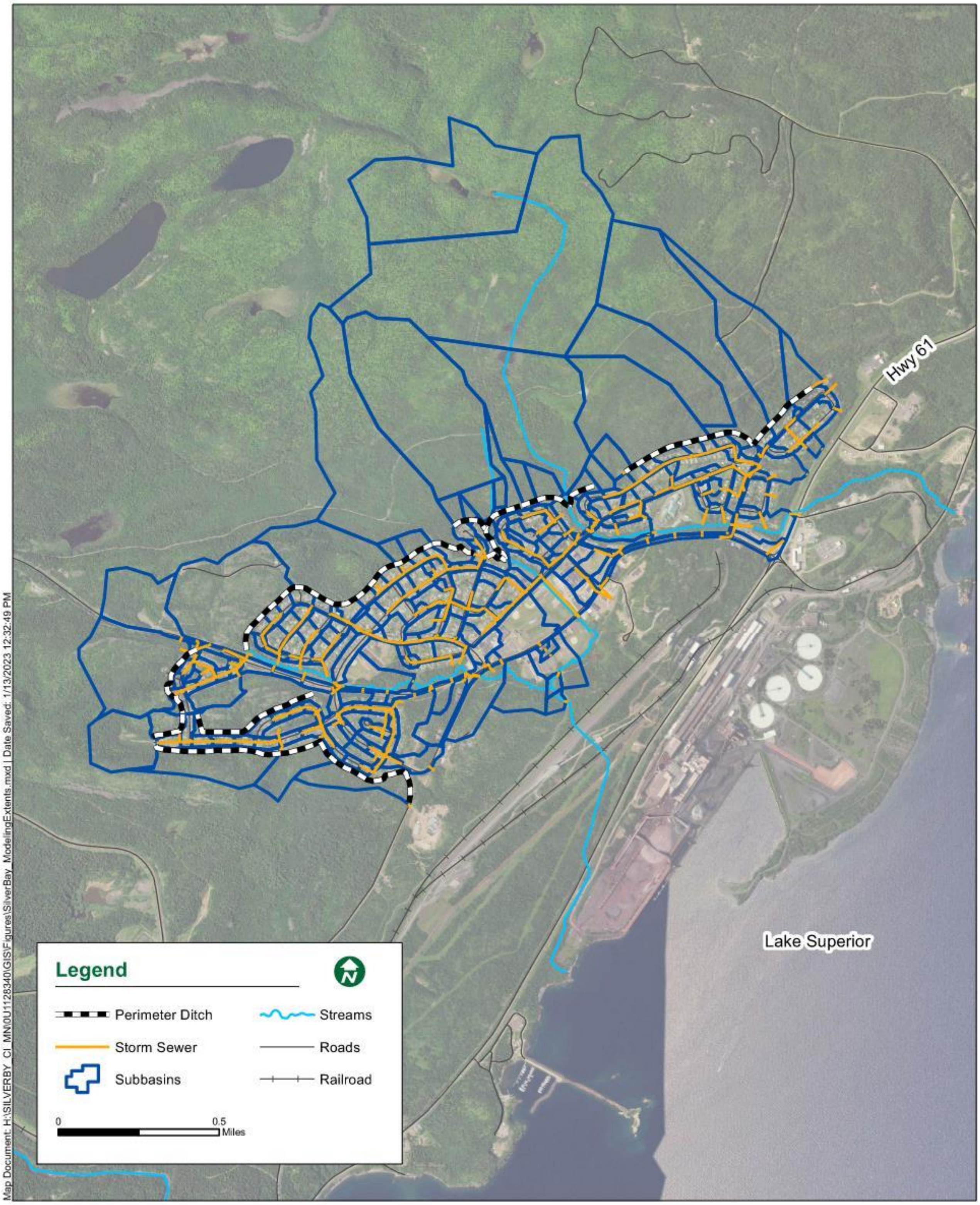


Figure 6: Modeling Extents

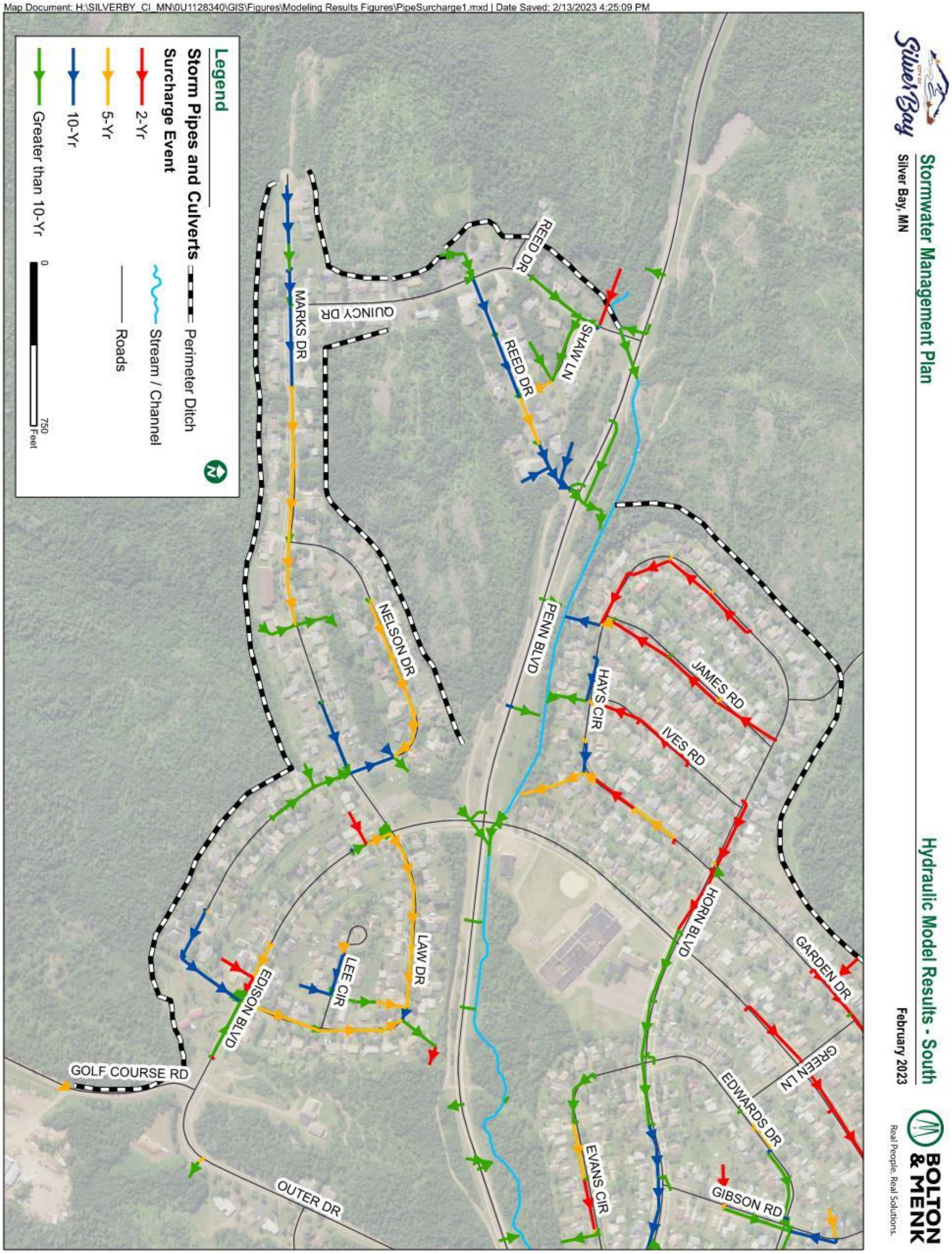


Figure 7: Storm Sewer Capacity Analysis - South

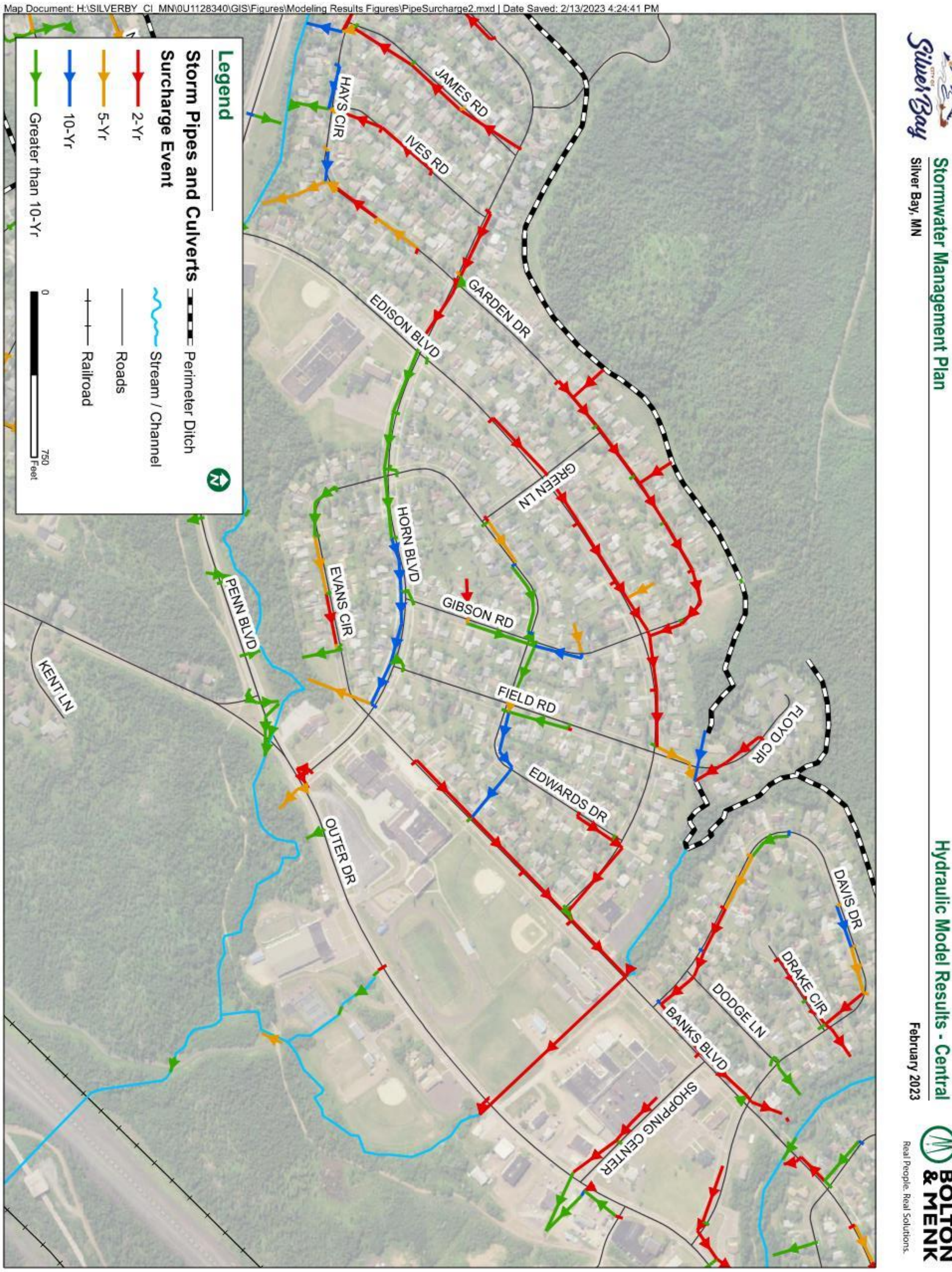


Figure 8: Hydraulic Capacity Analysis - Central

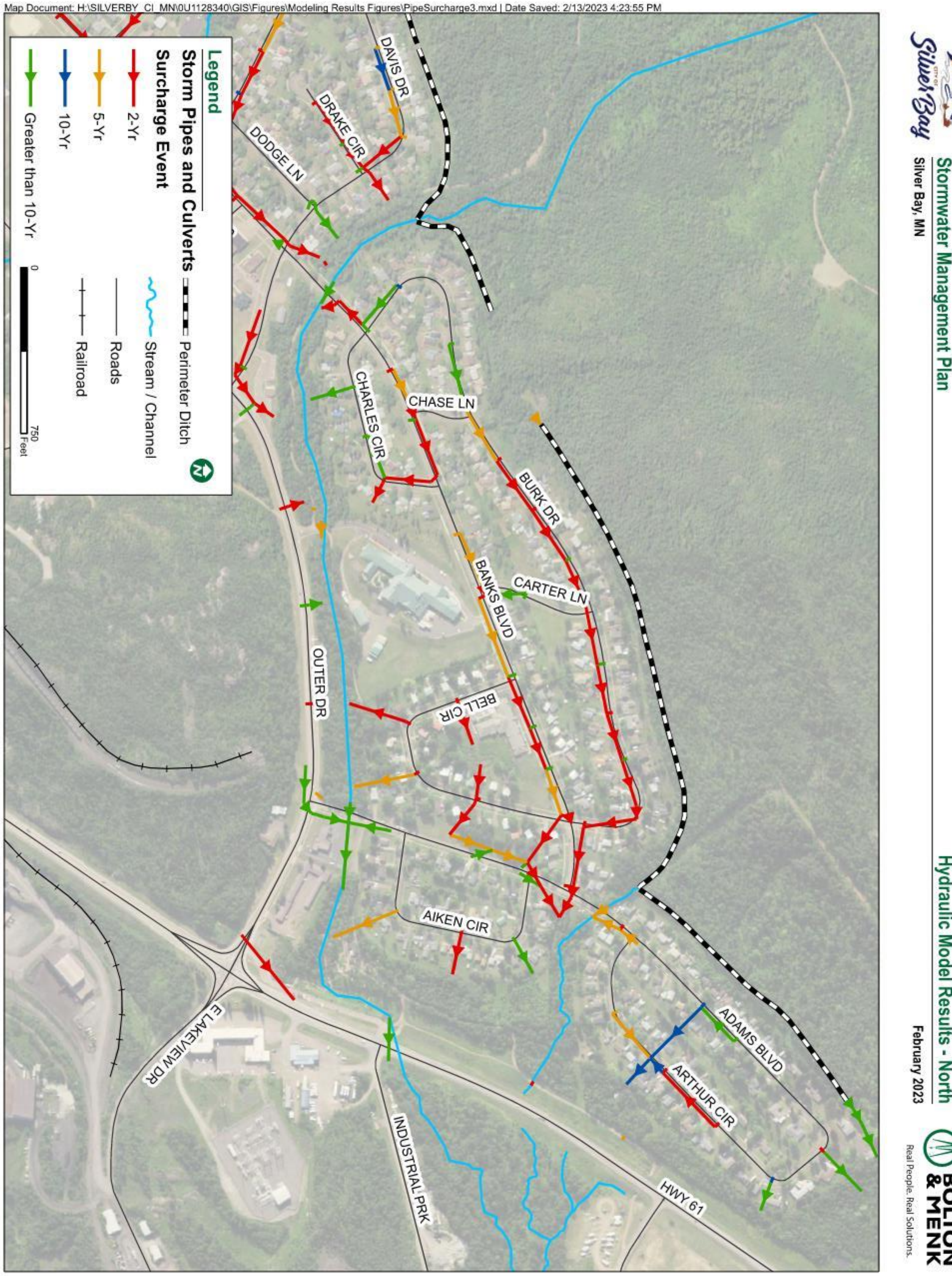


Figure 9: Storm Sewer Capacity Analysis -North

IV. Stormwater Management Planning and Water Quality Improvements

A variety of stormwater best management practices (BMPs) have been identified based on the location and proximity to critical surface water resources. The following options include maintenance of current stormwater infrastructure, construction of structural practices in conjunction with anticipated County and City capital improvement projects, and new BMPs at critical discharge points.

A. Hydrodynamic Separator and Debris Separating Baffle Box

One of the goals of the stormwater management plan was to evaluate ways to improve the water quality within the City. One way to accomplish improving water quality within the City is to treat the storm water runoff before it drains to the key surface waters within Silver Bay.

The stormwater runoff that is captured by the City's storm sewer system discharges into Lake Superior at two primary locations. The first location is located approximately 1000-feet north of the Silver Bay Marina. The second location is located at Black Beach Park. The stormwater is routed to each discharge location by way of an open channel stream. The City's storm sewer system outlets into the open channels at locations along Penn Boulevard, Davis Drive, and Outer Drive.

