BOZEMAN MT
Stormwater Division

2025 BOZEMAN STORMWATER FACILITIES PLAN

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EXECUTIVE SUMMARY

The City of Bozeman Stormwater Program has made tremendous strides since its development in 2012. Many of the recommendations from the *2008 Bozeman Stormwater Facilities Plan* [1], referred to herein as the 2008 Plan, have been implemented, including developing a robust database of the stormwater infrastructure, creating a stormwater management plan (SWMP) to comply with the Montana Department of Environmental Quality (MDEQ) MS4 Permit requirements, and developing a stormwater utility rate to partially fund operation, inspection, maintenance, and capital needs. Over the past fifteen years, Bozeman has undergone major changes due to rapid development across Gallatin Valley and evolving stormwater regulations. This changing dynamic created the need for a new Stormwater Facilities Plan that would include an assessment of their current program and new recommendations that can be the roadmap to guide their program in the coming years.

This 2025 Stormwater Facilities Plan, referred to herein as the 2025 Plan, examines the entire Stormwater Program and assesses key categories, including the Program's organization, policy and design criteria, inventory of existing facilities, operations and maintenance, deferred maintenance, capital improvements and planning, regulatory water quality compliance, program administration and management, and funding. The following summarizes the findings, conclusions, and recommendations for each section.

Stormwater Program Organization

The City of Bozeman’s Stormwater Program is managed by a dedicated administration team of five staff members, supported by operations and maintenance personnel from the Water/Sanitary/Storm (WSS) Operations and Street Maintenance (SM) groups. These groups oversee a range of activities, including annual inspections, maintenance of underground and surface facilities, capital improvement planning, and compliance with MDEQ MS4 Permit requirements. Key facilities managed include inlets, manholes, storm drains, storage ponds, outfalls, and curb chases. A primary focus of the program is meeting regulatory compliance, which entails significant documentation and annual reporting of the Stormwater Program.

Policy and Design Criteria

The City of Bozeman’s stormwater policy and design criteria have evolved since the adoption of the 2008 Plan. Key recommendations from the 2008 Plan, such as establishing a Stormwater Utility, inventorying stormwater assets, developing a GIS database, and enhancing compliance with MS4 Permit requirements, have been successfully implemented. The City has also upgraded infrastructure, created a GIS-based inspection system, and improved water quality treatment to address TMDL limits in Bozeman Creek.

Recent updates include a comprehensive rewrite of the City’s stormwater design standards, which had not been revised since 1980. These updates incorporate new precipitation data, refined design storm criteria, enhanced requirements for stormwater plans, and updated methodologies for hydrologic analysis and facility maintenance. As the City’s Stormwater Program matures, this facilities plan provides additional recommendations for expansion of the program.

GIS Inventory and Asset Management

The City of Bozeman has made substantial progress in developing a GIS-based inventory of its stormwater facilities, providing critical data for asset management, maintenance, and capital planning. A review of the March 2024 GIS datasets identified data gaps and missing information, such as watershed boundaries, underground storage facilities, and permeable pavers. To address these gaps, the City needs to develop and complete a comprehensive stormwater asset data management plan, emphasizing standardized attributes, predefined domains, and collaboration among GIS staff, stormwater administration, and external consultants. Following the development of this plan, field data collection will be necessary to populate all required attributes. This approach will allow for consistent data collection, improve data accuracy, and support further compliance with MS4 requirements. Addressing identified gaps, such as culvert data throughout the city limits, will enhance infrastructure representation. Additional measures, including integrating photo documentation, linking as-built drawings, and requiring new developments to submit GIS-compatible data, will further streamline data collection and promote comprehensive asset management.

Operations and Maintenance

The City utilizes CityWorks and GIS datasets for tracking and managing inspection and maintenance activities, aiming for a five-year maintenance cycle across its infrastructure. Key facilities, including inlets, manholes, storm drains, water quality treatment units, and culverts, are maintained with varying levels of efficiency. However, challenges such as insufficient staff, equipment, and space at the City Shops Complex limit the City's ability to improve its efforts. Additionally, the City does not have a structured program for inspecting, maintaining, and replacing or rehabbing its culverts, open channels, and ponds, which are all critical components of the stormwater system.

Currently, the City is falling short of its 20% annual inspection target and relies on a reactive maintenance approach for certain facilities like detention ponds, culverts, open channels, and underground storage. To address these issues, it is recommended that the City expand its resources and develop a Level of Service (LOS) matrix to assess operation and maintenance needs to meet various goals and incorporate additional facilities like culverts, ponds, and open channels. In addition, the City needs to develop systematic programs, particularly for culverts and open channel conveyances. For culverts specifically, a detailed workflow is provided to highlight steps to start developing a culvert program. It includes a phased approach that first gathers critical data such as culvert locations and conditions that will allow Bozeman to understand these assets and scale a program to protect and extend the life of its assets in a cost-effective, systematic way. Open channels are even more complicated, and the City needs to do an inventory and assessment of these channels to understand better the size, shape, and condition of these facilities. Addressing these challenges will require increased funding, staffing, and strategic planning to improve stormwater management efficiency and ensure long-term sustainability.

Deferred Maintenance and Replacement

The City of Bozeman faces considerable deferred maintenance across various stormwater infrastructure types, with conditions and responsibilities assessed using the latest GIS data and staff input. Key findings include the critical need for replacing vitrified clay pipes (VCP), which account for significant system deficiencies. The City has fallen behind on its 2030 VCP replacement target and needs to revise its goals and prioritize critical sections of storm drain. Detention ponds also require substantial attention, with 57% of all ponds needing maintenance or retrofits. While only 5% of City-owned ponds are in poor condition or undersized, privately owned ponds represent the bulk of deferred maintenance. Many require design retrofits or extensive repairs, as identified in the *Post-Construction Program Review and Recommendations* report [2]. Limited City involvement in privately owned ponds contributes to these challenges, emphasizing the need for improved oversight and collaboration.

Recommendations include developing targeted maintenance programs, conducting comprehensive inspections, developing a formal enforcement response plan (ERP), and integrating findings into capital improvement planning. A specific focus on detention ponds is necessary, with efforts to establish clear maintenance standards, increase inspections, and define responsibilities between the City and private owners. A needs-based utility rate study is advised to balance funding with maintenance timelines, aiming to address deficiencies over 5–20 years while ensuring financial sustainability. Coordination across facility types, improved inspection methods, and strategic prioritization are essential to addressing Bozeman's stormwater infrastructure challenges effectively.

Capital Improvements and Planning

Stormwater planning studies are critical for managing Bozeman's current and future infrastructure needs, addressing existing system bottlenecks, flooding, and water quality while guiding long-term growth. Historically, the City has relied on Stormwater Facilities Plans to identify stormwater capital improvement needs. The 2025 Plan evaluated pre-1980 facilities in downtown Bozeman but did not focus on other growth areas. Because the City does not currently have a comprehensive citywide plan, additional focused stormwater planning studies are necessary, particularly as Bozeman continues to expand. The West Bozeman – South and West Bozeman – North areas are identified as the most critical. These targeted efforts will support effective capital improvement planning and policy decisions and help identify potential regional detention facilities to facilitate responsible development.

The 2025 Plan assessed pre-1980 infrastructure through a planning-level model, revealing undersized pipes and significant surface flooding in multiple areas. Recommended capital improvements include major pipe replacements along S. 8th and 9th Avenues, S. Wallace Avenue, and W. Arthur Street to mitigate surcharge and ponding issues. In the downtown area, further studies refined the design of infiltration galleries and a potential bypass trunk line, with a recommended solution favoring infiltration galleries for both cost and water quality benefits. Additional projects that have not been addressed from the 2008 Plan remain a priority, and the City's Historic Pipe Replacement Program must accelerate VCP replacements to avoid long-term failures. Meanwhile, locations for water quality improvements, such as mechanical treatment units and infiltration facilities, have been identified to reduce sediment loads and meet regulatory obligations to Bozeman Creek. Collectively, these recommended projects and planning studies underscore the need for ongoing, strategic capital investments to address aging infrastructure, improve system capacity, and protect water quality as Bozeman continues to grow. The list below outlines the City's capital improvement and planning needs. Internal discussions by the City will be necessary to establish a prioritized plan for these projects.

Project Number	Project Name	Budget Level Cost Estimate
Stormwater Planning Studies		
1	West Bozeman – South Study	$330,000
2	Lower Bozeman Creek Study	$450,000
3	West Bozeman – North Study	$530,000
4	North Bozeman (N I-90) Study	$470,000
5	Hyalite Creek Watershed Study	$150,000
6	Upper Bozeman Creek Study	$330,000
7	East Bozeman Study	$290,000
8	Farmers Canal Capacity Study	$300,000
Stormwater Design and Construction Projects		
9	Mechanical Treatment – Peach St.	$280,000
10	Mechanical Treatment – Tamarack St.	$300,000
11	Historic Pipe Replacement Program	$37,000,000
12	N. 9th Ditch Rehabilitation	$450,000
13	Manley Ditch Rehabilitation	$520,000
14	S. 8th and S. 9th Avenues Improvements	$7,300,000
15	S. Wallace Avenue Improvements	$2,100,000
16	W. Arthur Street Improvements	$11,300,000
17	Downtown Bypass or Infiltration Galleries	$2,900,000
Water Quality Design and Construction Projects		
18	S. 11th and Koch St.	$330,000
19	Arthur Basin	$450,000
20	Willson Avenue	$530,000
21	Cooper Park Midtown	$470,000
22	Cherry Drive	$150,000
23	Langhor Avenue	$330,000
24	W. Olive St., S. 16th Ave., W. Babcock St.	$290,000
25	W. Cleveland St. / W. Garfield St.	$300,000
26	Kagy and Highland Boulevards	$470,000
27	S. 20th Avenue	$330,000
28	W. Babcock St. and S. Ferguson Avenue	$300,000
29	Durston Road and Meagher Avenue	$300,000
30	N. 20th Avenue and Durston Road	$300,000

Regulatory Water Quality Compliance

The City of Bozeman is required to comply with Montana's MS4 General Permit [3], which focuses on reducing pollutants in stormwater discharges to local waterways. Over time, the City has advanced its Stormwater Program, conducting thorough assessments, developing a Stormwater Management Plan (SWMP), and implementing various Minimum Control Measures (MCMs). MDEQ audits have generally recognized Bozeman's commendable efforts, with only a few remaining violations related to the City's post-construction stormwater pond inspection and enforcement procedures.

To address these deficiencies, the City plans to refine its post-construction program by adopting stricter design criteria, expanding inspection protocols, providing targeted public education, and developing a formal Enforcement Response Plan. Additional funding will be essential, likely sourced through the existing stormwater utility and guided by a needs-based utility rate study. Enhancements to flow sampling and continuous monitoring are also recommended to better capture real-time water quality data for further understanding of the City influences on Bozeman Creek. Overall, these measures will strengthen Bozeman's compliance with MS4 General Permit requirements, ensure effective long-term stormwater management, and protect local water resources as the city continues to grow.

Program Management and Administration

The City of Bozeman's Stormwater Program has demonstrated effective program management and administration through collaborative efforts involving Engineering, Finance, GIS, Street Maintenance, and Water/Sanitary/Storm Operations. However, ongoing challenges include limited office space and parking, a time-consuming billing process tied to impervious surface digitization, and fragmented records management. Recommended improvements include prioritizing expanded office space, streamlining GIS and billing processes, delegating SWPPP administrative tasks where possible, and consolidating stormwater records into a unified digital system accessible to both staff and the public. Strengthening inter-departmental collaboration and investing in larger-scale, regional stormwater planning studies will help the City meet future demands, integrate stormwater solutions with other infrastructure projects, and maintain an efficient, high-performing Stormwater Program.

Stormwater Program Funding Assessment

The City of Bozeman faces increasing pressure to sustainably fund its Stormwater Program, including operational needs, capital improvements, and regulatory compliance. A recent review by the FCS Group (FCS) confirms that current revenues and rate structures may not sufficiently address projected expenditures, particularly as costs for salaries, maintenance, and debt service outpace rate growth. Potential strategies include leveraging impact fees, grants, or debt financing to supplement ratepayer funding and better aligning stormwater fees with the cost of service by revisiting rate credit policies, considering single-family tiered rates, and ensuring City-owned properties pay stormwater charges. Integrating stormwater costs into transportation projects was also identified as an equitable option to avoid subsidizing stormwater infrastructure from other funds. To address these challenges comprehensively, it is recommended that the City undertake a needs-based rate study incorporating all program elements and deferred maintenance needs, thereby guiding future rate adjustments, evaluating facility-specific funding, and ensuring Bozeman's Stormwater Program remains financially resilient.

Priority-Based Action Plan

The City of Bozeman faces numerous challenges within its Stormwater Program, including compliance with MS4 regulations, aging infrastructure, rapid growth, and the need for sustainable funding. The 2025 Plan highlights a wide range of potential improvements across various elements of the program and provides a prioritized approach for the City to address these needs effectively.

1. **Resolve MS4 Compliance Violations**: To meet regulatory requirements, immediate action is required to resolve violations and establish robust post-construction management policies, inspection workflows, and enforcement mechanisms.

2. **Secure Sustainable Funding**: Transitioning to a needs-based utility rate system is essential for supporting the program's operations, maintenance, and capital improvements.

3. **Address Deferred Maintenance**: Aging infrastructure, particularly vitrified clay pipes, poses risks of failure and flooding. Accelerated replacement and proactive maintenance are critical to mitigating these threats.

4. **Complete West Bozeman Planning Studies**: Comprehensive studies are needed to address stormwater management in the rapidly growing western areas, including potential regional detention solutions and development coordination.

5. **Develop a Culvert Maintenance and Replacement Program**: Implementing a culvert maintenance program will help the City better manage these critical assets, reducing the risk of localized flooding and failures.

6. **Enhance Understanding of Open Channels:** A detailed assessment of open channels will identify bottlenecks, improve capacity, and enhance water conveyance to the East Gallatin River.

7. **Advance Capital Improvement Projects**: Continued investment in capital projects will address deferred maintenance, improve water quality, and enhance capacity to meet future needs.

8. **Enhance Operations and Maintenance Practices:** As funding becomes available, the City should expand staff, equipment, and maintenance programs to manage new and existing facilities effectively.

9. **Improve GIS Inventory and Asset Management:** Upgraded GIS systems and data management will increase operational efficiency and provide a clearer understanding of stormwater assets.

10. **Address Program Administration Improvements:** Minor improvements in administrative processes, such as billing and departmental coordination, can enhance program efficiency.

This strategic prioritization ensures Bozeman can address immediate concerns while planning for long-term growth and resilience. By implementing these recommendations, the City can create a sustainable, well-funded Stormwater Program that meets both current regulatory requirements and future community needs.

1.0 INTRODUCTION

The City of Bozeman (City) retained the consultant team of DOWL, Morrison-Maierle Inc (MMI), and FCS Group (FCS) to complete an update to the Bozeman *2008 Stormwater Facilities Plan* [1], referred to herein as the 2008 Plan. The objectives of the City's Stormwater Program are to protect public safety, improve water quality, and comply with environmental regulations. The City of Bozeman has a responsibility to the larger watershed community to reduce and treat non-point sources of pollution generated within the City Limits, and mitigate the impacts of impervious surfaces to the volume and timing of water delivery to the receiving streams. The Stormwater Division is committed to managing stormwater that does not degrade urban streams and wetlands and for the water flowing out of our city to be as clean or cleaner than when it flowed in. Since initiating its stormwater management program based on the recommendations of the 2008 Plan, the City has continued to expand its efforts, addressing stormwater-related challenges as they arise. Over the last decade, Bozeman has experienced unprecedented growth, resulting in a substantial expansion of its stormwater infrastructure. This rapid growth has placed increasing demands on the City stormwater staff and program. Additionally, the City faces new stormwater regulations related to its Municipal Separate Storm Sewer System (MS4) Permit issued by the Montana Department of Environmental Quality (MDEQ) [3]. With these dynamics at play, the City needs a new Stormwater Facilities Plan to identify programmatic gaps and provide recommendations to guide its Stormwater Program in the future.

2.0 PURPOSE

This document provides a comprehensive overview of the City's Stormwater Program as of 2023–2024. A summary of the City's stormwater facilities is included along with key program activities and tasks, the current levels of service provided, funding methods, and general recommendations for program improvements. The City has identified specific program elements requiring a higher level of assessment and more specific recommendations. These elements include:

- Open Channel Stormwater Conveyance (Section 6.8)
- Stormwater Planning Studies and Assessment of Regional Facilities (Section 8.1)
- Pre-1980 Facilities Capacity Evaluation (Section 8.2)
- Downtown Stormwater Infiltration Study (Section 8.3)
- Post-Construction Program Review and Recommendations (Section 9.6.1)
- Stormwater Program Funding Assessment (Section 11.0)
- Culvert Maintenance and Replacement Program (Section 13.0)

These program elements reflect areas where the City is currently facing challenges within the Stormwater Program, whether in managing assets, securing adequate funding, or the need for additional studies to understand system impacts and to identify capital improvement needs.

3.0 CITY OF BOZEMAN STORMWATER PROGRAM

The City's Stormwater Program is managed by the Stormwater Administration team, which includes five staff members: the program manager, a program specialist, two program technicians, and a project coordinator. This team is supported by operations and maintenance staff within two primary groups: the Water/Sanitary/Storm (WSS) Operation group and the Street Maintenance (SM) group. These groups include numerous employees responsible for various maintenance activities. The Stormwater Program funds two to three WSS employees, who focus their efforts on inspecting and maintaining underground facilities, and two SM employees, who are responsible for the inspection and maintenance of surface facilities. The Stormwater Administration team also collaborates with the City's Engineering Group on an as-needed basis for engineering support. Figure 1 illustrates the organizational structure of the City of Bozeman Stormwater Program.

The City's Stormwater Program is responsible for a broad range of activities and facilities, including annual operation, inspection, and maintenance of stormwater assets, developing capital improvement plans to address deferred maintenance and other capital needs, water quality compliance in accordance with MS4 Permit requirements, general program administration, and miscellaneous other stormwater/drainage needs. The stormwater facilities currently managed by the City include:

- Inlets
- Manholes
- Storm Drain
- Underground and Surface Storage (Ponds)
- Outfalls
- Culverts
- Curb Chases
- Miscellaneous Features

While many of these facilities are City-owned and located within the City's right-of-way, other stormwater infrastructure within city limits is owned and maintained by private entities, Gallatin County, Montana State University (MSU), and the Montana Department of Transportation (MDT). This mix of ownership complicates maintenance and oversight responsibilities. Additionally, the City maintains interest in numerous facilities it does not own or manage directly.

A significant portion of the current Stormwater Program effort is dedicated to complying with MDEQ MS4 Permit requirements. These requirements include conducting inspections, reviewing plans, documenting activities, and preparing annual Stormwater Management Program (SWMP) reports for MDEQ. A comprehensive understanding of the City's stormwater infrastructure is a key requirement of the MS4 Permit. Further details on regulatory compliance and MS4 activities are provided in Section 9.0.

Figure 2 illustrates the key program elements and activities of the City of Bozeman Stormwater Program.

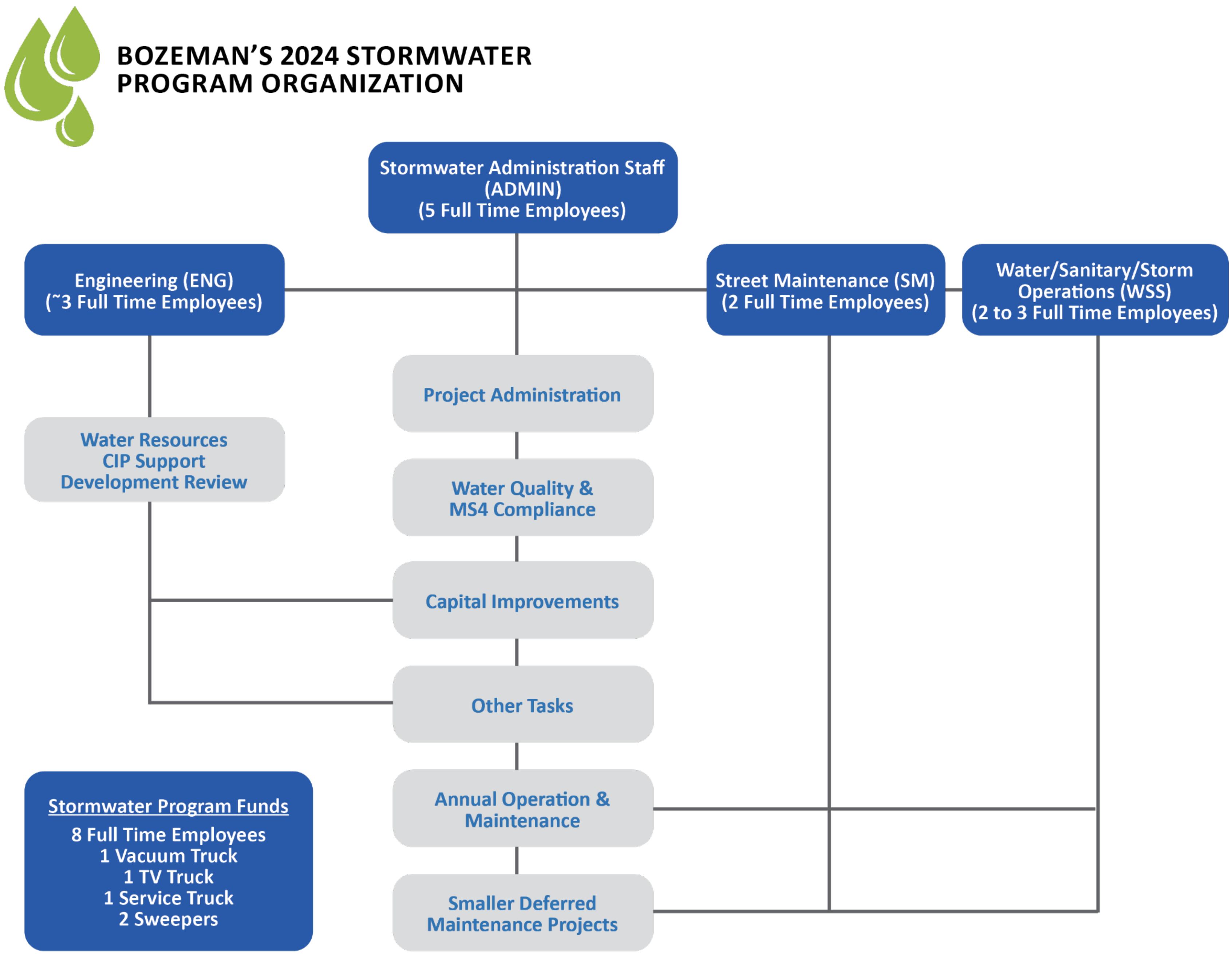

Figure 1 – City of Bozeman Stormwater Program – Organization Chart

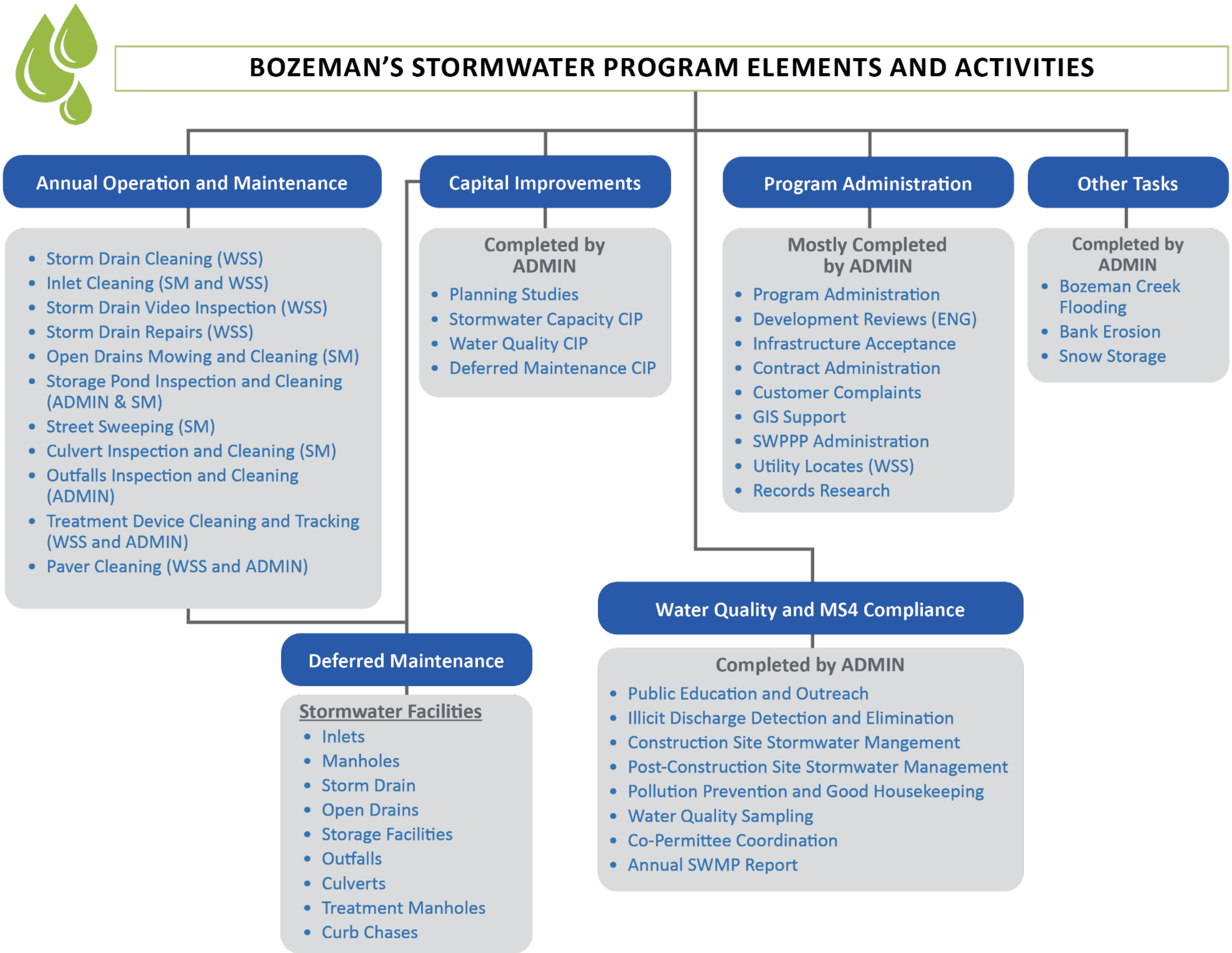

Figure 2 – Stormwater Program Elements and Activities

4.0 POLICY AND DESIGN CRITERIA

The 2008 Plan provided a summary of stormwater policies as they existed at that time and provided recommendations for policy and design criteria improvements. The design criteria and policy-related recommendations from the 2008 Plan are generally summarized as follows:

- Implement a Stormwater Utility as a funding vehicle for improvements to the City of Bozeman Stormwater Program.
- Inventory City Stormwater Assets (storm drains, manholes, inlets, treatment devices, ponds, outfalls, etc.) and develop a GIS database of stormwater assets.
- Provide best management practice (BMP) guidance for construction site runoff control and enforce requirements for MDEQ MS4 Permit compliance.
- Develop a plan for condition assessments, periodic inspections, and maintenance priority ranking of the stormwater facilities (asset management).
- Require runoff control to pre-development levels for multiple storm events rather than just for the 10-year storm.
- In addition to controlling the rate of runoff through detention storage, also require the treatment of the "water quality" or "first flush" storm runoff.
- Limit the use of the Rational Method and Modified Rational Method to smaller developments and utilize hydrograph routing methods for detention pond sizing for larger developments.
- Require that adequate clearance is maintained above the 100-year water surface elevations to building finished floor elevations and other structures.
- Require analysis of the 100-year storm in evaluating the risk of downstream flood damage due to runoff from the proposed development and in assessing flood risks to the proposed development from upstream runoff.
- Encourage the use of low-impact development (LID) techniques and Best Management Practices (BMPs) for runoff source control.
- Encourage the use of infiltration galleries to reduce surface runoff.
- Require that historic drainage patterns not be altered through development.
- Limit the depth of detention ponds for public safety.
- Require that detention ponds be equipped with overflow spillways to pass excess runoff safely during extreme storms.
- Limit stormwater spread widths within street sections.
- Limit outfall flow velocities into natural channels and require energy dissipation where necessary to prevent erosion and channel instability.
- Identify appropriate locations for regional detention facilities through storm drainage master planning to better emulate natural hydrology.

- Require that on-site stormwater facilities be constructed in accordance with the design intent and that they are operated and maintained by the landowners or property owners' associations for long-term functionality.
- Require a standardized format for storm drainage report submittals.

Since the 2008 Plan was adopted, the City of Bozeman has addressed several of the policy recommendations and has made great strides in developing a functioning Stormwater Program, with an initial emphasis on compliance with the MDEQ MS4 Permit requirements and TMDL limits [4]. Some of the key recommendations from the 2008 Plan that were addressed in these formative years are summarized as follows:

- Adopted Ordinance 1831 in June 2012, which created a Stormwater Utility and provided revenue collection for the operation and maintenance of the City's stormwater system.
- Adopted a new level of service and rate model in February 2015 to collect service fees based on individual property's impact on the stormwater system
- Inventoried stormwater assets and developed a GIS database of stormwater infrastructure.
- Developed a Stormwater Management Plan (SWMP), a guidance document for sediment control during construction, and began performing construction site runoff control inspections.
- Installed several water quality treatment devices focused on addressing the TMDL limits instituted for Bozeman Creek and Mandeville Creek and completed stormwater system upgrades to address some of the known deficiencies.
- Developed a GIS-based stormwater facility inspection and maintenance system for storm drains, inlets, and manholes.
- Developed a GIS system of past and planned future stormwater capital improvements.

The 2025 Plan provides additional recommendations as the City of Bozeman Stormwater Program continues to develop and mature. In particular, Section 6.0 provides recommendations for expanding the operations and maintenance program to address treatment units, stormwater ponds, outfalls, storm drains, culverts, and curb chases. Section 8 provides recommendations for using infiltration galleries to improve the level of service of the downtown storm drain system by reducing surface runoff and for initiating master planning efforts to identify regional outfall conveyance ditches and potential locations for regional detention ponds.

Independent of this update to the Stormwater Facilities Plan, the City also commissioned an effort in 2020 to update the City of Bozeman Design and Construction Standards. This included a complete rewrite of the stormwater design standards, which had not been updated since 1980. These new standards addressed the recommendations from the 2008 Plan and included many other updates consistent with the current state of practice. The new Design and Construction Standards were adopted in January 2025. Key updates from Chapter 6 (Storm Drainage Design) of the new Design and Construction Standards are summarized as follows:

- New design storm precipitation data is provided based on an analysis of Bozeman precipitation records.

- The design storm for conveyance sizing is updated to reflect a 10-year Minor Storm, flood hazard assessment for the 100-year Major Storm is now required, and the criteria for detention pond sizing is revised to require runoff control for the full range of storm events (2-year through 100-year).
- The stormwater Drainage Plan's requirements are detailed, including a standardized outline for the Stormwater Drainage report and guidance on completing a geotechnical/hydrogeologic evaluation when needed.
- Criteria are provided for what is to be included with the As-Built Construction Plans submittal for storm drainage facilities, including size, type, location, and elevation data.
- Criteria are provided for the design, construction, and maintenance of stormwater detention and retention ponds, including considerations for elevated water table conditions and multi-purpose use.
- The criteria for selecting appropriate hydrologic methods are updated to limit the use of the Rational Method and Modified Rational Method to smaller sites; they now include the NRCS hydrograph method and the EPA SWMM runoff simulation method.
- The design criteria are updated to include the requirements from the Montana Post-Construction Storm Water BMP Design Guidance Manual [5] for permanent (post-construction) water quality treatment for the water quality design storm (first 0.5 inches) and provides additional requirements for select sites such as fueling stations and similar types of facilities.
- Criteria are included for developing an Operation, Inspection, and Maintenance Plan for stormwater facilities, including identifying the responsible party, the requirements for a Stormwater Facility Inspection Form specific to the proposed facilities, a financial plan and sinking fund calculations for perpetual inspection and maintenance as well as periodic replacement of the facilities, a signed Waiver of Protest to the Formation and Participation in a Special Improvement District to fund delinquent operation, inspection, and maintenance activities, and a signed Acknowledgement of Stormwater Facility Maintenance Requirements.

5.0 INVENTORY OF STORMWATER FACILITIES

5.1 Summary GIS Data

Since the 2008 Plan, the City has made significant strides in inventorying and developing a GIS database of stormwater infrastructure. Most of the City's stormwater facilities have been spatially defined within a GIS database. The City's GIS department manages and maintains an Infrastructure Viewer, as shown in Figure 3, which includes stormwater infrastructure data, operations and maintenance records, record drawings, and capital improvement projects (CIP).

In March 2024, DOWL collaborated with the City's GIS department to gather the available stormwater GIS data. The City provided eleven unique datasets, though not all of these are currently accessible through the Infrastructure Viewer. DOWL reviewed this data, focusing on identifying any data gaps to guide refinements for a comprehensive stormwater asset database. A summary of the asset inventory is provided in Table 1. A comprehensive summary of DOWL's assessment of the eleven existing stormwater datasets is provided in Appendix A.