Locations immediately upstream of the storm sewer outlets described above are the most effective and practical for treating stormwater runoff before it leaves the site. There are multiple challenges associated with treating the stormwater runoff at these locations:

- Limited space due to the area already being developed.
- The volume and rate of stormwater passing through these locations can be high due to large watershed areas.
- High costs for construction and roadway replacement when not connected to a linear capital improvement project (CIP).

Due to the spatial constraints, Manufactured Treatment Devices (MTD), such as a Hydrodynamic Separators (HDS) and Debris Separating Baffle Boxes (DSBB) provide a great solution to treating the stormwater. HDS and DSBB structures are installed below the street level and are designed to remove total suspended solids (TSS), capture free floating oils and trash, and some include an internal high flow bypass. Maintenance can be routinely performed for both types of structures using a vacuum truck. Additionally, these structures can easily be incorporated within upcoming City or County Street Improvement Projects.

1. Hydrodynamic Separators

A hydrodynamic separator (HDS) provides a minimally invasive solution by replacing an existing manhole with a proprietary mechanical structure often utilizing a system of weirs, orifices, swirl mechanisms, sumps, skimmers to remove grit, free floating oil, gross solids, and suspended sediment. One example is the SciClone X Separator by Contech, but many others exist on the market.

The total suspended sediment (TSS) removal efficiency of the SciClone X Separator was analyzed using the Sizing Hydrodynamic Separators and Manholes (SHASM) software. The results show that as the incoming flowrate increases, the structure size must also increase to maintain the same level of removal efficiency. The most cost-effective solution is to install the SciClone X Separator in drainage areas less than 15 acres. The drainage areas of the proposed locations vary in size between 3.99 – 13.2 acres, corresponding to an annual total suspended sediment load of 400 - 1391 lbs.

The removal efficiency of the SciClone Separator varies based on the particle size distribution used in the removal efficiency calculation. To better understand the performance potential of the SciClone separator, the MNDOT Road Sand particle distribution was analyzed. The MNDOT Road Sand particle distribution contains a higher amount of coarse sand particles ranging in size from 100-180 Microns. This particle distribution would commonly be used for gritting roads during winter weather. The SciClone Separators would be effective in removing 80-100% of the total load resulting from a MNDOT Road Sand particle distribution.

The proposed locations and corresponding drainage areas associated with each location are illustrated in **Figure 10**. Figures showing each location in more detail can be found in the **Appendix**. An example of the typical sediment loading and removal efficiencies of the SciClone Separator for a proposed location can be seen in **Table 3.** Anticipated costs and benefit are described in **Table 4.**

SciClone (Location 6) TSS Removal					
Name	Drainage Area (Acres)	Total Load / Year (lbs)	MNDOT Road Sand Distribution Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)
SciClone	6.1	730	90.7	5	4
SciClone	6.1	730	94.9	6	5
SciClone	6.1	730	97.3	7	6
SciClone	6.1	730	98.6	8	7
SciClone	6.1	730	99.3	9	8
SciClone	6.1	730	99.7	10	9
SciClone	6.1	730	99.8	11	10
SciClone	6.1	730	99.9	12	11
SciClone	6.1	730	100	13	12

Table 3: HDS Modeled Removal Efficiency

SciClone (Location 6) Cost Benefit				
Name	Drainage Area (Acres)	TSS Load Removed / Year (lbs)	Cost Installed ($)	Cost / Pound TSS Removed (30 Year Life)
SciClone	6.10	730	$ 27,000	$ 1.23

Table 4: HDS Cost Benefit

2. Debris Separating Baffle Box (DSBB)

A Debris Separating Baffle Box is a great solution to capture total suspended solids (TSS), free floating oils, and trash in storm sewer with large drainage areas. The most cost-effective solution is to install the DSBB in drainage areas larger than 10 acres or areas with higher concentrations of trash and liter. The outlet from the shopping center is an ideal location to install DSBB units in order to capture as many pollutants as possible before they discharge downstream. The DSBB is installed in line with the existing storm sewer and incorporates a high flow bypass system. Although the DSBB is larger in size compared to other HDS structures it is still installed below the street level. The drainage areas of the proposed locations vary in size between 6-12.6 acres, corresponding to an annual total suspended sediment load of 1175 - 1505 lbs. The Debris Separating Baffle Box would be effective in removing approximately 80% of the TSS load. The proposed locations and corresponding drainage areas associated with each location are illustrated in **Figure 10.** Figures showing each location in more detail can be found in the **Appendix**. Typical sediment loading and removal efficiencies of the DSBB for the proposed locations can be seen in **Table 5**. Anticipated costs and benefit are described in **Table 6**.

DSBB (Shopping Center): TSS Removal				
Name	Drainage Area (Acres)	Model	Total Load / Year (lbs)	Removal Efficiency (%)
DSBB	6.19	6 x 12	1427	80

Table 5: DSBB Estimated Removal Efficiency

DSBB (Shopping Center) Cost Benefit				
Name	Drainage Area (Acres)	TSS Load Removed / Year (lbs)	Cost Installed ($)	Cost / Pound TSS Removed (30 Year Life)
DSBB	6.19	1141	$ 80,000	$ 2.33

Table 6: DSBB Cost Benefit

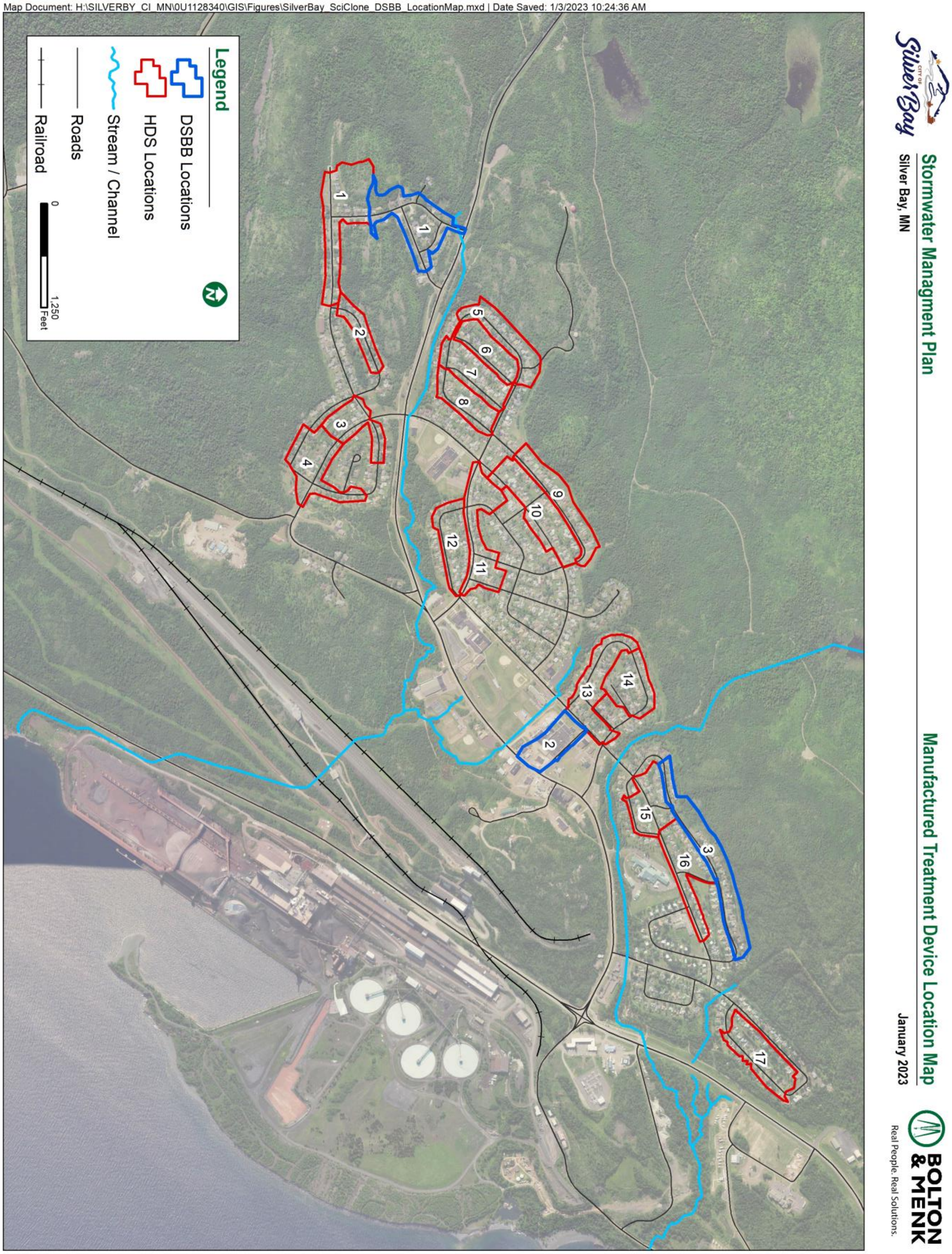


Figure 10: Manufactured Treatment Device Location Map

B. Drainage Improvements

Culvert Replacements

Early discussions with the City of Silver Bay staff identified two problem areas upstream of storm sewer culverts that experience frequent flooding. Rain events regularly cause water to pool upstream of the culverts until the storage capacity upstream is exceeded and the water flows across the road. The hydraulic modeling of the City's storm sewer confirmed that the two culverts were undersized to handle the current Atlas-14 design storms. The first culvert is approximately 1140-feet long and is located between Banks Boulevard and Outer Drive. The culvert starts 200-feet southwest of Davis Drive, and discharges 575-feet southwest of Shopping Center Road. Culvert 1, referred to as the "Shopping Center Culvert", is shown below in **Figure 11**. The second culvert is approximately 175-feet long and crosses under Adams Boulevard between Banks Blvd and Arthur Circle. The second culvert, referred to as the "Adams Boulevard Culvert", is shown in **Figure 12**, below.

1. Shopping Center Culvert Improvements

The Shopping Center culvert was built in sections starting in 1953. The original crossing under Banks Boulevard was constructed using two 246-foot long parallel 36" diameter corrugated metal pipes (CMP). The original crossing under Outer Drive was constructed using two 236-foot long parallel 42" dia. CMP. The culvert crossings at Banks Boulevard and Outer Drive were then connected by a 730-foot long open channel ditch. According to the as-built records, the ditch was constructed with a 6' bottom width and 2:1 side slopes. With development over time, the open ditch section was replaced by a single 48" dia. CMP.

The culvert is currently in poor condition with multiple indications of damage and corrosion. The culvert also presents maintenance challenges due to the wooded area upstream of the culvert and the lack of trash guards at either end of the culvert. Without trash guards, large debris can become wedged deep within the culvert, causing blockages, and reducing the overall conveyance capacity. Depending on the depth of the blockage, maintenance of the culvert can become quite challenging, labor intensive, and expensive. The culvert aprons should be replaced with safety aprons, and maintenance of the drainage ditch upstream of the culvert should be performed to reduce the amount of debris transported to the culvert.

The hydraulic modeling confirmed that the Shopping Center culvert is undersized to handle the current Atlas-14 design storms. The culvert is responsible for draining 345 acres of land. Of that, 100 acres consist of residential neighborhoods, and 245 acres is forested. The resulting runoff rates for the 25-, 50-, and 100-year design storm event are 421, 516, and 622 cfs respectively.

The existing 48" dia. CMP culvert is recommended to be replaced with two 60" dia. RCP culverts. The preliminary design is based on passing the 100-year flood without overtopping the roadway – however, since the proposed culvert is quite long and costly a hydraulic risk assessment is recommended (although beyond the scope of the storm water management plan). A risk assessment aims to consider multiple design alternatives with consideration given to the capital cost and risks; and other economic, engineering, social and environmental concerns. The preliminary cost to install the proposed culverts is listed below in **Table 7**.

Shopping Center Culvert Replacement - (2) 60" RCP					
February, 2023					
No.	**Item**	**Units**	**Approx. Qty**	**Estimated Unit Price**	**Estimated Total Price**
	BASE BID:				
1	MOBILIZATION	LS	1	$25,000	$25,000
2	TRAFFIC CONTROL	LS	1	$1,500	$1,500
3	CLEARING	AC	0.26	$5,650	$1,500
4	REMOVE AND REPLACE BITUMINOUS PAVEMENT	SY	320	$12	$3,900
5	REMOVE CULVERT	LF	1,140	$20	$22,800
6	60" RC PIPE CULVERT DESIGN 3006 CLASS IV	LF	2,280	$284	$647,900
7	60" RC FLARED END SECTION, WITH TRASH GUARD	EA	4	$6,000	$24,000
9	CONNECT TO EXISTING STORM SEWER	EA	2	$973	$2,000
10	RANDOM RIPRAP CLASS III	CY	56	$87	$4,900
11	EROSION CONTROL	LS	1	$8,000	$8,000
TOTAL ESTIMATED CONSTRUCTION COSTS					**$741,500**
PROJECT CONTINGENCY (10%)					**$74,200**
PROJECT OVERHEAD (20%)					**$148,300**
TOTAL ESTIMATED PROJECT COSTS					**$964,000**

Table 7: Shopping Center Culvert Replacement Cost Estimate

Shopping Center Culvert Alternative 1

As an alternative to installing the proposed 1140-foot long 60” RCP culvert, the drainage system could be restored to a design similar to its original design from 1953. The alternative design would include two 400-foot long 60” RCP culverts under banks boulevard and two 175-foot long 60” RCP culverts under Outer Drive. The two culverts would be connected in between by an open channel ditch. An open channel ditch with dimensions that include a 6-foot bottom width, 3:1 side slopes, 3-foot height, and 2.3% slope would have a conveyance capacity of roughly 680 cfs.

Advantages to installing an open channel ditch include ease of access for maintenance, and reduced construction costs compared to equivalent lengths of RC pipe. Disadvantages of installing an open channel ditch include the loss of developable space, potential utility conflicts, and increased difficulty in providing access to neighboring developable lots. The costs to install the proposed open channel ditch is listed below in **Table 8**.

Shopping Center Culvert Replacement - Open Channel Ditch					
February, 2023					
No.	**Item**	**Units**	**Approx. Qty**	**Estimated Unit Price**	**Estimated Total Price**
	BASE BID:				
1	MOBILIZATION	LS	1	$25,000	$25,000
2	TRAFFIC CONTROL	LS	1	$1,500	$1,500
3	CLEARING	AC	0.26	$5,650	$1,500
4	REMOVE AND REPLACE BITUMINOUS PAVEMENT	SY	320	$12	$3,900
5	REMOVE CULVERT	LF	1,140	$20	$22,800
6	TURF REINFORCED MAT	SY	490	$15	$7,400
7	COMMON EXCAVATION	CY	1,100	$14	$15,400
8	60" RC PIPE CULVERT DESIGN 3006 CLASS IV	LF	1,150	$284	$326,600
9	60" RC FLARED END SECTION, WITH TRASH GUARD	EA	4	$6,000	$24,000
10	CONNECT TO EXISTING STORM SEWER	EA	2	$973	$2,000
11	SEED MIX 33-261	LBS	20	$27	$600
12	RANDOM RIPRAP CLASS III	CY	56	$87	$4,900
13	EROSION CONTROL	LS	1	$8,000	$8,000
				TOTAL ESTIMATED CONSTRUCTION COSTS	**$443,600**
				PROJECT CONTINGENCY (10%)	**$44,400**
				PROJECT OVERHEAD (20%)	**$88,720**
				TOTAL ESTIMATED PROJECT COSTS	**$576,720**

Table 8: Shopping Center Culvert Replacement – Alternative 1 Cost Estimate

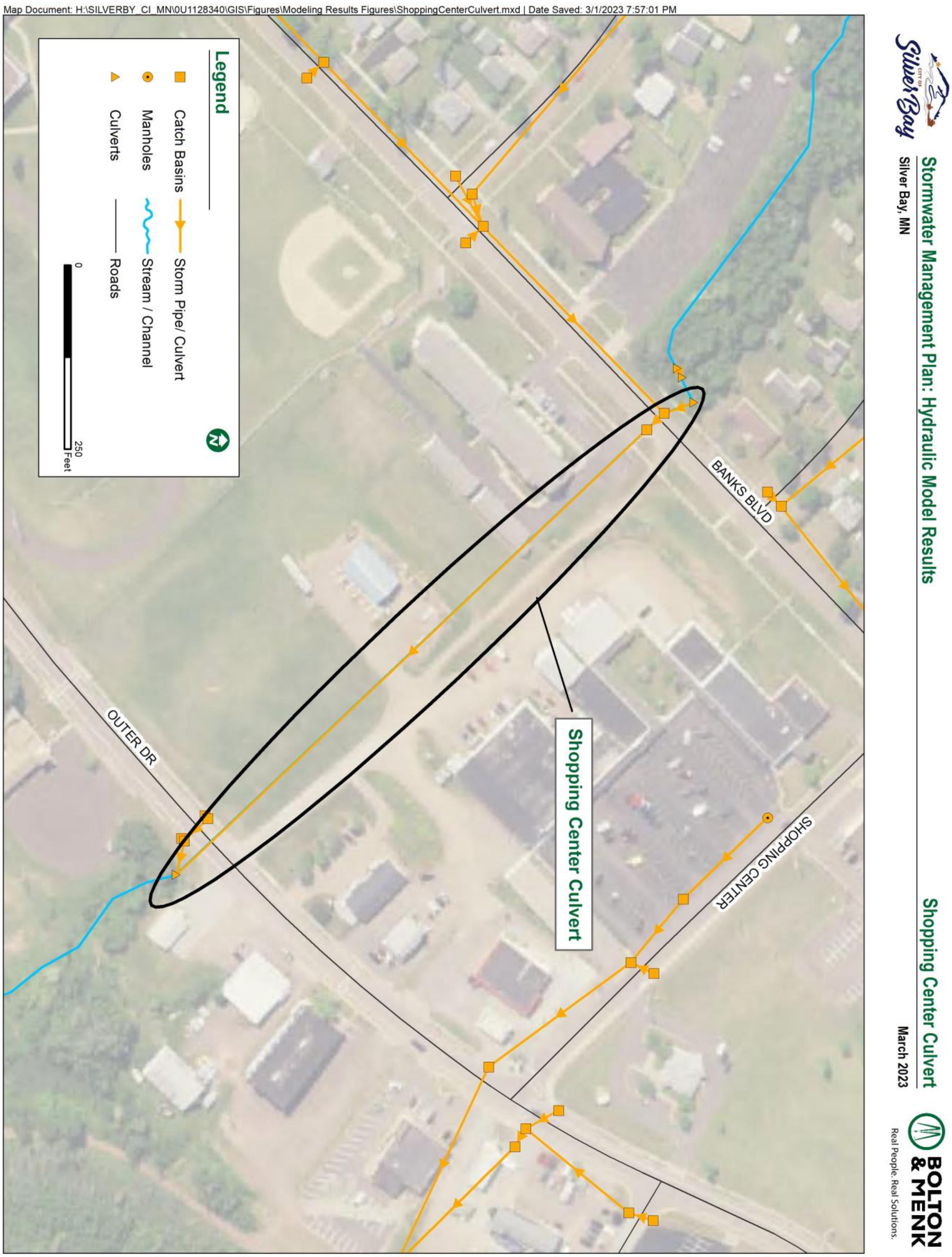


Figure 11: Shopping Center Culvert Replacement

2. Adams Boulevard Culvert Replacement

The Adams Boulevard culverts, located between Banks Boulevard and Arthur Circle, were originally constructed as part of the Adams Boulevard road project in 1953. The as-built records describe the culverts as a 176' long double barreled 42" corrugated metal pipe (CMP) culvert. The recent survey information indicated the presence of two 36" CMP culverts. The culverts may have deformed over the years or the size of the culverts may have been incorrectly recorded in either case.

The culverts are currently in poor condition with multiple indications of damage and corrosion. The culverts also present maintenance challenges due to the wooded area upstream of the culvert and the lack of trash guards at either end of the culvert. Without trash guards, large debris can become wedged deep within the culvert, causing blockages, and reducing the overall conveyance capacity. The culvert aprons should be replaced with trash guards, and maintenance of the drainage ditch upstream of the culvert should be performed to reduce the amount of debris transported to the culvert.

The hydraulic modeling confirmed that the Adams Boulevard culverts are undersized to handle the current Atlas-14 design storm. The culvert is responsible for draining 277 acres of forested land. The resulting runoff rates for the 25-, 50-, and 100-year design storm event are 159, 208, and 263 cfs, respectively.

The two existing 36" dia. CMP culverts are recommended to be replaced with a single 66" dia. RCP culvert. **Figure 12** summarizes the location and hydraulic conditions of the culvert. The costs to install the proposed culvert is listed below in **Table 9**.

Adams Blvd Culvert Replacement					
January, 2023					
No.	**Item**	**Units**	**Approx. Qty**	**Estimated Unit Price**	**Estimated Total Price**
	BASE BID:				
1	MOBILIZATION	LS	1	$12,000	$12,000
2	TRAFFIC CONTROL	LS	1	$1,500	$1,500
3	CLEARING	AC	0.1	$5,646	$600
4	REMOVE AND REPLACE BITUMINOUS PAVEMENT	SY	111	$12	$1,400
5	REMOVE CULVERT	LF	176	$20	$3,600
6	66" RC PIPE CULVERT DESIGN 3006 CLASS III	LF	176	$400	$70,400
7	66" RC SAFETY APRON	EA	2	$3,100	$6,200
8	RANDOM RIPRAP CLASS III	CY	22	$87	$1,900
9	EROSION CONTROL	LS	1	$6,000	$5,000
TOTAL ESTIMATED CONSTRUCTION COSTS					**$102,600**
PROJECT CONTINGENCY (10%)					**$10,300**
PROJECT OVERHEAD (20%)					**$20,520**
TOTAL ESTIMATED PROJECT COSTS					**$133,420**

Table 9: Adams Blvd Culvert Replacement Cost Estimate

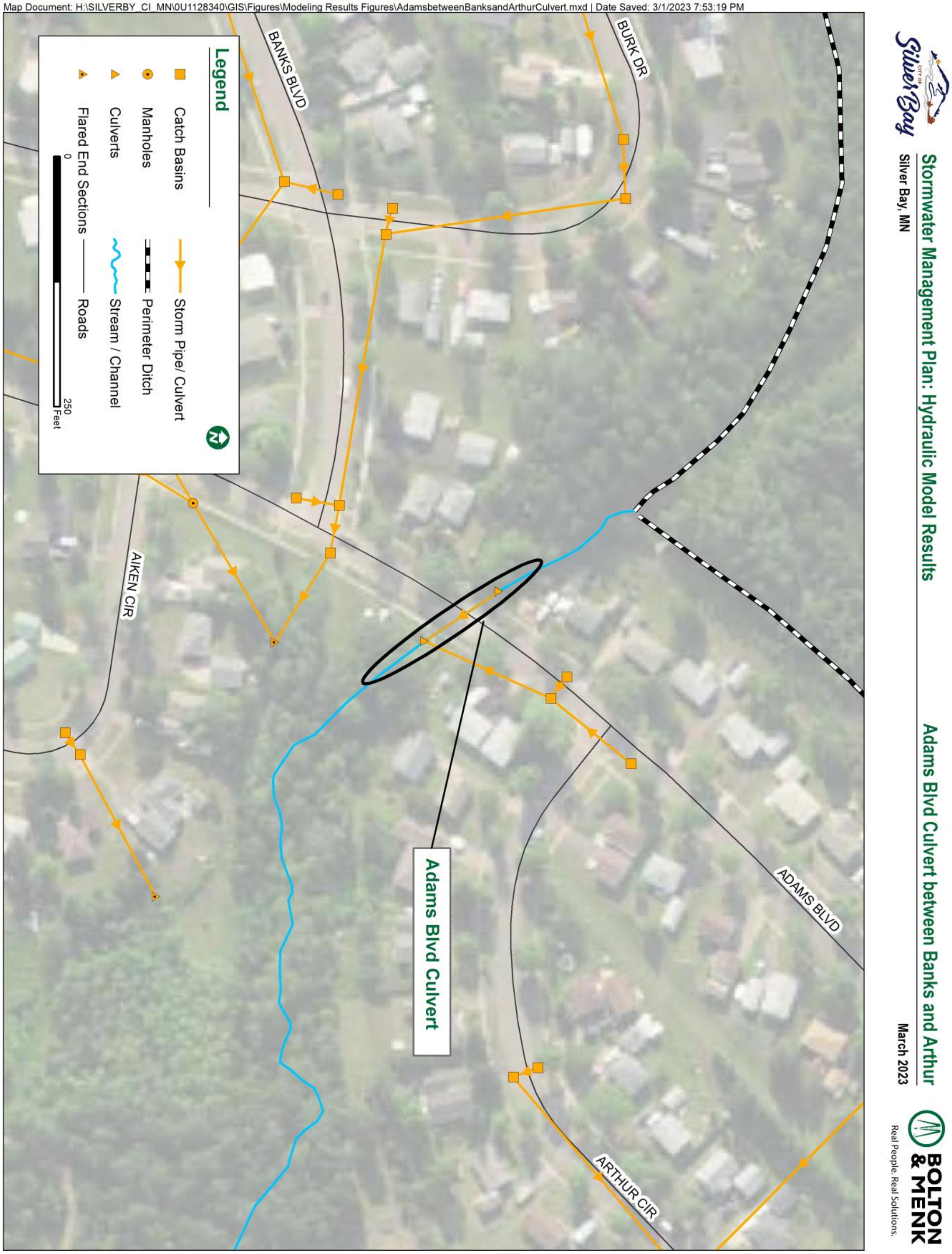


Figure 12: Adams Boulevard Culvert Replacement

C. Perimeter Ditch Access and Maintenance

When the City of Silver Bay was designed in 1953, the designers included a ditch positioned on the uphill perimeter of the residential homes. The perimeter ditch was designed to collect and manage the stormwater runoff stemming from 1.65 square miles of forested land uphill of the homes. The ditch routes the stormwater runoff into catch basins, through culverts, or into adjacent drainage channels and streams. This ditch is intended to collect runoff and add a measure of protection for the residential homes from overland flooding.

Maintenance on the perimeter ditch needs to be performed on regular intervals for the ditch to function as designed. Without proper maintenance, the ditch may become blocked with fallen trees, overgrown with vegetation, or fill in with sediment and organic material from the contributing watershed. These problems can reduce the hydraulic conveyance capacity of the ditch, which could result in flooding. Maintenance of the ditch may include clearing trees, cutting brush, mulching, trimming grass, and ditch bottom excavation. Typical maintenance might be performed using a small excavator, a skid steer utilizing brush cutter, forestry mulcher, and tree shear attachments. **Table 10** breaks down the expected cost to perform typical maintenance within the perimeter ditch. Please note that the costs listed in Table 10 do not include any direct or indirect costs associated with acquisition of the easements required to access the perimeter ditch. The easement acquisition costs include but are not limited to legal fees, professional survey, and compensation of land owners.

Adequate access to the perimeter ditch is required to perform maintenance. Access to multiple segments of the ditch are obstructed due to both physical and legal limitations. The physical limitations include rocky terrain, steep grades, or narrow passages, while the legal limitations are due to the absence of proper easements. The City is working to acquire the easements required to maintain sections of the ditch that are currently only accessible by private land owners.

Figure 13 illustrates the current maintenance needs and accessibility of each section of the ditch.

Perimeter Ditch Access and Maintenance					
February, 2023					
No.	**Item**	**Units**	**Approx. Qty**	**Estimated Unit Price**	**Estimated Total Price**
	BASE BID:				
1	MOBILIZATION	LS	1	$12,000	$12,000
2	CLEARING AND GRUBBING	AC	8.4	$1,800	$15,186
3	CLEAN OPEN DITCH 5' BOTTOM	LF	14,700	$2	$29,400
4	EROSION & SEDIMENT CONTROL	LS	1	$5,000	$5,000
TOTAL ESTIMATED CONSTRUCTION COSTS					**$61,600**
PROJECT CONTINGENCY (10%)					**$6,200**
PROJECT OVERHEAD (20%)					**$12,320**
TOTAL ESTIMATED PROJECT COSTS					**$80,120**

Table 10: Perimeter Ditch Maintenance Cost Estimate

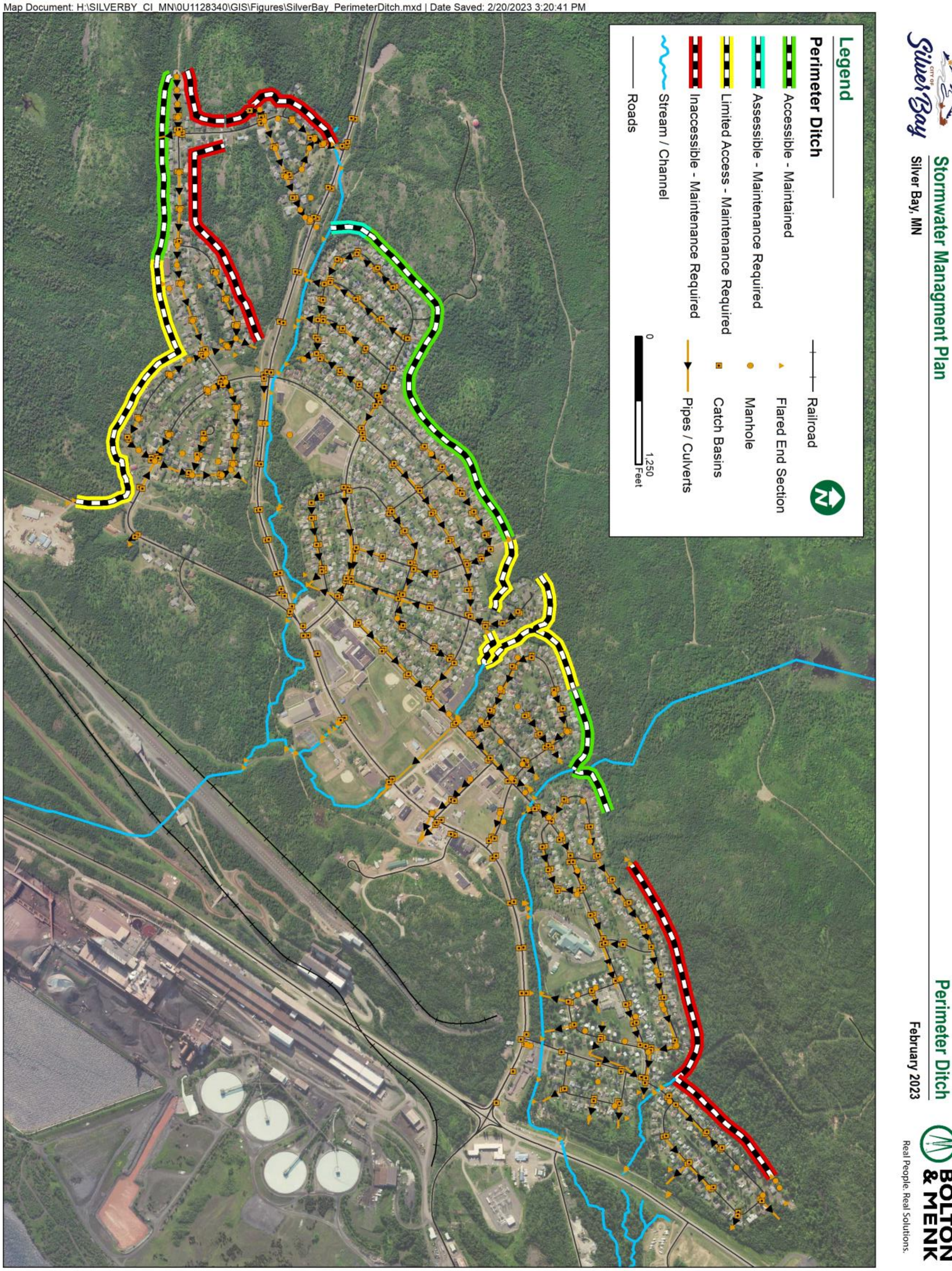


Figure 13: Perimeter Ditch Location Map

D. Silver Bay Golf Course Flooding – East Branch Beaver River

The East Branch of the Beaver River flows through the Silver Bay Municipal Golf Course. The River has experienced multiple flood events over the last decade, the worst of which was a 500-year flood event in June 2012. The flooding caused damages to the golf course in addition to severe erosion to the stream banks.