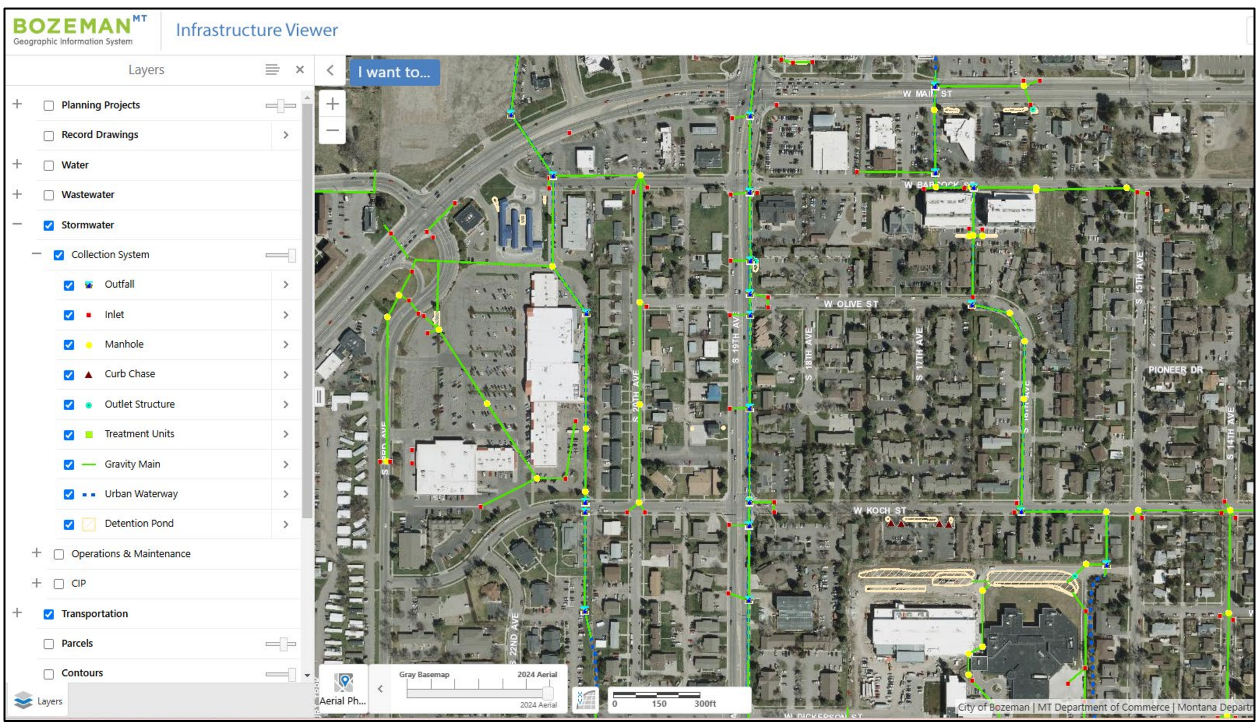

Figure 3 – Example of City of Bozeman Infrastructure Viewer and Stormwater Layers

Table 1 – City of Bozeman GIS Datasets

Datasets	Total Number/Length of Elements	Number/Length of Elements Managed by the City
Culverts (Culverts_Final_Draft)	721 18.1 miles	19.3 miles[1]
Detention Ponds (SWDetentionPond)	1,262 98.0 acres	15.7 acres
Gravity Main (SWGravityMain)	124.0 miles	79.2 miles
Inlets (SWInlets)	4,809	3,165
Manholes (SWManholes)	2,405	1,368
Outfalls (SWOutfalls)	704	550
Wells (SWWells)	16	16
Curb Chases (SWCurbChase)	237	131
Outlet Structures (SWOutletStructure)[2]	424	Unknown
Treatment Units (SWTreatmentSystem)	46	29
Open Channels (BozemanHydrology_202307)	106.7	Unknown

[1] The City estimates that there are 1.2 miles of culverts not shown within the GIS data
[2] Outlet structures estimated based on the online Infrastructure Viewer

5.2 Missing Datasets

Based on a review of the GIS data and information obtained from City Staff regarding their knowledge of the system, several facility types or GIS layers could be added for a more comprehensive representation of the stormwater system.

5.2.1 Drainage Area – Watersheds and Subbasins

Understanding the contributing stormwater drainage areas to key streams and stormwater features would be helpful for the management of the stormwater system. A GIS layer that delineates watershed boundaries of major streams and drainages—such as Bozeman Creek, Mandeville Creek, East Catron Creek, and Baxter Creek—would provide an important element to a comprehensive understanding of the system. A more detailed drainage area map of contributing areas to the storm drain outfalls, major culverts, and other critical stormwater infrastructure would provide the ability to assess infrastructure sizing, prioritize importance, and define boundaries for water quality treatment priorities.

5.2.2 Underground Storage Facilities

The City should consider creating a unique dataset for underground storage facilities that is distinct from detention ponds. Due to the high cost of real estate, these systems are increasingly favored over conventional surface ponds. The attributes and maintenance requirements for these facilities differ significantly from those of surface detention ponds, including the type and frequency of inspections as well as the appropriate cleaning methods and frequency. This dataset may require sub-categories due to differing maintenance requirements for various types of underground systems.

5.2.3 Stormwater/Groundwater Pumps

In many communities, stormwater pumps are included in GIS data sets to identify low points that cannot drain by gravity, often requiring lift stations and pump systems. The City currently doesn't have any stormwater pumps and only has some well pumps associated with wells along Bozeman Creek that pump groundwater for mitigating ice formation in the winter. It may be beneficial to create a unique GIS stormwater pump layer and include attributes such as the pump type, horsepower, and other key data to guide proper management and maintenance of these facilities.

5.2.4 Permeable Pavers

The City has implemented some low-impact development (LID) techniques, including the use of permeable pavers. It is recommended that parking areas or street sections using this LID technique be defined as a unique GIS layer with attributes to guide proper operations and maintenance of these assets. Periodic cleaning of these facilities is critical to their sustainability.

5.2.5 MS4 Boundary

A GIS layer defining the MS4 Permit boundary has not yet been developed but may become necessary in the future. Currently, the MS4 boundary corresponds to the Bozeman city limits. However, if Gallatin County is designated as an MS4 community, the boundary may extend beyond the city limits.

5.2.6 Other New Facilities Type

As the City continues to expand its stormwater infrastructure to include new facility types, additional GIS data layers may be needed to manage these assets effectively. LID facilities, such as bioswales, rain gardens, and other green infrastructure, will require regular inspection and maintenance, and appropriate GIS data will be beneficial in managing these new assets. Similarly, new treatment systems like filter units may need to be incorporated, either by expanding the existing treatment unit GIS layer or by creating unique layers for these facilities. As new stormwater facilities are added, careful consideration should be given to the most effective way to manage them within the GIS framework.

5.3 Data Gaps in GIS Data

Since the adoption of the 2008 Plan, the City has made significant progress in defining its stormwater infrastructure within the GIS framework. The existing datasets provide a solid foundation for understanding the system. However, gaps remain, particularly regarding stormwater facilities on the MSU campus. The culvert dataset also has gaps, and in several cases, it is unclear whether the asset exists, is operational, or has been abandoned. Additionally, Bozeman's rapid development may have introduced new private and public infrastructure that has not yet been incorporated into the GIS datasets.

Several datasets are missing key attributes that are crucial for fully defining the stormwater infrastructure. As further illustrated in Appendix A, key attribute gaps have been identified across different datasets. Filling in these missing attributes would be beneficial in assessing and managing its stormwater facilities. Many of these attributes, particularly those related to facility type, could benefit from establishing predefined domains for consistency in defining and classifying assets. For example, pre-defining the StorageType attribute choices for storage facilities as follows would result in a cleaner dataset:

- Detention_Pond
- Retention_Pond
- Underground_Storage
- Permeable_Paver
- Infiltration_Gallery
- Rain_Garden
- Other

Several datasets also contain attributes that may not contribute meaningfully to managing the stormwater infrastructure, resulting in unnecessary effort to populate them. The removal or modification of these attributes, as identified in Appendix A, should be evaluated to determine their relevance. Some of these attributes may not serve a stormwater-related function, and discussions to assess whether they should be retained or removed for data clarity and efficiency are recommended. Incorporating predefined domains for both new and existing attributes would help streamline the data collection process and ensure that only relevant and consistent information is gathered. Taking the time now to review the stormwater datasets, refine the attributes as appropriate, and establish predefined domains will provide long-term benefits by improving data accuracy, accessibility, efficiency, and utility for future stormwater management.

Significant gaps exist in the culvert data for areas near East Main Street/downtown, the Montana State University campus, and the historic district of Bozeman. The GIS data does not currently include any culverts in these regions. To address this issue, a thorough review of the open channel data and aerial imagery is recommended to identify potential culvert locations. These identified locations should then be field verified to ensure the data accurately reflects existing infrastructure.

5.4 Recommendations on GIS Data Collection

The City has made significant progress in its efforts to inventory and map its stormwater facilities within a GIS platform. This initiative has provided a strong foundation for managing the City's stormwater infrastructure by improving visibility and access to critical stormwater assets. However, while these initial steps have laid the groundwork, there is still room for improvement in developing a comprehensive stormwater asset management program. Additional efforts are needed to enhance data completeness, standardize attributes and domains, and implement condition assessments. These improvements will allow the City to better plan for maintenance, prioritize capital improvements, and ensure the long-term sustainability of its stormwater systems. Having a robust GIS dataset will be beneficial to the City in the future by minimizing and streamlining field data collection efforts for new infrastructure. Additional details of these recommendations are as follows:

5.4.1 Stormwater Asset Data Management Planning

It is recommended that the City conduct a review of the stormwater GIS datasets to determine the relevant attributes and domains to define and manage each stormwater asset effectively. Key considerations for this review include facility type, ownership, size, purpose, maintenance requirements, condition assessments, MS4 compliance requirements, and other potential data needs. Developing standardized and relevant attributes will provide a complete and accurate representation of the infrastructure. Establishing well-thought-out domains, such as type, material, and condition, will enhance consistency and accuracy across the database. It is recommended that the City's GIS department, Stormwater Administration, Street Maintenance, Water/Sanitary/Storm Operations, MSU, and stormwater asset management consultants collaborate to define the appropriate dataset for each stormwater facility and develop a plan to update the GIS datasets accordingly. The table in Appendix A outlines key elements of each dataset that may need to be removed, added, or fully populated and is intended to serve as a guide for this planning process.

5.4.2 Data Collection for Existing Data Gaps

Given the identified gaps in the existing datasets and the need to refine various attributes and develop domains, it is recommended that the City develop a plan to begin populating the additional data. Some of these tasks can be integrated into ongoing activities such as inspections, maintenance, and compliance reviews. For instance, video inspection crews could collect depth measurements from each pipe to the manhole rim while accessing the storm drain for cleaning and video inspections. Manhole rim elevations could be derived from LiDAR data, providing reasonably accurate reference points to calculate invert elevations, which can then be incorporated into the GIS database and stormwater model. Maintenance crews should also verify facility locations in the field and document discrepancies between the GIS data and actual facility locations during ongoing work. These discrepancies can then be remedied through future refinements to the GIS datasets.

In addition to leveraging City staff, the City could consider contracting this work out or hiring summer interns for several years to assist with data collection. A key step in this process will be developing a data collection resource that specifies the required attributes and domains, ensuring that data is collected consistently across different field teams. This data collection effort could be phased over several years to manage workload and cost.

While most of the City's stormwater GIS data includes necessary coordinate location information, there are areas where facility locations remain uncertain. Notably, the MSU campus has been identified as an area requiring further investigation to accurately map storm drains, inlets, culverts, and other facilities. It is recommended that the City develop a data collection plan to address this area and collaborate with MSU to gather the data.

5.4.3 Data Collection for New Stormwater Assets

Given the rapid development and new construction throughout Bozeman, it is recommended that the City consider requiring new developments to submit construction plans in a format that will facilitate the population of GIS data attributes for new stormwater facilities. This could be included as a requirement of the as-built construction drawings submittal process. This would help minimize and streamline the City's GIS data collection efforts and ensure that accurate, up-to-date stormwater data is available for planning, maintenance, and management.

5.4.4 Other Recommendations

It is recommended that photographs be incorporated into the GIS database for stormwater facilities. These images serve as a valuable resource, offering visual insights into structure type, condition, and potential issues. Additionally, they document changes over time, such as vegetation growth, structural wear, erosion, and sediment accumulation. By providing a clear visual record, photographs enable field crews, planners, and maintenance teams to assess facility conditions more efficiently, reducing the need for frequent on-site visits.

Additionally, it may be beneficial to include the pertinent as-built construction drawings for each project's storm drainage elements. These documents could be linked to each corresponding element in the GIS database, providing ready access during inspections and evaluations. Having these plan sheets readily available would allow staff and the public to more efficiently assess the condition of the infrastructure and provide valuable context when planning maintenance or designing related projects.

6.0 OPERATIONS AND MAINTENANCE

The City's stormwater operations and maintenance efforts are carried out through collaboration between the Stormwater Administration staff, Water/Sanitary/Storm (WSS) Operations staff, and Street Maintenance (SM) staff. Each group has distinct responsibilities:

- WSS Operations staff focus on the inspection and maintenance of underground stormwater facilities.
- SM staff are responsible for the inspection and maintenance of surface stormwater facilities.
- Stormwater Administration staff provide support to both groups, assisting with inspections and maintenance activities related to the storm drain infrastructure.

The following sections discuss the GIS tools used to manage and track stormwater infrastructure, provide an overview of the maintenance shop and equipment, and describe the City's facilities.

6.1 CityWorks and GIS Data

Since the 2008 Plan, the City has advanced its stormwater management by developing a GIS-based inspection and maintenance system for storm drains, inlets, and manholes—a key recommendation from the plan. Using CityWorks, the City efficiently tracks and manages inspection and maintenance activities, including inlet and manhole cleaning, painting and minor repairs, outfall inspections, and video inspections and cleaning of storm drain trunk lines and laterals. This system improves organization by generating work orders and displaying them on the CityWorks map, providing a clear visual representation of ongoing and completed maintenance. Once a work order is closed, the corresponding facility is updated on the map, ensuring accurate tracking of completed work. By implementing this system, the City has enhanced the efficiency and effectiveness of its stormwater maintenance efforts.

The City is organized into five maintenance districts, as illustrated in Figure 4. These districts are designed to facilitate the systematic maintenance of stormwater infrastructure. The goal is to service 20% of inlets, manholes, and storm drains annually, ensuring a consistent and comprehensive five-year maintenance cycle across all districts. Maintenance activities include video inspections and cleaning of storm drains, as well as cleaning inlets and manholes.

6.2 Maintenance Shops and Equipment

The City's maintenance operations are based at the City Shops Complex, located at 814 N. Bozeman Avenue. This site serves as the central hub for WSS, SM, and Park Maintenance staff and accommodates personnel, equipment, and material storage for a variety of municipal services. Currently, the complex includes six buildings hosting roughly 40 total staff and a wide array of equipment, including mowers, trucks, dump trucks, vacuum trucks, excavators, skid steers, and other machinery critical to daily operations.

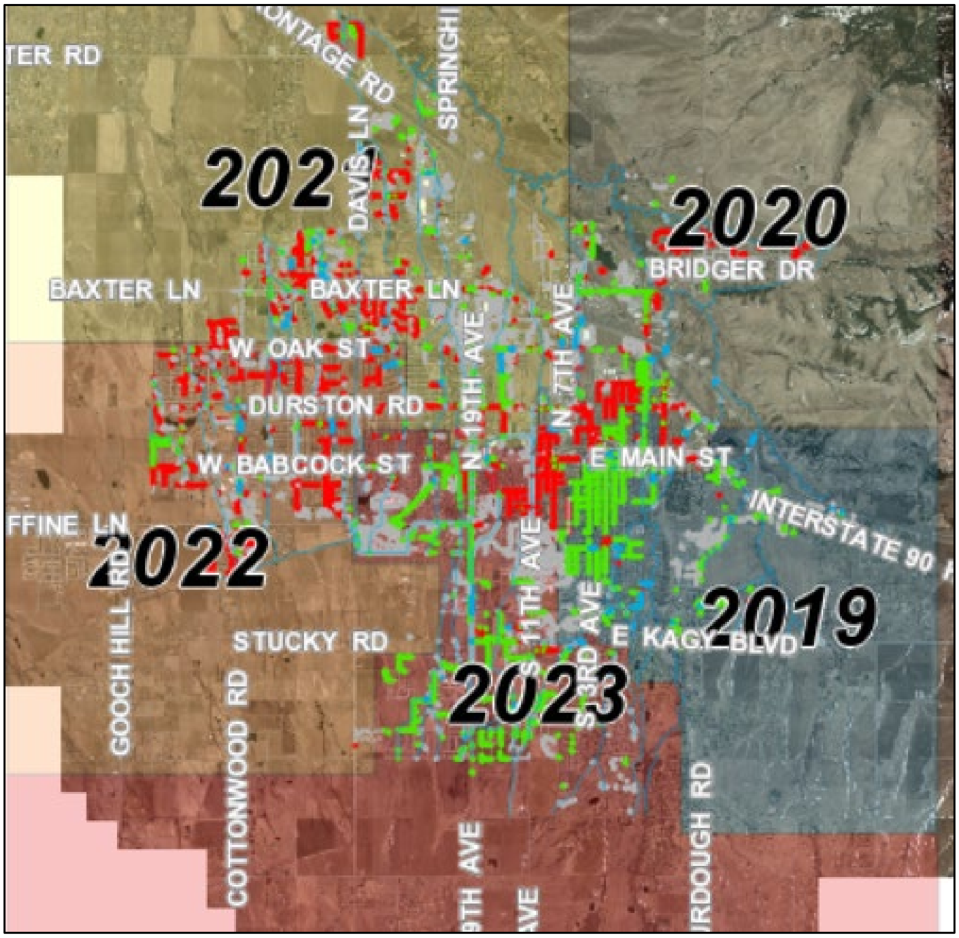

Figure 4 — City of Bozeman Maintenance Districts

Although not all equipment and facilities at the City Shops complex are dedicated to the Stormwater Program, the site is nearly at full capacity. There is limited space remaining to house additional equipment or staff. This lack of space presents a challenge as the City grows and the need for maintenance expands. With increased stormwater infrastructure and rising operational demands, the need for additional staff and equipment will further strain the already limited space at the current site.

To address these challenges, the City will need to consider expansion options. This may involve identifying a larger site and relocating the entire complex or establishing multiple maintenance facilities to distribute staff and equipment across Bozeman better. Proactive planning and budgeting for these needs will be essential to ensure the City can continue to meet its growing maintenance needs effectively and efficiently into the future.

6.3 Inlets

Storm drain inlet maintenance is a shared responsibility between SM and WSS, with each managing specific tasks. SM oversees surface-level features such as cleaning and painting inlet grates, while WSS takes care of underground maintenance, including sump cleaning. These tasks are typically performed along with the maintenance of manholes, mains, and laterals. A two-person crew equipped with a vac truck conducts cleaning, followed by video inspections using a TV truck or push cam. Two FTEs focus their time on stormwater maintenance and video inspections, typically allocating roughly 60% of their time to vac truck operations and 40% to video inspections. Across WSS and SM, approximately three FTEs are dedicated to fulfilling stormwater work orders.

There are approximately 3,200 City and MDT inlets; the City is responsible for some MDT inlets, although the exact number is not known. Maintenance operates on a five-year cycle within each maintenance district (Figure 4), although some inlets require more frequent cleaning due to debris or ice buildup. Undersized inlets are particularly prone to plugging. Currently, about 15% (480 inlets) are cleaned annually, falling short of the 20% goal by approximately 160 inlets. Meeting the five-year cycle target will require increasing annual cleaning capacity to include these additional inlets.

Figure 5 — Inlet Cleaning

6.4 Manholes

WSS is responsible for manhole cleaning, while SM occasionally completes repairs to manhole castings. WSS averages two casting repairs annually. Grade adjustments or casting repairs are completed using a Mr. Manhole system mounted on a skid steer (Figure 6). City staff rate their performance in this area high, with no recommendations for improvement.

There are approximately 1,400 City and MDT storm sewer manholes; the City is responsible for some MDT manholes. Manholes have not presented many issues for the City and are cleaned along with inlets, mains, and laterals. Currently, about 15% (210 manholes) are cleaned annually, falling short of the 20% goal by approximately 70 manholes. Meeting the five-year cycle target will require increasing annual cleaning capacity to include these additional manholes.

Figure 6 – Example of Mr. Manhole Grade and Casting Repair

6.5 Storm Drains

The City is responsible for the video inspection, cleaning, and repair of approximately 79 miles of storm drain infrastructure, consisting of 19.2 miles of laterals and 60 miles of trunk lines. To help differentiate between the two in the GIS data, laterals are defined as storm drains with a diameter of 12 inches or less, while trunk lines are those exceeding 12 inches in diameter. This maintenance responsibility includes all City-owned storm drains and roughly half of the MDT storm drain system.

6.5.1 Cleaning and Video Inspections

The City is divided into five maintenance districts. A crew of two WSS operators manages the TV inspection duties, with the goal of cleaning and video inspecting 20% of the city-owned storm drain pipe network annually. Typically, pipes are cleaned before undergoing video inspection. A push camera is used for lateral inspections of problematic pipes and project design. New infrastructure must be TV-inspected prior to City acceptance, with any necessary cleaning performed by the contractor. Once accepted, the infrastructure enters the standard 5-year City maintenance cycle.

In 2019, the City set a target to clean and inspect 13.2 miles of pipe (20% of the storm drain system). Since then, the system has grown from 66 miles to 79 miles. Further, inspection and cleaning have averaged 12% (approximately 9.5 miles) of the system per year, along with approximately two additional miles of inspections for new infrastructure and non-work order tasks. This pace has extended the maintenance cycle to approximately seven years, falling short of the 5-year goal.

The initial cleaning cycle of storm drain assets is expected to streamline future cleaning and inspections, which will likely improve the rate of completion. To improve efficiency, short clay pipe laterals could be inspected using push cameras after cleaning, potentially adding an extra mile of inspections annually with support from administrative staff. Additionally, districts with a high concentration of reinforced concrete pipe (RCP) and polyvinyl chloride (PVC) storm drains may require less frequent inspections. Vitrified clay pipe (VCP) should remain on a more frequent schedule due to its higher maintenance needs.

Figure 7 – Video Inspection Equipment

6.5.2 Repairs and Locates

WSS staff conduct approximately five storm drain repairs annually, each requiring an estimated 40-50 hours to complete. While SM is not responsible for the actual repairs, a two-person crew is dedicated to repaving once WSS Operations has completed the repair and backfilling. Additionally, stormwater administrators dedicate about 80-100 hours annually to preparation activities for excavations and addressing bore strikes. City staff consider their performance in this area to be meeting expectations, with no significant areas of improvement currently identified.

Figure 8 – Storm Drain Repair on N. Church St.

6.6 Water Quality Treatment Units

WSS is responsible for maintaining 29 stormwater quality treatment manholes, dedicating approximately 200 to 400 hours of labor annually to this task. Most of these manholes are Contech CDS units, which the City prefers because of their stable, concrete structure and user-friendly design, which makes them easier to clean and maintain. However, the City is open to other types of units, provided they can provide similar structural stability, performance, and ease of maintenance.

The City effectively maintains its treatment manholes, ensuring they remain clean and functional. Each treatment manhole is cleaned at least once per year to support annual reporting requirements and maintain sediment capture efficiency. For manholes with higher sediment loads, biannual cleanings are conducted to optimize performance. The sediment depth in treatment manholes is measured to determine the total sediment removed annually, and this data is documented in the annual Stormwater Management Plan (SWMP) report, per the MS4 requirements.

Figure 9 – Treatment Unit Debris Inspection and Measurement

6.7 Roadside Ditches

SM performs roadside ditch mowing primarily for aesthetics, fire prevention, and to maintain flow conveyance and dispersion. In 2023, crews logged 340 hours of mowing, which was tracked through CityWorks. While roadside ditches convey stormwater, they are not considered a primary stormwater facility.

6.8 Open Channel Stormwater Conveyance

Although much of the City's storm drainage infrastructure discharges into open channels, maintenance of these stormwater conveyances is mainly reactive, with issues addressed only when they become significant problems. Bozeman's stormwater open channels span 106.7 miles, including natural drainage ditches, irrigation ditches, and stormwater conveyance ditches. However, they are not part of a regular maintenance program and lack specific maintenance goals or dedicated funding for ongoing upkeep.

Several challenges hinder the City's ability to manage and maintain these facilities effectively. A significant issue is that the ownership and maintenance responsibility for these facilities is not clearly understood. This will require substantial time and effort to resolve and will involve extensive title research, legal analysis and interpretation of State statutes, and collaboration with other stakeholders to guide the City in establishing clear policies on what the City can and cannot do regarding these facilities. Another major challenge is access to the open channels. Many developments were built directly adjacent to these facilities, limiting maintenance access and complicating efforts to perform regular or emergency upkeep.

With no control over these ditches or development adjacent to these facilities, the City is at risk of losing the ability to convey stormwater from within the City effectively.

To address these challenges, it is recommended that the City begin by inventorying and conducting an initial assessment of the open channel stormwater conveyances. This process would help identify the channels most critical to the City's stormwater management and determine which channels fall under the City's responsibility. Such information would provide a clear focus for subsequent legal research and policy development efforts.

6.9 Detention Ponds

Stormwater Administration staff dedicate approximately 800 hours annually to preparing for and inspecting presumed city-owned stormwater features. The City does not currently maintain privately owned stormwater facilities. Minor cleaning is conducted on approximately three City-owned stormwater ponds per year, as time permits. This maintenance typically involves sediment, debris, and vegetation removal in the immediate vicinity of the outlet pipes and structures. However, no significant cleaning efforts, large-scale sediment removal, or clearing of wetland vegetation and invasive plant species are completed.

Major cleaning efforts are crucial, as accumulated sediment and vegetation overgrowth reduce the storage capacity of these ponds, impacting their long-term functionality. Some stormwater ponds also fail to perform as designed due to elevated groundwater levels, which diminish storage capacity and encourage wetland vegetation growth. These affected facilities require thorough review and potentially retrofit designs to restore their intended functionality.

MDEQ has highlighted violations in the City's MS4 Permit obligations regarding the management of these facilities and has requested a more formal inspection, maintenance, and enforcement process to manage both public and private facilities. In response, the *Post-Construction Program Review and Recommendations* report [2] was completed in July 2023 and offers guidance on enhancing the operations and maintenance of both City-owned and private post-construction stormwater facilities. Further details are provided in Section 9.6.1.

Figure 10 – Sediment Removal Maintenance on a Detention Pond

6.10 Underground Storage Facilities

The underground storage facilities are cataloged in the City's GIS system and are located within the detention ponds layer. No formal inspection or maintenance program currently exists for these assets. Maintenance activities are reactive, occurring only when water begins to pond in streets or other issues become visible. At that point, the facilities are inspected and cleaned as necessary.

A key challenge with underground storage facilities is the lack of access portals or inspection points in some systems. This design limitation makes it difficult, and in some cases impossible, to conduct routine inspections or cleaning. Without proper access, sediment and debris can accumulate undetected, reducing storage capacity and impairing system functionality over time.

Proactive inspection and maintenance of underground storage facilities could prevent costly repairs, improve system performance, and extend the lifespan of these assets. However, some of the facilities may require retrofit design to include access for proper inspection and maintenance.

6.11 Stormwater Outfalls

The City inspects outfalls annually as part of the Illicit Discharge requirement of the MS4 Permit. This includes annual inspections of 10 high-priority outfalls and inspection of all lower-priority outfalls during each 5-year MS4 General Permit term. While the primary focus is on illicit discharge detection, the City also provides a condition assessment that focuses on outlet condition and erosion. A two-person crew of Stormwater Administration staff, equipped with a laptop and pickup truck, dedicate approximately 300 hours annually to fieldwork. A single staff member provides an additional 80 hours of preparation and office support. There are approximately 700 pipe terminus features, 480 of which are classified as regulatory outfalls. While inspecting every pipe terminus is not mandatory, the City exceeds the MS4 Permit requirements by inspecting over 20% of these features annually.

6.12 Bozeman Creek Wells and Pumps

The City maintains several wells along Bozeman Creek to mitigate flooding due to ice jams during winter months. Annual maintenance requirements are minimal and vary based on need. Street Maintenance oversees well operations, with pump servicing typically performed in the summer to ensure reliable performance in winter. The operations and maintenance of these wells and pumps require minimal time.

6.13 Drainage Culverts

The City currently performs minimal maintenance of culverts within city limits. SM staff inspect and clean culverts with trash racks during or after storm events on an as-needed basis to prevent flooding and mitigate traffic impacts. Other culvert-related issues are addressed reactively as they arise.

Due to the lack of proactive inspection, maintenance, and repair, there is a clear need for a Culvert Maintenance and Replacement Program. A framework for establishing this program is outlined in Section 13.0.

6.14 Curb Chases

Curb chases are maintained reactively by SM, with cleaning performed using a vac truck or manual labor with a shovel and brooms when needed. In 2024, crews logged 260 hours of inspecting and maintaining curb chases, which may not include cleaning activities associated with ice removal. The Stormwater Administration staff cleans them on occasion, which totals roughly 20 hours per year. SM always performs ongoing maintenance, and these facilities are constantly in need of cleaning due to sediment and ice accumulation throughout the winter. To reduce future maintenance demands, it is recommended that new developments avoid the use of high-maintenance features such as curb chases and valley gutters to the extent possible. If these facilities are required, consideration should be given to providing as much slope on these facilities as possible to improve conveyance and reduce sediment and ice accumulation. This would help to reduce future maintenance requirements.

Figure 11 – Curb Chase Cleaning

6.15 Utility Locates

Utility locates for City facilities are primarily contracted out, with WSS staff providing support and orchestrating after-hours emergency locates. While this work requires minimal staff time, it does require that staff be available to be present to witness cross-bores and other sensitive activities. One staff member is made available during business hours for assistance, while the on-call staff member, in coordination with WSS, is responsible for after-hours requests. The objective of this activity is to comply with State law, prevent infrastructure damage, and ensure timely service.

Figure 12 – Utility Locate on Mendenhall St

6.16 Street Sweeping

Street sweeping serves a dual purpose: it improves the city's appearance by maintaining clean streets and is also one of the most cost-effective methods for enhancing water quality. By removing trash, sediment, and other contaminants, street sweeping helps prevent pollutants from entering the storm drain system. This essential function is performed by the SM team, with sweeping operations typically concentrated during spring and fall cleanup periods. Beyond the key cleanup periods, the street sweeper is utilized daily whenever weather conditions permit, with efforts focused on bike lanes throughout the summer and systematically working to cover the entire City as time allows.

The City expects to receive a new street sweeper, which will bolster its capacity for these operations. Despite this, the primary limitation in expanding street-sweeping efforts is staffing. With additional personnel, the City could significantly increase the frequency and coverage of street sweeping activities, further improving both aesthetics and environmental outcomes.

https://www.elginsweeper.com/about/whats-new/6-ways-to-prepare-your-street-sweeper-for-leaf-season

Figure 13 – Fall Street Sweeping

6.17 Porous Paver Cleaning

Porous pavers are used to reduce surface runoff through stormwater infiltration. The City maintains porous paver systems along North 7th Avenue and at City Hall. While streets with porous pavers are swept at the same frequency as other streets, maintaining these areas requires additional effort. This includes inspections, maneuvering around features, and maintenance coordination. Maintaining and cleaning the pavers is a collaborative effort between SM, WSS, and Stormwater Administration.

6.18 Recommendations

The City excels in the operation and maintenance of water quality treatment units, stormwater outfalls, and Bozeman Creek wells and pumps, exceeding expectations and ensuring the reliability and effectiveness of these critical systems. However, the City is not currently meeting the targeted 20% annual pipe inspection goal or its five-year maintenance cycle for stormwater facilities with existing operations. Inlets, manholes, and storm drains are currently inspected and cleaned on a roughly seven-year cycle. To address this shortfall, modernized equipment—specifically a replacement TV truck and a vacuum truck—has been included in the Capital Improvement Plan (CIP) for Fiscal Year 2026. Additional equipment would enhance the City's ability to meet its operation and maintenance goals; however, the current limited storage space prevents the acquisition of more vehicles. Further, facilities such as detention ponds, culverts, and underground storage systems are not actively or systematically inspected and maintained. The current approach focuses on reactive maintenance, often triggered when problems, such as water ponding in streets, arise. It is recommended that additional staff, equipment, and maintenance facilities be considered to support expanded operations to overcome this shortfall.

As an initial step, it is recommended that the City develop a Level of Service (LOS) Matrix to define activities associated with different levels of operations and maintenance service, the associated staffing and equipment needs, and the desired outcomes. This matrix of information would provide a framework for assessing needs and costs for enhancing the operations and maintenance of the City's stormwater system to various degrees. An example Level of Service (LOS) matrix is described below, utilizing three Levels of Service and the associated objectives:

- Minimum LOS (Bronze):
    - Maintains the current seven-year cycle for inlets, manholes, and storm drains.
    - Adds basic inspection and maintenance for ponds, culverts, and underground storage facilities.
    - This level represents a modest improvement over the current reactive approach to some facility types while reducing risks by being somewhat more proactive.
- Proactive LOS (Silver):
    - Increase inspection and maintenance efforts of stormwater infrastructure, including ponds, culverts, and underground storage facilities, to meet the desired five-year maintenance cycle target.
    - Requires additional staff, equipment, and resources to systematically address all stormwater assets.
- Best Practices LOS (Gold):
    - Increases inspection and maintenance efforts such that maintenance of critical infrastructure can be accomplished more frequently than every 5 years.
    - Incorporates best practices for stormwater management, such as advanced condition assessments, preventative maintenance, and targeted rehabilitation programs.
    - Requires the highest investment in staff, equipment, buildings (and land) to achieve optimal long-term system performance.

These examples are offered as a starting point, but the City can modify these Level of Service objectives to best fit its needs. The resulting Level of Service Matrix can then be used to assess the associated costs, including staff, equipment, land, and other resources required to meet these targets. The challenge lies in securing sustainable funding to support these variable service levels. This is typically provided through stormwater utility rates. A needs-based stormwater utility rate analysis would provide valuable insight into how the City could align its financial strategy with its operational goals for the Stormwater Program.

Drainage culverts are not currently part of the systematic maintenance program, with no dedicated funding, exacerbating the challenges of aging infrastructure and deferred maintenance. To address these shortcomings, it is recommended that the City establish a Culvert Maintenance and Replacement Program. This program would define clear maintenance objectives, inspection cycles, and resource allocations for maintaining this critical stormwater facility type. Further details and recommendations for this program are provided in Section 13.0.

Due to the various complexities involved with open channel stormwater conveyances, it is recommended that the City begin initial investigations to map their locations, general sizes, capacity constraints, and contributing drainage areas of storm drain outfalls that discharge to them. This initial data collection will provide a foundation for focusing on the next steps to support informed policy discussions.

7.0 DEFERRED MAINTENANCE AND REPLACEMENT

The City's stormwater deferred maintenance is categorized by facility type. Facility quantities and ownership data are based on the most recent GIS information provided by the City in June 2024. To assess deferred maintenance, City staff completed detailed questionnaires and populated matrices with their best estimate of the current state of their stormwater facilities. The following sections summarize the findings based on this input.

7.1 Inlets

There are 3,165 City and MDT inlets in the City of Bozeman. The City is responsible for cleaning, repairing, and replacing all City and some MDT inlets. The condition for these inlets was estimated by City staff and is summarized in Table 2. SM and WSS Operations share the responsibility for replacing inlets with the goal of progressively replacing the worst inlets/castings. Currently, the City replaces the worst inlets/castings at a rate of approximately two per year; however, nearly 390 inlets need full replacement as many of these inlets are undersized and are prone to plugging. It is recommended that the City consider implementing an inlet replacement program and include this in capital improvement planning with an objective of replacing these inlets over the next 10 to 20 years (20 to 40 inlets a year).

Figure 14 – Undersized Inlet and Lateral on S. Willson Ave. and W. Olive St.