As a result of the damages sustained in the 2012 flood, the City of Silver Bay sent out a request for proposal (RFP) in 2016 to restore an area on the East Branch Beaver River directly upstream to the Silver Bay Golf Course. The goals of the project were to a) protect golf course infrastructure, b) restore river channel to a “stable state”, and c) use “natural channel design” methods to accomplish the above objectives. The project site is on land owned by the City of Silver Bay and the de-stabilized conditions at the site presented a risk to the infrastructure of the Silver Bay Golf Course. The area restored connects two stable reaches of river and serves to ensure that future flooding events will not threaten municipal infrastructure. The restoration project ensures floodplain connectivity within the reach and incorporates in-stream grade control structures to maintain appropriate dimension, pattern, and profile of the river. In addition to stabilizing this reach of river, these elements also integrate excellent in-stream and riparian habitat to support the fish and macro invertebrate populations in the river. The project was completed in 2018.

The most recent flooding event was observed at the golf course on May 14, 2022 as a result of a 3-inch rainfall event. The lower reaches of the river, adjacent to Hole # 8, were the most affected by the flood waters. Hole # 8 is located on the outside bend of the river before the river passes under the railroad and leaves the site. A location map of the Silver Bay golf course and development is displayed in **Figure 14**. The flooding left a significant amount of large debris and silt on the course, damaged the cart path, and deposited rocks along the edge of the river banks. Pictures 1-4, shown below, illustrate some of the damages observed from the May 14th event. Hydraulics analysis of the river alignment, streambank design, and the capacity of the downstream railroad crossing is needed to address the flooding issues observed near the 8th hole.

Photo 1: Debris seen on Hole #8

Photo 2: Silt Deposits

Photo 3: Damage to Cart Paths

Photo 4: Rocks Deposited on Riverbanks

E. Silver Bay Golf Course Residential Subdivision

The City of Silver Bay is proposing to construct 48 parcels as a part of the Silver Bay Golf Course Residential Subdivision. The development is located on the north side of the Silver Bay Golf Course and is adjacent to the East Branch Beaver River. The MPCA lists Beaver River as an impaired stream for turbidity. The east branch of Beaver River meets the main branch immediately downstream of the golf course, therefore permanent stormwater management of the subdivision will be important to ensure that flooding and water quality conditions downstream are not degraded.

There are two sets of rules/permits that apply to the stormwater aspects of the Silver Bay Golf Course Subdivision.

1. The City of Silver Bay Zoning/Land Use Permit,

2. NPDES Construction Stormwater Permit.

The NPDES Construction Stormwater Permit Rules are as follows:

- Permittees must design the project so all stormwater discharged from the project during and after construction activities does not cause a violation of state water quality standards, including nuisance conditions, erosion in receiving channels or on downslope properties, or a significant adverse impact to wetlands caused by inundation or decrease of flow.
- Permittees must calculate the water quality volume as one (1) inch times the net increase of impervious surfaces created by the project.
- Permittees must first consider volume reduction practices on-site (e.g., infiltration or other) when designing the permanent stormwater treatment system.

The subdivision has the opportunity in the planning phase to go above and beyond when it pertains to the strategy of stormwater management. Additional best management practices (BMPs), including bioretention filtration basins, wet sedimentation basin, native vegetation, and buffer zones adjacent to the river, would all provide benefit to the Silver Bay golf course and Beaver River in the form of flood control and water quality by means of reduction of the total suspended sediment (TSS) that would be discharged into the river.

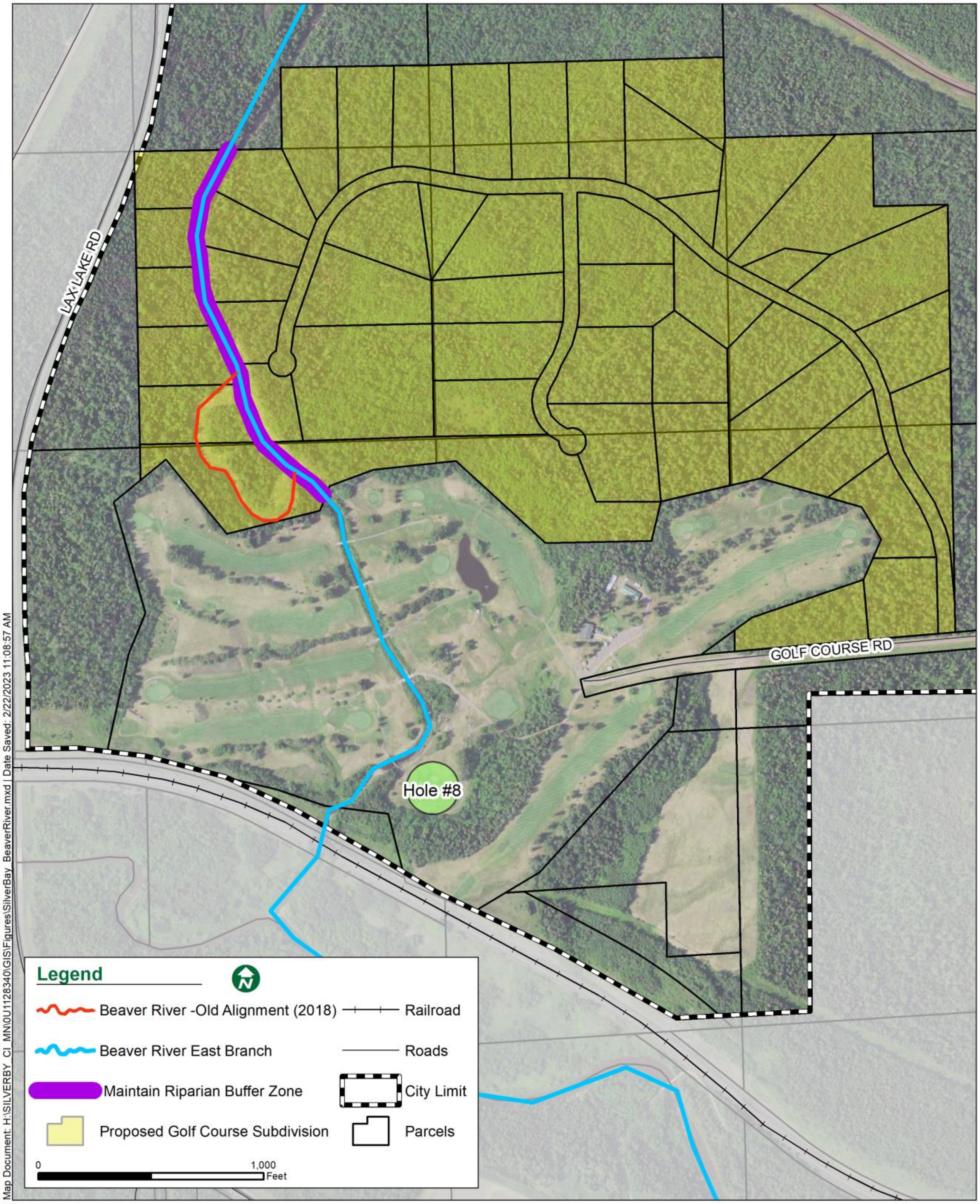


Figure 14: Silver Bay Golf Course Development

F. Green Street and Low Impact Development in Residential Areas

Water Quality can be enhanced by utilizing Green Street and Low Impact Development practices and programs. Examples of these design practices include bioretention filtration basins, also known as rain gardens, vegetated swales, and buffer zones. Upcoming roadway improvement projects are a great time to consider integrating Green Street and Low Impact Development practices as integrating these practices with an existing project can help reduce overall costs. Furthermore, educational programs such as Street Sweeping, Low Salt Solutions, and the Adopt-a-Storm-Drain program have been found to be very effective at improving the water quality at little cost to the City.

Green Street / Bioretention Filtration Basins (Rain Gardens)

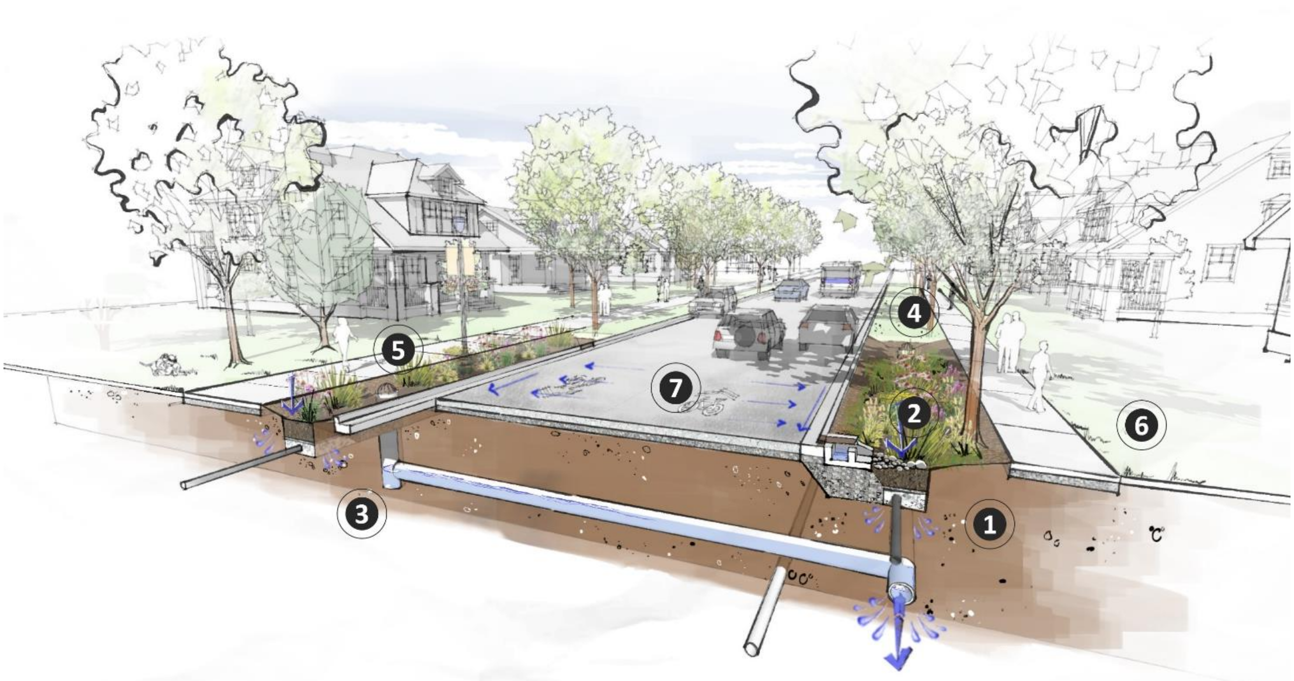


Figure 15: Neighborhood Rain Garden Corridor, Residential Setting

1. Soils in residential areas may be conducive to infiltrating stormwater, but they should be assessed to determine the presence of compaction, clay soils or high groundwater. If the soils are healthy and uncompacted, they are more likely to infiltrate stormwater into the subsoils below resulting in less runoff into the below grade storm drains.
2. In ideal conditions, curb inlets along a street can be directed into street-side bioretention areas designed to collect and infiltrate stormwater. Managing stormwater on the surface reduces stormwater runoff thereby reducing size and scale of below-grade storm drain infrastructure. These bioretention areas should include integrated pretreatment zones to intercept trash and sediment from stormwater before it enters the landscaped area. An engineered filter media, typically a sandy lightweight soil mix, is utilized to increase percolation and filtration of stormwater and promote healthy plant life. A subsurface underdrain allows heavy rain events to drain away after being filtered through the engineered soils. Most stormwater from light to moderate rain events will infiltrate into the native soil below or be taken up by native plant material.

3. Larger rain events are directed through overflow structures and storm drain systems to ensure safe travel on streets and sidewalks.
4. Street trees are a vital part of the larger urban forest and contribute to reducing ambient air temperature increase caused by hot pavement in the summer sun, often referred to as the heat island effect. Street trees also contribute to traffic calming, beautification, and health benefits in residential neighborhoods.
5. Educational opportunities like interpretive signage can explain the importance of bioretention areas and how they contribute to sustainable stormwater management. Potential partnerships with residents for bioretention area care and maintenance can reduce the burden on municipalities.
6. A healthy street reduces the hard surface footprint in public right-of-way resulting in more green than grey space.
7. Reducing widths of travel lanes reduces impervious surface area, reduces traffic speeds while increasing driver awareness, and creates more room for pedestrian and bike travel.

Street Sweeping

Roadways accumulate harmful pollutants such as sediment, trash, organics, vehicle waste, and metals. Street Sweeping refers to the removal of these harmful pollutants from the roadway using a mechanical broom and vacuum. There are multiple benefits to street sweeping including improved air and water quality, increased roadway safety, and enhanced roadway appearance. An effective street sweeping program optimizes collection times to maximize the amount of pollutants that are removed from the street. Street sweeping has the additional benefit of helping reduce the pollutant load to downstream BMP's, extending the life of the BMP's and reducing their maintenance intervals.

Chloride Reduction - Low Salt Solutions

Chloride is a top pollutant of concern in most cold climates and deicing salt is the main culprit. Winter maintenance professionals can be trained to reduce the amount of salt used in winter operations. Low Salt Solutions is a set of design guidelines focused on improved winter performance. These design concepts can easily be incorporated into all infrastructure projects, saving the City money by reducing winter maintenance effort, salt costs, infrastructure damage, and environmental impacts.

Low Salt Solutions can be applied to the design of roads, parking lots, sidewalks, intersections, bridges, ramps, salt storage, and other critical salted surfaces. Low Salt Designs consider factors such as prevailing wind directions, sun exposure, unintentional snow fences, meltwater directions, and critical braking and pedestrian zones.

Adopt-a-Storm-Drain

Stormwater runoff collects anything that's on streets and other paved surfaces and washes them down storm drains into lakes, rivers, and wetlands. Adopt-a-Storm-Drain is an educational program that asks residents to "adopt" a storm drain in their neighborhood and keep it clear of leaves, trash, and other debris to reduce water pollution. https://mn.adopt-a-drain.org/

V. Funding Opportunities

The City and Lake County SWCD should pursue cooperating project funding. Implementing these types of plans, which are cooperatively constructed, will aide in obtaining grants and outside agency funding. Lake SWCD and the City of Silver Bay have developed successful partnerships and will continue to identify water quality improvement projects that have regional significance. **Table 11** is a summary of available grants. These grants are subject to change and include variations of the following.

- Partnership and submittal requirements.
- Minimum and maximum project costs.
- Available funding and cost share/match requirements.
- Measurable water quality outcomes and project goal requirements.