Table 2 — Inlet Deferred Maintenance

Condition	Recommended Action	Percentage of Inlets	Number of Inlets	Comments
Good Condition	No Action	86.8%	2,747	
Fair Condition	Minor Repairs	1.0%	32	Grate Replacement
Poor Condition/Undersized	Full Replacement	12.2%	387	All small 12”x12” or 14”x14” grates that require replacement
	TOTAL	100%	3,165	Includes all City and MDT inlets

7.2 Manholes

Similar to inlets, the City is responsible for the maintenance of all City and some MDT manholes. There are nearly 1,400 City and MDT manholes. The estimated conditions of these structures are summarized in Table 3. While the castings are generally in good condition, the rims and lids sometimes require replacement as the pavement around them settles. The key deferred maintenance objective is to prevent damage to castings by plows and graders. This can typically be achieved within a year with proper communication and a dedicated budget for castings and lid replacements. Structural repairs of manholes are not common, and staff can only recall having done two or three manhole structure repairs in the last 10 years. There is very little deferred maintenance associated with manholes, and the City’s current operations and maintenance seem adequate to address issues as they arise.

Table 3 — Manhole Deferred Maintenance

Condition	Recommended Action	Percentage of MH	Number of MH	Comments
Good Condition	No Action	97.0%	1,327	
Fair Condition	Minor Repairs	2.0%	27	Grade adjust or patch infiltration
Poor Condition/Undersized	Full Replacement	1.0%	14	Includes the 10 manholes with heavy lids
	TOTAL	100%	1,368	Includes all City and MDT manholes

7.3 Storm Drains

7.3.1 Vitrified Clay Pipe (VCP)

There is an estimated 8.5 miles of VCP within the City of Bozeman, and nearly all of it is in poor condition and/or undersized. The replacement of VCP currently occurs opportunistically, often aligned with other capital improvement projects involving road reconstruction or replacement of other utilities. The City set a goal in 2015 to replace all 14 miles of clay tile trunk lines by 2030 but has fallen behind schedule. Significant progress was made until 2018 when factors such as contractor shortages, rising costs of city street rehabilitation projects, and a lack of willing SID partners slowed progress. At the current replacement rate of 0.3 to 0.5 miles per year, meeting the 2030 target appears unlikely.

To address this shortfall, the City intends to establish a revised VCP replacement goal, explore alternative rehabilitation methods such as sliplining and pipe-bursting, and integrate pipe replacement into other planned projects within the same area. Additionally, the City will adopt a more targeted approach, prioritizing pipe replacements based on criticality and likelihood of failure. These measures aim to address the most urgent needs while identifying cost-effective solutions for replacing aging infrastructure. Further details on the VCP replacement strategy are outlined in Section 8.4.3.

Figure 15 — Downtown VCP Pipe Condition

7.3.2 Laterals

Storm drain laterals are defined as pipes with diameters less than or equal to 12 inches. It is assumed that the City is responsible for all City storm drains and half of the MDT storm drains, equating to 19.2 miles of laterals. The condition breakdown of the laterals, which includes VCPs, is shown in Table 4. Lateral replacements are coordinated with adjacent main replacements and with some of the undersized inlet replacements. The majority of the 5.2 miles of full replacement is for the aging VCP pipe laterals. The City typically averages one lateral pipe repair each year.

Table 4 — Storm Drain Laterals (D <= 12 inches) Deferred Maintenance

Condition	Recommended Action	Percentage of Pipe	Miles of Pipe	Comments
Good Condition	No Action	72.4%	13.9	
Fair Condition	Minor Repairs	0.5%	0.1	On Pre-1980 Systems
Poor Condition/Undersized	Full Replacement	27.1%	5.2	Mostly VCP Replacement
	TOTAL	100%	19.2	Includes all City laterals and half of MDT laterals

Figure 16 – Undersized Storm Drain Lateral on Main and Grand

7.3.3 Trunk Lines

Storm drain trunk lines are defined as pipes with diameters greater than 12 inches. It is assumed that the City is responsible for all City storm drains and half of the MDT storm drains, equating to 60.0 miles of trunk lines. The deferred maintenance for the trunk lines, which includes VCPs, is shown in Table 5.

The majority of the 1.5 miles of full replacement is for the aging VCP. The City averages about two trunk line pipe repairs each year. Highly deteriorated trunk lines are typically not repaired until the entire line can be replaced.

Table 5 — Storm Drain Trunk Lines (D > 12 inches) Deferred Maintenance

Condition	Recommended Action	Percentage of Pipe	Miles of Pipe	Comments
Good Condition	No Action	90.0%	54.0	
Fair Condition	Minor Repairs	7.5%	4.5	Non-clay pipes with a Grade 2 or worse rating.
Poor Condition/Undersized	Full Replacement	2.5%	1.5	Mostly VCP Replacement
	TOTAL	100%	60	Includes all City trunk lines and half of MDT trunk lines

7.4 Water Quality Treatment Units

The City maintains 29 of the existing water quality treatment units. The City is proactive in maintaining the existing water quality treatment units since sediment removal and associated maintenance are driven by annual MS4 reporting requirements. As such, there is no deferred maintenance associated with treatment units. The City's goal is to keep pace with this maintenance as Bozeman continues to grow and more treatment units are added to the system.

Table 6 — Treatment Units Deferred Maintenance

Condition	Recommended Action	Percentage of MH Treatment Units	Number of MH Treatment Units	Comments
Good Condition	No Action	100.0%	29	
Fair Condition	Minor Repairs	0.0%	0	
Poor Condition/Undersized	Full Replacement	0.0%	0	
	TOTAL	100.0%	29	

Figure 17 – Vac Truck Cleaning of a Treatment Unit

7.5 Open Channels Stormwater Conveyance

There are 106.7 miles of open channel stormwater conveyances; however, no goals or funding have been established for their maintenance due to the lack of understanding of this critical component of the City storm drainage network. City staff have estimated the condition of these open drains, as summarized in Table 7.

Table 7 — Open Channels Deferred Maintenance

Condition	Recommended Action	Percentage of Open Drain	Miles of Open Drain	Comments
Good Condition	No Action	10.0%	10.7	
Sediment and Debris Issues	Open Drain Cleaning	55.0%	58.7	
Fair Condition	Minor Repairs	10.0%	10.7	
Poor Condition/Undersized	Full Replacement	25.0%	26.7	
	TOTAL	100%	106.7	

Figure 18 – Vegetation Overgrowth into Open Channel Along Davis Lane

7.6 Detention Ponds

The City performs limited maintenance on City-owned ponds but does not conduct major maintenance activities. Additionally, no maintenance is performed on privately owned detention ponds. As a result, the deferred maintenance associated with surface ponds is substantial. It is estimated that 57% of all detention ponds within the City require minor to major maintenance and repairs or even full retrofit design, as summarized in Table 8. Most detention ponds are privately owned. In contrast, only 5% of City-owned ponds are anticipated to be in poor condition or undersized. The *Post-Construction Program Review and Recommendations* report [6], completed in July 2023, provides detailed guidance on improving the operations and maintenance of both City-owned and privately managed post-construction stormwater facilities. Further insights can be found in Section 9.6.1.

Table 8 — City-Owned and Private Detention Ponds Deferred Maintenance

Condition	Recommended Action	Percentage of Ponds	Acres of Ponds	Comments
Good Condition	No Action	43.0%	39.1	
Fair Condition	Minor Repairs	36.0%	32.8	
Poor Condition/Undersized	Major Repairs / Redesign	21.0%	19.1	
	TOTAL	100%	91.0	Total acreage of surface features.

Table 9 — Subset — City-Owned Detention Ponds Deferred Maintenance

Condition	Recommended Action	Percentage of Ponds	Acres of Ponds	Comments
Good Condition	No Action	66.0%	10.4	
Fair Condition	Minor Repairs	29.0%	4.6	
Poor Condition/Undersized	Major Repairs / Redesign	5.0%	0.8	
	TOTAL	100%	15.7	

Figure 19 – Wetland Overgrowth in the Laurel Glen Detention Pond

7.7 Stormwater Outfalls

The City manages 550 outfalls, excluding privately owned ones, with ownership typically linked to the associated pipe or pond. Approximately 30 outfalls require replacement due to poor conditions or being undersized, and 140 need minor repairs to address issues such as erosion and scour. Improved tracking of erosion conditions and adjacent landowner information is recommended to enhance management. While current maintenance procedures will remain unchanged, in the future, work orders will be created for City-owned outfalls that need attention. Additionally, introducing a standardized notification form for private owners could encourage collaboration and accountability for privately owned outfalls in poor condition. Deferred maintenance will be addressed over time through continued operations and maintenance efforts.

Table 10 — Outfalls Deferred Maintenance

Condition	Recommended Action	Percentage of Outfalls	Number of Outfalls	Comments
Good Condition	No Action	60.0%	330	
Sediment and Debris Issues	Outfall Cleaning	10.0%	55	
Fair Condition	Minor Repairs	25.0%	138	
Poor Condition/Undersized	Full Replacement	5.0%	28	
	TOTAL	100.0%	550	

Figure 20 – Erosion at a Stormwater Outfall

7.8 Bozeman Creek Wells and Pumps

Bozeman Creek wells and pumps are checked annually, and there are no deferred maintenance needs associated with these facilities.

7.9 Drainage Culverts

The City oversees 19.3 miles of culverts, with condition estimates provided by staff as summarized in Table 11. Currently, there are no formal deferred maintenance efforts or dedicated funding for these facilities, as culverts were not included in the original Stormwater budget. It is recommended that the City establish a Culvert Maintenance and Replacement Program first to identify the City-owned culverts and then conduct comprehensive inspections to assess their condition and maintenance requirements. This program will help quantify deferred maintenance needs and guide prioritization of remediation efforts. It is recommended that culvert remediation be included in future capital improvement planning. Further details of the culvert condition evaluation are provided in Section 13.0.

Table 11 — Culverts Deferred Maintenance

Condition	Recommended Action	Percentage of Culvert	Miles of Culvert	Comments
Good Condition	No Action	40.0%	7.7	
Sediment and Debris Issues	Culvert Cleaning	40.0%	7.7	
Fair Condition	Minor Repairs	15.0%	2.9	
Poor Condition/Undersized	Full Replacement	5.0%	1.0	
	TOTAL	100.0%	19.3	

7.10 Curb Chases

There are about 130 curb chases maintained by the City, and the deferred maintenance of these facilities is summarized in Table 12. Most curb chases are in good structural condition; however, 10% are in fair or poor condition and require minor maintenance or full replacements.

Table 12 — Curb Chases Deferred Maintenance

Condition	Recommended Action	Percentage of Curb Chase	Number of Curb Chase	Comments
Good Condition	No Action	90.0%	118	
Fair Condition	Minor Repairs	5.0%	7	
Poor Condition/Undersized	Full Replacement	5.0%	7	Broken bolts, old standards
	TOTAL	100%	131	

7.11 Recommendations

Due to the City's diligent maintenance efforts, there is little to no deferred maintenance on its water quality treatment units and Bozeman Creek wells and pumps. These facilities exemplify the benefits of consistent upkeep and serve as a model for what could be achieved with more regular maintenance of the remaining stormwater infrastructure. To achieve this, it is recommended that the City develop a structured approach to addressing deferred maintenance for its stormwater facilities, including inlets, manholes, storm drains, treatment manholes, open channels, detention ponds, outfalls, culverts, and curb chases. Current deferred maintenance estimates provide a foundation, but a comprehensive review is recommended to better assess facility conditions and deficiencies. A recommended prototype for this analysis is the methodology used for surface detention ponds, as outlined in the *Post-Construction Program Review and Recommendations* [6]. This would involve performing inspections on a sampling across the various facility types to assess current conditions and identify specific deficiencies. The results of these inspections of the sample set could then be used to estimate repair costs for the rest of the system, providing a clearer understanding of the total cost required to bring the stormwater infrastructure to a sustainable condition.

The deferred maintenance backlog can then be divided into those deficiencies that can be resolved through increased annual maintenance efforts versus those more significant deficiencies that will need to be resolved through long-term capital improvement planning and funding.

Once the deferred maintenance costs are determined, it is recommended that a timeline for completing the necessary repairs be established. This could range from 5 to 20 years based on funding availability and the desired level of service for this utility. Since deferred maintenance would typically be funded through stormwater utility rates, it is recommended that this analysis be conducted in conjunction with a needs-based utility rate study. Balancing the timeline for overcoming the deferred maintenance backlog with the associated rate adjustments will be necessary for the financial viability and acceptability of the plan.

Deferred maintenance programs are recommended for each of the stormwater facility types. For example, an inlet replacement program should be developed to address undersized inlets. While the City already has a historical pipe replacement program for VCP, revisions may be necessary to address funding challenges and to improve coordination with other City projects to minimize surface disturbances. For culverts and open channels, the City must first develop a better understanding of the ownership and condition of these facilities.

8.0 CAPITAL IMPROVEMENTS AND PLANNING

This section outlines the capital improvement planning studies and known capital improvement projects to be addressed in the coming years. The downtown area of Bozeman was identified as a priority for resolving known stormwater issues. DOWL evaluated the pre-1980 stormwater system in downtown Bozeman to identify existing flooding issues and potential capital improvement project solutions. The evaluation also explored stormwater management strategies, including the use of infiltration galleries to address capacity concerns identified through the recently completed alleyway trunk line lining project. This section provides a summary of the recommended capital improvement planning studies as well as the already identified capital improvement projects.

8.1 Stormwater Planning Studies

Stormwater planning studies play a crucial role in managing current and future stormwater infrastructure needs. These studies help identify existing stormwater challenges, plan for future development, and explore cost-effective solutions to mitigate drainage issues. They provide a comprehensive evaluation of the current stormwater system, pinpointing performance issues such as bottlenecks, drainage inefficiencies, and localized flooding concerns. These studies project future storm drainage needs by considering fully developed land use conditions, establishing special drainage criteria for specific areas, and determining needed regional and local stormwater facilities. These planning studies support Capital Improvement planning, policy recommendations, and recommendations for water quality enhancements to meet regulatory standards.

The last comprehensive stormwater planning study for Bozeman was completed with the 2008 Plan. The 2025 update to this plan did not include citywide planning but instead focused on the downtown area and those stormwater facilities built prior to the 1980s. This focused study assessed the capacity of the existing systems but did not consider future, fully developed conditions of the other areas of the community. Additional stormwater planning studies will be necessary to guide stormwater management for the entire community as Bozeman continues to grow.

The following sections describe specific areas and watersheds within the City of Bozeman that require stormwater planning studies. They provide a framework for comprehensively addressing the City's stormwater management needs over time. Figure 21 illustrates the boundaries for these studies. The recommended studies are presented in order of priority. All cost estimates are based on 2024 dollars and should be adjusted based on inflation if they are included in future capital improvement cost estimates.

8.1.1 West Bozeman – South Planning Study

The West Bozeman – South Planning Study focuses on a rapidly developing area with complex drainage and irrigation challenges. This region includes several natural south-to-north drainages, such as Baxter Creek and Aajker Creek, as well as various irrigation ditches. The Farmers Canal intersects these drainages, with stormwater runoff in some areas flowing directly into the canal. In other locations, it is conveyed beneath the canal to downstream reaches of natural waterways. The Farmers Canal continues eastward, ultimately flowing into a storm drain through the developed part of the city. Groundwater conditions, irrigation activities, and downstream developments further complicate stormwater management in this area.

This planning study is crucial for identifying cost-effective outfall solutions that mitigate flooding risks and ensure effective stormwater management for both private developments and new City streets. The study should also evaluate the feasibility of regional detention solutions versus relying on numerous individual onsite facilities, offering the City a strategic approach to managing stormwater in this growing area. Consideration should also be given to mapping the floodplains for Baxter Creek and Aajker Creek to help define the limits of flooding and guide development to prevent flooding along these larger drainages.

The study should involve modeling the south-to-north drainage system and parts of the stormwater system within the West Bozeman – North Planning Area to assess which drainages can accommodate additional runoff from future development. The estimated cost for this study in 2024 dollars is $330,000. As part of the 2025 Plan, DOWL collected flow measurements from June to November 2023 at six sites, including Aajker Creek (1 site), Baxter Creek (1 site), Farmers Canal (2 sites), and an unnamed tributary (2 sites). These measurements provide important baseline data for the analysis. Additional details on the flow measurement locations and recorded flows are provided in Appendix C.

8.1.2 Lower Bozeman Creek (Mid-town) Planning Study

The Lower Bozeman Creek (Mid-town) Planning Study would expand on the pre-1980 analysis conducted for the 2025 Plan. While the original analysis focused on existing infrastructure capacity, it did not address future developments or infrastructure needs. This study area incorporates additional drainage contributions from the east, necessitating an expansion of the existing model. The study includes several waterways, such as Catron Creek, Farmers Canal, Mandeville Creek, Lower Bozeman Creek, Matthew Bird Creek, and Figgins Creek. FEMA floodplains are delineated for Bozeman Creek, Matthew Bird Creek, and Figgins Creek, and further analysis could identify potential flood mitigation projects to reduce flooding risks along these drainages.

Collaboration with City planning, engineering, and stormwater administration staff will be critical to developing stormwater recommendations that ensure proper functionality under anticipated future growth conditions. This will involve identifying capacity limitations and recommending capital improvement projects to accommodate development and mitigate flooding risks. The estimated cost of this planning study, in 2024 dollars, could be as high as $450,000, depending on the required level of detail. Cost estimates should be adjusted based on inflation if they are included in future capital improvement cost estimates. Additional efforts could include identifying capacity issues and prioritizing capital improvement projects to support long-term stormwater management in the basin.

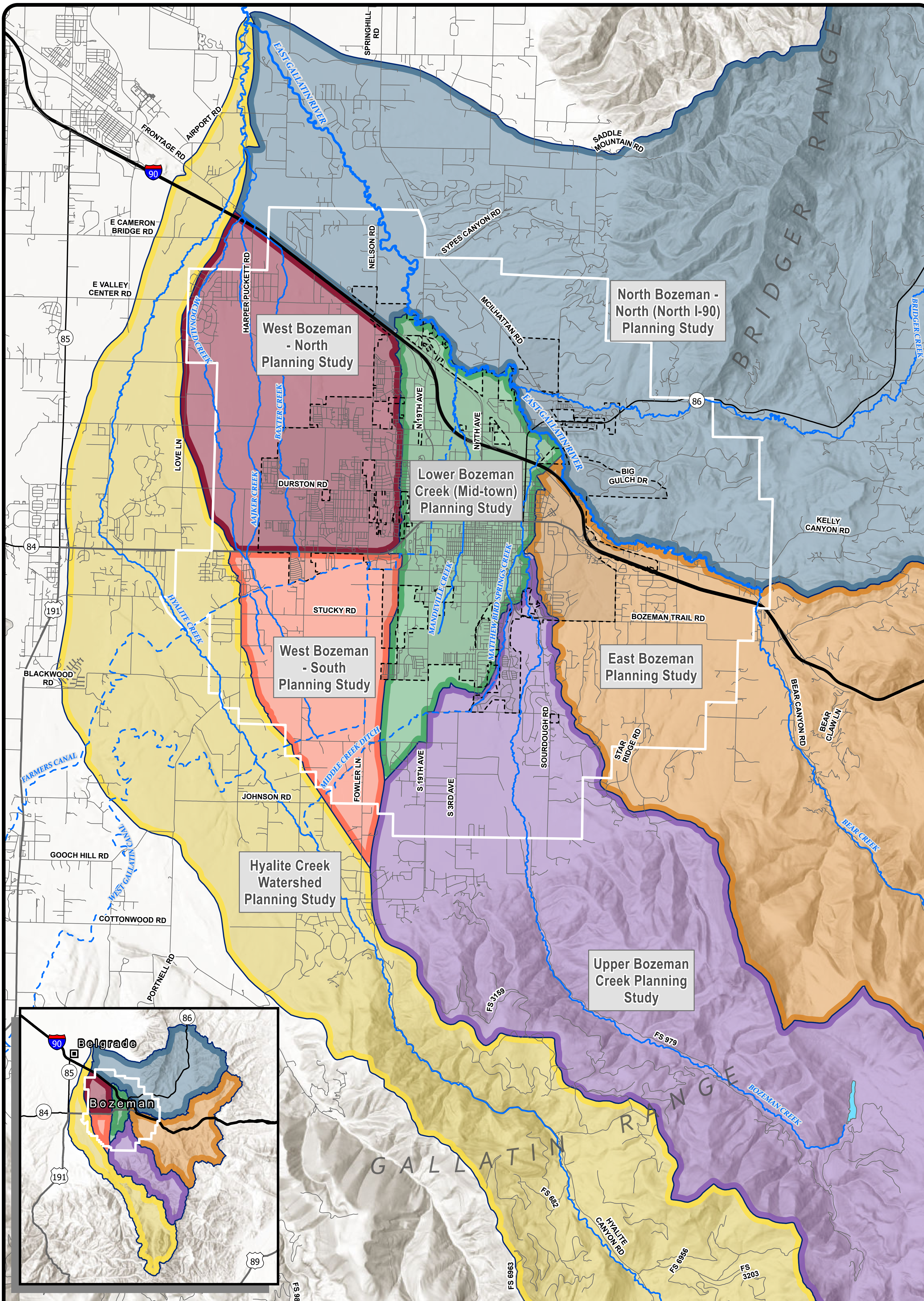

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FIGURE 21
PLANNING STUDIES

- Waterway
- Irrigation Ditch
- Community Planning Boundary
- Bozeman City Limits

0 0.5 1 2 Miles

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8.1.3 West Bozeman – North Planning Study

The West Bozeman – North Planning Study focuses on an area with a mix of developed and undeveloped land. The undeveloped lands are further west along Huffine Lane and in the northern portions of the basin. As development continues to expand in this region, understanding the drainage patterns and challenges associated with future buildout is critical to guiding sustainable development and meeting stormwater management and water quality needs. Key waterways in this area include Aajker Creek, Baxter Creek, Maynard Border Ditch, Mandeville Creek, and various unnamed drainages, all of which play a significant role in the region's drainage network.

This study would build on the preliminary model developed through the West Bozeman – South Planning Study, allowing for a more focused assessment of future development impacts and stormwater infrastructure requirements. Recommendations from the South Planning Study on key drainage outfalls will provide a foundation for evaluating drainage solutions within this study area. The study will include an evaluation of existing storm drain systems to ensure they meet current design requirements and can support future growth. Similar to the South Planning Study, consideration should be given to mapping the floodplains for Baxter Creek and Aajker Creek to understand the limits of flooding and help protect development from flooding occurring along these larger drainages. The estimated cost of this planning study, in 2024 dollars, could be as high as $530,000, depending on the level of detail required.

8.1.4 North Bozeman (North of I-90) Planning Study

The North Bozeman (North of I-90) Planning Study addresses an area that has experienced limited growth over the last decade. However, there is significant undeveloped land, which could create a need for a comprehensive stormwater planning study. This study would evaluate the watersheds in this area, with a specific focus on existing and future stormwater needs from I-90 to the foothills of the Bridger Mountains. Key drainages in this area include Bridger Creek, East Gallatin River, Middle Cottonwood Creek, Sypes Creek, and Churn Creek, each contributing to the area’s complex hydrology.

A critical component of this study will be addressing floodplain impacts, particularly along the East Gallatin River and Bridger Creek, which have detailed FEMA-designated floodplains. The study would evaluate flood mitigation efforts to minimize risks to existing developments and identify opportunities to improve resiliency against potential flooding. The study would also guide stormwater infrastructure needs to support future development while balancing water quality requirements and environmental considerations. Given the diverse challenges in this area, this planning study is estimated to cost up to $470,000, depending on the level of detail required. The study will offer essential recommendations for managing stormwater and mitigating flood risks, ensuring sustainable growth in this part of Bozeman.

8.1.5 Hyalite Creek Watershed Planning Study

As the City continues to expand westward, a comprehensive stormwater planning study for the Hyalite Creek Watershed will be needed. This study would extend west of the existing West Bozeman planning areas, reaching from the foothills to the south, potentially up to I-90 or the confluence with the East Gallatin River. The study aims to address stormwater management needs and evaluate the impacts of future development within this area.

A key focus of this study will be mapping the floodplain of Hyalite Creek to better understand the extent of flooding and identify areas at risk. This information will be instrumental in guiding development to reduce flood risks along this drainage. Given the scale and complexity of this watershed, the planning study is estimated to cost up to $150,000, depending on the level of detail desired. This study will offer essential guidance for managing stormwater, mitigating flood impacts, and planning for future development in the Hyalite Creek Watershed.

8.1.6 Upper Bozeman Creek Planning Study

The Upper Bozeman Creek Planning Study is a lower-priority stormwater study, with most of the study area located outside of the city limits. However, this study may become necessary as the City expands southward along the Bozeman Creek drainage. Currently, this area consists primarily of sporadic low-density housing, but future development may extend to the foothills of the watershed, necessitating proactive planning for stormwater management. This study will encompass the entire watershed, including Upper Bozeman Creek, Leverich Creek, Limestone Creek, and Nicholas Creek, with a primary focus on planning for future development rather than evaluating existing stormwater facilities. Several of these drainages have FEMA-delineated floodplain boundaries that are currently used to guide development and minimize flood risks. The study will assess the need for new stormwater infrastructure to support anticipated growth and ensure effective drainage while minimizing flooding risks.

With the potential for significant development in this area over time, this planning study is estimated to cost up to $330,000, depending on the level of detail desired. While not an immediate priority, this study will provide valuable insights and recommendations for managing stormwater in the Upper Bozeman Creek watershed as development pressures increase.

8.1.7 East Bozeman Planning Study

The East Bozeman Planning Study is also a lower-priority stormwater study, with most of the study area located outside of current city limits. However, it may become necessary as the City begins extending water and sanitary services to the east. Proactive planning in this area will be valuable for guiding development with responsible stormwater management practices and utilizing the various drainages. This study will focus on the stormwater needs associated with future development, incorporating existing drainages such as Cannon Creek, Bear Creek, and various unnamed tributaries. By assessing these waterways and the broader drainage network, the study can provide recommendations for stormwater infrastructure to support development while mitigating flooding risks. This planning study is estimated at up to $290,000, depending on the desired level of detail. While not an immediate priority, this study will offer critical insights for managing stormwater as East Bozeman becomes more developed.

8.2 Pre-1980 Capacity Evaluation

As part of the 2025 Plan update, the capital improvement needs for the pre-1980 stormwater facilities were assessed. This effort included collecting and evaluating data on existing stormwater infrastructure, developing a planning-level stormwater model for this area, and identifying capacity constraints.

A planning-level Autodesk Storm and Sanitary (SSA) model was created to assess the performance of the pre-1980 stormwater facilities, which are primarily located within Basin #1. However, some facilities extend into Basins #4 and #5. The area defined by these basins was evaluated holistically, as runoff from Basin #5 flows into Basin #1 and subsequently into Basin #4. These three basins were modeled to reflect future build-out conditions, allowing for an evaluation of the performance of pre-1980 stormwater facilities with full development, as shown in Figure 22. The yellow boundary outlines the study area for a detailed analysis of the downtown Bozeman stormwater system and infiltration galleries, as discussed in Section 8.3.

DOWL identified three locations within the study area where significant surface flooding and an undersized storm drain were identified using the planning-level model. These locations all feature undersized VCPs that surcharge for an extended period of time during the 2-year, 24-hour storm event. New developments within the City are required to install infrastructure designed to detain or retain the 10-year 2-hour storm and convey the 25-year storm, as calculated using the Rational Method [7]. However, most of the stormwater facilities within the study can’t convey the 10-year event, with portions surcharging at the 2-year event. The 2-year, 24-hour synthetic storm event was used to identify capacity constraints within the stormwater system, and the proposed system was designed to convey this event without surcharging. Designing the proposed system to convey the 10-year event would require upsizing most of the existing storm drain system throughout the pre-1980 boundary and will likely result in significant downstream flooding that would be worse than current conditions. Three actual storms, derived from the Montana State University (MSU) Optical Remote Sensor Laboratory (ORSL) precipitation data, were chosen as check storms to verify the existing conditions model and proposed design.

The *Capital Improvement Needs for Pre-1980 Stormwater Facilities* report in Appendix B provides additional detail on this work. The following sections describe the identified capital improvement projects.

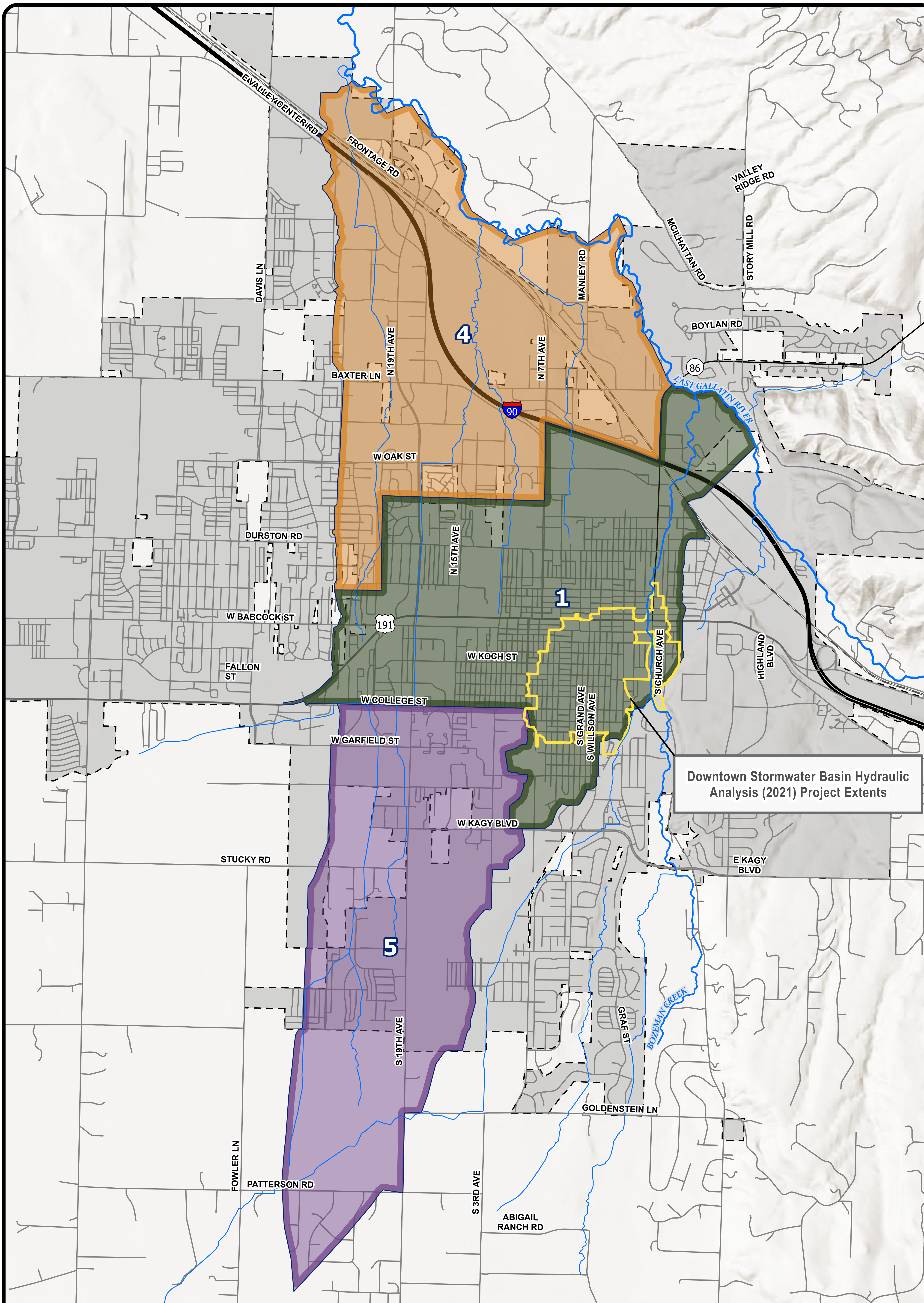

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FIGURE 22
PRE-1980 CAPACITY EVALUATION
PROJECT EXTENTS

Basin 1: 3.57 Square Miles
Basin 4: 3.76 Square Miles
Basin 5: 3.28 Square Miles
Waterway
Bozeman City Limits

0 0.25 0.5 1 Miles

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8.2.1 S. 8th and S. 9th Avenues Improvements

The S. 8th Ave. and W. Main St. storm drains are primarily VCP 10 inches or smaller, as shown in Figure 23. The system connects to a 24 to 30-inch RCP trunk line that extends north for 1,500 feet before discharging into an open ditch drain north of W Villard St, as shown in Figure 24. Under existing conditions, the storm drains south of W. Olive St. and along W. Main St. exhibit significant flooding at the 2-year event. Based on the surface flooding model, this is an area of concern as water can pond up to 3 feet deep in areas along the storm drain system. City staff confirmed that this is a problem area and that the lid of MH-3 floats during larger storm events.

DOWL evaluated the impacts of upsizing the current VCP lines for the entire system. Increasing the size of the upstream pipes resulted in higher flow rates through the downstream system. To accommodate the higher flows, the pipe between MH-3 and MH-4 was increased from 15 inches to 30 inches, resulting in MH-4 surcharging. To eliminate the surcharging at MH-4, the entire downstream system was increased to 36-inch RCP, as shown in Figure 24. In total, 6,620 feet of storm drain would be replaced. Under the proposed conditions, the system no longer surcharges during the 2-year, 24-hour synthetic storm event or any of the three actual storms used for verification. Recommended capital improvement projects do not consider improvements to the trunk line to the west since the planning-level model did not show this storm drain system surcharging for a significant period of time, and the City indicated that this was not an area of concern. Additional evaluation is required during final design to determine the downstream impacts of increasing the flow to the open ditch outfall.