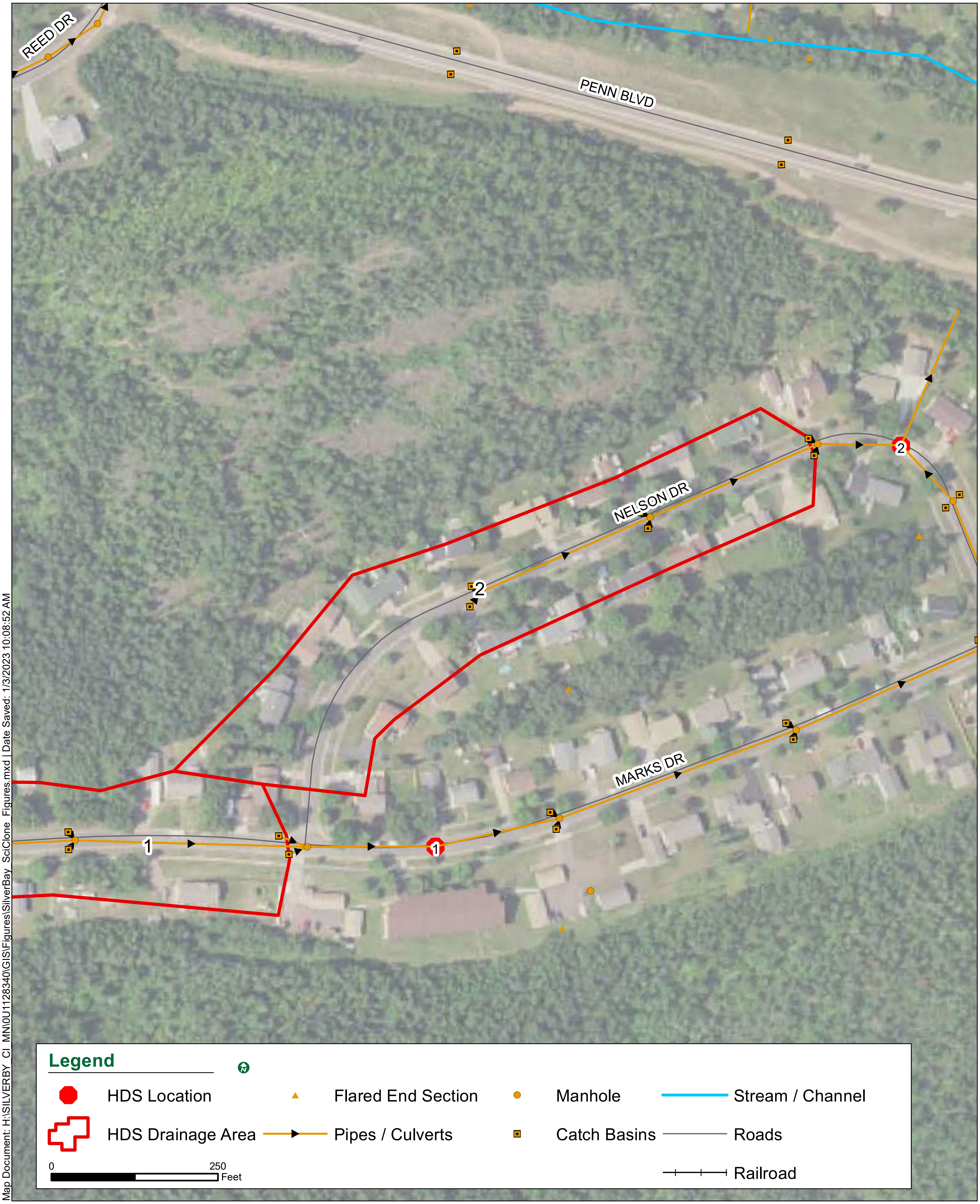
Name	Summary	Agency	Eligibility
Clean Water Fund Competitive Grant	Protecting, enhancing, and restoring water quality in lakes, rivers, and streams in addition to protecting ground water and drinking water sources from degradation.	Minnesota Board of Water & Soil Resources (BWSR)	County; Watershed District
Clean Water Funding - Conservation Corps	Provides hands-on environmental stewardship and service-learning opportunities to youth and young adults while providing low cost labor to eligible applicants.	Minnesota Board of Water & Soil Resources (BWSR);	City; County
Clean Water Partnership Loan Program	Control of nonpoint source pollution to surface and groundwater.	Minnesota Pollution Control Agency (MPCA)	City; County; State Agency; Tribal; Watershed District
Conservation Partners Legacy Grant Program	To restore, protect or enhance prairies, wetlands, forests, or habitat for fish, game, or wildlife in Minnesota.	Minnesota Department of Natural Resources (MNDNR)	City; County; State Agency; Federal Agency
Environment and Natural Resources Trust	ENRTF aims to protect, conserve, preserve, and enhance Minnesota's air, water, land, fish, wildlife, and other natural resources.	Environment and Natural Resources Trust Fund (ENRTF)	City; County; State Agency; Federal Agency; Tribal
Five Star and Urban Waters Restoration Grant Program	Develop community capacity to sustain local natural resources by improving water quality, watersheds and the species and habitats they support.	National Fish and Wildlife Foundation; Other - Minnesota	City; County; State Agency
One Watershed One Plan - Planning Grants	Supports partnerships of local governments in developing prioritized, targeted, and measurable implementation plans for planning at the major watershed scale and aligning local plans with state strategies.	Minnesota Board of Water & Soil Resources (BWSR)	City; County; State Agency; Watershed District
Section 319 Small Watersheds Focus Group A	Funding for projects to reduce nonpoint source pollution in lakes, rivers, and streams in areas with approved plans.	Minnesota Pollution Control Agency (MPCA)	City; County
Short Term Action Request (STAR) Grant	Minnesota's Costal Program Grant to help communities, agencies, and organizations balance protection of Lake Superior costal resources.	Minnesota Department of Natural Resources (MNDNR)	City; County; State Agency; Tribal; Watershed District
Stormwater Best Management Practices Loans	Offers low-interest loans for projects to control stormwater runoff. The loans offer incentives for installing infiltration-based stormwater quality practices.	Iowa Department of Agriculture and Land Stewardship (IDALS)	City; County; Private
Wellhead Protection Partner Grants	Establish protection of wellhead protection areas where state-held easements are not viable or desirable.	Minnesota Board of Water & Soil Resources (BWSR)	City; County
USACOE 569	U.S. ACOE aid for design and construction assistance for water-related environmental infrastructure and resource protection and development projects	U.S. Army Corps of Engineers	City / County
GLRI	Supports GLRI focus areas including: Nonpoint Source Pollution Impacts on Nearshore Health, Toxic Substances and Areas of Concern, and Foundation for Future Restoration Actions.	Environmental Protection Agency	City; County; State Agency; Federal Agency; Tribal
One Minnesota Budget: Climate Adaptation and Mitigation	DNR funding to connect Minnesotans' to the outdoors, mitigate and adapt to climate change, manage natural resources proactively, and address operational needs.	DNR	City; County; State Agency

Table 11: Summary of Potential Funding Opportunities

Appendix

Hydrodynamic Separator Locations


PENN BLVD
SHAW LN
REED DR
REED DR
QUINCY DR
MARKS DR
NELSON DR
HAYS CIR
JAMES RD
1
2
5
6
7
Legend
HDS Location
HDS Drainage Area
Flared End Section
Pipes / Culverts
Manhole
Catch Basins
Stream / Channel
Roads
Railroad
0
250
Feet


REED DR
PENN BLVD
NELSON DR
MARKS DR
1
2
Legend
HDS Location
HDS Drainage Area
Flared End Section
Pipes / Culverts
Manhole
Catch Basins
Stream / Channel
Roads
Railroad
0
250
Feet

Hydrodynamic Separator Location 3

January 2023

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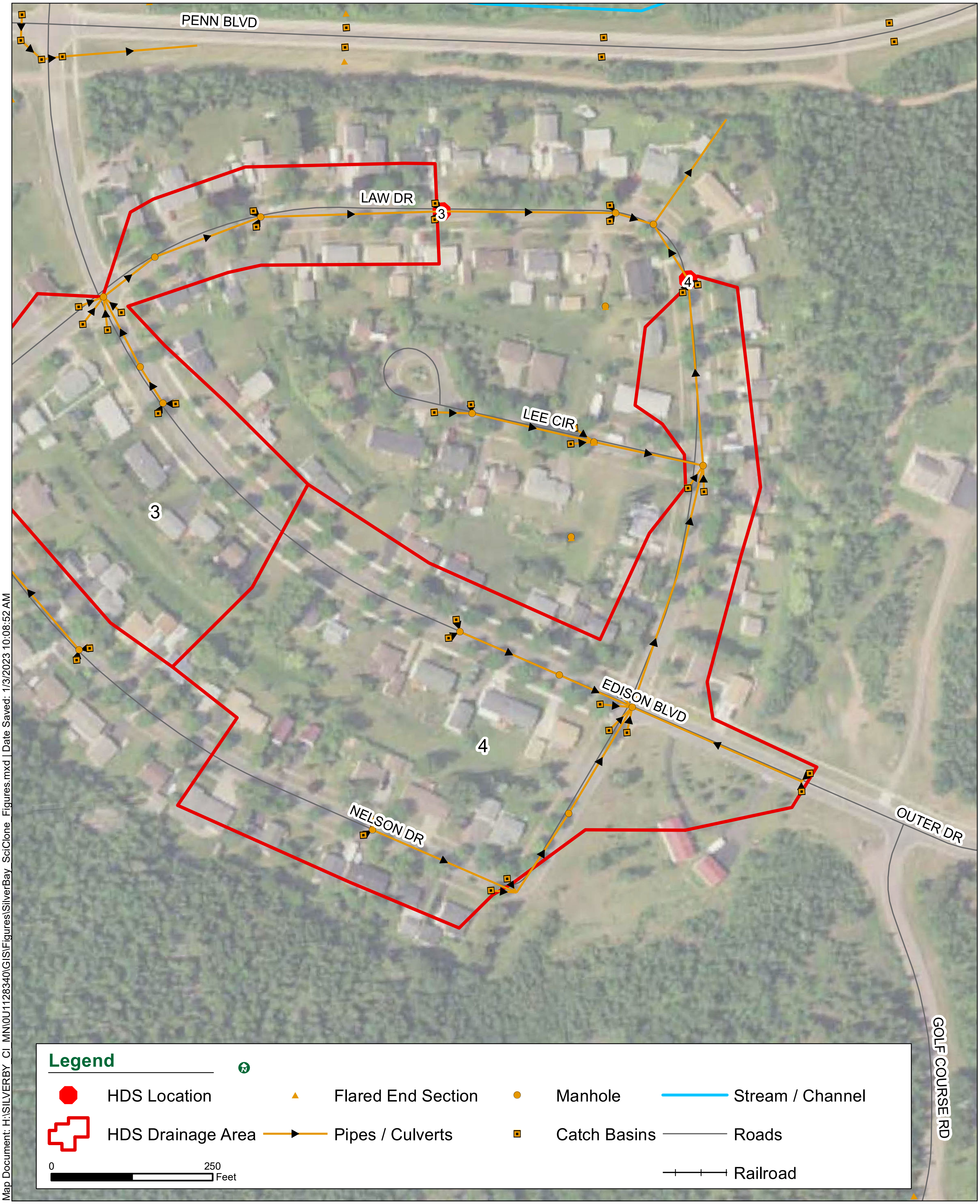

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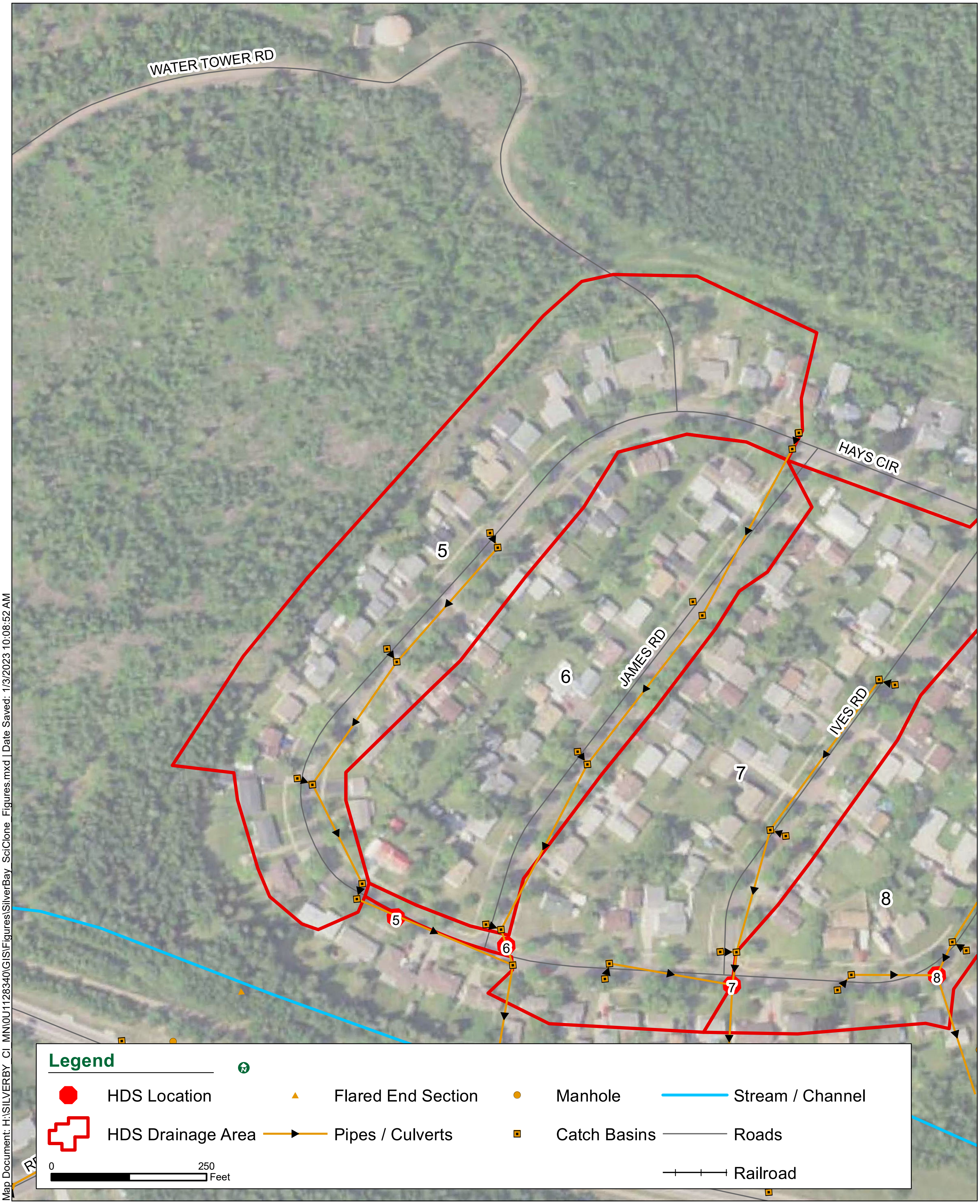