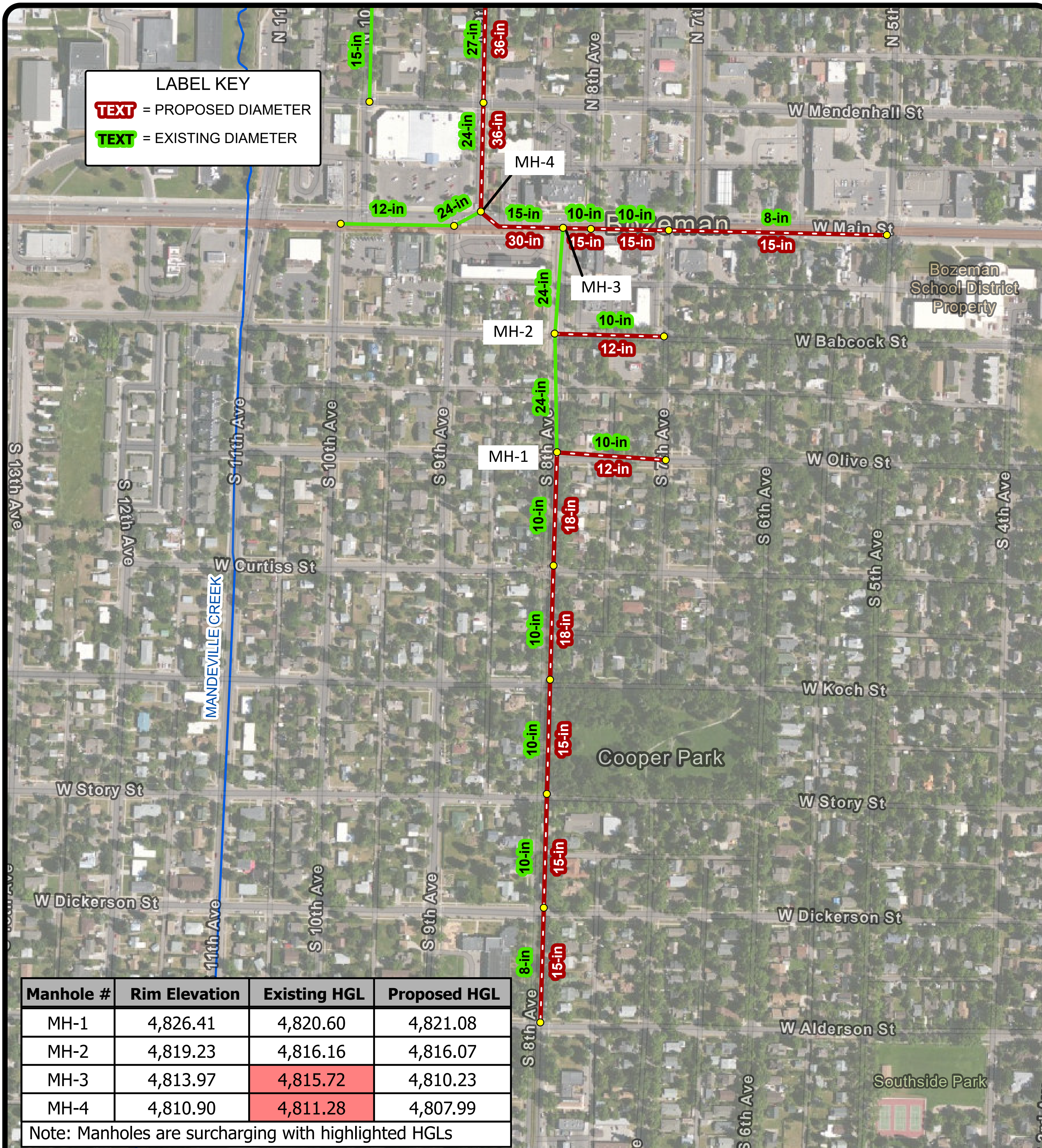
This project requires replacing 6,620 feet of storm drain and 21 manholes. The estimated cost in 2024 dollars, including design and construction administration, is $7.3 million. This cost should be adjusted to account for inflation if used for capital improvement cost estimates in the future.

8.2.2 S. Wallace Avenue Improvements

The existing storm drain down S. Wallace Ave. is 10-inch VCPs that discharge into an 18-inch PVC pipe, as shown in Figure 25. During the 2-year storm event, the storm drains from E. Babcock St. to E. Mendenhall St. surcharge out the manholes. The water flows north along the S. Wallace Ave. curb and gutter until it is intercepted via inlets. This location is outside of the study area of the surface flooding model; however, City staff confirmed that inlets and laterals surcharge in this area during significant storm events.

The four upstream VCP storm drains along S. Wallace Ave. were upsized to 12-inch and 15-inch diameters in the SSA hydraulics model, effectively eliminating surcharging at all three manholes. To manage the increased flow, the two pipe segments downstream of MH-3 would need to be upsized to 24-inch diameter. The remaining sections of the downstream storm drain system have sufficient capacity to accommodate the additional runoff intercepted. With these improvements, the system would no longer surcharge and overflow during the 2-year, 24-hour synthetic storm event nor the 2-year ORSL check storms. Further evaluation is required during final design to determine if there are impacts on Bozeman Creek.

This project requires replacing 1,990 feet of storm drain and seven manholes. The estimated cost, including design and construction administration, is $2.1 million. This cost is in 2024 dollars and should be adjusted to account for inflation if used for capital improvement cost estimates in the future.



Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-1	4,826.41	4,820.60	4,821.08
MH-2	4,819.23	4,816.16	4,816.07
MH-3	4,813.97	4,815.72	4,810.23
MH-4	4,810.90	4,811.28	4,807.99

Note: Manholes are surcharging with highlighted HGLs

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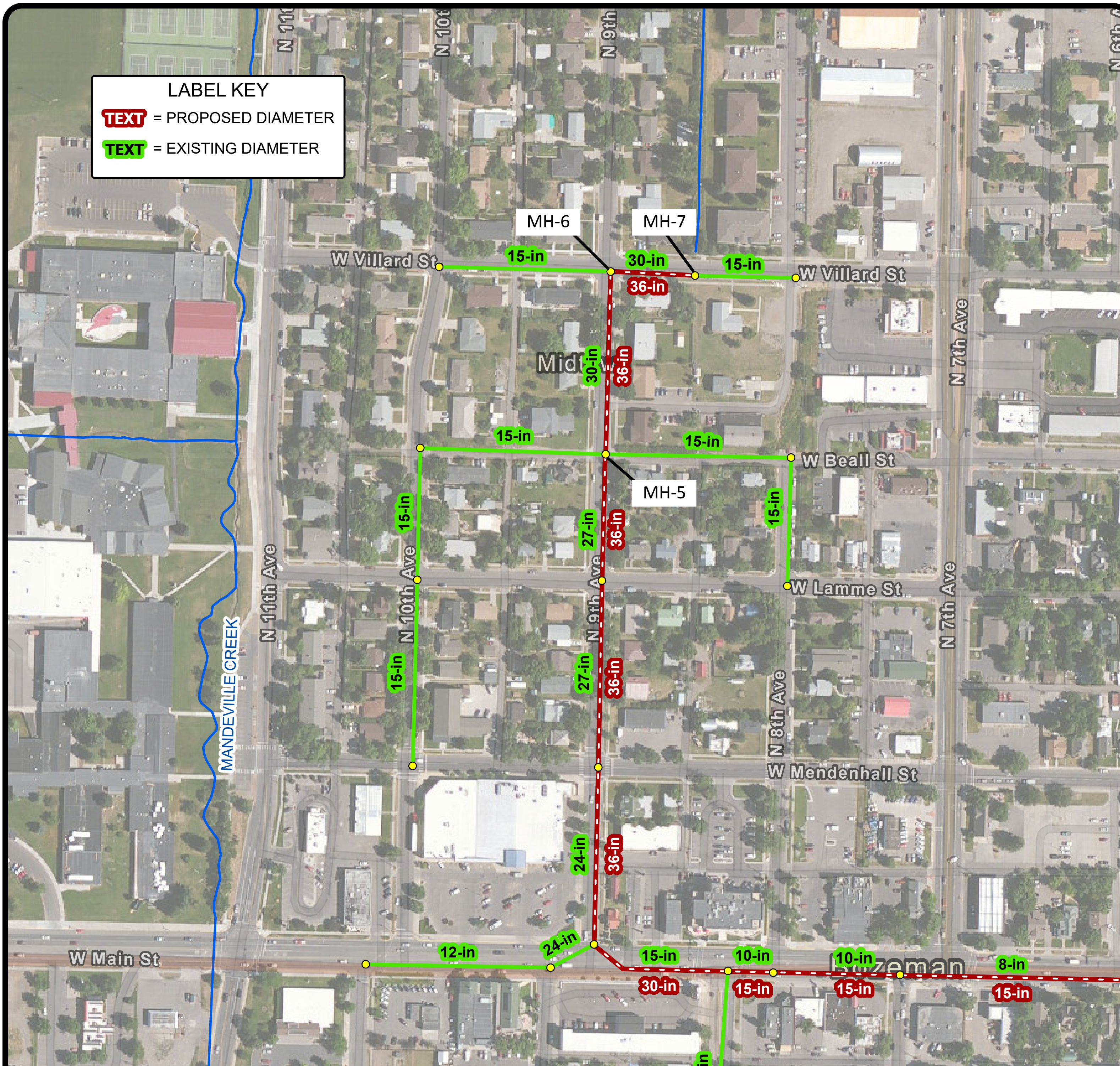
FIGURE 23

S. 8th AVENUE IMPROVEMENTS

Existing Pipe
Proposed Pipe
Stormwater Manhole

0 100 200 400 Feet

N



Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-5	4,801.37	4,802.49	4,797.05
MH-6	4,796.42	4,801.28	4,793.11
MH-7	4,795.45	4,800.95	4,790.17

Note: Manholes are surcharging with highlighted HGLs

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FIGURE 24

N. 9TH AVENUE IMPROVEMENTS

Existing Pipe
Proposed Pipe
Stormwater Manhole

0 100 200 400 Feet

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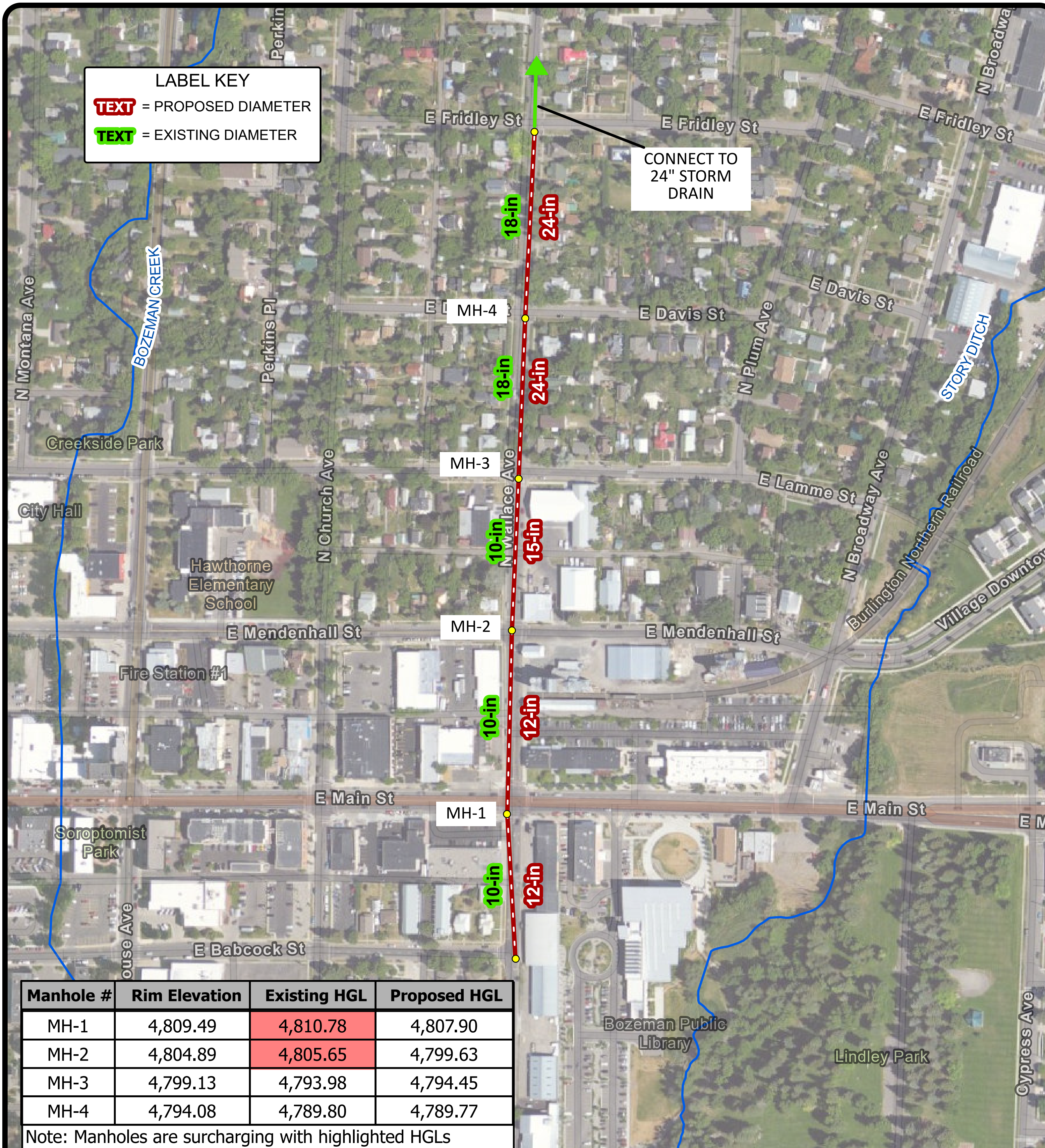

Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-1	4,809.49	4,810.78	4,807.90
MH-2	4,804.89	4,805.65	4,799.63
MH-3	4,799.13	4,793.98	4,794.45
MH-4	4,794.08	4,789.80	4,789.77

Note: Manholes are surcharging with highlighted HGLs

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FIGURE 25

S. WALLACE AVENUE IMPROVEMENTS

Existing Pipe
Proposed Pipe
Stormwater Manhole

0 125 250 500 Feet

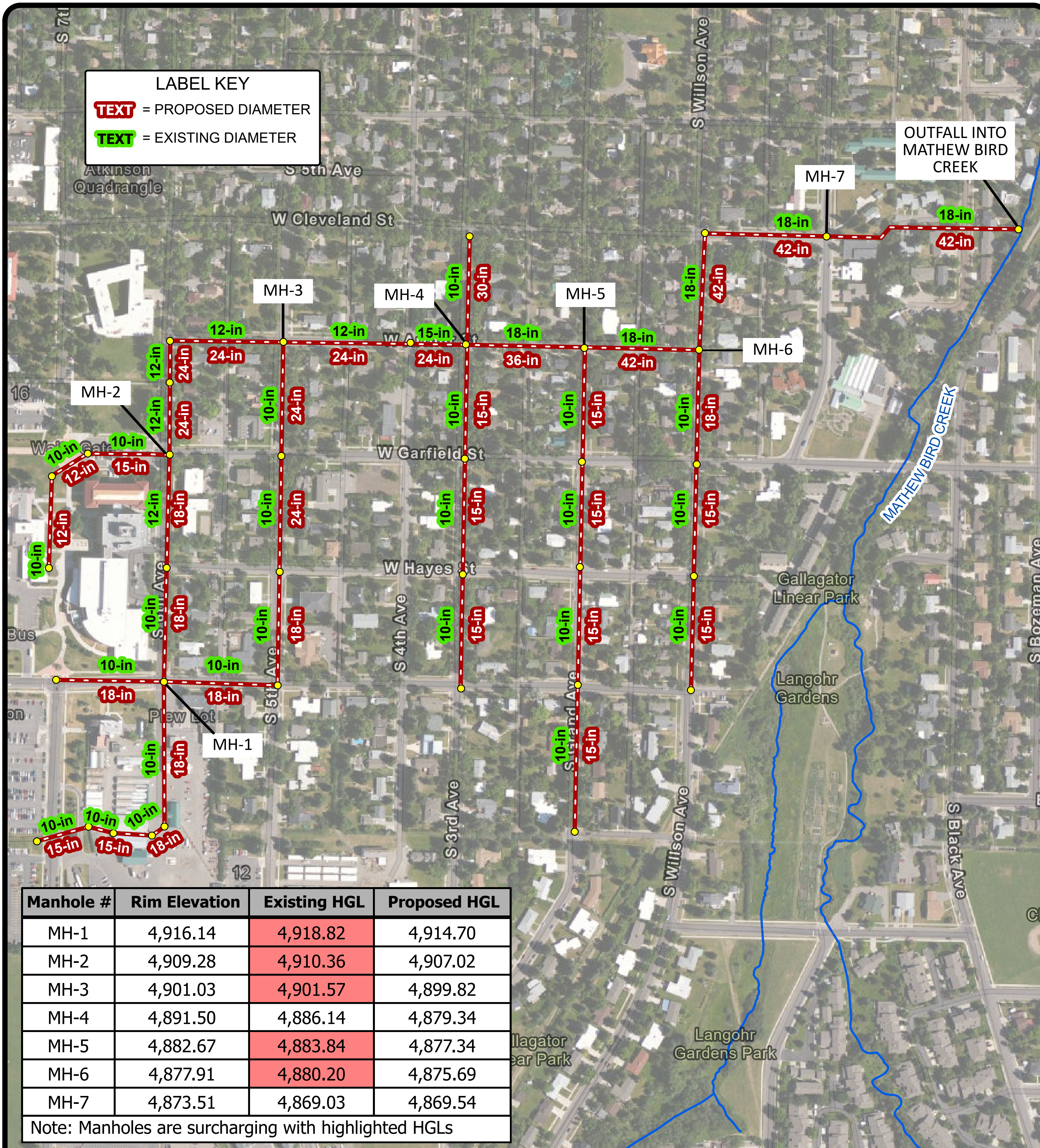
N

8.2.3 W. Arthur Street Improvements

The W. Arthur St. storm drain system collects runoff from W. Lincoln St. north to W. Cleveland St., in addition to portions of the Montana State University (MSU) campus. It consists of approximately 12,000 feet of storm drain that discharge into Matthew Bird Creek via an 18-inch RCP, Figure 26. The storm drain is a combination of VCP and RCP, and most of it is undersized. During the 2-year storm event, numerous manholes surcharge and overflow. Based on the 2018 LiDAR data and the model of surface flooding areas, water generally flows northeast through this area with ponding up to 3 feet deep in several locations. City staff confirmed that this area has experienced significant flooding during large storm events. Proposed improvements in this location involve upsizing the entire storm drain system, as shown in Figure 26. Laterals would be upsized from 10 inches to 15 inches, and the trunk line along W. Arthur St. would be upsized to 36 or 42-inch RCP. Increasing the pipe sizes would eliminate surcharging in the system during the 2-year, 24-hour synthetic storm event and the ORSL check storms.

A detailed study is needed during the final design phase to evaluate potential downstream flooding impacts from additional discharge into Matthew Bird Creek and to assess the existing storm drain infrastructure, including uncertainties about flow direction along S. 3rd Ave. Redevelopment on the MSU campus may alleviate some hydraulic load by contributing runoff at pre-disturbance rates, presenting an opportunity for the City and MSU to collaborate on low-impact development (LID) facilities. Additionally, the outlet pipe discharging into Matthew Bird Creek, which passes through a potentially encroached 20-foot easement, may require alternative solutions such as infiltration galleries or an additional outfall to manage stormwater and reduce trunk line size.

This project would replace 11,500 feet of storm drain and 35 manholes. The estimated cost, including design and construction administration, is $11.3 million. This cost is in 2024 dollars and should be adjusted to account for inflation if used for capital improvement cost estimates in the future.



Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-1	4,916.14	4,918.82	4,914.70
MH-2	4,909.28	4,910.36	4,907.02
MH-3	4,901.03	4,901.57	4,899.82
MH-4	4,891.50	4,886.14	4,879.34
MH-5	4,882.67	4,883.84	4,877.34
MH-6	4,877.91	4,880.20	4,875.69
MH-7	4,873.51	4,869.03	4,869.54

Note: Manholes are surcharging with highlighted HGLs

DOWL

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PROJECT: 4036.21888.02 DATE: 11/8/2024

CITY OF BOZEMAN

FIGURE 26

W. ARTHUR STREET IMPROVEMENTS

Existing Pipe
Proposed Pipe
Stormwater Manhole

0 100 200 400 Feet

N

8.3 Downtown Storm Drainage Improvements Studies

8.3.1 Downtown Storm Drainage Hydraulic Analysis (2021)

The Downtown Storm Drainage Improvements study builds upon the 2020 downtown stormwater analysis and model developed by DOWL. In 2020, an SSA model was created to identify capacity constraints in Bozeman's downtown storm drainage system, Figure 22. The model revealed significant issues, including surcharging and surface ponding at several manholes and overloading of the trunk main in the alley between Main Street and Mendenhall Street during a 2-year storm event.

Several alternatives for addressing these deficiencies were evaluated using the SSA model. Solutions evaluated included CIPP lining of the trunk main to increase capacity, upsizing lateral pipes, installing infiltration galleries to reduce stormwater runoff, and constructing a bypass storm drain system to offload a portion of the stormwater flows collected. The results of these evaluations indicated that a combination of infiltration galleries, a storm drain bypass system, and future upsizing of lateral pipes, along with CIPP lining of the alleyway trunk main, is the preferred solution.

8.3.2 Downtown Stormwater Study (2024)

The downtown stormwater study detailed below expands on the study completed in 2021. The SSA model and analysis completed in 2021 were used as the basis for a more detailed analysis of the infiltration galleries and bypass system to reduce hydraulic loading on the alleyway trunk line.

8.3.2.1 Infiltration Gallery Conceptual Design

The conceptual design of the typical infiltration gallery, developed in 2021, was refined through a review of soil data, infiltration rates, and a more accurate representation of soil profiles and permeable gravel layers. The study also aimed to optimize the design by comparing the performance of alternative system designs.

It was determined that an underground infiltration gallery connected directly to the storm drain system is significantly more effective at infiltrating accumulated stormwater runoff compared to a rain garden, Figure 27, which is limited to capturing stormwater runoff from streets at specific locations. The size, depth, and storage pipe diameter were also refined from the conceptual infiltration gallery design through site-specific evaluations at potential locations. These evaluations considered factors such as the presence of underground utilities, property boundaries, and obstructions like trees and utility poles. Representative dimensions and design parameters were determined through this analysis and are summarized in Table 13.

Figure 27 – City of Bozeman Rain Garden / Infiltration Boulevard

Table 13 — Infiltration Gallery Calculations

Type	Storage Pipe Diameter (ft)	Length (ft)	Width (ft)	Depth (ft)	Infiltration Rate (in/hr)	Constant Infiltration Rate (cfs)
Underground Gallery	4	150	12	12	30	1.25

8.3.2.2 Design Alternatives

Future upgrades to downtown stormwater infrastructure assume the replacement of small VCP laterals and trunk lines with larger pipes (15 inches or greater). This, however, increases hydraulic loading on the alleyway storm drain trunk line, causing surcharging during 2-year storm events. Three design alternatives were developed to address this issue:

1. **Alternative 1**: Install four underground infiltration galleries connected directly to the storm drain system to reduce flows and provide water quality treatment. This option requires fewer galleries

compared to rain gardens and captures larger runoff volumes. The estimated cost for this alternative is $2.1 million.

2. **Alternative 2**: Construct a new 24 to 30-inch bypass storm drain along Olive St. and S. Bozeman Ave. to reroute storm drainage to Bozeman Creek and alleviate capacity issues in the alleyway trunk line. This option does not provide water quality benefits. The estimated cost for this alternative is $2.9 million.

3. **Alternative 3**: Combine an 18 to 24-inch bypass system with three underground infiltration galleries. This hybrid approach mitigates surcharging while offering water quality treatment. The estimated cost is $4.3 million.

8.3.2.3 Recommendation

Alternative 3 is not a viable option as there is still a significant cost to install the bypass system, which is not offset by eliminating just one infiltration gallery. Alternative 1 is the recommended project for improving drainage in the downtown area, including unloading the alleyway trunk line. This alternative is the least costly and provides additional water quality benefits. It is recommended that initial field investigations be completed for this project before advancing to final design. This would include utility locates and subsurface geotechnical investigation at the 10 potential infiltration sites identified to verify that four acceptable sites are available. For budgeting purposes, it is recommended that the project be budgeted based on the storm drain bypass system alternative (Alternative 2) in case four viable sites cannot be identified.

8.4 Other Capital Improvement Projects

8.4.1 Projects from the 2008 Plan

The 2008 Plan identified several studies and CIP projects aimed at addressing persistent flooding and maintenance challenges within the City's stormwater system. Some of these recommended studies or projects were not completed due to financial constraints and competing priorities. DOWL coordinated with City staff and reviewed these 2008 recommendations to identify the studies and projects that remain priorities. Table 14 summarizes the two unaddressed projects, including the updated 2024 cost estimates.

Table 14 – CIP Projects Not Completed from the 2008 Plan

Project Number	Project Name	Summary of Project	Budget Level Cost Estimate
1	Farmers Canal Downstream Capacity Study	Farmers Canal has insufficient capacity, particularly through developed areas of the City of Bozeman. This study is to assess potential solutions to understand ways to unload this downstream system and could be combined with the West Bozeman – South Planning Study.	$150,000
2	Valley Unit Park	Homes along Meagher Ave. south of Durston Rd. and east of the park have experienced basement flooding due to the adjacent detention pond. This project would redesign the pond outlet structure and emergency spillway to reduce flooding risks.	$120,000

8.4.2 2024 City of Bozeman Stormwater CIP Projects

The City's Stormwater Capital Improvement Plan provides a 5-year plan for addressing anticipated stormwater needs. Each year, the city prepares this plan to prioritize and allocate resources for critical stormwater improvements. The CIP includes a diverse range of capital improvement needs, such as the acquisition of operational equipment like inspection vans, vacuum and jetting trucks, and street sweepers, as well as essential studies, including a rate study and system evaluations. In addition, the plan includes the design and construction of key stormwater infrastructure projects aimed at reducing flooding, improving system efficiency, and maintaining compliance with the City's MS4 stormwater permit with Montana DEQ. Table 15 lists the CIP projects from the City's FY25-FY29 [8]and proposed FY26-FY30 [9] Capital Improvement Plans. This does not include the studies, equipment needs, and capital improvement projects identified through the 2025 Plan.

Table 15 – 2024 City of Bozeman Stormwater CIP Projects

Project Number	Project Name	Fiscal Year	Budget Level Cost Estimate
1	Mechanical Stormwater Treatment – Phase 3	2026-2028	$580,000
2	Historic Pipe Replacement Program	2026-2030	$2,034,700
3	N. 9th Ditch Rehabilitation	2029	$450,000
4	Manley Ditch Rehabilitation	2025	$520,000

<u>**Mechanical Stormwater Treatment Phase 3**</u>

The Mechanical Stormwater Treatment Phase 3 projects for Tamarack and Peach Streets aim to enhance stormwater quality for Bozeman Creek by installing mechanical separator units in the existing stormwater mains. These units will target pollutants such as sediments, oils, and greases, removing them before discharge. The Tamarack project will serve a 75-acre basin, while the Peach project will serve a 49-acre basin, both of which were developed prior to modern stormwater standards. Initially planned as a single project, the two were split due to high costs and logistical challenges. The cost for Tamarack has increased to $300,000 (scheduled for FY28), and for Peach, it has risen to $280,000 (scheduled for FY26), primarily due to inflation and the need for larger 8-foot units.

Historic Pipe Replacement Program

The Historic Pipe Replacement Program addresses the annual rehabilitation of approximately 700 feet of 100-year-old VCP that has exceeded its lifecycle, fails to meet capacity standards, and suffers from structural issues. Scheduled construction occurs every other year, with design efforts in the intervening years. The program allocates $110,000 to $156,000 per design phase and $535,400 to $675,500 per construction phase. Funded by rate revenue with a total cost estimated for the next 5 years of $2,034,700, the program mitigates risks of pipe collapse, flooding, and inefficient, piecemeal replacements.

Complementing this effort is the Annual Unplanned Pipe Rehabilitation program, which provides funding for the design and construction of unplanned pipe, drainage, and treatment projects to address failed infrastructure. With a total cost of $270,900 for the next 5 years, this program provides rapid response to unforeseen infrastructure issues, allocating $54,100 to $76,900 annually for both design and construction. Together, these programs balance planned and reactive maintenance to sustain a robust and reliable stormwater system.

DOWL completed a review of the Historic Pipe Replacement Program and assessed potential changes due to the Capital Improvements Project recommended from the pre-1980 capacity evaluation. Further details are provided in Section 8.4.3.

N. 9th Ditch Rehabilitation

The N 9th Ditch Rehabilitation project focuses on the design and rehabilitation of 900 feet of stormwater open channel conveyance near N. 9th Ave., extending from W. Villard St. to W. Peach St. The ditch serves a 142-acre urban drainage basin, with a vegetated swale that has degraded over time due to sediment deposition, overgrown vegetation, and bank erosion. The project is currently scheduled for FY29 and will cost $450,000.

Manley Ditch Rehabilitation

The Manley Ditch Rehabilitation project involves the design and rehabilitation of 1,500 feet of ditch located east of Manley Road, serving a 58-acre urban drainage basin. The ditch, which includes a vegetated swale, has experienced significant degradation, resulting in a nonfunctional conveyance system and an obstructed railroad-owned culvert crossing. The design is complete, and the project is bidding in January 2025 with an estimated project cost of $520,000, which covers construction and construction inspection costs.

8.4.3 Assessment of the City's Historical Pipe Replacement Program

The City has approximately 8.5 miles of VCP, most of which are undersized or in poor condition. Capital improvement projects identified through the 2025 Plan include replacing 2.3 miles through projects on S. 8th and S. 9th Avenues, S. Wallace Avenue, and W. Arthur Street, leaving 6.2 miles to be addressed via the Historic Pipe Replacement Program.

Despite the 2015 goal to replace 8,900 feet of VCP per year, progress has been slow due to contractor availability, rising project costs, and limited SID partner support. According to the City's Capital Improvement Plan, 700 feet of VCP are scheduled for replacement every two years through the Historic Pipe Replacement Program, alternating between a year of planning and a year of construction. At this pace, it would take over 90 years to replace the remaining 6.2 miles, likely resulting in frequent pipe failures and associated flooding issues during this timeframe.

To address this shortfall, it is recommended that the remaining VCP storm drains be replaced within 15 to 20 years. Achieving this timeline would require replacing 3,200 to 4,400 feet of pipe every two years or 1,600 to 2,200 feet annually. Priority should be given to the pipes in the worst condition and those located in areas with the highest risk of flooding. Sliplining and pipe-bursting should be considered as a cost-effective alternative where feasible.

To implement this strategy, a more comprehensive review of the VCP condition is necessary. This review should include video inspections to assess and prioritize pipe replacements based on their condition and criticality. Refined cost estimates are also needed for accurate budget forecasting. Based on the FY26-30 Capital Improvement Plan, VCP replacement would average approximately $1,120/ft or an estimated $37.0 million to replace the remaining 6.2 miles. More cost-effective solutions are likely possible with advanced planning and coordination with other utility or street reconstruction projects.

Developing a more strategic plan based on planning studies will enable the City to address this deferred maintenance and replacement need effectively and minimize future pipe failures.

8.5 Water Quality Capital Projects

The City has included a CIP project referred to as Mechanical Stormwater Treatment Phase 4, scheduled for 2025 and 2026, with an estimated cost of $550,000. This project involves the installation of two stormwater treatment units near the intersections of N. Rouse Ave. / E. Peach St. and N. Rouse Ave. / E. Tamarack St. The project is intended to reduce the Total Suspended Solids (TSS) loading to Bozeman Creek, addressing key requirements of the Bozeman Creek Total Maximum Daily Load (TMDL) Action Plan [4]. Several alternatives were considered, but no other treatment approach was found to offer comparable ease of maintenance, construction footprint, or pollutant removal efficiency. The approved stormwater treatment units are expected to remove approximately 11 tons of pollutants annually from the 124-acre contributing drainage basin.

The City and DOWL have collaborated to identify additional stormwater treatment needs within the City by assessing existing treatment units and the contributing areas they serve. This process helped to identify gaps in coverage and potential locations for new treatment units, including mechanical separation, infiltration galleries, dry wells, and detention facilities. Stormwater quality projects were identified based on the size of the contributing basin, land use, and feasibility of treatment unit installation. A total of 13 sites were identified, as summarized in the Table 16 and shown on Figure 28. Further details of each of the following projects are provided in Appendix D.

Table 16 – Stormwater Water Quality Projects

Project Number	Project Location	Watershed	Basin Size (Acres)	Treatment Type	Budget Level Cost Estimate
1	S. 11th Ave. and Koch St.	Mandeville Creek	32.3	MT	$330,000
2	Arthur Basin	Bozeman Creek	131	MT / IG	$450,000
3	S. Willson Avenue	Bozeman Creek	38.6	MT / IG	$530,000
4	Cooper Park Midtown	Mandeville Creek	129	MT / IG	$470,000
5	Cherry Drive	Rocky Creek	12.0	IG / DW	$150,000
6	Langhor Avenue	Bozeman Creek	90.0	MT / IG	$330,000
7	W. Olive St, S. 16th St., W. Babcock St.	Mandeville Creek	40.0	MT / IG	$290,000
8	W. Cleveland St. / W. Garfield St.	Bozeman Creek	31.0	MT / IG / DF	$300,000
9	Kagy and Highland Boulevards	Bozeman Creek	29.0	MT / IG	$470,000
10	S. 20th Avenue	E. Fork Catron Creek	27.0	MT / IG	$330,000
11	W. Babcock St. and S. Ferguson Avenue	West Gallatin Canal	26.0	MT /DF	$300,000
12	Durston Road and Meagher Avenue	West Gallatin Canal	22.0	MT	$300,000
13	N. 20th Avenue and Durston Road	E. Fork Catron Creek	19.0	MT	$300,000

MT = Mechanical Treatment, IG – Infiltration Gallery, DW – Dry Well, DF = Detention Facility

8.6 Summary of Stormwater Capital Improvement Recommendations

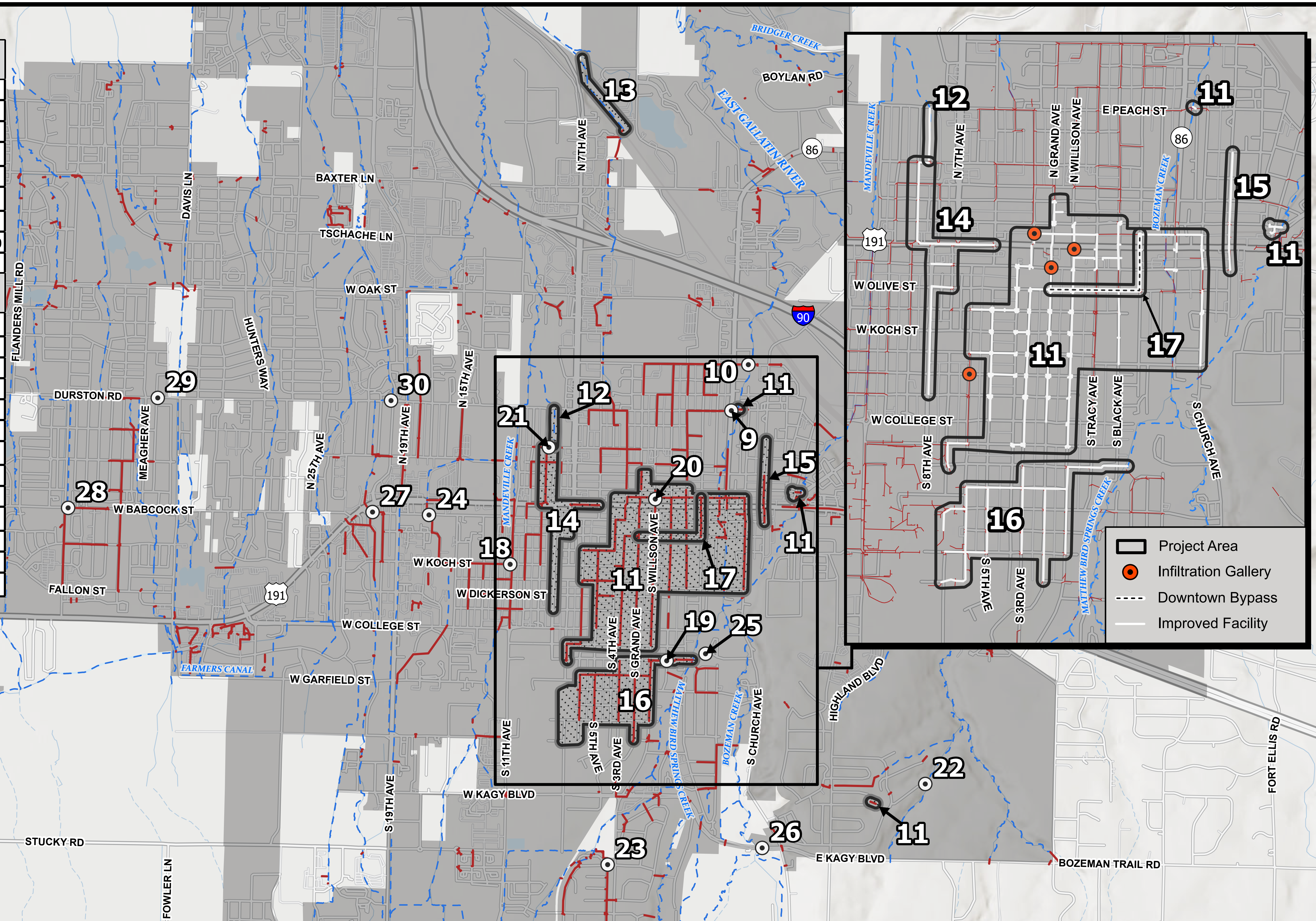
A list of capital improvement projects and planning studies that are recommended to improve the City's Stormwater Program is summarized in Table 17. The list is not presented in order of priority, and it is recommended that it be reviewed annually as part of the CIP planning process. Additionally, a project prioritization matrix could be developed to assist in project selection. Figure 28 shows the locations of the various projects.