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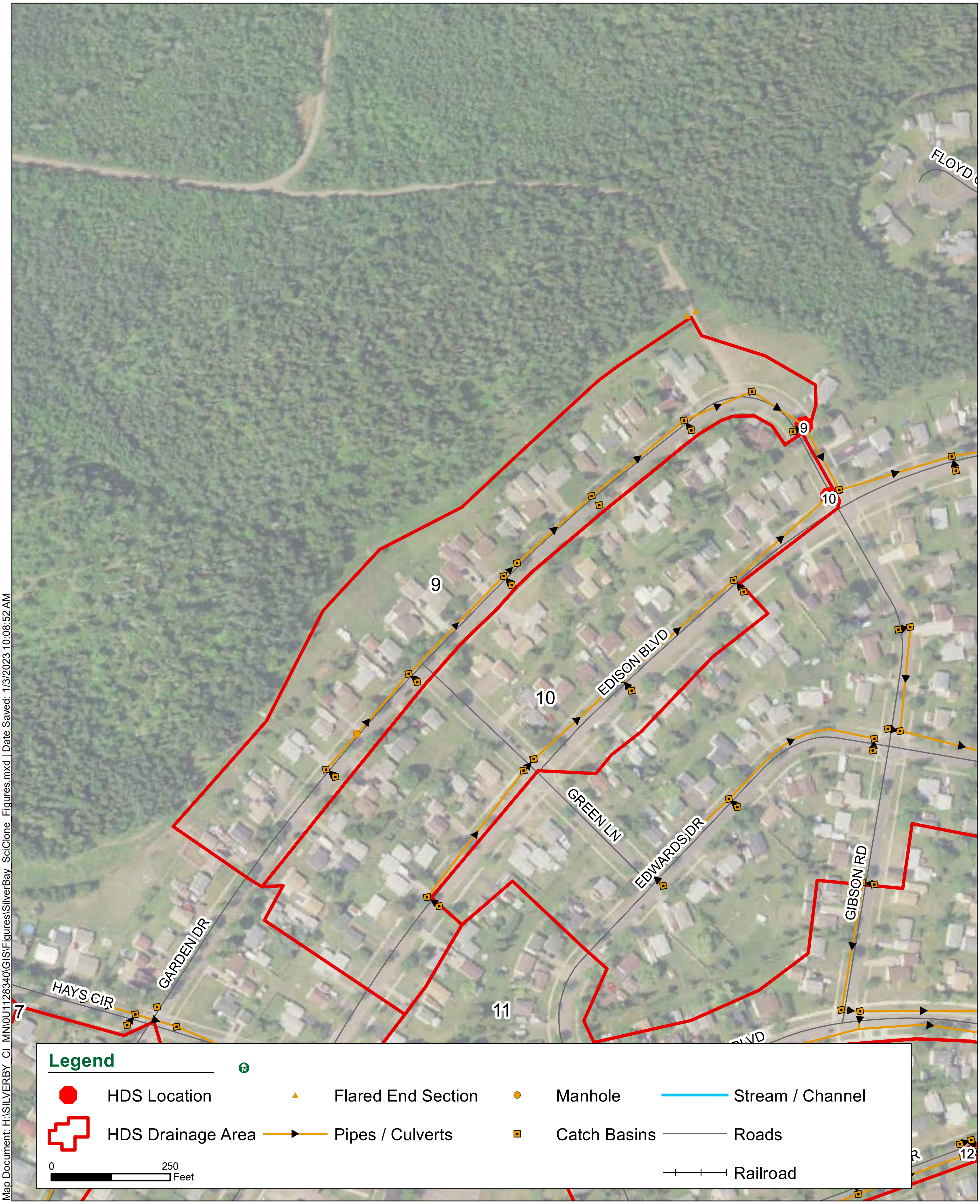
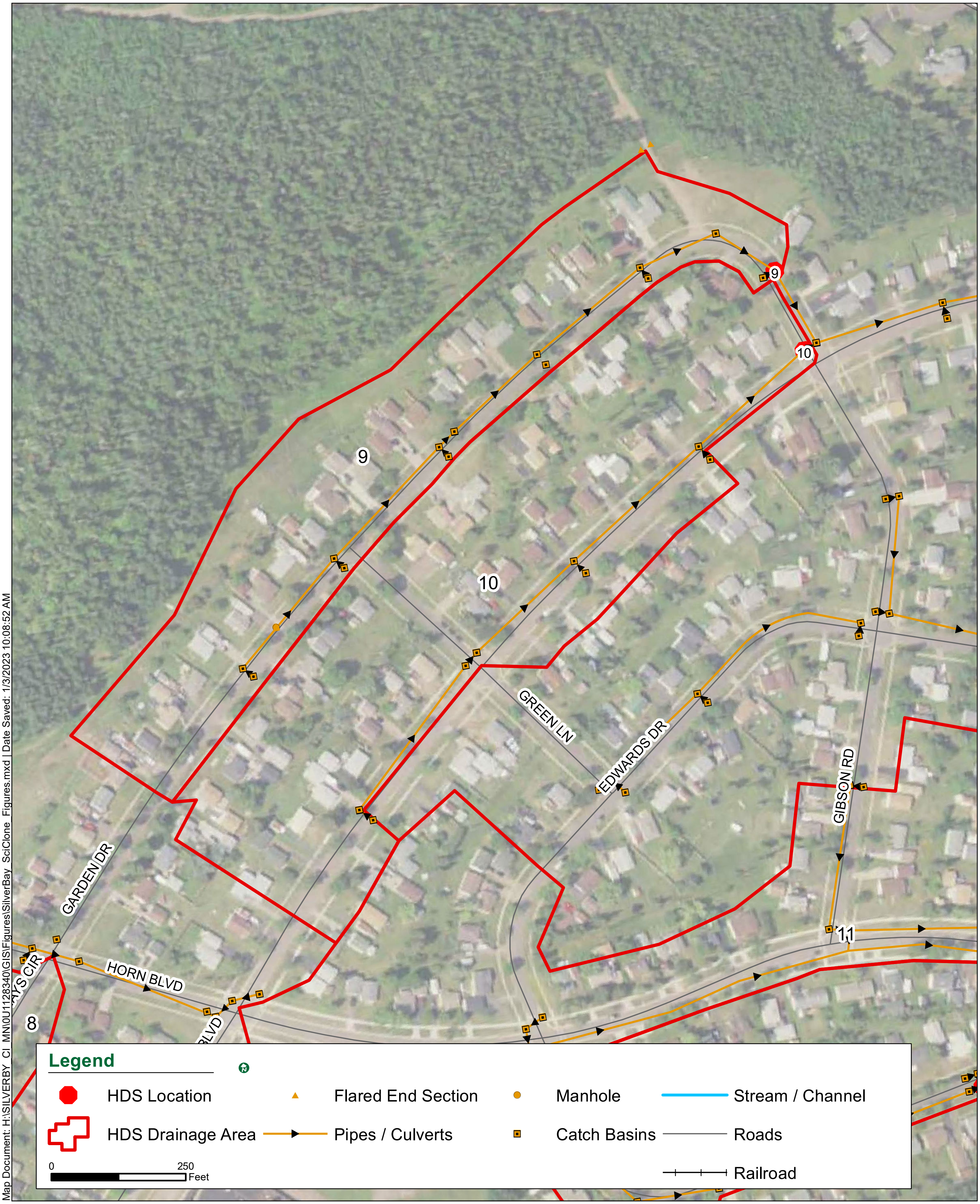
WATER TOWER RD
JAMES RD
IVES RD
HAYS CIR
5
6
7
8
Legend
HDS Location
HDS Drainage Area
Flared End Section
Pipes / Culverts
Manhole
Catch Basins
Stream / Channel
Roads
Railroad
0
250
Feet


WATER TOWER RD
JAMES RD
IVES RD
HAYS CIR
PENN BLVD
EDISON BLVD
5
6
7
8
Legend
HDS Location
HDS Drainage Area
Flared End Section
Pipes / Culverts
Manhole
Catch Basins
Stream / Channel
Roads
Railroad
0
250
Feet

Map Document: H:\SILVERBY_CI_MN\0U1128340\GIS\Figures\SilverBay_SciClone_Figures.mxd | Date Saved: 1/3/2023 10:08:52 AM


FLOYD
9
10
9
10
EDISON BLVD
GREEN LN
EDWARDS DR
GIBSON RD
GARDEN DR
HAYS CIR
7
11
12
Legend
HDS Location
HDS Drainage Area
Flared End Section
Pipes / Culverts
Manhole
Catch Basins
Stream / Channel
Roads
Railroad
0
250
Feet



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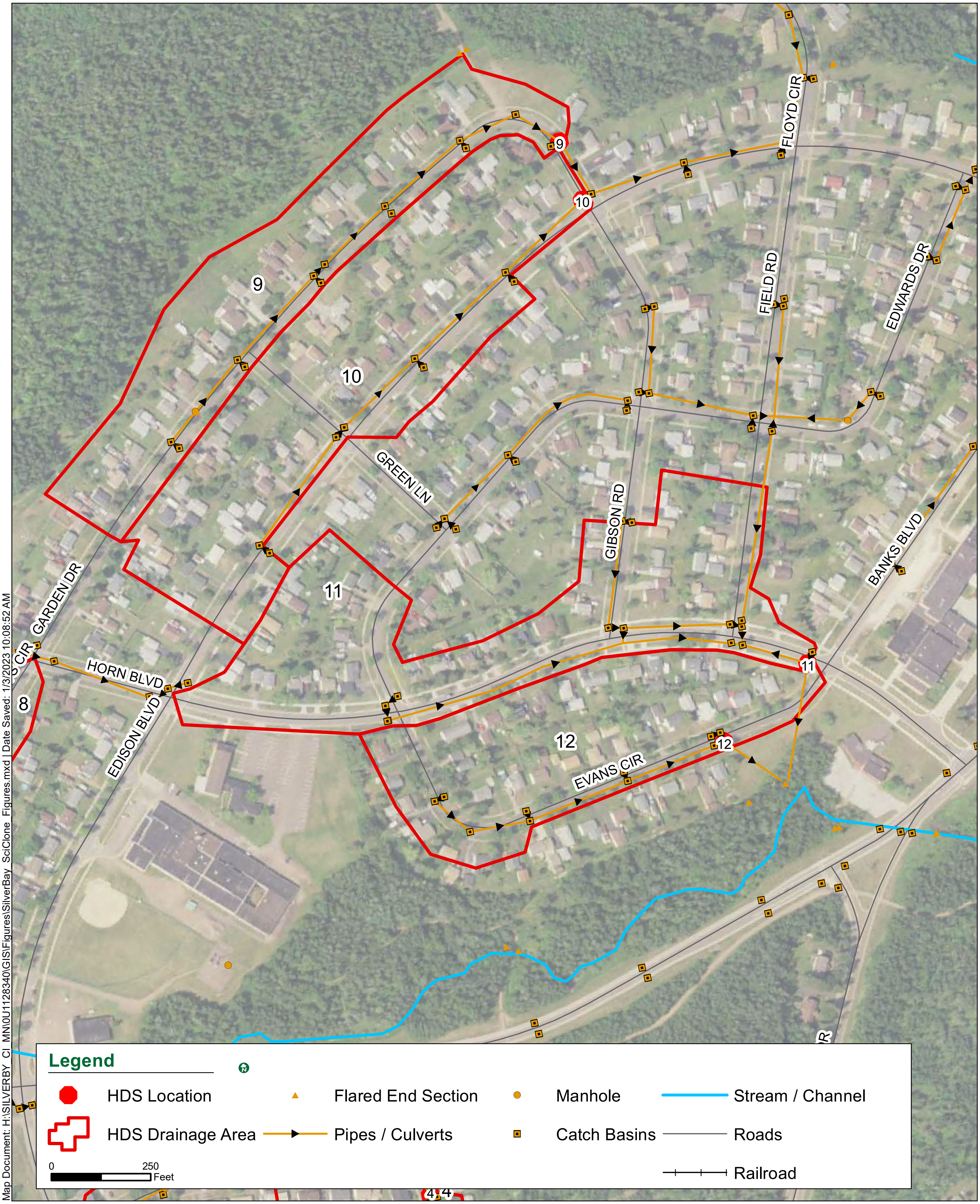

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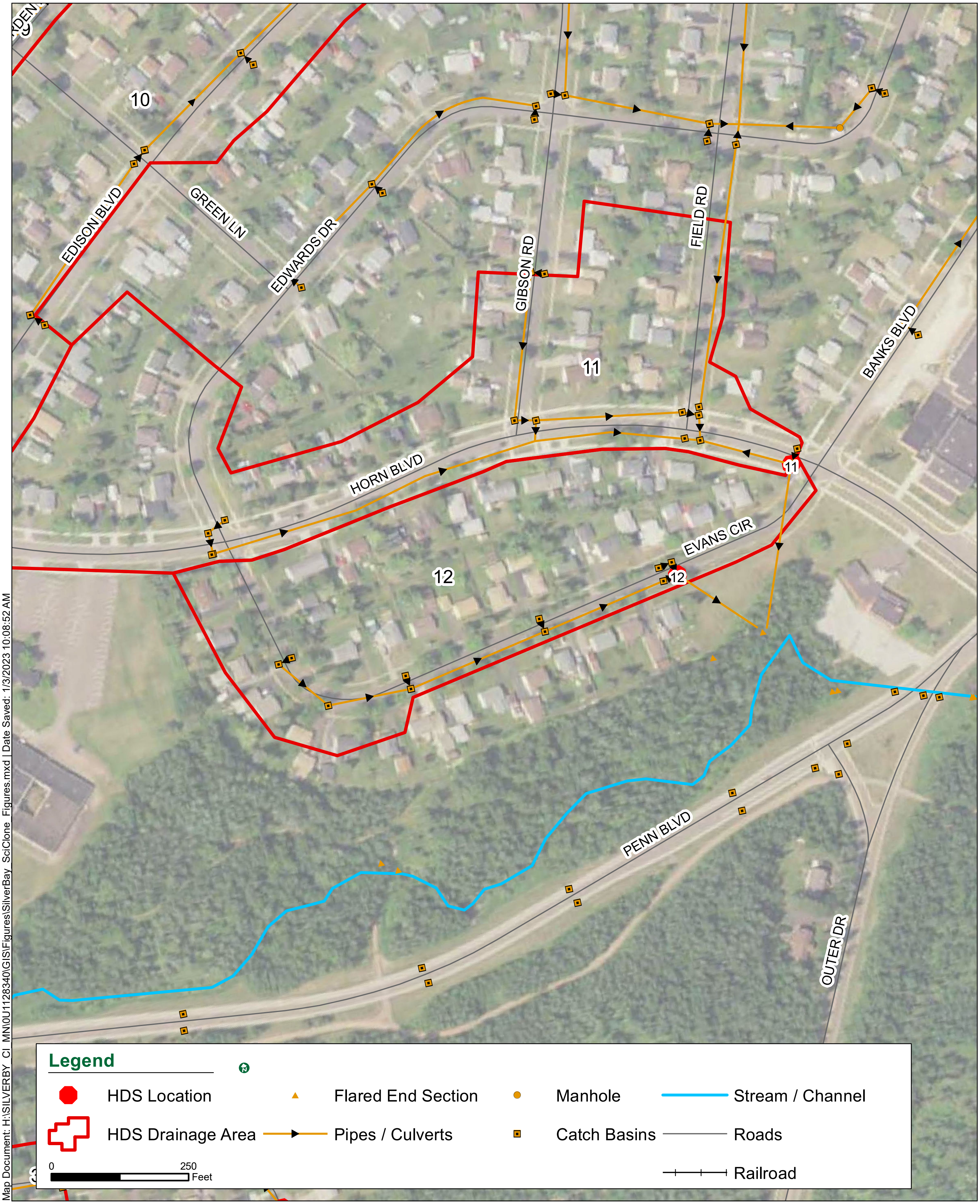

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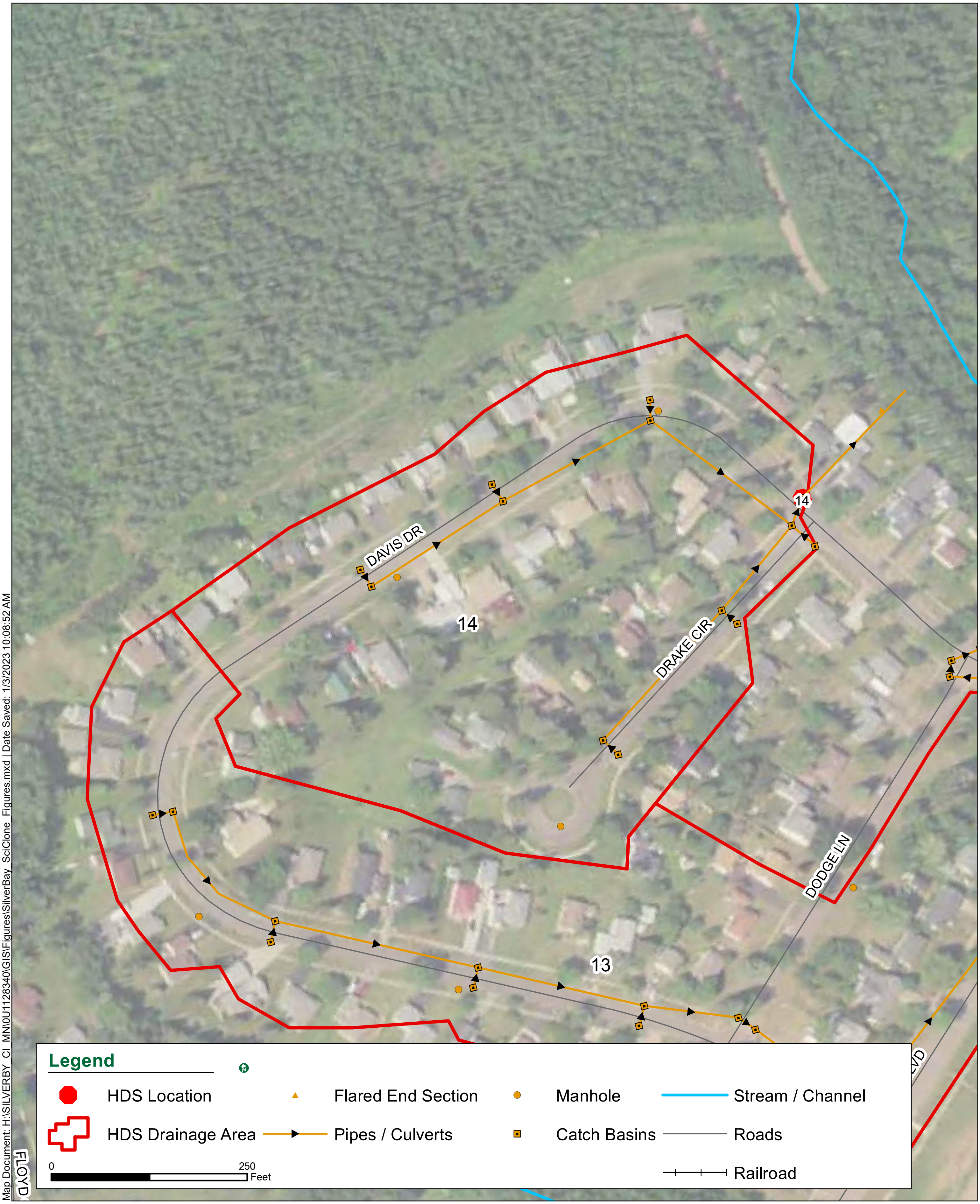
Hydrodynamic Separator Location 14

January 2023



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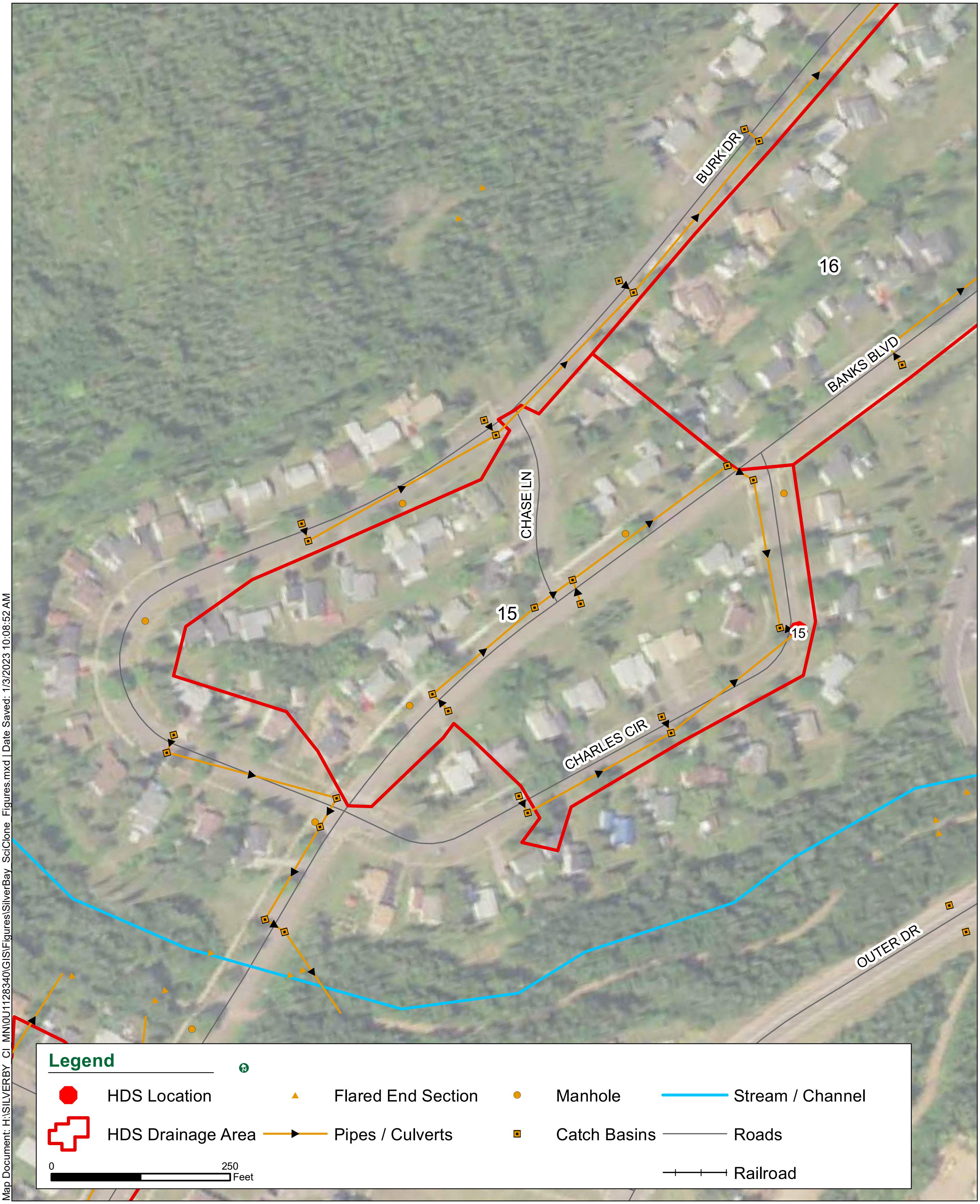

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Hydrodynamic Separator Location 16

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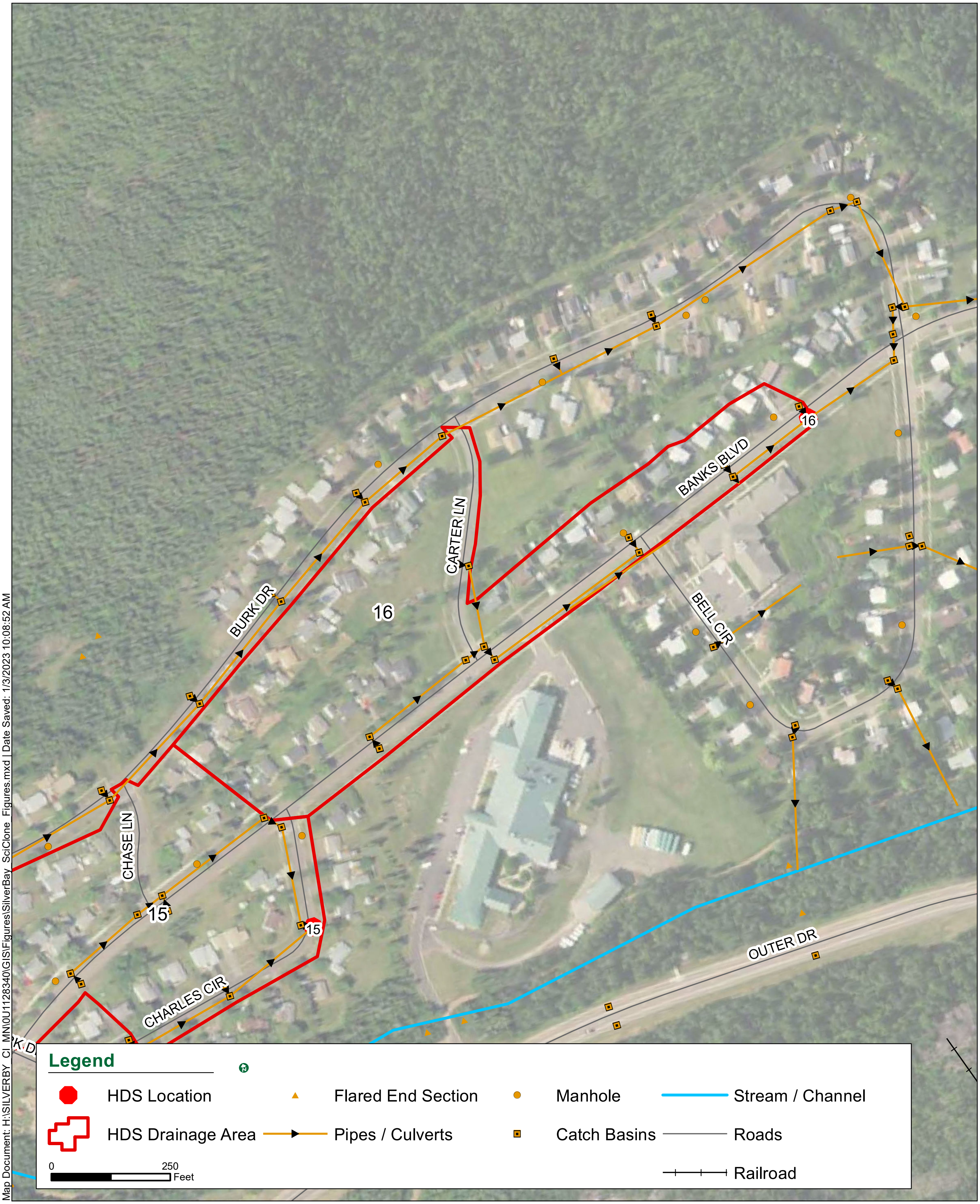

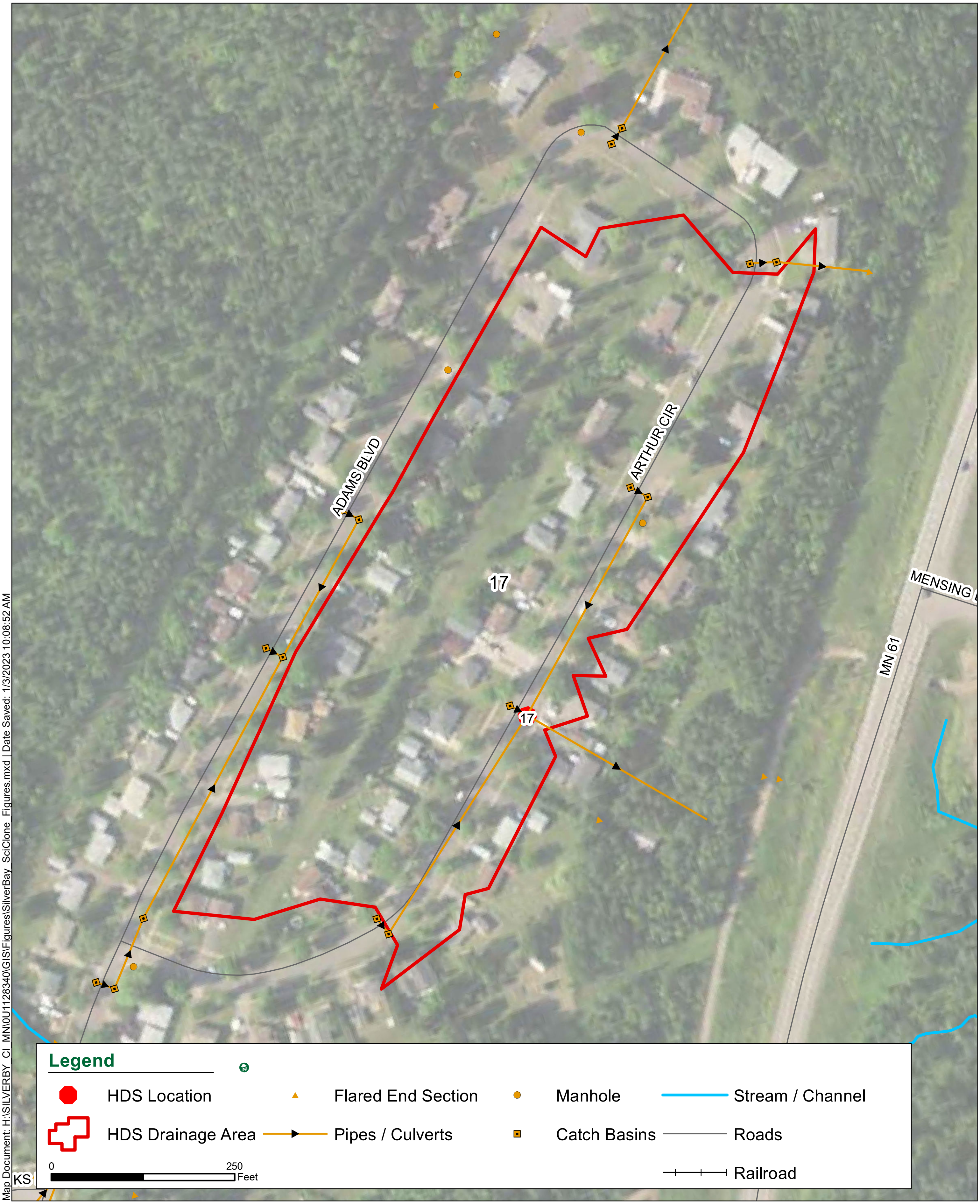
ADAMS BLVD
ARTHUR CIR
17
MENSING
MN 61
KS
Legend
HDS Location
HDS Drainage Area
Flared End Section
Pipes / Culverts
Manhole
Catch Basins
Stream / Channel
Roads
Railroad
0
250
Feet

Stormwater Management Plan

City of Silver Bay

DSBB Location 1

January 2023

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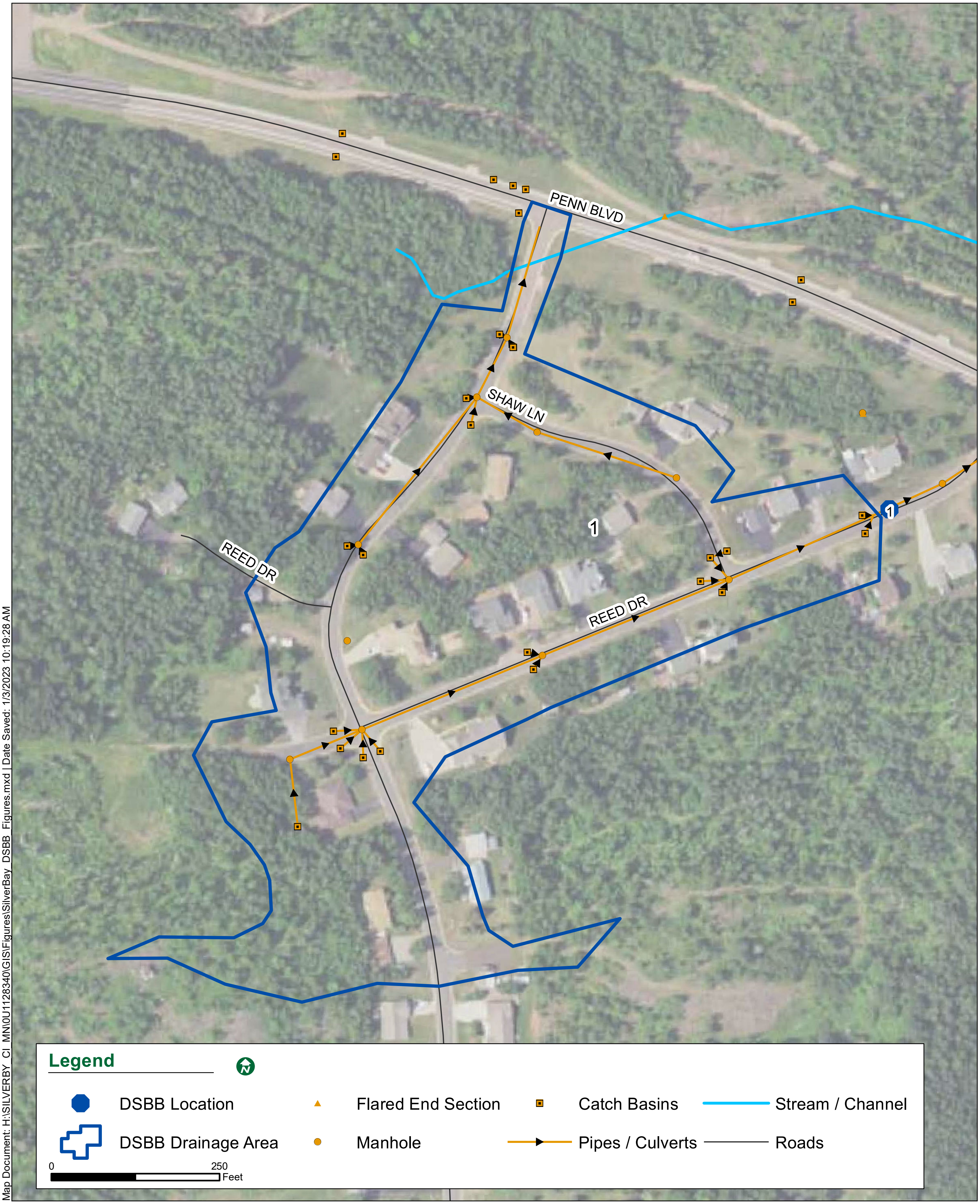