Table 17 – Planning Studies and Capital Improvement Projects

Project Number	Project Name	Budget Level Cost Estimate
Stormwater Planning Studies		
1	West Bozeman – South Study	$330,000
2	Lower Bozeman Creek Study	$450,000
3	West Bozeman – North Study	$530,000
4	North Bozeman (N I-90) Study	$470,000
5	Hyalite Creek Watershed Study	$150,000
6	Upper Bozeman Creek Study	$330,000
7	East Bozeman Study	$290,000
8	Farmers Canal Capacity Study	$300,000
Stormwater Design and Construction Projects		
9	Mechanical Treatment – Peach St.	$280,000
10	Mechanical Treatment – Tamarack St.	$300,000
11	Historic Pipe Replacement Program	$37,000,000
12	N. 9th Ditch Rehabilitation	$450,000
13	Manley Ditch Rehabilitation	$520,000
14	S. 8th and S. 9th Avenues Improvements	$7,300,000
15	S. Wallace Avenue Improvements	$2,100,000
16	W. Arthur Street Improvements	$11,300,000
17	Downtown Bypass or Infiltration Galleries	$2,900,000
Water Quality Design and Construction Projects		
18	S. 11th Ave. and Koch St.	$330,000
19	Arthur Basin	$450,000
20	Willson Avenue	$530,000
21	Cooper Park Midtown	$470,000
22	Cherry Drive	$150,000
23	Langhor Avenue	$330,000
24	W. Olive St., S. 16th Ave. W. Babcock St.	$290,000
25	W. Cleveland St. / W. Garfield St.	$300,000
26	Kagy and Highland Boulevards	$470,000
27	S. 20th Avenue	$330,000
28	W. Babcock St. and S. Ferguson Avenue	$300,000
29	Durston Road and Meagher Avenue	$300,000
30	N. 20th Avenue and Durston Road	$300,000

[1] Planning study cost estimates are based on study area size and previous projects

Stormwater Design & Construction Projects		
9	Mechanical Treatment – Peach St.	$280,000
10	Mechanical Treatment - Tamarack	$300,000
11	Historic Pipe Replacement Program	$2,035,000
12	N 9th Ditch Rehabilitation	$450,000
13	Manley Ditch Rehabilitation	$520,000
14	S 8th and 9th Avenue Improvements	$7,300,000
15	S Wallace Avenue Improvements	$2,050,000
16	W Arthur Street Improvements	$11,300,000
17	Downtown Bypass or Infiltration Galleries	$2,900,000
Water Quality Design and Construction Projects		
18	S 11th & Koch St.	$325,000
19	Arthur Basin	$450,000
20	Wilson Avenue	$530,000
21	Cooper Park Midtown	$465,000
22	Cherry Drive	$150,000
23	Langhor Avenue	$330,000
24	W Olive St, S. 16th,St. W Babcock St.	$290,000
25	W Cleveland St. / W Garfield St.	$300,000
26	Kagy & Highland Boulevard	$465,000
27	S 20th Avenue	$330,000
28	W Babcock St. & S Ferguson Avenue	$300,000
29	Durston Road & Meagher Avenue	$300,000
30	N. 20th Avenue & Durston Road	$300,000



DOWL

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PROJECT: 4036.21888.02 DATE: 4/14/2025

CITY OF BOZEMAN

FIGURE 28

CAPITAL IMPROVEMENT PROJECTS AND STUDIES

9.0 REGULATORY WATER QUALITY COMPLIANCE

The City of Bozeman is a Municipal Separate Storm Sewer System (MS4) community. It is required to follow conditions under the Clean Water Act to manage stormwater discharges under the Montana Department of Environmental Quality's (MDEQ) General Permit for Stormwater Discharges. This permit aims to reduce pollutants in stormwater that discharges into local water bodies. The MS4 General Permit is effective for a five-year term and is re-issued by MDEQ upon expiration. The City is currently operating under the 2022 to 2027 MS4 General Permit term, with the MS4 boundary being the current city limits. The MS4 General Permit requires the development, implementation, and enforcement of a Stormwater Management Plan (SWMP) that is developed and updated annually. This SWMP summarizes the City's effort in how their Stormwater Program is meeting the requirements of the MS4 General Permit, including the six minimum control measures (MCM) highlighted below and any special conditions like stormwater sampling and monitoring.

1. MCM 1 — Public Education and Outreach
2. MCM 2 — Public Involvement and Participation
3. MCM 3 — Illicit Discharge Detection and Elimination (IDDE)
4. MCM 4 — Construction Site Runoff Control
5. MCM 5 — Post-Construction Stormwater Management
6. MCM 6 — Pollution Prevention and Good Housekeeping
7. Special Conditions

The following sections detail more specifics of the various elements of the MS4 General Permit.

9.1 Regulatory History

Modern stormwater management in the City of Bozeman began with the 1982 Stormwater Master Plan. This plan examined the impacts of stormwater runoff to surface water quality, provided modern design criteria, and proposed stormwater ordinances giving the City authority over the storm sewer system. In 1999, the Environmental Protection Agency (EPA) issued the Phase 2 Stormwater Rule, requiring the City to obtain a National Pollution Discharge Elimination System (NPDES) stormwater permit for the lawful discharge of runoff into local waterways. A Phase 2 permit application was submitted in March 2003. At that time, MDEQ had yet to issue an MS4 General Permit, resulting in the City relying on federal stormwater regulations. In January 2005, MDEQ issued its first MS4 General Permit, requiring the City to obtain permit coverage. The 2008 Plan was subsequently developed to address both the NPDES Phase II Stormwater Rule and MDEQ's MS4 General Permit regulations. Since its adoption, the plan has guided the City's stormwater management efforts.

9.1.1 2005 to 2009 Permit

During the 2005 – 2009 permit term, the City was required to develop a Stormwater Management Plan (SWMP), collect stormwater runoff samples, and implement various compliance programs. Compliance responsibilities were completed primarily by the Engineering and Streets Divisions. A 2006 City Commission stormwater workshop emphasized MS4 General Permit requirements and potential compliance solutions, including necessary ordinance updates. The 2008 Plan, adopted during this permit term, served as a blueprint for developing a Stormwater Program. It included an inventory and modeling of the storm sewer system, the formalization of an operations and maintenance program, identification of water quality and pipe replacement capital improvement projects, evaluation of MS4 General Permit compliance, and financial recommendations.

9.1.2 2010 to 2014 Permit and Extension

In 2010, MDEQ issued the second MS4 General Permit (2010 – 2014). During this term the City adopted Ordinance 1763, detailing provisions such as construction stormwater permits and illicit discharge prohibitions. In 2011, MDEQ conducted a compliance audit of the City's Stormwater Program, resulting in eight commendable efforts, 16 program deficiencies, and one violation for lack of an available comprehensive storm sewer system map. The City responded to the audit in 2012 by creating a Stormwater Utility and a staff work plan. The work plan led to a storm sewer system inventory and condition assessment completed during 2013 – 2014. Stormwater Utility staff presented storm sewer system inventory and condition assessment results, compliance needs, and level of service options to the City Commission. In December 2014, the City Commission endorsed a $1.2 million/year level of service, providing dedicated funding towards MS4 General Permit compliance, operations and maintenance program, and capital projects.

In 2013, the MDEQ issued a draft MS4 General Permit for the 2014 – 2018 permit term. Entities regulated by the MS4 General Permit, including the City, objected to the draft permit, recognizing the requirements contained therein were not all achievable. As a result, MDEQ administratively extended the 2010 – 2014 MS4 General Permit, and a working group was formed to draft a new permit. The working group consisted of regulated entities, MDEQ, and other stakeholders. After two years, MDEQ issued the 2017 – 2021 MS4 General Permit.

9.1.3 2017-2021 MS4 Permit

Under this permit, the City has made significant advancements in its Stormwater Program, continually improving compliance with the MS4 Permit. Five annual SWMP reports have been posted on the City website. Many action plans developed in the early 2017 SWMP report have been successfully implemented throughout this permit period. Refinements have been made to the language and documentation of the various MCM associated with the annual SWMP, further improving clarity and effectiveness. In June 2021, MDEQ conducted a compliance audit of the City of Bozeman's MS4 General Permit, resulting in a positive review that highlighted many commendable efforts. The audit also provided a small list of potential improvements and violations.

9.1.4 2022-2026 MS4 Permit

The City is currently in year three of the 2022 – 2026 MS4 General Permit term and continues to implement improvements to its stormwater compliance programs. The City's 5-year CIP includes additional water quality treatment mechanical separators, which advance the TMDL Action Plan [4]. This 2025 Plan will provide further improvements to compliance by addressing a post-construction facility enforcement response plan and inspection frequency. It also guides water quality projects beyond the 5-year CIP horizon and a more complete and well-funded program to meet the permit requirements.

9.2 Co-Permittees

Stormwater discharge originating from Montana State University (MSU) campus, located within the Bozeman city limits, is also regulated under the MS4 General Permit. Due to overlapping boundaries and a shared storm sewer system, the City and MSU work as co-permittees on various MS4 General Permit compliance programs, outlined in a Memorandum of Understanding (MOU). The MOU assigns specific responsibilities for each MCM and stormwater sampling. The City and MSU collaborate on capital projects on an opportunistic basis. The City may complete various MSU storm sewer maintenance tasks due to ownership of specialized equipment and operation and maintenance expertise.

Montana Department of Transportation (MDT) and the City formerly operated as co-permittees under previous MS4 General Permits to manage stormwater discharges from MDT roadways and infrastructure within the Bozeman city limits via inter-local agreements. Co-permittee status between the City and MDT ceased in 2015, with MDT applying for MS4 Individual Permit coverage. MDT and the City have begun the process of mapping MDT outfalls within the Bozeman city limits to determine maintenance and regulatory responsibilities.

The City also collaborates with other local organizations that are not Co-Permittees, including the National Municipal Stormwater Alliance (NMSA), Gallatin Local Water Quality District (GLWQD), Montana State Extension Water Quality, Montana Water Environment Association (MWEA), the Gallatin Watershed Council (GWC). Many of these organizations help with the public education and outreach portion of the MS4 General Permit.

9.3 Impaired Waterways

There are four named impaired waterbodies that receive stormwater discharge within the City of Bozeman MS4 boundary and include Bozeman Creek, a.k.a. Sourdough Creek, Mandeville Creek, Bridger Creek, and the East Gallatin River. The most recent impairment information is obtained from Montana DEQ's Clean Water Act Information Center [10]. Table 18 provides a summary of impairments for each waterbody.

Table 18 – Impaired Waterbody and Impairments with MS4 Boundary

Stream	Total Suspended Solids (TSS)	Total Nitrogen (TN)	Total Phosphorus (TP)	E. coli	Chlorophyll a	Alterations in stream side or littoral vegetative cover
Bozeman Creek	X	X		X	X	X
Mandeville Creek		X	X			
Bridger Creek		X			X	
East Gallatin River		X	X			

Montana DEQ completed TMDL assessments on the above waterbodies to determine pollutant impairments and MS4 Waste Load Allocations (WLA). Bozeman Creek is the only identified waterbody with an MS4 WLA for TSS. The City of Bozeman is not assigned a WLA for total nitrogen, total phosphorus,

E. coli, chlorophyll-a, or alterations in stream-side or littoral vegetative cover. As a result, the City prioritizes sediment reduction BMPs over other treatment needs.

Table 19 summarizes the Lower Gallatin TMDL's Sediment Source Assessment, Allocations, and TMDL for lower Bozeman Creek. Table 20 highlights the load reduction goal the City has self-imposed for Mandeville Creek to further reduce TSS beyond the minimum requirements set forth by MDEQ.

Table 19 – TMDL for Lower Bozeman Creek

Sediment Source	Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% Reduction Tons/Year)
Bozeman Storm Sewer System	218	137	37% - 81 tons/year

Table 20 – Mandeville Creek TMDL Goal

Sediment Source	Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (Tons/Year)
Mandeville Creek	None	None	10 tons/year[1]

[1] Load reduction goal set by the City of Bozeman (not an MDEQ requirement)

The City currently meets the WLA by complying with MS4 General Permit requirements, including implementation of a TMDL Action Plan, which is part of the City's five-year capital plan. The TMDL Action Plan/capital plan identifies water quality projects intended primarily to remove sediment from stormwater.

9.4 Permit Requirements

The MS4 General Permit requires the City to implement a Stormwater Management Plan, including the six minimum control measures (MCM) described below. Implementing a Stormwater Sampling and Evaluation Plan, Capital Improvement Plan (CIP), and staff training are three additional programs needed to comply with MS4 General Permit regulations. Program effectiveness is tracked via various performance measures unique to each MCM. The following summarizes the City's current efforts to meet the conditions of the MS4 General Permit. Further details of the City's efforts are provided in the 2024 SWMP Report [11].

9.4.1 MCMs 1 and 2 — Public Education, Outreach, Involvement, and Participation:

Under these two MCMs, the City is required to identify key target audiences that are common sources of stormwater pollution, illicit discharges, spills, dumping, and/or owners of stormwater infrastructure requiring regular maintenance. After defining these audiences, the City plans and executes passive and active engagement strategies that are tailored to each key target audience to reduce their contribution of pollutants to waterbodies.

The City documents these efforts in the annual SWMP report, including past, ongoing, and future engagement strategies. In the recent 2023 SWMP, the City has identified residents, the construction industry, students, homeowner associations (HOA), restaurants/food trucks, and pet owners as the key targeted audiences and has implemented outreach strategies like adopt a storm drain program, educational stormwater videos, a dog waste campaign, post-construction stormwater training, MSU classes, and educational events. The City's Stormwater Program has invested between 200 to 500 hours annually of stormwater administration staff time between 2017 and 2023 to meet this requirement of the MS4 General Permit.

9.4.2 MCM 3 — Illicit Discharge Detection and Elimination (IDDE):

The City has incorporated an Illicit Discharge program into the Bozeman Municipal Code §40.04.200, which prohibits illicit discharge via the implementation of IDDE corrective action and enforcement response plans. This includes responding to spills, illegal dumping, and other pollution events. Another condition of the MCM 3 is completing an outfall reconnaissance inventory and performing a dry-weather screening of all outfalls for illicit discharges.

The City documents each illicit discharge event and provides a summary of the dry-weather outfall inspection in the annual SWMP report. Over the last six years, the City has been experiencing between three to nine illicit discharge events per year, all of which have a minimal to moderate impact on public safety, infrastructure, and the environment. The City inspects 10 high-priority outfalls annually and typically also inspects roughly 460 lower-priority outfalls, roughly half of the total outfalls. The City's Stormwater Program has invested additional time over the past few years due to urban camping issues and is currently spending between 200 to 500 hours annually of stormwater administration staff time to meet this requirement of the MS4 General Permit.

9.4.3 MCM 4 – Construction Site Stormwater Management:

As part of MCM 4, the City enforces Bozeman Municipal Code §40.04.350, 75-5-101 Montana Code Annotated (MCA), and 17.30.1101, 17.30.1301 et seq., and 17.30.601 et seq. Administrative Rules of Montana (ARM) by completing construction stormwater permit reviews, site inspections, and the implementation of an enforcement response plan. At the end of the year, an annual construction site compliance audit is completed to track program performance.

The City reviews a construction stormwater permit for each new construction project and sends a confirmation letter. Over the last four years, the City has issued between 200 and 400 stormwater construction permits and inspected 7 to 20% of those construction projects. With the accelerated growth within Bozeman, the City has spent 1,300 to 2,300 hours annually of stormwater administration staff time to meet this requirement of the MS4 General Permit. Because compliance has improved over the last several years, the City is planning to streamline its permit review and site inspection processes.

9.4.4 MCM 5 – Post-Construction Site Stormwater Management:

To meet MCM 5, the City has implemented water quality standards that require runoff reduction on new and redevelopment projects by completing plan reviews, maintaining an inventory of post-construction facilities, and inspecting post-construction facilities to assess condition and functionality. The stormwater facilities that MDEQ focuses on include both surface and underground storage facilities, such as retention and detention ponds. Additionally, an annual post-construction facility condition audit is conducted at the end of each year to track program performance.

The City documents the review process, inventory of new facilities, post-construction facility inspections, and ongoing and future initiatives to enhance its program in the annual SWMP report. There are roughly

1,144 storage facilities, and stormwater administration staff have been increasing efforts to include more inspections over the last few years. The City has spent 1,000 to 2,300 hours annually of stormwater administration staff time to meet this requirement of the MS4 General Permit.

9.4.5 MCM 6 – Pollution Prevention and Good Housekeeping:

Under MCM 6, the City needs to have storm sewer infrastructure operations and maintenance programs, a pollution prevention program for City-owned facilities and city activities, and provide stormwater training for plan and permit reviewers and operations staff.

The City documents the annual inspection and maintenance performance of the stormwater infrastructure described in Section 6.0. The City and MSU have a total of nine facilities with Facility Pollution Prevention Plans (FSWPPP), including the City Shop Complex, Vehicle Maintenance Facility, Water Treatment Plant, Water Reclamation Facility, East Gallatin Storage Area, Solid Waste Landfill, Snow Storage Area, University Shops Facility, and MSU Material Storage Area. Fourteen activities are identified with standard operating guidelines to reduce target pollutants. These activities range from the construction of sidewalks and curbs to standard maintenance activities like park mowing to maintenance of parking lots and parking garages. Stormwater staff train operations staff on these facilities and activities as required by the MS4 Permit. Staff time totals 300 to 850 hours per year.

9.4.6 Special Conditions

In addition to the MCMs, the City is also required to document its stormwater sampling and evaluation program. The City monitors stormwater discharge based on land-use types, completes TMDL monitoring by collecting in-stream wet-weather samples, measures sediment captured by stormwater treatment units to track progress toward the 81-ton load reduction target set for Bozeman Creek, and monitors long-term trends in macro-invertebrates.

The City has eight flow sampling locations, including two residential sites, two industrial sites, and sites on Bozeman Creek and Mandeville Creek upstream and downstream of the MS4 boundary. Water quality samples are taken twice a year during a storm event at each location. Sediment is measured and then removed from the water treatment manholes using a vac truck to determine the annual sediment removal totals. This information is documented in the annual SWMP report, which includes a graded evaluation of the samples associated with storm events, in-stream wet weather monitoring, and stream health monitoring. An overall program performance measure combines these three individual scores with sediment reduction monitoring. The City's Stormwater Program has invested between 200 to 400 hours annually of stormwater administration staff time in meeting this requirement of the MS4 General Permit.

9.4.7 Other

The annual SWMP report also includes a section on Program Administration and Capital Improvement Planning. Sections 8 and 10 provide further details of these programs.

9.5 2021 MDEQ MS4 Permit Audit Summary

From June 15–18, 2021, MDEQ conducted a compliance audit of the City's Stormwater Program. The audit assessed the City's SWMP programs, including each MCM, training, sharing of responsibilities, and stormwater sampling, for compliance with the 2017–2021 MS4 General Permit requirements. In total, the

City received 21 Commendable Efforts, 16 Areas for Improvement and Recommendations, and five Violations.

The five violations include the following:

- Stormwater Management Plan
    - The city has not formalized a complete organization chart to address responsibilities for specific MCMs and primary points of contact.
- Illicit Discharge Detection and Elimination
    - Formalize an MOU between the City and MSU to document specific MS4 General Permit compliance responsibilities.
- Post-Construction Site Stormwater Management
    - Failure to conduct inspections of high-priority post-construction BMPs, annually.
    - The City has not developed a complete Enforcement Response Plan (ERP) to ensure compliance with installation, operations, and maintenance requirements on regulated projects, including private property.
    - Failure to require self-inspections and reporting of post-construction BMP features.

The City has resolved three of the five violations identified above, including:

- Stormwater Management Plan
    - The city updated its organizational chart to include the Parks and Recreation Department, the new City management structure, and positions(s) responsible for specific MCMs and added primary points of contact. The City will need to complete annual updates to the organization chart to incorporate changes as they occur.
- Illicit Discharge Detection and Elimination
    - A MOU between the City and MSU was formalized, documenting the MS4 Permit compliance responsibilities. The MOU is effective from February 2022 through 2026. In addition, a formal inter-local agreement for emergency services for spill response was submitted for the two co-permittees. This emergency services agreement will be renewed annually, and the MOU will be renewed for the next MS4 Permit.
- Post-Construction Site Stormwater Management
    - In 2022 and 2023, the City has identified and inspected the high-priority post-construction BMPs. The City will update the high-priority construction BMP analysis to identify new features on an annual basis.

The two violations that are not currently resolved are within the Post-Construction Site Stormwater Management area. These violations include the failure to require self-inspection and reporting of the post-construction BMPs and the development of a formal enforcement response plan. The following section addresses these violations.

9.6 Regulatory Water Quality Compliance Recommendations

The City is currently generally satisfied with its performance under the MS4 General Permit, noting that it has established a good process and is meeting the permit requirements, aside from the noted unresolved violations. At this time, the City does not elect to increase the level of service to achieve a higher level of service beyond the current program. The City will make the necessary adjustments to address the noted violations and will continue to monitor program performance and respond as needed to address future requirements of MDEQ.

The following recommendations are specifically focused on improving the post-construction stormwater pond program and addressing the remaining permit violations to ensure continued compliance and effectiveness in stormwater management.

9.6.1 Post-Construction Program Review and Recommendations

A detailed evaluation of the City of Bozeman's post-construction stormwater ponds program was conducted as part of the 2025 Plan. This evaluation included a review of programs of other similar communities, an assessment of the current City of Bozeman program, and recommendations for improvement. The review of representative communities looked at their post-construction programs and what they do regarding level of service, ownership, design criteria, construction inspection, post-construction inspection and maintenance, enforcement, program administration, and funding. A detailed inspection of a sample set of post-construction facilities (ponds) across the City of Bozeman was also completed in developing a methodology to estimate the total deferred maintenance cost for these facilities. The following summarizes the recommendations for the post-construction stormwater ponds program.

- Design Criteria and Construction Inspection
  - It is recommended that additional requirements be added to the as-built drawing submittal in the design criteria manual to facilitate post-construction inspections. This would include an operations and maintenance plan, key elevations, storage requirements, contours, water surface elevations, a design storage versus constructed storage comparison table, inflow rates, and the trigger elevation for when sediment removal is needed. The submitted plan should be an as-built certified by an engineer registered in the State of Montana. These requirements have been included in the updated City of Bozeman Design and Construction Standards pending approval by the City Commission.
- Inspection Workflow
  - Perform a rapid assessment for every City-Owned post-construction facility every five years and utilize the rapid assessment to identify high-priority facilities. Over the next four years, perform a detailed pond inspection for the top 25 to 50% of the post-construction ponds identified through the rapid assessment as being in the worst condition.
  - Require detailed inspections of HOA and private facilities to be completed by qualified inspectors retained by the private entity or HOA on a five-year cycle. The detailed inspection reports would require certification by a Professional Engineer or Professional Land Surveyor. It is recommended that the City complete a rapid assessment of 5% to 10% of the private and HOA facilities annually to identify violations and verify submitted inspections. During the ramp-up period of requiring detailed inspections, it is suggested that the City inspects 10% to 20% of these facilities using the rapid assessment on an annual basis.
  - Additional recommendations on the rapid and detailed inspection forms and assessment methodologies are provided in the *Post-Construction Review and Recommendations* report [6]. "The updated City of Bozeman Design and Construction Standards include the recommended post-construction stormwater pond inspection forms.

- Public Education
  - A review of the Stormwater Facility Maintenance Guide was completed, and recommendations for minor refinements were provided. A marked-up document is included in the *Post-Construction Review and Recommendations* report [6].
- Enforcement Response Plan
  - DEQ has indicated that the City needs to develop an enforcement response plan (ERP) and has recommended that it be modeled after the ERP developed by the City of Kalispell. The City of Kalispell ERP not only focuses on post-construction stormwater pond inspection and maintenance but also on illicit discharge and construction site inspections. Minimum recommendations for each section of the ERP are included in the *Post-Construction Review and Recommendations* report [6].
- Program Management and Administration
  - It is recommended that the City review the recommendations of this report and assess the associated staffing needs. Additional details of the recommended program management and administration are provided in Section 10.0.
- Funding
  - Based on an evaluation of potential funding mechanisms for an expanded post-construction stormwater pond inspection and maintenance program, it is recommended that this be funded through the existing stormwater utility. Adjustments to the stormwater utility rate and the rate credit policy should be evaluated to establish an appropriate rate and the associated level of service. It is recommended that a needs-based stormwater utility rate study be completed for this purpose and for implementing other recommendations provided in this report.

9.6.2 Flow Sampling Enhancement

The City could consider installing water quality monitoring devices on Bozeman Creek and Mandeville Creek to gain a better understanding of water quality dynamics of various parameters with varying hydrologic, climatic, or other conditions. Utilizing the Insitu 800 device or an equivalent manufacturer equipped with sensors for parameters such as turbidity offers a cost-effective solution, with a single site setup costing approximately $2,000 to $3,000. Continuous monitoring would provide valuable data on TSS and other parameters, capturing fluctuations during dry periods and storm events to identify trends. Incorporating a piezometer would enhance the system by measuring water depth, which, combined with a rating table, would also provide continuous flow rates. Strategically placing multiple units along Bozeman Creek—such as upstream and downstream of the MS4 boundary or near storm drain outfalls—would facilitate a comprehensive assessment of water quality. Moreover, this equipment is portable and could be relocated in the future to other sites, enabling adaptive monitoring as baseline data are established.

10.0 PROGRAM MANAGEMENT AND ADMINISTRATION

The City has staff that manages and administrates the Stormwater Program. The information summarized below was provided by City staff through a questionnaire, the development of a matrix of tasks, and follow-up discussions. The matrix framework provided to the City allowed for a listing of specific tasks, the associated staff and equipment needed to complete the task, the City grading of existing performance, any challenges or issues associated with the task, and any City recommendations to improve performance. The feedback generally focused on ongoing challenges and additional needs to effectively manage and operate the Stormwater Program. Some of the activities discussed below overlap with other City departments, including Finance, Engineering, GIS, Street Maintenance, and Water / Sanitary / Storm Operations to fully address these activities.

10.1 Current Program Management and Administration Activities

10.1.1 Stormwater Program Administration

The Stormwater Administration staff is responsible for the overall program management, which includes the following tasks:

- Accounts payable,
- Developing and managing the operating budget,
- Managing and training personnel,
- Updating the Stormwater Rate and addressing related issues,
- Digitizing new impervious areas for ERU calculations and providing Finance the ERU determinations,
- Managing office space, and
- Assisting in litigation.

These responsibilities primarily fall to the Stormwater Program Manager, although other members of the Stormwater Program contribute to meeting these obligations. Completing these tasks typically requires between 0.50 and 0.85 full-time equivalent (FTE) staff effort.

10.1.2 Office Space and Parking

The City of Bozeman Stormwater Administration office is currently located at 7 East Beall Street, where it shares space with the Water Conservation Division and Bozeman’s Metropolitan Planning Organization (MPO). The building is occupied by five Stormwater staff members, five Water Conservation Division staff members, and one MPO staff member. Although the current office space meets the City’s current needs, it cannot accommodate staff additions and equipment storage. There is also limited parking available for additional staff. As the City continues to grow and the demands on the Stormwater Program increase, it will likely be necessary to identify a permanent office space that provides sufficient room for expansion to support the City’s long-term goals. It is recommended that the City prioritize finding a suitable location for future expansion of the Stormwater Program.

10.1.3 Subdivision and Commercial Site Development Review

The Stormwater Administration staff and the Engineering Department collaborate on development site reviews, which include technical design reviews, pre-application meetings, pre-construction meetings, pre-paving meetings, final walkthroughs, two-year warranty reviews, and occupancy reviews. The Stormwater Operations staff conduct video inspections of new infrastructure and oversee repairs to ensure final acceptance. Additionally, the Engineering Department oversees development reviews for all public infrastructure.

Based on the City's estimates, these development reviews and associated meetings utilize up to 0.65 FTE of stormwater staff time. The division of responsibilities between stormwater and engineering staff appears to function effectively, with strong communication between the two groups. Overall, the City believes they are performing above average in site development reviews. However, with the upcoming update to the stormwater design criteria, the City anticipates that reviews may take more time as both the City and the design community adapt to the new requirements.

One challenge identified by the stormwater staff is the time required to locate key documents for design and construction reviews associated with post-construction facility inspections. Files are sometimes duplicated or saved in multiple locations, leading to inefficiencies. Implementing a more formal file-tracking system for stormwater design reports, maintenance plans, record drawings, and other pertinent data would streamline access to these documents, improving the transition from design to construction inspection and, ultimately, to post-construction inspection.

As discussed in Section 8.1, completion of the recommended storm drainage planning studies would help guide development consistent with regional stormwater solutions.

10.1.4 Work Order (Contract) Administration

The Stormwater Administration staff typically manages one outreach contract and two infrastructure contracts per year. Their project management duties include developing and negotiating scopes of work and budgets, contracting, tracking progress and budgets, and reviewing planning reports, final design plans, and specifications. For many stormwater infrastructure projects, the administration staff also serves as the Resident Project Representative (RPR), ensuring construction adheres to contract requirements and construction plans. The stormwater staff estimates that approximately 0.33 full-time equivalent (FTE) is dedicated annually to managing these work order projects and fulfilling RPR responsibilities.

The City adjusts its level of involvement in these projects based on the capacity of stormwater administration and engineering department staff. Some contracts are outsourced when specialized skills are required that City staff cannot provide. Balancing the workload remains a primary focus for the City, particularly as other demands fluctuate. There is an ongoing emphasis on the contracting process to help streamline efforts in getting these outsourced projects executed and moving forward. The City has also allocated additional time to contract management and continues to provide ongoing training to staff to improve their understanding of the contracting process.

10.1.5 Responding to Customer Concerns

The Stormwater Administration staff primarily handles stormwater complaints and issues related to flooding and water quality. They also field calls that must be referred to other City departments. On average, they receive seven flood-related complaints annually, including issues such as plugged inlets, sump pumps, and surcharging manholes. This number does not include complaints handled by the City's maintenance staff. In addition, the staff receives an average of 10 complaints per year regarding water quality, not including the Illicit Discharge Detection and Elimination (IDDE) events discussed earlier.

The City believes it provides an above-average level of service in addressing these complaints. However, a challenge lies in the variability of complaints and the need to pause other tasks to respond promptly. The City has observed an increase in complaints, likely tied to enhanced outreach and education efforts. As the City grows and additional inspections and responsibilities are assigned to the Stormwater Administration staff, the volume of complaints is expected to rise further.

10.1.6 Stormwater CIP Planning

Each year, the City develops a five-year Capital Improvement Plan (CIP) to define infrastructure projects and other capital needs. This process includes opportunities for public comment, is approved by the City Commission, and is incorporated into the corresponding fiscal year's budget.

The Stormwater Administration staff focuses on River Health projects, deferred maintenance initiatives, planning studies and reports, and addressing equipment needs. The River Health projects include MS4 compliance needs and addressing total suspended solids (TSS) reduction. The deferred maintenance projects include replacing historic pipe conveyance systems and rehabilitating ditches. Many projects also involve conceptual analyses, prioritization, and collaboration with other departments. Two dedicated staff members, with input from additional personnel, contribute to developing the CIP, requiring approximately 200 hours annually (0.1 FTE).

Currently, the Stormwater Administration does not evaluate stormwater needs associated with street reconstruction projects, which the Engineering Department manages. This separation reduces opportunities to proactively identify and integrate stormwater improvements with other infrastructure projects, potentially foregoing cost efficiencies through project consolidation.

The Special Improvement District (SID) process is currently in flux, complicating the ability to predict the timing, location, and stormwater needs in these areas.

10.1.7 GIS Support

The GIS team provides essential support to Stormwater Administration through a variety of tasks critical to the management and operation of the Stormwater Program. These tasks include importing impervious surface and account data into the enterprise database for billing purposes, updating the database to reflect new infrastructure and repairs, and managing tools such as CityWorks and dashboards for performance tracking and troubleshooting. Additionally, GIS staff support various projects, including alignment efforts with Montana Department of Transportation (MDT) and Montana State University (MSU) data, as well as biweekly updates to impervious surface data.