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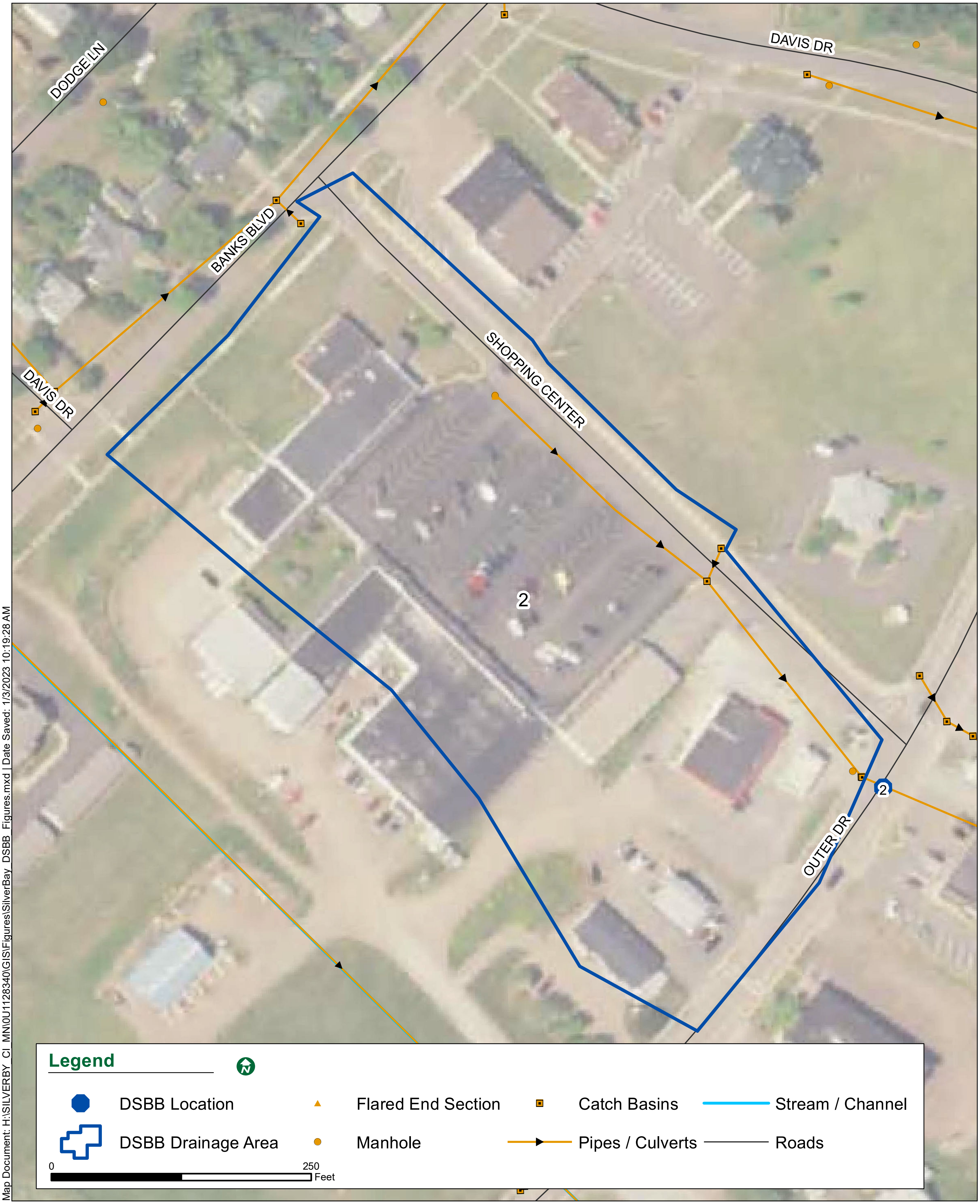

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Map Document: H:\SILVERBY_CI_MN0U1128340\GIS\Figures\SilverBay_DSBB_Figures.mxd | Date Saved: 1/3/2023 10:19:28 AM

Hydrodynamic Separator Removal Efficiency

Location 1			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	13.20		SciClone	4	13567	10987	845	81	5	4	24
Impervious (%)	21	1/3 acre lots	SciClone	5	13567	11869	913	87.5	6	5	30
Hydraulic Length (ft)	1520	with open space	SciClone	6	13567	12429	956	91.6	7	6	36
Average Slope (%)	4.5		SciClone	7	13567	12801	985	94.4	8	7	42
CN Pervious	80		SciClone	8	13567	13054	1004	96.2	9	8	48
Incoming Pipe Size	24		SciClone	9	13567	13230	1018	97.5	10	9	54
			SciClone	10	13567	13350	1027	98.4	11	10	60
			SciClone	11	13567	13431	1033	99	12	11	66
			SciClone	12	13567	13482	1037	99.4	13	12	72

Location 2			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	3.99		SciClone	4	5204	4865	374	93.5	5	4	24
Impervious (%)	30	1/3 Acre Lots	SciClone	5	5204	5032	387	96.7	6	5	30
Hydraulic Length (ft)	961		SciClone	6	5204	5117	394	98.3	7	6	36
Average Slope (%)	4.57		SciClone	7	5204	5161	397	99.2	8	7	42
CN Pervious	80		SciClone	8	5204	5184	399	99.6	9	8	48
Incoming Pipe Size	18		SciClone	9	5204	5194	400	99.8	10	9	54
			SciClone	10	5204	5200	400	99.9	11	10	60
			SciClone	11	5204	5202	400	100	12	11	66
			SciClone	12	5204	5203	400	100	13	12	72

Location 3			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	6.05		SciClone	4	7887	7112	547	90.2	5	4	24
Impervious (%)	30	1/3 acre lots	SciClone	5	7887	7454	573	94.5	6	5	30
Hydraulic Length (ft)	1245		SciClone	6	7887	7645	588	96.9	7	6	36
Average Slope (%)	3.58		SciClone	7	7887	7756	597	98.3	8	7	42
CN Pervious	80		SciClone	8	7887	7818	601	99.1	9	8	48
Incoming Pipe Size	21		SciClone	9	7887	7852	604	99.6	10	9	54
			SciClone	10	7887	7869	605	99.8	11	10	60
			SciClone	11	7887	7878	606	99.9	12	11	66
			SciClone	12	7887	7882	606	99.9	13	12	72

Location 4			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	10.04		SciClone	4	13142	11059	851	84.2	5	4	24
Impervious (%)	30	1/3 acre lots	SciClone	5	13142	11843	911	90.1	6	5	30
Hydraulic Length (ft)	1521		SciClone	6	13142	12325	948	93.8	7	6	36
Average Slope (%)	3.25		SciClone	7	13142	12628	971	96.1	8	7	42
CN Pervious	80		SciClone	8	13142	12823	986	97.6	9	8	48
Incoming Pipe Size	21		SciClone	9	13142	12950	996	98.5	10	9	54
			SciClone	10	13142	13031	1002	99.2	11	10	60
			SciClone	11	13142	13079	1006	99.5	12	11	66
			SciClone	12	13142	13106	1008	99.7	13	12	72

Location 5			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	7.80		SciClone	4	12113	10907	839	90	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	12113	11448	881	94.5	6	5	30
Hydraulic Length (ft)	1290		SciClone	6	12113	11750	904	97	7	6	36
Average Slope (%)	0.5		SciClone	7	12113	11921	917	98.4	8	7	42
CN Pervious	80		SciClone	8	12113	12016	924	99.2	9	8	48
Incoming Pipe Size	18		SciClone	9	12113	12066	928	99.6	10	9	54
			SciClone	10	12113	12091	930	99.8	11	10	60
			SciClone	11	12113	12102	931	99.9	12	11	66
			SciClone	12	12113	12108	931	100	13	12	72

Location 6			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	6.10		SciClone	4	9482	8599	661	90.7	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	9482	9002	692	94.9	6	5	30
Hydraulic Length (ft)	884		SciClone	6	9482	9223	709	97.3	7	6	36
Average Slope (%)	0.8		SciClone	7	9482	9347	719	98.6	8	7	42
CN Pervious	80		SciClone	8	9482	9416	724	99.3	9	8	48
Incoming Pipe Size	18		SciClone	9	9482	9451	727	99.7	10	9	54
			SciClone	10	9482	9468	728	99.8	11	10	60
			SciClone	11	9482	9475	729	99.9	12	11	66
			SciClone	12	9482	9479	729	100	13	12	72

Location 7			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	7.99		SciClone	4	12394	10750	827	86.7	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	12394	11424	879	92.2	6	5	30
Hydraulic Length (ft)	861		SciClone	6	12394	11820	909	95.4	7	6	36
Average Slope (%)	0.9		SciClone	7	12394	12057	927	97.3	8	7	42
CN Pervious	80		SciClone	8	12394	12202	939	98.5	9	8	48
Incoming Pipe Size	18		SciClone	9	12394	12289	945	99.2	10	9	54
			SciClone	10	12394	12339	949	99.6	11	10	60
			SciClone	11	12394	12365	951	99.8	12	11	66
			SciClone	12	12394	12379	952	99.9	13	12	72

Location 8			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	6.29		SciClone	4	9781	8758	674	89.5	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	9781	9211	709	94.2	6	5	30
Hydraulic Length (ft)	690		SciClone	6	9781	9464	728	96.8	7	6	36
Average Slope (%)	0.8		SciClone	7	9781	9609	739	98.2	8	7	42
CN Pervious	80		SciClone	8	9781	9692	746	99.1	9	8	48
Incoming Pipe Size	24		SciClone	9	9781	9737	749	99.6	10	9	54
			SciClone	10	9781	9760	751	99.8	11	10	60
			SciClone	11	9781	9770	752	99.9	12	11	66
			SciClone	12	9781	9775	752	99.9	13	12	72

Location 9			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	8.27		SciClone	4	12861	11326	871	88.1	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	12861	11976	921	93.1	6	5	30
Hydraulic Length (ft)	1600		SciClone	6	12861	12350	950	96	7	6	36
Average Slope (%)	1.1		SciClone	7	12861	12571	967	97.7	8	7	42
CN Pervious	80		SciClone	8	12861	12702	977	98.8	9	8	48
Incoming Pipe Size	18		SciClone	9	12861	12778	983	99.4	10	9	54
			SciClone	10	12861	12818	986	99.7	11	10	60
			SciClone	11	12861	12839	988	99.8	12	11	66
			SciClone	12	12861	12850	988	99.9	13	12	72

Location 10			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	11.63		SciClone	4	18088	14945	1150	82.6	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	18088	16123	1240	89.1	6	5	30
Hydraulic Length (ft)	1595		SciClone	6	18088	16846	1296	93.1	7	6	36
Average Slope (%)	1.1		SciClone	7	18088	17305	1331	95.7	8	7	42
CN Pervious	80		SciClone	8	18088	17599	1354	97.3	9	8	48
Incoming Pipe Size	21		SciClone	9	18088	17789	1368	98.3	10	9	54
			SciClone	10	18088	17911	1378	99	11	10	60
			SciClone	11	18088	17986	1384	99.4	12	11	66
			SciClone	12	18088	18030	1387	99.7	13	12	72

Location 11			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	10.31		SciClone	4	15987	13175	1013	82.4	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	15987	14218	1094	88.9	6	5	30
Hydraulic Length (ft)	1645		SciClone	6	15987	14869	1144	93	7	6	36
Average Slope (%)	2.7		SciClone	7	15987	15280	1175	95.6	8	7	42
CN Pervious	80		SciClone	8	15987	15544	1196	97.2	9	8	48
Incoming Pipe Size	30		SciClone	9	15987	15715	1209	98.3	10	9	54
			SciClone	10	15987	15825	1217	99	11	10	60
			SciClone	11	15987	15894	1223	99.4	12	11	66
			SciClone	12	15987	15934	1226	99.7	13	12	72

Location 12			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	7.60		SciClone	4	11784	9885	760	83.9	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	11784	10629	818	90.2	6	5	30
Hydraulic Length (ft)	1000		SciClone	6	11784	11078	852	94	7	6	36
Average Slope (%)	3.4		SciClone	7	11784	11353	873	96.3	8	7	42
CN Pervious	80		SciClone	8	11784	11521	886	97.8	9	8	48
Incoming Pipe Size	18		SciClone	9	11784	11625	894	98.6	10	9	54
			SciClone	10	11784	11690	899	99.2	11	10	60
			SciClone	11	11784	11729	902	99.5	12	11	66
			SciClone	12	11784	11753	904	99.7	13	12	72

Location 13			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	9.92		SciClone	4	15380	12781	983	83.1	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	15380	13759	1058	89.5	6	5	30
Hydraulic Length (ft)	1800		SciClone	6	15380	14365	1105	93.4	7	6	36
Average Slope (%)	3.1		SciClone	7	15380	14745	1134	95.9	8	7	42
CN Pervious	80		SciClone	8	15380	14986	1153	97.4	9	8	48
Incoming Pipe Size	18		SciClone	9	15380	15142	1165	98.5	10	9	54
			SciClone	10	15380	15241	1172	99.1	11	10	60
			SciClone	11	15380	15301	1177	99.5	12	11	66
			SciClone	12	15380	15336	1180	99.7	13	12	72

Location 14			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	7.88		SciClone	4	12216	10175	783	83.3	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	12216	10965	843	89.8	6	5	30
Hydraulic Length (ft)	875		SciClone	6	12216	11445	880	93.7	7	6	36
Average Slope (%)	2.7		SciClone	7	12216	11741	903	96.1	8	7	42
CN Pervious	80		SciClone	8	12216	11923	917	97.6	9	8	48
Incoming Pipe Size	18		SciClone	9	12216	12037	926	98.5	10	9	54
			SciClone	10	12216	12109	931	99.1	11	10	60
			SciClone	11	12216	12153	935	99.5	12	11	66
			SciClone	12	12216	12180	937	99.7	13	12	72

Location 15			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	7.46		SciClone	4	11584	9686	745	83.6	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	11584	10429	802	90	6	5	30
Hydraulic Length (ft)	950		SciClone	6	11584	10877	837	93.9	7	6	36
Average Slope (%)	3.7		SciClone	7	11584	11151	858	96.3	8	7	42
CN Pervious	80		SciClone	8	11584	11318	871	97.7	9	8	48
Incoming Pipe Size	18		SciClone	9	11584	11422	879	98.6	10	9	54
			SciClone	10	11584	11487	884	99.2	11	10	60
			SciClone	11	11584	11527	887	99.5	12	11	66
			SciClone	12	11584	11551	889	99.7	13	12	72

Location 16			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	8.90		SciClone	4	13795	11334	872	82.2	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	13795	12259	943	88.9	6	5	30
Hydraulic Length (ft)	1320		SciClone	6	13795	12830	987	93	7	6	36
Average Slope (%)	3.96		SciClone	7	13795	13189	1015	95.6	8	7	42
CN Pervious	80		SciClone	8	13795	13416	1032	97.3	9	8	48
Incoming Pipe Size	15		SciClone	9	13795	13561	1043	98.3	10	9	54
			SciClone	10	13795	13653	1050	99	11	10	60
			SciClone	11	13795	13711	1055	99.4	12	11	66
			SciClone	12	13795	13746	1057	99.6	13	12	72

Location 17			Name	Model	Total Load (lbs)	Total Load Removed (lbs)	Total Annual Load Removed (lbs)	Removal Efficiency (%)	Model Height (ft)	Model Diameter (ft)	Pipe Diameter (inches)
Area (Acres)	8.99		SciClone	4	13946	11130	856	79.8	5	4	24
Impervious (%)	38	1/4 acre lots	SciClone	5	13946	12174	936	87.3	6	5	30
Hydraulic Length (ft)	825		SciClone	6	13946	12809	985	91.8	7	6	36
Average Slope (%)	3.1		SciClone	7	13946	13217	1017	94.8	8	7	42
CN Pervious	80		SciClone	8	13946	13478	1037	96.6	9	8	48
Incoming Pipe Size	21		SciClone	9	13946	13645	1050	97.8	10	9	54
			SciClone	10	13946	13754	1058	98.6	11	10	60
			SciClone	11	13946	13825	1063	99.1	12	11	66
			SciClone	12	13946	13872	1067	99.5	13	12	72