In recent years, GIS operations have faced significant challenges due to high turnover and understaffing, leading to a substantial backlog of work. However, the team is now fully staffed and has begun making measurable progress in addressing this backlog. As part of this effort, the GIS Division is conducting a comprehensive needs assessment and overhauling its software and programs to improve overall efficiency.

The City currently rates GIS support for stormwater administration below average, highlighting the need for greater collaboration between GIS leadership and stormwater administration to ensure all stormwater-related GIS needs are adequately addressed. A primary focus is associated with finding ways to streamline the impervious area digitization and updating of impervious area data for billing processes. There appears to be a lot of cleanup of the impervious areas during the billing process. The Finance Department is currently exploring new software solutions that may assist with these efforts. At a minimum, the City should develop a periodic quality control check in GIS to catch billing errors and eliminate inactive accounts that are currently in the GIS.

10.1.8 SWPPP Administration

The City plays a key role in administering Stormwater Prevention and Pollution Plans (SWPPP) for various City and MDT projects, particularly those that are complex, involve multiple contractors, or have phased development. The City's SWPPP efforts fluctuate based on the size and complexity of the projects and the construction timelines. On average, the City estimates that this effort requires around 100 hours annually, though this may vary depending on the number of projects and their stages of development.

The City's SWPPP administration efforts include the development of permits, management, and oversight of these permits throughout the project lifecycle, as well as the implementation of pollution prevention strategies. This includes conducting regular inspections to ensure compliance with stormwater regulations and best management practices. The City's proactive approach helps mitigate the impact of construction activities on water quality and ensures that stormwater runoff is properly managed to protect the environment. However, these SWPPP administration tasks can be time-consuming and often take valuable time away from other program needs. Proactive planning and early engagement in these projects are necessary for the City to allocate resources better and manage workloads effectively. Additionally, when possible, the City should consider delegating SWPPP administration to the primary contractor to streamline the process and improve overall efficiency, ensuring that City staff can focus on higher-priority tasks while still maintaining compliance and oversight.

10.1.9 Records Research and Document Management

The City dedicates significant time to researching and organizing records necessary for post-construction stormwater management. These efforts include locating and reviewing engineering design documents, a task shared by Stormwater Administration staff, the Public Works Administration, and the City Clerk's office. While record research hours are typically categorized under post-construction activities, there is an ongoing need to integrate and streamline the organization of historical engineering records as part of the post-construction workflow.

One major challenge in this process is the varied state of records from 1980 to the present. Records may exist in paper format, in digital files, or within older systems that are difficult to navigate. This inconsistency complicates efforts to move smoothly from the design and construction phases to post-construction reviews.

To address these challenges, the City recommends scanning all remaining paper documents to create a comprehensive digital archive, establishing an improved filing system for both new and legacy records, and developing a public-facing interface to provide the general public and design community with access to information about stormwater features.

Currently, the City ranks the record research process as below average, emphasizing the need for significant improvements to reduce inefficiencies and ensure that critical information is more readily available for stormwater management.

10.2 Recommendations

The City generally feels good about the current state of program management and administration. Operations have been running relatively smoothly, aided by low turnover among stormwater administration staff. The following recommendations are provided to improve overall program efficiency, enhance resource allocation, and ensure the program's continued success.

10.2.1 Office Space and Parking Expansion

As the City of Bozeman and the Stormwater Program continue to grow, it will be necessary to secure expanded office space that can accommodate future staffing, equipment storage, and additional parking. It is recommended that identifying and securing a suitable location be prioritized with a target of resolving this issue over the next decade to support the Stormwater Program in meeting its long-term goals.

10.2.2 Streamline Billing and GIS Process

The City should focus on improving the efficiency of digitizing impervious surface data and streamlining the billing process. Implementing a periodic quality control check within GIS will help to catch billing errors, reduce the cleanup efforts required during the billing process, and eliminate inactive accounts that clutter the process. Additionally, the City should explore investing in software solutions that integrate the billing process with GIS data, enabling smoother operations and freeing up staff time for higher-priority tasks.

The City could also consider revising the policy for impervious area delineation by conducting an annual update based on aerial imagery. By contracting a service to provide an impervious surface layer derived from the imagery, the City would obtain more accurate data that reflects current conditions. This approach could reduce data discrepancies and streamline updates. However, there would still be a need for overrides in specific cases, such as when more accurate survey-based parcel data is provided. Consideration should also be given to requiring contractors to calculate the impervious area of a site and submit it with the as-built construction plans.

10.2.3 SWPPP Administration

Given the fluctuating demands of SWPPP administration, it is recommended that the City engage in more active planning to allocate resources better and manage workloads. Early engagement in these projects will allow for more time to assign appropriate staff and streamline efforts. Additionally, when possible, the City should consider delegating the responsibility of SWPPP administration to the prime construction contractor, ensuring compliance and oversight without overburdening City staff.

10.2.4 Records Research and Document Management

To address challenges with locating and organizing engineering records, it is recommended that the City focus on scanning all remaining paper documents to create a comprehensive digital archive. Establishing an improved filing system for both new and legacy records and developing a public-facing interface for access by the general public and design community will enhance efficiency, streamline post-construction workflows, and improve accessibility to essential stormwater management information.

10.2.5 Increase Collaboration between Departments

It is recommended that the City continue to strengthen communication and collaboration between the Stormwater staff and other departments, particularly GIS, Engineering, Finance, and Street Maintenance. Improved coordination on tasks such as site development reviews, work order administration, and stormwater CIP planning will help streamline processes, reduce duplication of efforts, and ensure that stormwater needs are incorporated into broader city planning and infrastructure projects.

10.2.6 Investing in Long-term Planning with Regional Stormwater Solutions

It is recommended that the City complete planning studies to guide development consistent with planned regional stormwater solutions. A holistic approach to stormwater planning, rather than individual project-by-project solutions, will provide the City insight into the potential risks and benefits of alternative solutions in meeting the community's stormwater management needs.

11.0 STORMWATER PROGRAM FUNDING ASSESSMENT

A challenge facing many stormwater programs is finding funding to manage the City's stormwater assets proactively. The FCS conducted a detailed review of the City's Stormwater Program funding, including an examination of the current financial situation, the established stormwater utility rates, and rate credits. They also provided recommendations and strategies to increase funding. The following section introduces utility ratemaking, provides an overview of the necessary information for a rate study, and assesses the utility rates.

11.1 Introduction to Utility Ratemaking

Utility rates should be set to recover the cost of providing service. Therefore, one of the key elements of a rate study is to develop a funding plan ("revenue requirement"). The duration of the funding plan varies, but it is generally a good idea to align it with a utility's capital improvement program (CIP). For example, if a utility has a five-year CIP, it makes sense to develop (at least) a five-year revenue requirement forecast.

The revenue requirement analysis determines the total funding needed for a utility to operate independently, accounting for operating and maintenance costs, fiscal policy goals, and capital project needs. A typical study approach is shown in Figure 29.

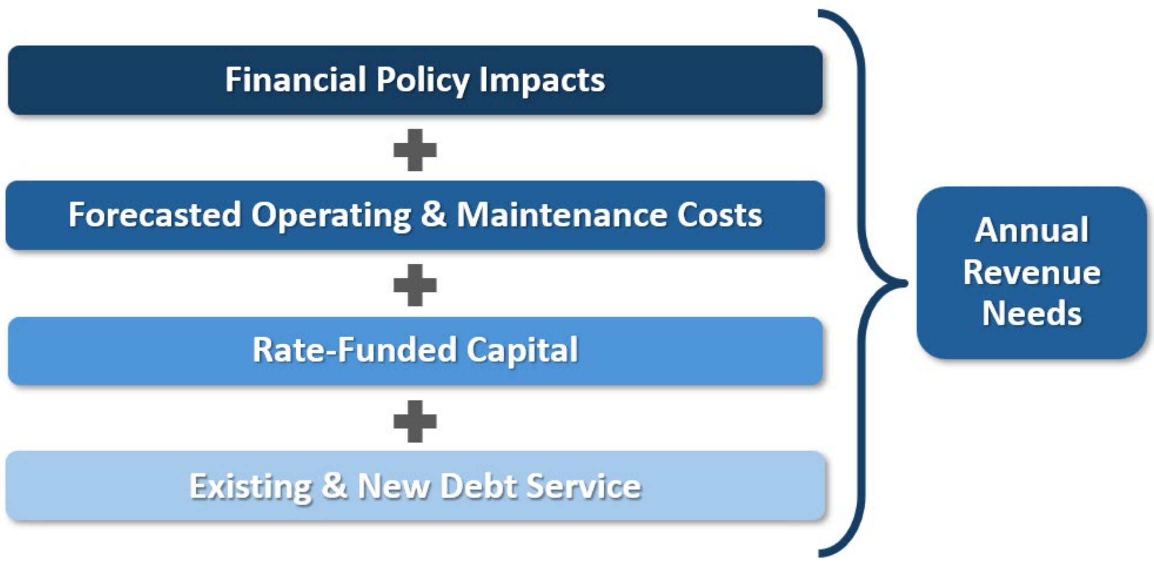


Figure 29 — Revenue Requirement Overview

11.1.1 Overview of Capital Funding Strategies

For most utilities, there are three common sources of cost responsibility: property owners (e.g., developers), outside parties with a policy interest, and ratepayers.

11.1.1.1 Property Owners (connection charges/impact fees)

Property owners typically contribute to capital funding through connection charges and/or impact fees. These fees help recover a proportionate share of the utility's capital infrastructure investment from new customers. Their primary purposes are to ensure equity between existing and new customers and to provide a sustainable funding source as the utility grows. Additionally, these charges uphold the principle that 'growth helps pay for growth.' They are generally applied to both new developments and redevelopments that increase system capacity demands.

11.1.1.2 Outside Parties (grants)

Grants are typically provided by state, federal, and occasionally county governments. They are made available because an outside government has a policy interest—such as promoting clean water—and has decided that some local utilities will not realistically have enough ratepayer resources to make the capital investments that further that policy interest.

Grants are usually highly competitive, and often, an important criterion is the rate impact of a given capital project in relation to the economic circumstances of the utility customers. In addition, a local utility needs to be willing to accept the "strings attached" to compete for a federal or state grant.

11.1.1.3 Ratepayers (cash and debt-funded capital)

For a utility, the default cost responsibility rests with the ratepayers. They are the ultimate funding source. If the cost responsibility cannot be shifted to someone else, then a capital project will be funded – either now or later – by ratepayers, if it is to be funded at all.

Ratepayers generally do not like extreme swings in their rates, so there needs to be a way to smooth out the variability in capital spending. Either the utility needs to save up in advance, borrow, or do some combination of both.

11.1.2 Discussion of Cash versus Debt

This section discusses some considerations in deciding how much to rely on debt as opposed to cash financing.

11.1.2.1 Current Rate Revenue

Current rate revenue is clearly eligible as a funding source for stormwater utility capital projects. While it is a flexible source of revenue, its biggest disadvantage is that the amount available in any given year is limited, whereas the amounts needed to fund the capital program might vary widely. To smooth out the financial demands over time, utilities typically need to either save money in advance or borrow. Still, with good financial planning, a significant part of a utility's CIP might be able to be funded with rate revenue.

11.1.2.2 Cash Reserves

In this discussion, "cash reserves" refer to the beginning cash balances from prior-year rate revenue. These reserves can be broadly used for the City's stormwater utility capital needs, provided they are not restricted to specific purposes. Cash reserves are advantageous because they allow the utility to earn interest on balances instead of paying interest on debt. They also provide financial flexibility, enabling the utility to manage sudden cash squeezes by drawing down reserves or deferring capital projects, unlike debt service payments, which cannot be skipped.

However, relying on cash reserves requires advance savings, emphasizing the need for forward-thinking financial planning. This strategy is particularly suitable for scalable capital projects that can be anticipated well in advance, such as pipe replacement programs or repairs of catch basins, inlets, and manholes. In cases of spikes in capital spending needs, such as replacing multiple stormwater culverts or coordinating with significant transportation projects, it might not be feasible to raise rates suddenly enough to cover costs without borrowing.

11.1.2.3 Debt

Debt is a valuable capital funding tool that helps mitigate rate impacts by providing funds when needed beyond available savings. It spreads capital costs over a prolonged period, such as 20 years, benefiting both existing and future customers. Additionally, another key advantage to borrowing is that capital projects can be funded and executed quicker than saving up cash in advance, thereby reducing the effects of long-term cost inflation.

However, debt comes with issuance and interest costs, and a utility's ability to meet debt service coverage and other requirements may limit the amount of additional debt it can issue. Excessive debt can also affect a utility's credit rating and its ability to secure low-interest debt in the future. Debt is best suited for large, discrete projects rather than ongoing capital programs or system replacement. It creates intergenerational equity, as those who benefit from the capital improvement also carry the cost burden. However, issuing debt requires paying interest, which reduces financial flexibility and increases the risk of disruptive effects from unanticipated contingencies.

11.1.2.4 Resulting Considerations

Ultimately, over time, the City may want to consider a hybrid approach. For example, the City could use rate revenues to fund annual repair and replacement projects and consider a combination of cash and debt for large, one-time projects that may be difficult to fund solely with rate revenues.

11.1.2.5 Across the Industry

Drawing from the *2021 Stormwater Utility Survey* report [12], of the 73 participants surveyed (from 20 states), 78% of participants funded most capital projects with cash versus 22% funding most projects with debt. This result is slightly different from previous years – 87% of participants funded most projects with cash in 2018, and 88% did so in 2016.

11.1.3 Summary

The following matrix provides an overview of how these various funding sources can be used for operating and/or capital expenditures.

Table 21 – Capital Funding Matrix

Funding Sources	Operations and Maintenance	Capital
Rate revenues	Yes	Yes
Bonds and loans	n/a	Yes
Grants	Uncommon	Yes
Impact fees	Only administrative portion[1]	Yes

[1] "An impact fee may include a fee for the administration of the impact fee not to exceed 5% of the total impact fee collected." Montana Code 7-6-1601.

11.2 What Information is Needed for a Rate Study?

In addition to the capital needs in Table 23, the City is undergoing an evaluative process for its stormwater ponds and will undergo similar evaluations across a variety of categories and program elements, which could include those identified in Figure 30.

These evaluations may identify additional operating and/or capital needs. Under each element, key variables such as inspection frequency, team size, required equipment, the cost and timescale of deferred maintenance and capital improvements, etc., could impact a funding plan.

A comprehensive rate study would include all (or most) elements simultaneously instead of 1-2 at a time, allowing decision-makers to prioritize various elements against funding constraints. Table 22 demonstrates a hypothetical outcome of a comprehensive rate study that incorporates many program elements simultaneously.

Table 22 – Level of Service Matrix – SAMPLE ONLY

Program Element	Bronze	Silver	Gold
Deferred Maintenance	40-year completion	30-year completion	20-year completion
Capital Improvements	40-year completion	30-year completion	20-year completion
Operation and Maintenance	Reactive: (ponds, culverts) Proactive: (inlets, manholes, WQ)	Reactive: (culverts) Proactive: (inlets, manholes, WQ, ponds)	Proactive: (inlets, manholes, WQ, ponds, culverts)
MS4 Compliance	Meet Minimum Requirements	Meet Anticipated Future Requirements	Meet Anticipated Future Requirements
Program Administration	Status Quo	More quickly address complaints Enhance GIS capabilities	+ Robust public outreach
Other	Address Bank Erosion	+ Address Bozeman Creek Flooding	+ Snow Storage
Monthly Rate	$	$$	$$$

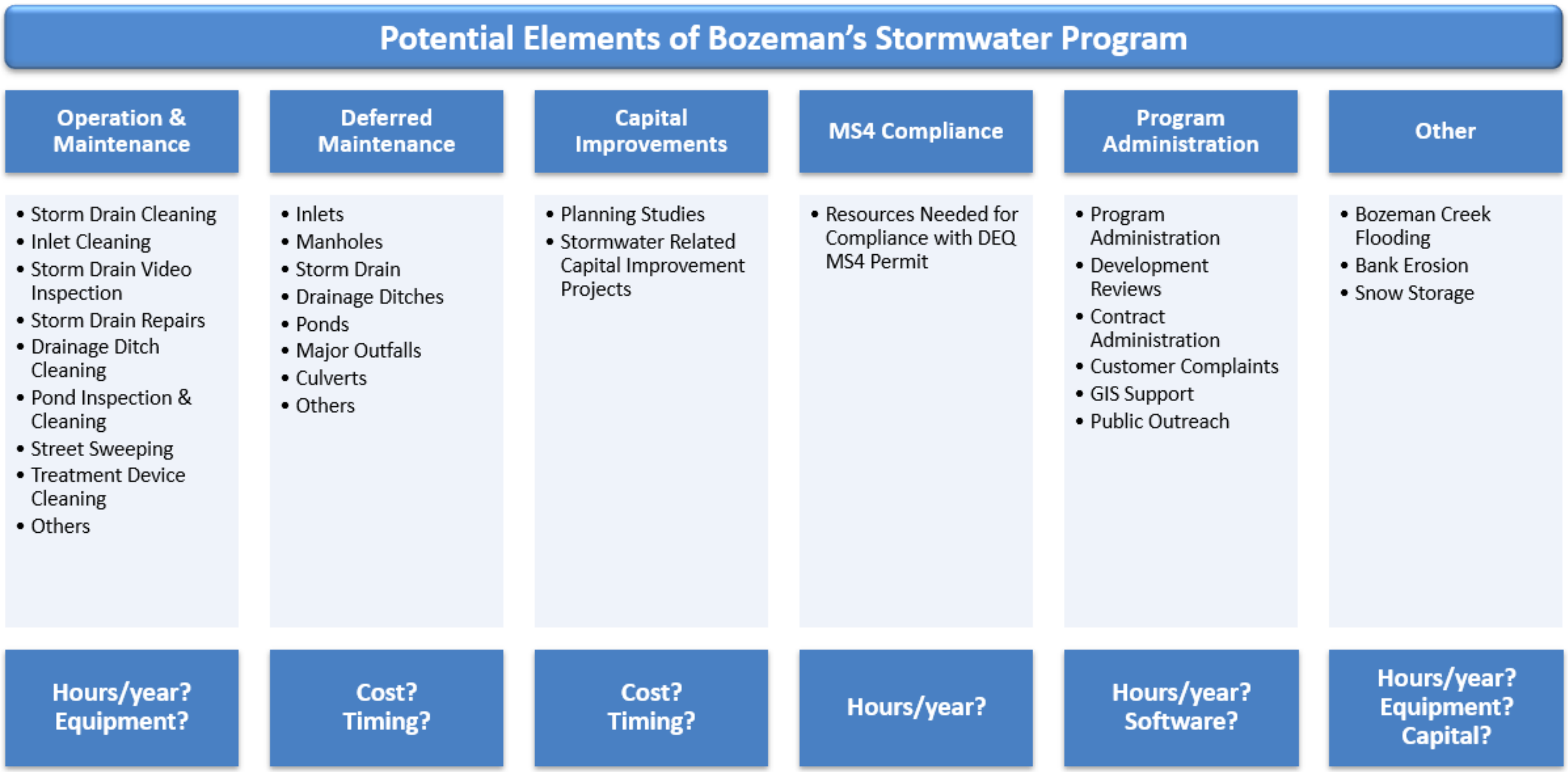


Figure 30 – Potential Elements of the City's Stormwater Program

This 2025 Plan provides a summary of existing tasks and levels of effort as well as identifying areas of improvement. It, however, stops short of defining increased levels of service to better meet the community's stormwater management needs and the associated staff, equipment, timeframe, and costs for achieving these program objectives. It is recommended that the City use the findings of this report, fill in data gaps in deferred maintenance costs, define alternative levels of improved service, and complete a needs-based stormwater utility rate study to determine the appropriate balance of stormwater utility rates and level of service.

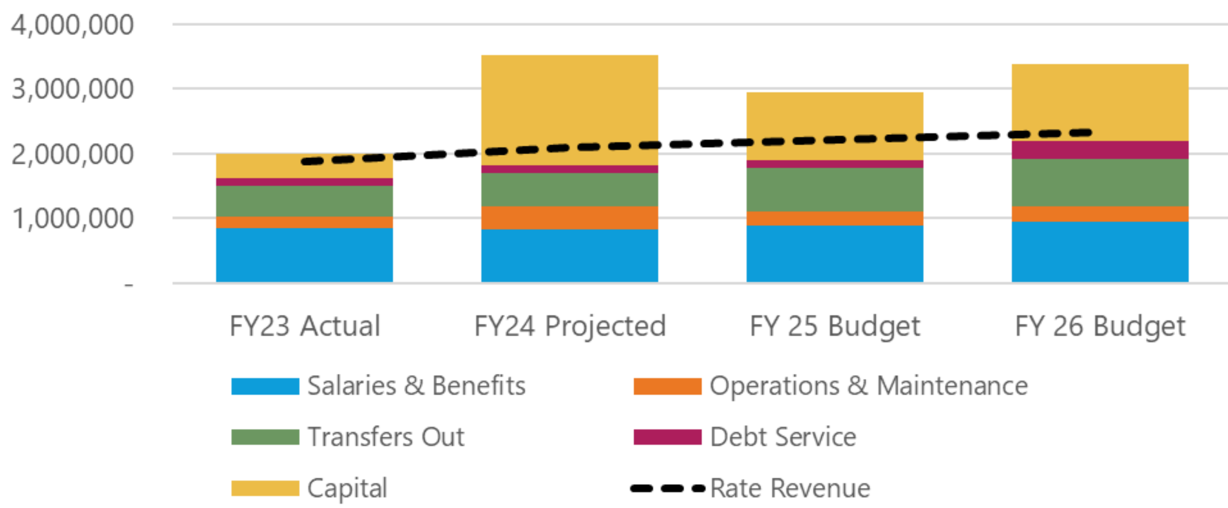
11.3 Current Financial Position of Stormwater Utility

This section provides a snapshot of the City's financial performance based on the adopted FY 2025-26 budget. Note that a more comprehensive rate study is being performed concurrently, and the following provides a high-level analysis based on the City's budget. These observations are not meant to supersede any recommendations or findings resulting from the broader water, sewer, and stormwater utility rate study.

Increases in salaries, benefits, operations and maintenance, and debt service appear to be "squeezing" out rate-funded capital for the City's stormwater utility. For example, consider the following trends comparing FY 2023 actuals to the FY 2026 budget:

- Total salaries and benefits, maintenance and operations, transfers out, and annual debt service expenditures are projected to increase by 35%.
  - The Salaries and Benefits category is projected to increase by 11%.
  - The Operations and Maintenance category is projected to increase by 44%.
  - The Transfers Out category is projected to increase by 48%.
  - Debt Service is projected to more than double if the City borrows $1.275 million, as noted in the budget for FY 2025.
- During this time, the Charges for Services category (rate revenue) is budgeted to increase by just 24%.
  - It appears that the budget assumes annual increases of roughly 5.7% per year for FY 2025 and FY 2026, presumably because of some combination of customer growth and rate adjustments.

As costs increase faster than rate revenues, the amount of rate revenues available for capital projects is projected to decrease from over $262,000 in FY 2023 to $147,000 in FY 2026. As a result, more capital projects need to be funded through drawdowns of cash reserves, additional borrowing, or delayed unless additional rate adjustments are implemented.



Source: City of Bozeman 2025 Biennium Adopted Budget (page 114/269) https://www.bozeman.net/home/showpublisheddocument/14358/638634614563530000

Figure 31 – Multi-Year Financial Performance for Stormwater Utility (based on FY 2025-2026 Budget)

Table 23 details the City's 2024-2031 preliminary capital improvement program, which totals over $9.4 million (with inflation). The ongoing rate study assumes a 90% completion factor, so the effective total capital plan is $8.5 million, slightly lower than what is shown in the table.

If FY 2026 rates can support roughly $150,000 of rate-funded capital per year, the City will need to adjust rates higher, receive outside grant funding, and/or borrow (if rates can support debt service) to execute the planned capital program. As previously noted, the ongoing rate study has tentatively assumed annual rate increases of 3% per year and nearly $6 million of borrowing.

Table 23 – 2024-31 Stormwater Utility Capital Program – Inflated Dollars in $10k (DRAFT)

Code	Project Description	2024	2025	2026	2027	2028	2029	2030	2031	Total
STDM02	Manley Ditch Rehab	-	54	-	-	-	-	-	-	$ 54
STOP04	Pipe Inspection Van (#01)	-	34	-	-	-	-	-	-	$ 34
STDM04	Historic Pipe Replacement Program	8	55	11	65	12	83	14	-	$ 248
STDM05	Annual Unplanned Pipe Rehabilitation	5	6	6	7	8	9	-	-	$ 42
STDM03	Downtown Trunk Line Ph2	-	-	-	-	-	-	-	-	$ -
STDM06	N 9th Ditch Rehab	-	-	-	-	-	45	-	-	$ 45
STDM17	Stmwtr Facility Plan Ph2	5	13	-	-	-	-	-	-	$ 18
STDM19	Downtown Stormwater Capacity	-	-	-	-	-	-	62	67	$ 129
STOP03	Stormwater Vehicle (#01)	-	-	-	5	-	-	-	-	$ 5
STOP05	Street Sweeper(#01)	28	-	-	-	-	-	-	-	$ 28
STOP07	Stormwater Service Vehicle #1	-	-	-	-	-	-	-	9	$ 9
STOP08	Vacuum & Jetting Truck #1	-	-	65	-	-	-	-	-	$ 65
STOP09	Stormwater Sidewalk Machine	-	-	-	-	-	-	-	-	$ -
STRH01	Downtown Mech Storm Phase 3	5	32	-	-	-	-	-	-	$ 36
STRM58	Operations Site Upgrade & Maintenance	-	-	-	-	-	-	22	-	$ 22
STRM59	Design Standards Update	5	-	-	-	-	-	-	-	$ 5
STRM60	River Health - Mechanical Treatment - Peach	-	-	28	-	-	-	-	-	$ 28
STRM61	River Health - Mechanical Treatment - Tamarack	-	-	-	-	30	-	-	-	$ 30
STUO01	Stormwater Facility Plan	5	1	-	-	-	-	-	-	$ 6
	Shops Complex	-	-	140	-	-	-	-	-	$ 140
	Total (in $10k)	**$ 59**	**$ 195**	**$ 250**	**$ 77**	**$ 50**	**$ 137**	**$ 97**	**$ 76**	**$ 942**

[1] Draft Capital Improvement Program from the On-going Water, Sewer, and Stormwater Rate Study

As previously noted, based on these findings, the City's Stormwater Program appears to be underfunded and will not be able to address all the capital needs. Furthermore, Table 23 does not include additional initiatives, CIP projects, and recommendations from this 2025 Plan. The city should review the stormwater utility rate, considering the identified needs for each element of the Program.

11.4 Rate Structure Review

11.4.1 City's Existing Rate Structure

The City's current rate structure includes a flat rate of $4.67 per account per month plus a variable rate of $3.87 per month per equivalent residential unit (ERU). For a typical single-family customer, this equates to $8.54 per month per account.

For non-single-family customers, the flat rate of $4.67 per month applies once per account, and the $3.87 per ERU charge applies to each 2,700 impervious square feet associated with the property.

Table 24 – City of Bozeman's Current Stormwater Rate Structure (FY 2025)

Rate Type	Monthly Charge
Flat Rate per Account	$4.67 per account
Variable Rate per Account	$3.87 per equivalent residential unit

Source: https://www.bozeman.net/departments/utilities/stormwater/learn-about-my-utility-bill

In the cases where a customer does not have a water meter but they do have an impervious area, it is our understanding these "stormwater only" accounts still get a flat and variable rate as appropriate.

If the City does not already charge City-owned parcels (e.g., City Hall, parks, etc.), it should consider doing so, just as those parcels pay for other utilities such as water, sewer, electricity, etc.

11.4.2 Rate Structure Policy Analysis

The most common approach in the stormwater utility industry is to charge customers based on impervious surface area, resulting in a rate expressed as a dollar amount per equivalent residential unit (ERU). Impervious surface area is a generally accepted measure of runoff contribution, providing the basis for rates in most stormwater utilities.

Some communities are beginning to consider or have already implemented "fixed plus variable" rate structures (like the City of Bozeman). For example, a per-account charge that recovers costs that tend not to vary from customer to customer (e.g., customer billing, education, outreach, etc.) would be supplemented by a "variable" charge based on the impervious area to recover remaining costs.

Another emerging trend in stormwater ratemaking is tiered rate structures for single-family homes. To provide more tailored billing, parcels by impervious footprint are categorized into "Small," "Medium," "Large," and/or "Measured" tiers. Despite potential added administrative costs, utilizing a tiered single-family stormwater rate structure generally results in more equitable (cost-of-service equity) treatment of single-family customers by further aligning charges with the impervious areas.

11.4.3 Rate Structure Evaluation

FCS provided the following suggestions during a meeting with City staff in April of 2023:

- The City's rate structure includes both a flat and variable rate. The variable rate is based on impervious surface area. No changes are recommended to the structure at this time, as this is generally consistent with industry best practices.
    - Consider evaluating the "flat charge" amount to determine if this recovers costs that tend not to vary from customer to customer (e.g., customer billing, education and outreach, program administration, etc.).
- The City charges for impervious areas even if a parcel has no water meter, which is a good practice (e.g., a parking lot).

Another observation is that the City's definition of an equivalent residential unit is defined in a rate resolution which is a good practice.

As the monthly single-family rate increases over time, the City might consider evaluating whether it would be administratively feasible to implement single-family tiered rates to better align residential rates with the variety of impervious footprints that exist across residential parcels.

11.5 Rate Credit Review

11.5.1 City's Existing Credit and Discount Programs

The City currently offers two types of rate adjustments – infrastructure credits and low-income discounts – as detailed in Figure 32.

Section 4 – Credit for Properties with Existing Stormwater Infrastructure

Select properties located within the city limits shall receive a monthly credit (deduction) if determined to have or directly contribute to stormwater infrastructure meeting current engineering design standards.

Section 5 - Low Income Charge Assistance

Customers who apply for and qualify under the State's Low Income Property Tax Assistance Program, as set forth in Section 15-6-134 MCA, will receive a credit equal to their monthly stormwater flat rate charge listed above.

Source: https://legistarweb-production.s3.amazonaws.com/uploads/attachment/pdf/1052165/Resolution_5272_-_Stormwater_Rates_FY22.pdf

Figure 32 – Current Credits / Discounts According to City of Bozeman Resolution 5272

The City's website notes that multiple levels of credits fall within Section 4. Some parcels receive automatic enrollment to the 45% credit level. These levels are shown in Table 25.

Table 25 – City of Bozeman's Utility Rate Credit Program

Credit Level	Variable Rate Discount	Quality Requirement
Level 1	45%	Infiltrate first .50" OR Treat to 80% TSS Removal
Level 2	65%	Infiltrate first 0.51" to 0.99"
Level 3	85%	Infiltrate first 1.0" or more

Source: https://www.bozeman.net/departments/utilities/stormwater/learn-about-my-utility-bill

11.5.2 Rate Credit Policy Analysis

When considering if and how much to charge or credit different types of customers, it is important to remember that a stormwater rate is a fee for service, not a tax. As such, the level of a customer's charge must relate to that customer's proportionate share of the utility's costs.

Overly "generous" credit policies that provide credits that are not cost-based have the potential to move a utility away from the rational linkage between the service delivered and the fee amount. Hence, the utility should bear in mind the financial ramifications, including the cost-of-service equity and legal defensibility of any proposed credits, as well as the burden required to implement and administer such programs.

Many stormwater utility costs are essentially "fixed" regardless of the level of mitigation collectively provided by ratepayers. Thus, rate credits should only compensate for the "variable" program cost components that onsite mitigation can impact. Utilizing such a methodology aligns the credits offered with the estimated reduction in utility expenditures from creditable activities.

A possible analysis framework could allocate all the stormwater utility's costs into either "fixed" or "variable" categories. For example, the stormwater utility's administrative costs are considered "fixed" costs because they do not generally change with varying levels of onsite mitigation on specific parcels. Meanwhile, "variable" costs (e.g., repair and maintenance) are generally more likely to vary with the amount of stormwater runoff managed by customers onsite.

There is no one-size-fits-all approach to stormwater rate credit programs. Many utilities offer multiple types of rate credits, while others do not. Practices vary by jurisdiction based on policy goals, staff's ability to administer the program, and even the capabilities of the billing system.

11.5.3 Rate Credit Evaluation

FCS provided the following suggestions during a meeting with City staff in April of 2023:

- Consider requiring an application instead of automatically applying the 45% credit.
- Consider only offering credits for parcels that exceed current engineering standards.
    - It could be argued that the cost of meeting current jurisdiction standards and constructing onsite mitigation should be considered a cost of developing within the service area, with no offsetting credits or assistance, since onsite mitigation only partially neutralizes the impact of developing the property in the first place.
- Consider evaluating potential cost savings for each level to determine whether the credit level aligns with utility cost savings (especially the 65% and 85% credits).

11.6 Facility-Specific Funding Options

Many communities have implemented monthly service rates or connection charges that recover a subset of overall operating (service rates) or capital (connection charge) costs. The City was interested in some examples used by other communities that they could potentially implement in the future. Below are a few examples.

- The Cities of Redmond, WA, and Bothell, WA, have additional facilities charges (connection charges) that apply to select subbasins to recover the cost of regional facilities that serve such basins. These charges are shown in Figure 33 and Figure 34.

Capital Facilities Charge—Citywide	Citywide $1,342.00 for each impervious unit (impervious unit = 2,000 sf. of impervious area)	At Issuance of Building Permit
Capital Facilities Charge—Regional **	Overlake sub-basin $10,929.00 for each impervious unit Downtown sub-basin $5,979.00 for each impervious unit (impervious unit = 2,000 sf. of impervious area)	At Issuance of Building Permit

Source: Development Engineering Fee Schedule, Effective 2/1/2024, https://www.redmond.gov/504/Development-Services-Fees

Figure 33 – City of Redmond, WA – Regional Capital Facilities Charge

City of Bothell

DEVELOPMENT SERVICES

BUILDING • COMMUNITY RISK REDUCTION • ENGINEERING • PLANNING • PERMIT SERVICES • TRANSPORTATION

PUBLIC WORKS FEES - 2024 E

Storm Drainage Facility Charges:
Citywide: ....$1,815 per Impervious Surface Unit
Downtown Sub-Basin Area:....................$18,299 per Impervious Surface Unit

Source: https://www.bothellwa.gov/DocumentCenter/View/879/E---Public-Works-Fees-PDF?bidId=

Figure 34 – City of Bothell, WA – Downtown Sub-Basin Area Facility Charge

- Certain customers in Pierce County, WA, pay water quality and/or river services charges on top of a base charge that all customers pay. This type of structure helps recover certain types of costs from a subset of customers that specifically benefit from such services. This structure is shown in Figure 35.

Parcel Classification	Base Rate	Base plus Water Quality Services	Base plus River Services	Base plus Water Quality and River Services
Residential and Equivalent	$129.61	$144.94	$151.81	$167.14

Figure 35 – Pierce County, WA – Area Specific Service Charges

The development of basin or facility-specific monthly rates or connection charges can allow a utility to better recover subsets of costs from certain groups of customers that benefit from said costs. However, it can also require more time to set up, maintain, and account for both revenues received and how revenue is spent. That additional administrative burden must be weighed against the greater cost of service equity.

The City could consider incorporating connection charges/system impact fees for different parts of the City to help fund the construction of the stormwater infrastructure. This could include impact fees for new and redevelopment in the downtown area to help fund upsizing storm drains constructed prior to 1980, including VCP (clay-tile) pipe. With the growth of the City to the west, the City could look at system impact fees for West Bozeman to deal with stormwater infrastructure in West Bozeman. It could include paying for improvements to the open channel and culverts that ultimately convey the stormwater to the Gallatin River. Other basin or facility-specific funding may be considered in the future after stormwater planning studies are completed and the feasibility of regional stormwater solutions is investigated.

11.7 Funding the Stormwater Facilities of Transportation Projects

Based on our understanding, through discussions with DOWL, the City of Bozeman Stormwater Program currently does not fund stormwater infrastructure associated with transportation-related capital improvement projects. These improvements are typically financed through other City funds and not through the stormwater utility. The following summarizes industry practices and recommendations on how the City could fund this stormwater infrastructure through the stormwater utility in the future.

11.7.1 Industry Practices

Within an equitable cost recovery framework, it is reasonable that those respective utilities should pay for major costs related to enterprise fund utilities. It follows, then, that a stormwater utility may, and perhaps should, pay for the stormwater-related capital cost within a transportation project. Additionally, it is often more cost-effective to coordinate the timing of various utility projects when possible so that the street does not need to be torn up and restored to install stormwater infrastructure at a different time.

In practice, it is not uncommon for a stormwater utility to fund stormwater capital costs that are specifically related to transportation projects. FCS has recently worked with several jurisdictions that contribute resources to these types of expenses.

11.7.2 City Objectives

The City's stormwater utility fund is organized as an enterprise fund. Therefore, the stormwater utility is intended to be self-sustaining and recover its operating and capital costs. Based on these objectives, it may be concluded that the Stormwater Utility should fund both standalone and related stormwater portions of transportation projects to avoid a subsidy from the transportation fund.

11.7.3 Recommendations and Approaches

Based on the analysis above, FCS recommends that the City's stormwater utility fund the portions of transportation projects that can be attributed to stormwater-related functions provided that the following items are verified and monitored over time: the methodology of the contribution amount; potential differences between budgeted transfers versus actual expenditures; and the City's transportation impact fee does not include duplicative stormwater-related capital expenditures (if the City were ever to implement a stormwater impact fee).

The amount of stormwater costs relative to transportation-only costs should be developed in a defensible way, such as by using one of the following methodologies:

- **Project-by-project basis:** If the unique amount of each project related to stormwater management can be easily identified, it is the most defensible accounting practice to isolate and transfer just that amount.

- **Apply a percentage:** Another alternative would be to analyze several "as-builts" or project bids to determine an average (or median) amount of a typical transportation project that is stormwater related. For example, if it is determined that 20% of a typical transportation project serves stormwater functions, that percentage could be applied to the annual transportation capital spending budget to arrive at an amount that the stormwater utility should fund. It is recommended that the rate be occasionally reviewed and updated as necessary. This methodology helps avoid a potentially time-consuming analysis for each transportation project.

- **Fixed annual amount:** A third approach is to establish an average annual funding transfer from stormwater to help fund the stormwater portion of transportation projects. This approach requires periodic calibration but is perhaps the easiest to budget from year to year. The required transfer is stable and predictable.

If the stormwater fund provides resources to the transportation utility before projects are constructed, actual versus budgeted transportation capital spending should be evaluated on a routine basis.

11.7.4 Stormwater Impact Fee vs. Transportation Impact Fee

If the stormwater utility funds portions of transportation infrastructure related to stormwater management, those stormwater assets should then be booked and accounted for in the stormwater utility and should not be included in the transportation impact fee. This would help the City avoid including the same project in the transportation impact fee and a potential stormwater impact fee if the City were to consider and/or implement a stormwater impact fee in the future.

11.8 Funding for New Buildings and Land

Through discussions with DOWL, FCS is aware of the need for additional space to accommodate vehicles and equipment. The costs associated with land and building required for new acquisitions, such as a vac truck and a TV van, would be factored into the utility rate study. As part of the ongoing Water, Sewer, and

Stormwater rate project, the City has begun addressing this issue through the "Shops Complex" project, as shown in Table 23.

11.9 Summary and Recommendations

11.9.1 Rate Study Overview

A utility's rates should be set to recover the cost of providing service, which includes funding both operating and capital expenditures. Funding for capital expenditures could come in the form of monthly rate revenue, one-time connection charges/impact fees paid by developers, and/or from borrowing money via state loans or by issuing revenue bonds.

While operating and capital requirements may vary by program element (e.g., operations and maintenance vs. capital improvements vs. program administration), it is essential to base rate decisions on a wholistic rate evaluation that considers all elements of a utility so that decision-makers can evaluate the rate impacts of various components and prioritize as needed.

Over the past couple of years, the City's expenses have increased faster than rate revenues, which has reduced the amount of rate revenue that is available for capital. Rates will likely need to increase to cover financial obligations already identified as well as obligations identified in upcoming element-specific evaluations.

With the different recommendations highlighted above, when said information is available, it is recommended that the City complete a detailed, needs-based stormwater rate study focusing on various levels of services for each major part of the program. The City can start with the information provided in this report, refine the data, and fill in the data gaps with some additional investigation to help define costs associated with staff, equipment, and other capital projects. This information can then be broken down into various service levels to help understand the stormwater utility rate needed to meet the desired levels of services. By providing multiple levels of service, the City can clearly define to the commission and community what they would be getting with different levels of associated rate adjustments.

FCS is currently assisting the City with a water, sewer, and stormwater rate study. If element-specific evaluations are available at the time of the current multi-year study, that information should be incorporated into said rate study. Otherwise, once a gap analysis has been performed in the future, as described in Figure 30 and Table 22, the City should reevaluate the sufficiency of the rates at that time.

11.9.2 Rate Structure and Rate Credits

The City's rate structure is generally in line with industry best practices, and no material changes are recommended at this time. However, the City may want to consider tiered single-family rates in the future.

FCS recommends that the City review its rate credit policies and consider whether credits should be given for simply meeting development requirements rather than only for exceeding them.

FCS also recommends that the City evaluate the level of its credits to determine if it is giving away more credits than it is receiving in value from a customer's onsite activities. The City's current rate credits range from 45% to 85%. Many of a utility's costs are essentially fixed and tend not to be impacted by customer actions.

11.9.3 Facility-Specific Fund Strategies

The City could consider a Citywide system impact fee or area-specific fees for areas affected by new or redevelopment projects. Conducting this fee assessment would help determine a justifiable fee and evaluate the costs of administering these fees.

12.0 RECOMMENDATIONS

Over the last few decades, the City's Stormwater Program has made impressive strides by embracing modern technology and innovative practices. The program integrated advanced GIS mapping and CityWorks to enhance operational capacities, significantly boosting work efforts and documentation for MS4 compliance. Additionally, an enhanced inspection and maintenance process has been established for most facilities, reflecting a strong commitment to proactive management. With all of these advancements, there is still some room for improvement in the City's Stormwater Program. The City currently faces a range of critical needs, spanning MS4 compliance, operations and maintenance, planning, capital improvement, and administration needs. One of the most significant challenges facing the program is securing adequate funding to support these efforts. This 2025 Plan highlights a range of potential improvements to the City's Stormwater Program; however, not all of these can be addressed at once. The following is DOWL's prioritized plan for addressing the recommendations outlined in this Stormwater Facilities Plan.

12.1 Priority-Based Action Plan

1. Resolve MS4 Compliance Violations

Meeting compliance with the MDEQ MS4 program is a top priority for the City. Recent audits have highlighted violations that require immediate attention, which can be addressed with the current Stormwater Program staff and funding. The City should develop formal policy changes for post-construction stormwater management and establish an inspection workflow for public, private, and HOA facilities. In addition, the City should create policies for private and HOA facilities, including an enforcement response plan, and identify and prioritize ponds with design-related issues for redesign and planning future capital improvement projects to fix these facilities. These measures will ensure the City remains compliant with MS4 requirements while setting a better foundation for its Post-Construction Inspection program.

2. Secure Sustainable Funding

The success of many program improvements hinges on securing additional funding. The City must transition from relying on managing and operating the Stormwater Program on available funds from the current stormwater utility rate to conducting a needs-based assessment. Key steps include performing a gap analysis to define service levels and associated costs, identifying necessary investments in staff, equipment, and other budgets to meet their needs, conducting a rate study to determine adjustments to the stormwater utility rate, and an assessment of development impact fees. After gaining this information, the City can engage and educate the public and City Commission to achieve consensus on the appropriate rate increases. This process will provide a stable funding source, enabling the City to address other priorities on this list.

3. Address Deferred Maintenance

Aging infrastructure presents significant risks, including localized flooding, road closures, disruptions to the community and nearby businesses, and expensive emergency repairs. Priority should be given to facilities nearing failure, particularly the vitrified clay tile storm drain. While this pipe is currently being repaired or replaced through the Historic Pipe Replacement Program, the current replacement rate is insufficient, increasing the likelihood of failures if the pace is not accelerated. Other critical facilities, such as culverts and inlets at risk of failure, should also be evaluated and prioritized based on their potential impacts. Efforts to secure additional funding through a utility rate adjustment will provide the resources needed to plan these replacement projects without relying solely on or waiting for other project opportunities. Proactively addressing deferred maintenance will enable the City to avoid costly emergencies, enhance public safety, and maintain more stable and reliable long-term capital improvement plans.

4. Complete West Bozeman Planning Studies

Bozeman's rapid westward growth necessitates comprehensive planning to guide responsible stormwater management. Having more information on the holistic drainage needs of West Bozeman can help the City guide new developments and come up with practical stormwater solutions that benefit the new developments and the City. The West Bozeman South and North planning studies would give the city more information on the impacts and limitations of the Farmers Canal, addressing south-to-north drainage systems, defining the potential for regional detention facilities, and identifying opportunities for collaborative solutions with future developments. These studies will help the City stay ahead of development pressures and prevent missed opportunities for effective stormwater management. As the city continues to grow, additional planning study areas may need to be evaluated to stay ahead of development demands.

5. Develop a Culvert Maintenance and Replacement Program

Understanding the condition and functionality of the City's culverts is essential for long-term operations and maintenance. Implementing the culvert program recommendations provided in Section 13.0 will allow the City to understand this asset better and establish a routine maintenance program and deferred maintenance needs.

6. Enhance Understanding of Open Channels

Open channels play a vital role in conveying stormwater away from the City and into the Gallatin River. To better understand these critical assets, the city should conduct a detailed inventory to identify capacity and bottlenecks.

7. Advance Capital Improvement Projects

The City should continue to invest and plan out capital improvement projects. As efforts from Priority #2 become available, the City will have more funding to implement additional capital improvement projects. The City should prioritize deferred maintenance projects as discussed in Priority #3, focus on water quality needs on Bozeman Creek and Mandeville Creek, and then finally address capacity need projects, as many of these projects are associated with nuisance flooding with little to no damage claims. Priority should be given to projects addressing multiple issues, such as downtown infiltration galleries and Arthur Street improvements. The downtown infiltration galleries project addresses deferred maintenance issues while incorporating water quality benefits. The Arthur Street improvement project addresses deferred maintenance and capacity-related issues.

8. Enhance Operations and Maintenance Practices

As additional funding becomes available, the City should expand operations and maintenance efforts to include new facilities like ponds, culverts, and open channels and increase staff, equipment, and budgets to meet their desired five-year maintenance cycle.

9. Improve GIS Inventory and Asset Management

The City is currently operating and maintaining its stormwater facilities using the current GIS data. Recommendations in this report should be implemented sooner rather than later to increase data reliability and improve efficiencies throughout their program; however, this is not as important as the priorities above. A sophisticated GIS program is desired in the future. As funding or resources allow, the City should look at doing a stormwater asset data management project and additional inventory of the stormwater facilities to document its assets better. However, it is recommended that as the City proceeds with the above priorities, the existing GIS data be updated as information becomes available. This may include populating the size and material of culverts that are investigated as part of the Culvert Maintenance and Replacement Program, updating the storm drain data as pipes are replaced as part of the Historic Pipe Replacement Program, and documenting survey data such as invert and rim elevations that may be collected as part of the West Bozeman Planning Studies.

10. Address Program Administration Improvements

Minor program administration enhancements can increase efficiency and should be implemented as opportunities arise. These include improving GIS and billing processes, delegating SWPPP administration, and enhancing departmental coordination and record-keeping systems.

12.2 Conclusion

While this prioritization plan provides a structured approach to addressing the City's stormwater needs, it is essential to remain flexible as circumstances evolve. By focusing on these recommendations in order of priority, Bozeman can build a resilient and sustainable Stormwater Program that meets current and future challenges.

13.0 CULVERT MAINTENANCE AND REPLACEMENT PROGRAM

The City currently does not have a formal program for culvert inspection, maintenance, and replacement. The following section describes a process that the City could implement to initiate such a program. The goal of the City of Bozeman Culvert Maintenance and Replacement Program is to effectively manage and maintain its stormwater culvert assets by identifying responsibilities, documenting key attributes, establishing inspection protocols, and prioritizing maintenance, repair, and replacement activities. Development of this program can be completed with the City's Stormwater Administration staff if time is available, but it can also be outsourced to an experienced professional.

13.1 Preliminary Inventory

The preliminary inventory phase is a critical first step in developing the Culvert Maintenance and Replacement Program. The process begins with a review of available data and using aerial imagery and LiDAR mapping to help identify culverts that convey stormwater runoff from the City facilities. This office review would be followed by a field verification process to sort out areas of uncertainty or discrepancy. Coordination with other stakeholders, such as Montana State University (MSU), Gallatin County, and the Montana Department of Transportation (MDT), is essential to clarify the ownership and maintenance responsibilities for the identified culverts. This phase will also involve defining annual maintenance responsibilities, including trash removal after storms, sediment cleanout, and structural repairs and replacements as necessary. Discussions should also address when maintenance responsibilities are transferred from one stakeholder to another, such as when the City annexes areas. By the end of this phase, the City should have a solid understanding of which culverts fall under its responsibility for ongoing management and maintenance.

13.2 Preliminary Inspection Protocols

The next phase involves the development of inspection protocols, including a preliminary inspection form to assess the condition and attributes of the culverts identified in the inventory phase. A review of existing culvert inspection programs and guidelines would be a good starting point in developing a preliminary inspection form. Key programs and guidelines to review and emulate include the Federal Highway Administration (FHWA) Culvert Inspection Manual, the Montana Department of Transportation (MDT) preliminary inspection process, and guidelines from the National Association of Sewer Service Companies (NASSCO). Drawing from these resources, the preliminary inspection form will document key culvert attributes, including size, material, length, end treatment, cover, purpose, flow condition (whether continual or intermittent), and deficiency types and severity. DOWL has provided recommendations for essential culvert attributes to be included, as presented in Appendix A.

A key component of the inspection process will involve developing a field data collection system, such as an ArcGIS Online or ArcGIS Enterprise database, which allows crews to input data directly from mobile devices while capturing photos of conditions. The input on this form may also benefit from consultation with the City asset management specialist to ensure comprehensive data collection. The form will identify common culvert deficiencies, including sediment deposition, debris accumulation, corrosion, deflections, cracking, joint separations, and inlet or outlet erosion. The severity of these deficiencies could be classified as minor, moderate, and major. Additionally, it will assess risks such as failure or clogging, including whether upstream properties could be impacted. While the form could initially be in paper format, the goal is to transition to a GIS-based system for efficient management and data access.

To test the effectiveness of the preliminary inspection form, a sample of 50 to 100 culverts would be assessed, providing insights that may lead to adjustments in the form or GIS database. Based on this initial assessment, a classification system would be developed to prioritize maintenance, repairs, or replacements. Deficiencies would be categorized as minor (requiring no action but ongoing monitoring), moderate (requiring repair and scheduled cleaning), or major (requiring immediate attention). This process would be facilitated by the GIS database, which will serve as a tool to track inspections and document culvert conditions for long-term management.

A culvert deficiencies and severity guidance document is essential for maintaining consistency across inspections conducted by various personnel. The City should clearly define each type of deficiency—such as sediment deposition, corrosion, or joint separations—and link them to specific severity ratings (minor, moderate, or major) so that the inspectors evaluating the conditions are using the same criteria. Incorporating photographs that visually represent these deficiencies and their severity levels provides a standardized reference, reducing subjectivity and improving the accuracy of assessments.

The City will also need to complete a capacity analysis of the culverts. This analysis will require detailed information on culvert inlet and outlet elevations, length, inlet and outlet treatments, overtopping elevation, downstream channel section and slope, and photographs to estimate channel roughness to determine the capacity of the culvert before overtopping. In some cases, base flows within the channel will need to be estimated to understand the reduction in culvert capacity to convey stormwater flows. A flow measurement program on the open channel could greatly assist in understanding channel performance and baseflows.

13.3 Inspection Frequency

Inspection frequency should be determined based on the overall number of culverts for which the City is responsible, the availability of staff and resources, and the condition of individual culverts. A baseline frequency of inspecting all culverts every five years is recommended, with adjustments made as staff capacity increases or specific needs arise. Culverts identified as being in poor condition or those showing signs of deterioration should be inspected more frequently to mitigate risks and prioritize timely repairs.

Additional factors, such as the material, age, location, and load-bearing capacity of the culverts and those exposed to significant stormwater flows, should also inform inspection schedules. In addition to periodic inspections, the City's Streets Division currently cleans debris and track racks after major storm events to maintain functionality and prevent blockages. While primarily focused on debris removal, these efforts can also serve as an opportunity for a preliminary site review of the culvert, potentially identifying issues that warrant a more thorough inspection.

13.4 Maintenance, Repairs, and Replacement

Effective maintenance, timely repairs, and strategic replacement are essential components of the City of Bozeman's Culvert Program to ensure the functionality and longevity of its stormwater infrastructure. Routine maintenance tasks, such as debris removal, vegetation management, erosion control, joint and seal cleaning, and inlet/outlet repairs, can be handled by the City's maintenance staff. These activities may require specialized equipment, such as vacuum trucks, jetting tools, and erosion protection materials. Additional tasks, including patching, crack repairs, replacing deteriorated sections, and applying coatings or paints to prevent corrosion, are also within the scope of regular maintenance.

For larger projects, the City must determine whether rehabilitation work, such as lining culverts or performing full replacements, can be accomplished by City crews or if outsourcing is necessary. Emergency responses, such as addressing culvert failures, as well as major projects like full replacements, upsizing, or relining, may require outsourcing to contractors. In these cases, bundling multiple culverts into a single project could improve efficiency and reduce costs.

Permitting requirements will also guide maintenance and repair activities. Minor tasks, such as debris removal, vacuuming, and minor bank shaping, may not require permits. However, significant work in flowing channels, including jetting, riprap placement, or dewatering, may necessitate permits. To streamline this process, the City should consider applying for a 10-year Army Corps of Engineers maintenance permit to cover ongoing maintenance activities, reducing the need for site-specific permits for individual culverts.

13.5 Culvert Deferred Maintenance

Assessing deferred maintenance is a critical step in understanding the overall condition of the City's culvert system and planning for long-term management. Using a sample set of inspected culverts, the City can evaluate current conditions and define the required maintenance, repair, and replacement activities. By assigning costs to these activities—such as debris removal, erosion control, patching, or full replacements—the City can develop a cost framework for various levels of maintenance.

The conditions observed in the sample set will provide the basis for extrapolating the overall state of the City's culvert inventory. A methodology should be developed to correlate the findings from the sample to the larger system, using factors such as culvert size, material, age, location, and observed deficiencies. This approach allows the City to estimate deferred maintenance needs across its entire inventory, even for culverts not yet individually inspected. By correlating culvert conditions to maintenance costs, the City can generate a comprehensive estimate of deferred maintenance requirements.

13.6 Program Planning and Funding

After determining the overall deferred maintenance cost, the City should start planning and budgeting for the various culvert maintenance needs. Using data from inspections and condition assessments, it is recommended that the City develop an annual culvert maintenance budget.

Based on the extrapolated condition data, the City can estimate a realistic timeline for addressing deferred maintenance. This timeline will serve as a roadmap for completing necessary repairs, rehabilitations, and replacements while minimizing disruptions to the stormwater system. Concurrently, the City should initiate planning for a future Capital Improvement Program (CIP) dedicated to culvert rehabilitation and replacement, incorporating findings from the condition assessments and estimated costs.

Additionally, staff and equipment costs for performing certain maintenance activities in-house should be identified and incorporated into the annual operations and maintenance budget. By balancing internal resources with the need for outsourced contractors on larger projects, the City can create a sustainable program that addresses both immediate and long-term culvert maintenance needs.

13.7 Implementation

It is recommended that the City utilize a phased approach to implementation that starts with inventorying the culvert ownership and responsibilities, developing an inspection form and process, and conducting a sample set of inspections for extrapolating an estimate of deferred maintenance needs. This will determine the necessary staff, equipment, and funding to establish the program. With these steps completed, the City will have a clearer understanding of the scope of work required and can make informed decisions regarding the timeline to get to a fully developed program. The preliminary phase may take a few years to complete, and the next phase could include inspecting all the culverts over a five-year timeline. The program can be adjusted as new information becomes available.

14.0 REFERENCES

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[11] City of Bozeman, "Stormwater Management Plan 2023 Update," Bozeman, 2024.

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[13] MDEQ, "Storm Water Discharges Associated with MS4s," Bozeman, 2023.

APPENDIX A: GIS TABLES

Data Sets	Number/Length of Elements	Existing Key Attributes	O&M Attributes	Attributes to Delete	Missing Attributes	Data Gaps	Potential Recommendation
Culverts (Culverts_Final_Draft)	721 18.1 miles	Owner_Name Pipe_Material Pipe_Shape Length Pipe_Diameter Upstream_Invert Downstream_Invert Install_Date	Yes	Main_Category	Inlet & Outlet Treatment Types Road Crossing	60% of Ownership is Unknown 100% of Invert Elevations is Unknown 35% of Install Date is Unknown Missing Data on Shape and Size	Change Pipe_Diameter to Pipe_Size to handle arch and box culverts with different span and rise dimensions Inspect and populate Unknown Data & Ownership Add Inlet & Outlet Treatment Type & Road Crossing Attributes Inventory Missing Culverts Should define culverts versus pipelines/storm drain Rename and overwrite SWCulvert Data Set Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset
Detention Ponds (SWDetentionPond)	1262 98.0 acres	Owner_Name Volume Install_Date Length Width Depth	No	Slope Invert_Height GNSS_Height Hyperlink Warranty_Date GPS_Date Datafile Rcvr_Type Vert_Prec Horz_Prec	Storage_Type Owner_Type Maintenance & Inspection Tracking Attributes	82% to 100% of Storage Facility Dimension is Unknown 97% of Install Date is Unknown	Change data set name to SW_Storage_Facilities and add attribute for Storage_Type Add Owner_Type attribute to focus on HOA, Private, Public, and Other; Put HOA name only into the Owner_Name attribute Inspect and populate Unknown Data Change attribute name Data_Source to Waterway Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset In lieu of recording GPS_Date, Rcvr_Type, etc, add a Collection_Type attribute that records how data was collected (survey, LiDAR, etc)
Gravity Main (SWGravityMain)	7395 124.0 miles	Owner_Name Pipe_Material Pipe_Shape Length Pipe_Diameter Upstream_Invert Downstream_Invert Install_Date	Yes			100% of Invert Elevations is Unknown 43% of Install Date is Unknown Missing Data on Shape, Size & Pipe Material 10% of Pipe Material and Diameter are unknown	Change Pipe_Diameter to Pipe_Size to handle arch and box storm drain sizes with different span and rise dimensions Inspect and populate Unknown Data Inventory MSU Storm Drain to Verify Facilities Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset
Inlets (SWInlets)	4809	Owner_Name Inlet_Type Grate_Type Barrel_Type Inlet_Depth Invert_Height Invert_Elevation Install_Date	Yes		Inlet_Condition (Sag or On-grade)	10% of Inlet Type is Unknown 26% of Grate Type is Unknown 100% of Grate and Invert Elevations is Unknown 39% of Install Date is Unknown	Rename Invert_Height attribute to Grate_Elevation Refine Domain for Inlet_Type & Grate_Type to more typical naming convention Inspect and populate Unknown Data Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset

Data Sets	Number/Length of Elements	Existing Key Attributes	O&M Attributes	Attributes to Delete	Missing Attributes	Data Gaps	Potential Recommendation
Manholes (SWManholes)	2405	Owner_Name Cover_Type Access_Diameter Barrel_Depth Barrel_Width Wall_Material Invert_Height Invert_Elevation Sump_Depth Install_Date	Yes	Hyperlink Datafile Rcvr_Type Vert_Prec Horz_Prec	N/A	82% of Wall Material is Unknown 100% of Lid and Invert Elevations is Unknown 96% of Barrel Width is Unknown 50% of Install Date is Unknown	Rename Invert_Height attribute to Lid_Elevation Inspect and populate Unknown Data Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset In lieu of recording GPS_Date, Rcvr_Type, etc, add a Collection_Type attribute that records how data was collected (survey, LiDAR, etc)
Outfalls (SWOutfalls)	704	Owner_Name Diameter Pipe_Material Waterway ORI Flow Present Terminus_Type Discharge_Type Install_Date Invert_Elevation Install_Date	No	Invert_Height GNSS_Height	Outlet Structure and Protection Erosion	21% of ORI Flow Present is Unknown 15% of Discharge Type is Unknown 15% of Material Type and Diameter is Unknown	Inspect and populate Unknown Data Add attribute for Outlet Structure or Outlet Protection Add a yes and no attribute for Erosion Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset
Wells (SWWells)	16	Owner_Name Type Install_Date	No	Invert_Height Hyperlink GPS_Date Datafile Rcvr_Type Vert_Prec Horz_Prec	Depth Purpose	Only Location Identify in Attributes	Need to determine domains for Type, Depth, and Purpose Is the asset you're managing the pump or the well? Should this be a "Pump" feature class with a "Well" attribute option? One point calls out lift station, should this be moved to a pump data? Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset In lieu of recording GPS_Date, Rcvr_Type, etc, add a Collection_Type attribute that records how data was collected (survey, LiDAR, etc)
Curb Chases (SWCurbChase)	237	Owner_Name Height Width Length Invert_Height Invert_Elevation Install_Date	Yes	Invert_Height Warranty_Date Hyperlink GPS_Date Datafile Rcvr_Type Vert_Prec Horz_Prec	Type (Curb Bulbout, Sidewalk, Valley Gutter)	60% of the Dimensions are Unknown 100% of Invert Elevation is Unknown 100% of the Install Date is Unknown	Inspect and populate Unknown Data Add attribute for Type Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset In lieu of recording GPS_Date, Rcvr_Type, etc, add a Collection_Type attribute that records how data was collected (survey, LiDAR, etc)

Data Sets	Number/Length of Elements	Existing Key Attributes	O&M Attributes	Attributes to Delete	Missing Attributes	Data Gaps	Potential Recommendation
Outlet Structures[1] (SWOutletStructure)	424	Owner_Name Slot_Dimension Slot_Height Barrel_Type Barrel_Width Barrel_Depth Invert_Height Invert_Elevation Install_Date	No	Invert_Height Shape Data_Sourc Invert_Height GPS_Date Datafile Rcvr_Type Vert_Prec Horz_Prec	Type (Grate, Multi-Stage Structure,etc.) Storage Facility Associated With	71% of the Dimensions are Unknown 100% of Invert Elevation is Unknown 98% of the Install Date is Unknown	Inspect and populate Unknown Data Add attribute for Type Associate Outlet Structures with Storage Pond Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset In lieu of recording GPS_Date, Rcvr_Type, etc, add a Collection_Type attribute that records how data was collected (survey, LiDAR, etc)
Treatment Units (SWTreatmentSystem)	46	Owner_Name Name Type Invert_Height Invert_Elevation Install_Date	No	Feature_Cl Field_Name Field_Type Precision_ Scale Length Data_Sourc Invert_Height GPS_Date Datafile Rcvr_Type Vert_Prec Horz_Prec	N/A	20% of the Ownership is Unknown 100% of Type is not filled out 46% of the Install Date is Unknown	Inspect and populate Unknown Data Populate Type with type of treatment system and remove description from Name attribute Change projected coordinate system units from meters to feet Consider making a separate GIS feature class that has all "Removed" and "Abandoned" structures and deleting them from the primary dataset In lieu of recording GPS_Date, Rcvr_Type, etc, add a Collection_Type attribute that records how data was collected (survey, LiDAR, etc)
Open Channels (BozemanHydrology_202307)	106.7 milies	Owner_Name Stream_Order Flow Length Name Shape	No	Join_Count Target_FID Join_ Cou_1 Target_F_1 Type_20220 Secondary_ Orig_FID Orig_SEQ	Type (Drainage, Irrigation, Combination, Stream)	12% of DLG_Status is not filled out 49% of RESP_PARTY is not filled out	Remove Stream name from the Comment Field Add dimensions for the fields Add Water Source field Change projected coordinate system units from meters to feet Identify which drainages the City has interest in maintaining

[1] Outlet structures estimated based off of the online Infastructure Viewer

APPENDIX B: CAPITAL IMPROVEMENT NEEDS FOR PRE-1980 STORMWATER FACILITIES

CITY OF BOZEMAN – 2025 STORMWATER FACILITIES PLAN UPDATE

Capital Improvement Needs for Pre-1980 Stormwater Facilities

Prepared for:

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DOWL

1283 N. 14th Ave. Suite 101
Bozeman, MT 59715

February 2025

4036.21888.02

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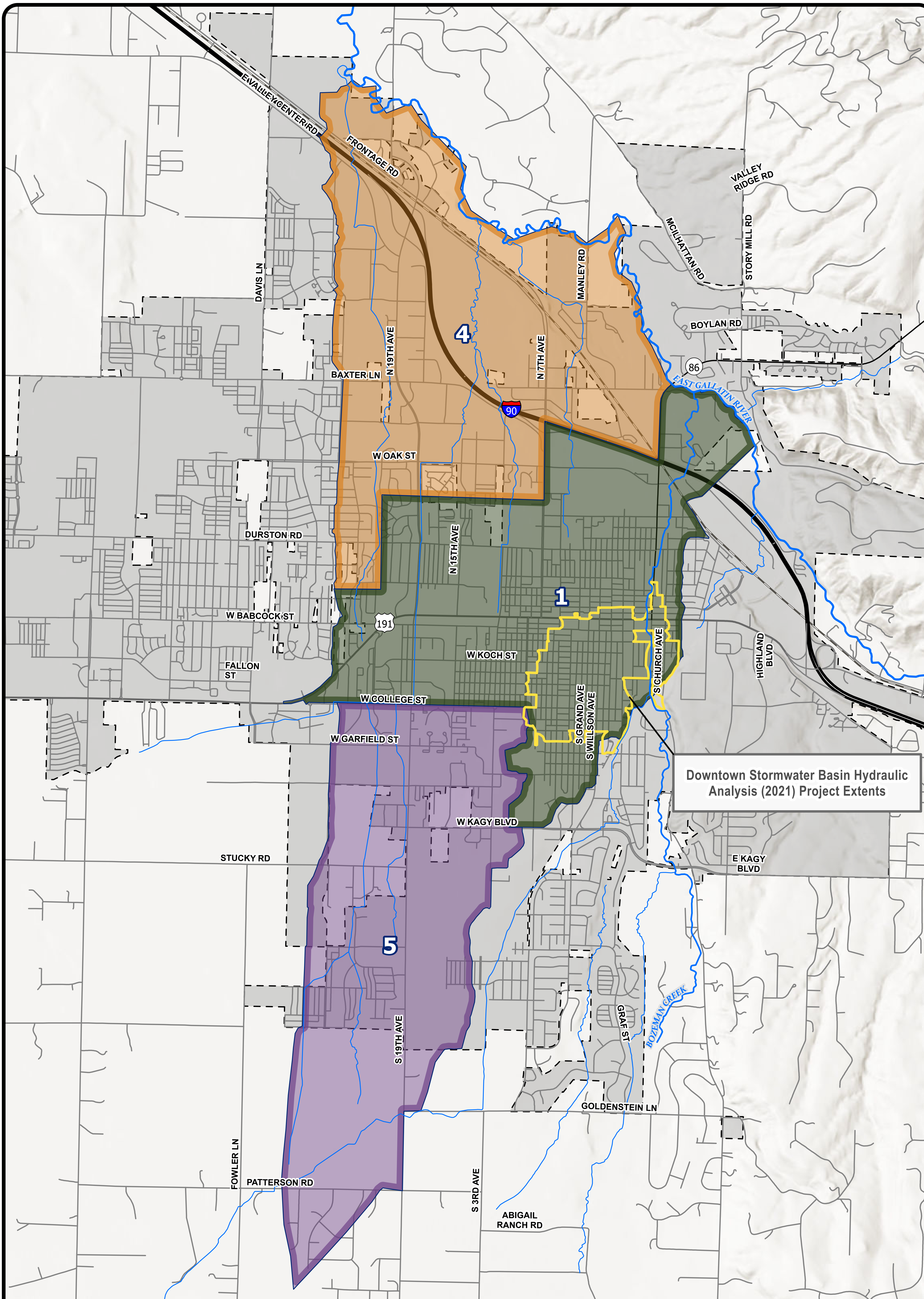
SUPPLEMENTS

1.0 INTRODUCTION

As part of the Phase II Stormwater Facilities Plan Update, the capital improvement needs for the pre-1980 stormwater facilities were assessed. These efforts included collecting and evaluating data regarding the existing stormwater facilities, developing a planning-level stormwater model of the whole region, identifying capacity constraints, and expanding the existing downtown stormwater study to further evaluate infiltration galleries and storm drains. This report documents the methodologies used to complete these analyses and the results.

For the planning-level stormwater model, DOWL delineated the drainage basins within the Community Plan boundary, as shown in Figure 1, to help define master planning study areas for defining capital improvement needs. The pre-1980 stormwater facilities are primarily located within Basin #1, but some facilities extend into Basin #4 and #5. The area defined by these basins was evaluated holistically since runoff from Basin #5 spills into Basin #1 and then into Basin #4. These three basins were modeled to reflect future build-out conditions to evaluate the performance of the pre-1980 stormwater facilities within the currently fully developed areas. The downtown stormwater model is contained within Basin #1 and expands on the previous studies completed in 2012, 2021, and 2023.



DOWL

1283 N. 14th Ave. Suite 101
Bozeman, Montana 59715
406-586-8834

PROJECT: 4036.21888.02 DATE: 11/11/2024

CITY OF BOZEMAN

FIGURE 1

PROJECT EXTENTS

Basin 1: 3.57 Square Miles
Basin 4: 3.76 Square Miles
Basin 5: 3.28 Square Miles
Waterway
Bozeman City Limits

0 0.25 0.5 1 Miles

N

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2.0 PREVIOUS STUDIES

The following section summarizes the previously completed studies relevant to the City of Bozeman's Pre-1980 stormwater facilities.

2.1 Rouse Ave. – Bozeman (2012)

Hydrologic and hydraulic analysis was completed by DOWL in 2012 for the Montana Department of Transportation (MDT) for the reconstruction of Rouse Avenue. Precipitation data from the City of Bozeman Design Standards and Specifications Policy (March 2004) was used to develop 24-hour precipitation hyetographs for various recurrence intervals. Peak flows were calculated using the EPA SWMM hydrology method. StormNET Version 4.21.0 from BOSS International was used to model drainage basins, drainage ditches, culverts, storm drains, and inlets for downtown Bozeman. StormNET models were used for hydraulic analysis of existing conditions and proposed alternatives (DOWL, 2012).

2.2 Downtown Stormwater Main Rehabilitation Evaluation – Precipitation Frequency Analysis (2021)

In 2021, DOWL analyzed precipitation data near Bozeman to develop design data for the downtown stormwater system as part of the Downtown Stormwater Basin Hydraulic Analysis. This included a frequency analysis of local gage data from the Montana State University (MSU) Optical Remote Sensor Laboratory (ORSL) weather station and comparing these findings with previous frequency analyses DOWL conducted on National Climatic Data Center (NCDC) data from the Gallatin Field weather station (ID 240622).

Based on the study results, DOWL selected precipitation depths derived from the frequency analysis of Gallatin Field data, recently published in the MDT Hydrology Chapter, Appendix B, to analyze downtown Bozeman's stormwater infrastructure. While this weather station is approximately 10 miles from the downtown area, it offers a significantly longer period of record. In addition, it benefits from rigorous, documented quality control procedures, making it a reliable source despite being less local than the MSU station.

As part of the 2021 study, DOWL also analyzed and selected specific "check storms" for comparison, evaluating 14 rainfall events of varying intensity and duration. A complete list of these check storms is provided in Supplement A (DOWL, 2021).

2.3 Downtown Stormwater Basin Hydraulic Analysis (2021)

The existing downtown Bozeman stormwater collection system was evaluated to identify potential improvements and increase the level of service. The project extent is illustrated in Figure 1. In 2020, DOWL completed a topographical survey and assessment of the condition of stormwater manholes. Hydraulic analyses were performed to estimate the hydraulic capacity of the stormwater trunk main. The StormNET stormwater model developed in 2012 for the Rouse Avenue reconstruction project was converted to Autodesk Storm and Sanitary Analysis 2018 (SSA) and expanded using the collected hydraulic survey data. The SSA model was used to identify locations of inadequate capacity in the existing stormwater system. The existing conditions SSA model results reveal surcharging and surface ponding at several manholes at the 2-year storm event.

Alternatives were developed and analyzed in SSA to decrease hydraulic loading to the alleyway trunk main. CIPP-lining of the alleyway trunkline, upsizing the laterals, installation of infiltration galleries, and construction of a bypass storm drain system were all investigated as ways to increase the level of service of the downtown stormwater system. One alternative, Alternative 3, incorporated infiltration galleries to store and slowly exfiltrate runoff, reducing hydraulic loading to the stormwater system and providing water quality treatment. The modeled infiltration galleries were based on a rain garden design installed at the intersection of Mason Street and Tracy Avenue. Twenty-seven infiltration galleries were modeled to prevent surface ponding. A second alternative, Alternative 4, proposed adding a 24 to 30-inch storm drain bypass system along Olive St and S Bozeman Avenue to unload the alleyway trunkline. Additional details can be found in the Downtown Stormwater Basin Hydraulic Analysis Report.

Incorporating infiltration galleries and the storm drain bypass system was recommended in conjunction with the future upsizing of lateral pipes and installation of CIPP lining in the alleyway trunk main. This solution results in a 2-year level of service, water quality treatment, and improved performance during high-volume storms. Combining Alternatives 3 and 4 requires fewer infiltration galleries and a reduction of the bypass system pipe size (DOWL, 2021).

2.4 Pre-1980 Surface Flooding (2023)

DOWL developed a preliminary rain-on-grid HEC-RAS model to evaluate the potential flooding risks through areas with pre-1980 stormwater facilities. Many facilities constructed before 1980 were smaller pipes (6 to 10 inches) that don't meet current design criteria. The rain-on-grid model highlights potential locations with significant flooding depth, assuming no interception from the stormwater facilities. Figures were developed showing the flooding extent at the 2-year, 24-hour storm event and are provided in Supplement D.

3.0 DATA COLLECTION

3.1 LiDAR

The LiDAR DEM created from the City of Bozeman Aerial Survey in 2018 was used in the stormwater model. The flight provided 0.5-meter cell resolution across the entire study area and has a horizontal and vertical coordinate system of NAD 1983 (2011) State Plane Montana FIPS 2500 (Meters) and NAVD88 height (m), respectively.

3.2 GIS Data

The City of Bozeman supplied spatial data for the stormwater infrastructure, covering the locations and attributes of some stormwater manholes, gravity mains, open channels, and culverts. However, the datasets lacked key attributes such as invert and rim elevation, pipe size, and pipe material. Rim elevations for manholes were estimated using the 2018 LiDAR. The City of Bozeman provided tabular datasets containing select TV-measuredown values, which were subtracted from LiDAR-derived rim elevations to calculate invert elevations. This information was then integrated into the spatial files. However, there were many facilities where these key attributes were not provided. Significant data gaps were discovered at MSU and the Main Street corridor.

3.3 As-Builts

As-builts were obtained from the City of Bozeman and reviewed to fill gaps in the spatial data. Multiple local vertical datums were referenced in the as-built drawings. To maintain consistency throughout the stormwater facilities data, the measuredown was calculated by determining the difference between the rim and invert elevations. The measuredown was then subtracted from the LiDAR-derived rim elevation to determine the invert elevation. However, there were still several areas across the study area, including MSU and the Main Street corridor, where large data gaps existed.

3.4 Survey Data Request

DOWL reviewed areas with missing storm drain invert data. Where sufficient surrounding data existed, missing pipe elevations were interpolated. A prioritized list of survey pickups was created for locations without enough data for interpolation. Survey pickups were organized by criticality, with two survey requests submitted to Morrison-Maierle (MMI): the first request included 50 high-priority structures, and the second included 11 structures to refine the model further. MMI provided XYZ coordinates of the manholes, sketches, and measuredowns for all associated pipes. This data was incorporated into spatial datasets to be used in the development of the model.

4.0 DESIGN CRITERIA

New developments within the City are required to install infrastructure designed to detain or retain the 10-year, 2-hour storm and convey the 25-year storm, as calculated using the Rational Method (City of Bozeman, 2024). However, most of the stormwater facilities within the study area can’t convey the 10-year event, with portions surcharging at the 2-year event. The 2-year, 24-hour synthetic storm event was used to identify capacity constraints within the stormwater system, and the proposed system was designed to convey this event without surcharging. Designing the proposed system to convey the 10-year event would require upsizing most of the existing storm drain system throughout the pre-1980 boundary and will likely result in significant downstream flooding that would be worse than current conditions.

The 2-year synthetic storm serves as a baseline for pre-1980 areas, enabling the City to design a cohesive stormwater system focused on minimizing flood risks from current conditions while avoiding upsizing large outfalls, like the one on Rouse Avenue. Pipes upgraded to meet the minimum size and material requirements and designed to handle this baseline storm have demonstrated effective performance during actual representative storm events, showing no signs of surcharging. Additionally, these upgrades have reduced maintenance efforts and minimized clogging at inlets, enhancing the overall reliability and efficiency of the system.

5.0 HYDROLOGY

The precipitation depth-duration relationship for Gallatin Field was developed as part of the Downtown Stormwater Main Rehabilitation Evaluation, as summarized in Section 2.2. The depth-duration relationship is presented in Table 1 (DOWL, 2017). DOWL used these values with a nested storm hyetograph to develop the synthetic storms for this analysis.

Table 1: Gallatin Field Rainfall Depth – Duration Relationship

Storm Duration	Precipitation Depth at Select Recurrence Intervals (inches)					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5-min	0.17	0.26	0.32	0.40	0.45	0.51
10-min	0.25	0.38	0.47	0.58	0.66	0.74
15-min	0.31	0.47	0.57	0.71	0.81	0.90
20-min	0.33	0.50	0.61	0.75	0.86	0.96
25-min	0.35	0.53	0.65	0.80	0.92	1.03
30-min	0.37	0.56	0.69	0.85	0.97	1.09
35-min	0.38	0.58	0.71	0.87	1.00	1.12
40-min	0.39	0.59	0.73	0.90	1.02	1.15
45-min	0.40	0.61	0.75	0.92	1.05	1.18
50-min	0.41	0.62	0.76	0.94	1.07	1.20
55-min	0.42	0.63	0.77	0.95	1.08	1.22
1-hr	0.42	0.64	0.79	0.97	1.10	1.24
2-hr	0.49	0.68	0.81	0.98	1.10	1.22
3-hr	0.56	0.74	0.86	1.01	1.12	1.23
6-hr	0.71	0.88	0.99	1.14	1.24	1.35
12-hr	0.91	1.12	1.26	1.43	1.56	1.69
24-hr	1.18	1.49	1.70	1.96	2.15	2.34

Frequently, synthetic hyetographs, such as the nested storm hyetograph method and storm types published by the Soil and Conservation Service (SCS), are used to analyze and design storm drainage infrastructure. Unlike actual storms, synthetic storms encompass the peak precipitation depth at each storm duration interval and, therefore, can overpredict volume compared to actual storms in larger study areas. Using actual precipitation hyetographs developed from regionally appropriate precipitation gage data provides an additional tool for evaluating stormwater infrastructure performance. Three events, shown in Table 2, were chosen to use as check storms after modeling each storm in SSA 2024 and using the EPA SWMM method to simulate rainfall runoff.

Table 2: Check Storms

Storm Date	Storm Duration (hr)	Total Storm Depth (in)	Maximum Intensity (in/hr)	Recurrence Interval at Total Storm Duration	Controlling Recurrence Interval	Data Source
2-year Storms						
6/12/2017	24	1.50	2.2	2.5-yr	3.7-year (24-hr)	ORSL
6/16/2019	0.7	0.38	2.3	1.5-yr	3.2-yr (10-min)	ORSL
5-year Storms						
8/14/2017	2.0	0.67	1.8	4.9-yr	5.2-yr (30-min)	ORSL

6.0 PLANNING-LEVEL STORMWATER MODEL

6.1 Model Development

A hydraulic model was developed in SSA to identify areas of improvement within the study area, as shown in Figure 1. The existing stormwater system was modeled using subbasins, conveyance links for the pipe network, junctions at manholes, inlets, and outfalls. The EPA SWMM hydrology method simulates subbasin runoff with hydrodynamic routing and the SCS curve number method models infiltration losses.

6.1.1 Basin Parameters

Subbasins were delineated using the 2018 LiDAR data and aerial imagery. A total of 554 basins were delineated, ranging in size from 0.2 to 328.3 acres. Basins were generally delineated based on manholes or culverts inlets.

Basin parameters were established by compiling spatial datasets and applying geoprocessing workflows within GIS. Weighted curve numbers were derived using the National Land Cover Dataset (NLCD) raster and soil data from the Web Soil Survey. Much of downtown Bozeman is classified as urban land (UL), which lacks specific hydrologic soil group information. However, most surrounding areas fall within hydrologic soil group B, which was therefore used to assign curve numbers within the UL classification. Using this approach, subbasins were categorized and assigned curve numbers, as shown in Table 3 (MDT, 2023).

Table 3: Hydrologic Soil Group Curve Numbers

Landcover	Curve Number			
	A	B	C	D
Developed, Open Space	49	69	79	84
Developed, Low Intensity	61	75	79	87
Developed, Medium Intensity	77	85	79	92
Developed, High Intensity	89	92	94	95
Deciduous Forest	-	48	57	63
Shrub	-	51	63	70
Herbaceous	-	71	81	89
Hay/Pasture	49	69	79	84
Cultivated Crops	67	78	85	89

The City of Bozeman provided impervious area feature classes, which were implemented in the calculation. Two impervious layers, one that considered the residential and commercial properties and one that considered the roads, were combined to form a layer that represented all the impervious areas within the study area, as shown in Figure 2.

Figure 2: Impervious Area Layer

Subbasin slopes were calculated based on the provided LiDAR DEM. A geoprocessing workflow was developed to determine the maximum flow length for each subbasin, which was the basis for determining the equivalent widths. Assumed variables included Manning's values of 0.2 for pervious areas, 0.1 for impervious areas, and a depression depth of 0.08 inches. The internal routing flow property for the subbasins was modeled as direct to outlet, a conservative approach that typically results in larger peak flows.

6.1.2 Storm Drains

A stormwater network was created in GIS by employing the spatial data for storm drain systems provided by the City of Bozeman and record drawings. The model was developed using the most up-to-date GIS data available. Recent storm drain improvements that have been completed but are not yet incorporated into the GIS data are not included in the model. The planning-level model simplified the Bozeman stormwater facilities by modeling trunklines and primary laterals. Manning's n values for pipes ranged from 0.012 to 0.015. Entrance and exit losses for all pipes were specified at 0.5.

6.1.3 Open Channels

Open channel conveyance links were developed from the Bozeman Hydrology spatial data. Cross-sections were developed for representative locations for each waterway using the 2018 LiDAR. Points were generated to capture the channel's geometry, and the values were implemented in SSA using the irregular channel input. A Manning's n value of 0.032 was applied to each open channel conveyance link. Invert elevations for the conveyance links were determined using LiDAR and invert elevations of culverts and storm drains.

6.1.4 Detention Ponds

The model was initially developed without including detention ponds. After evaluating the model's performance, detention ponds were added where necessary to mitigate the impact on the downstream storm drain system. This determination was made by assessing whether the storm drain downstream of a potential pond location experienced surcharging during the 2-year storm event. If surcharging occurred, a pond was incorporated into the model. Each pond was modeled with a functional storage type using a constant surface area derived from aerial imagery, while the invert and maximum elevations were estimated using LiDAR data. Ultimately, two detention ponds were added to the model.

6.2 Existing System Performance

The planning-level model was utilized to evaluate the performance of the existing stormwater system. Overall, while most portions of the system do not meet the 10-year design criteria, the west side of the study area outperforms the pre-1980 facilities located in downtown Bozeman within Basin 1 (Figure 1). The west side benefits from a different system configuration, with shorter storm drain networks that discharge directly into open channels. These open channels play a critical role in conveying runoff from the south side of Bozeman to the north and are an integral component of the city's stormwater management infrastructure.

The 2008 Stormwater Facilities Plan report identified several locations with known flooding issues. For example, manholes at the intersections of Willson and Cleveland and Willson and Garfield frequently pop off during significant storm events, indicating undersized pipes. The planning-level model confirms surcharging at both locations, and recommendations for increasing the pipe size in this storm drain system are discussed in Section 6.3.3.

The open ditch near 20th Avenue was also identified in the previous stormwater facilities plan as having insufficient capacity. However, this issue may have been resolved when flows from the Farmers Canal were redirected. While the planning-level model does not indicate capacity concerns for this ditch, it does not account for base flows in the ditches, which could still impact its overall performance.

Flooding risk has also been identified near the intersection of Babcock Street and Willson Avenue. The planning-level model indicates that surcharging occurs at the storm drain manhole in this location due to an undersized storm drain system. Section 7.0 provides additional details and recommendations for improving the downtown stormwater system.

The existing system evaluation revealed numerous locations within the study area where pipes and manholes experience surcharging during the 2-year storm event, indicating that the system is undersized. The pre-1980 surface flooding model helped identify areas prone to surface flooding. DOWL focused on flooding duration, peak flows, and flood volume to determine the primary areas of concern. Additionally, both 2-year ORSL check storms were simulated. The simulations revealed less surcharging within the stormwater system when real storm events were modeled. These results helped identify and narrow down specific areas of concern within the study area.

6.3 Evaluation of Proposed Stormwater Improvement

DOWL identified six locations where the planning-level model indicated significant surface flooding and an undersized storm drain system based on the conservative 2-year, 24-hour synthetic storm. These locations were reviewed with the City of Bozeman staff. Of the six, three were eliminated due to recent upstream improvements not yet captured in the GIS data or due to planned projects aimed at resolving flooding issues at these locations. The remaining three locations, which all feature undersized vitrified clay pipes (VCP), surcharge for an extended period at the 2-year, 24-hour storm event. An SSA model was developed for each location, and system improvements were implemented to eliminate surcharging during the 2-year, 24-hour storm event. Additionally, the potential downstream impacts of the proposed changes were evaluated, and cost estimates were developed for each improvement.

The potential improvements outlined in the following sections are preliminary designs based on a planning-level model. These designs require additional data collection and further refinement before advancing to final design. For all locations, more detailed models should be developed to account for elements such as curbs and gutters, inlets, laterals, and more precise basin delineation. This process will aid in refining pipe sizes and inlet locations and dimensions.

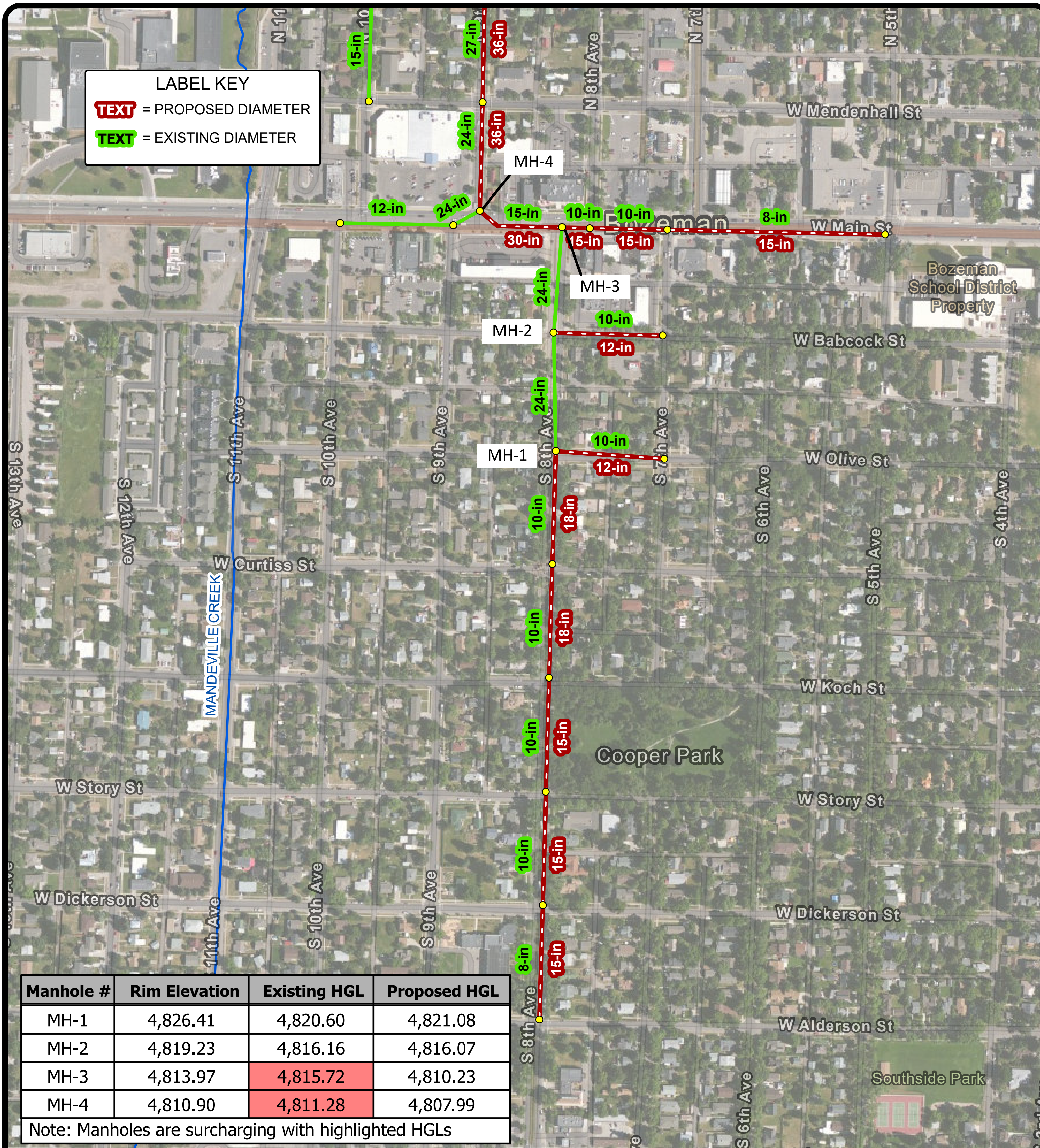
Field surveys should also be conducted to verify the invert elevations of pipes and manholes, as well as the rim elevations of manholes. Additionally, utility locations, right-of-way limits, and groundwater levels have not yet been considered and must be evaluated during the design process. Some locations may also benefit from exploring alternative design options, including the incorporation of other stormwater facilities such as infiltration galleries, additional outfalls, and detention ponds.

6.3.1 S 8th and 9th Avenue Improvements

The S 8th Avenue and W Main St storm drains, located in the Parks & Trails Gap Area, are primarily VCPs 10 inches or smaller, as shown in Figure 3. The system connects to a 24–30-inch reinforced concrete pipe (RCP) trunkline that extends north for 1,500 feet before discharging into an open ditch drain north of W Villard St, as shown in Figure 4. Under existing conditions, the storm drains south of W Olive Street and along W Main Street exhibit significant flooding at the 2-year event. Based on the surface flooding model, this is an area of concern, and water can pond up to 3 feet deep in areas along the storm drain system. City of Bozeman staff confirmed that this is a problem area, and the lid of MH-3 floats during larger storm events.

DOWL evaluated the impacts of upsizing the VCP for the entire system, as shown in Figure 3. Increasing the size of the upstream pipes resulted in higher flow rates through the downstream system. To accommodate the higher flows, the pipe between MH-3 and MH-4 was increased from 15 inches to 30 inches, resulting in MH-4 surcharging. To eliminate the surcharging at MH-4, the entire downstream system was increased to 36-inch RCP, shown in Figure 4. In total, 6,620 feet of storm drain would be replaced. Under the proposed conditions, the system no longer surcharges during the 2-year, 24-hour synthetic storm event and all three ORSL check storms. Improvements do not consider any stormwater improvements along the trunkline system to the west. An additional evaluation is required during final design to determine the downstream impacts of increasing the flow to the open ditch.

This project requires replacing 6,620 feet of storm drain and 21 manholes. The estimated cost, including design and construction administration, is $7.29 million; more details are in Supplement C.



Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-1	4,826.41	4,820.60	4,821.08
MH-2	4,819.23	4,816.16	4,816.07
MH-3	4,813.97	4,815.72	4,810.23
MH-4	4,810.90	4,811.28	4,807.99

Note: Manholes are surcharging with highlighted HGLs

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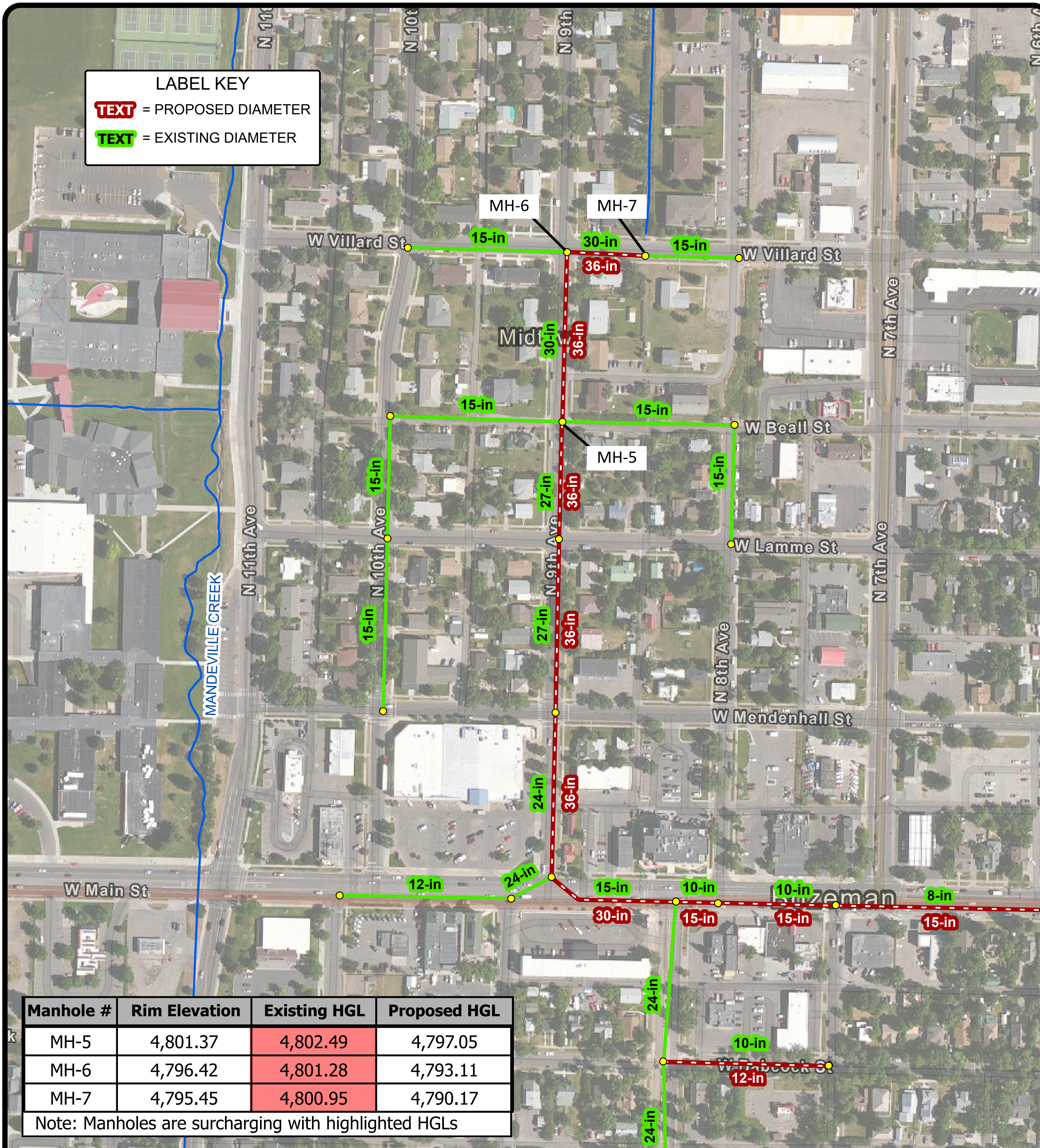
S 8TH AVENUE IMPROVEMENTS

FIGURE 3

UPSIZED SYSTEM FOR 2-YEAR LEVEL OF SERVICE



Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-5	4,801.37	4,802.49	4,797.05
MH-6	4,796.42	4,801.28	4,793.11
MH-7	4,795.45	4,800.95	4,790.17

Note: Manholes are surcharging with highlighted HGLs

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N 9TH AVENUE IMPROVEMENTS

FIGURE 4

UPSIZED SYSTEM FOR 2-YEAR LEVEL OF SERVICE

Existing Pipe
Proposed Pipe
Stormwater Manhole

0 100 200 400 Feet

N

6.3.2 S Wallace Avenue Improvements

The existing storm drain down S Wallace Avenue is 10-inch VCPs that discharge into an 18-inch PVC pipe, as shown in Figure 5. At the 2-year event, the storm drain from E Babcock St to E Mendenhall St surcharges through the manholes. The water flows north along the S Wallace Avenue curb and gutter until it is intercepted via inlets. This location is outside of the study area of the surface flooding model; however, City of Bozeman staff confirmed that inlets and laterals surcharge in this area during significant storm events.

The four upstream VCPs along South Wallace Avenue were upsized to 12-inch and 15-inch diameters, effectively eliminating surcharging at all three manholes during the conservative 2-year, 24-hour synthetic storm. To manage the increased flow, the two pipe segments downstream of MH-3 were upgraded to 24-inch pipes. The remaining sections of the downstream storm drain system have sufficient capacity to accommodate the additional runoff. The proposed system no longer surcharges during the 2-year, 24-hour synthetic storm event and the 2-year ORSL check storms. However, further evaluation is required during final design to determine if there are impacts on Bozeman Creek.

This project replaces 1,990 feet of storm drain and 7 manholes. The estimated cost, including design and construction administration, is $2.04 million; more details are in Supplement C.

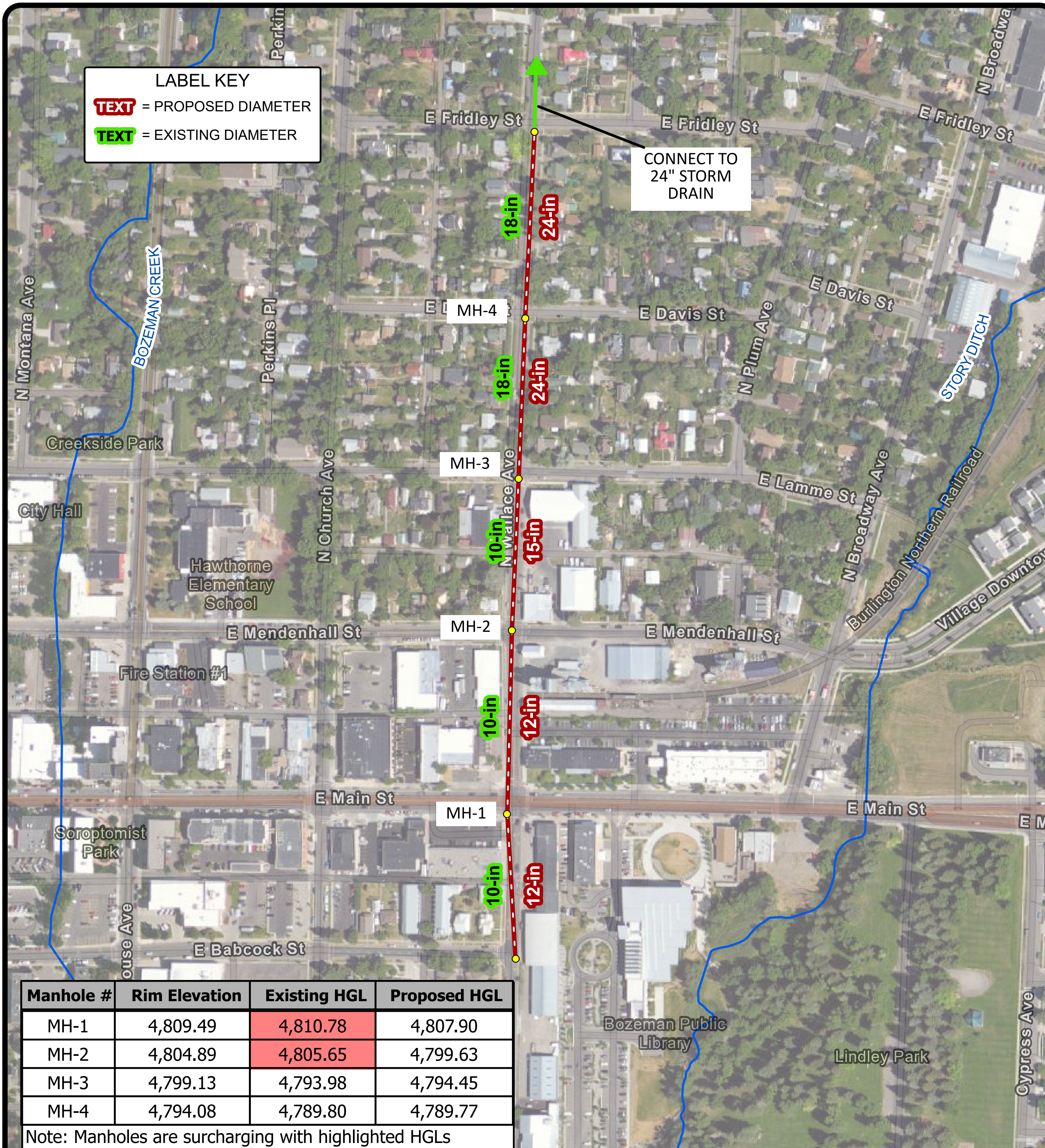
6.3.3 W Arthur Street Improvements

The entire W Arthur Street storm drain system collects runoff from West Lincoln Street north to W Cleveland Street, in addition to portions of the Montana State University (MSU) campus. It consists of approximately 12,000 feet of storm drain that discharge into Matthew Bird Creek via an 18-inch RCP. The pipe in the system is a combination of VCP and RCP; however, most of it is undersized. At the 2-year event, numerous manholes surcharge. Based on the 2018 LiDAR data and the surface flooding model, water generally flows northeast through this area with ponding up to 3 feet deep in several locations. City of Bozeman staff confirmed that this area has experienced significant flooding during large storm events.

Proposed improvements in this location involved upsizing the entire storm drain system, as shown in Figure 6. Laterals were increased from 10 inches to 15 inches, and the trunk line along W Arthur Street was increased to a 36-42-inch RCP. Increasing the pipe sizes eliminates all surcharging in the system at the 2-year, 24-hour synthetic storm event and the ORSL 2-year storm events.

A detailed study is required during the final design phase to assess whether the additional discharge into Matthew Bird Creek will cause downstream flooding impacts. This study should also evaluate the existing storm drain infrastructure, as there is uncertainty about whether the storm drain along South 3rd Avenue flows south into the downtown system.

Portions of the MSU campus that discharge into this system are currently undergoing redevelopment and will contribute runoff at pre-disturbance rates for up to the 10-year, 2-hour storm event, potentially alleviating the hydraulic load on the stormwater system. With portions of the MSU campus draining into this system, there is an opportunity for coordination between MSU and the City to incorporate low-impact development (LID) facilities.



Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-1	4,809.49	4,810.78	4,807.90
MH-2	4,804.89	4,805.65	4,799.63
MH-3	4,799.13	4,793.98	4,794.45
MH-4	4,794.08	4,789.80	4,789.77

Note: Manholes are surcharging with highlighted HGLs

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S WALLACE AVENUE IMPROVEMENTS

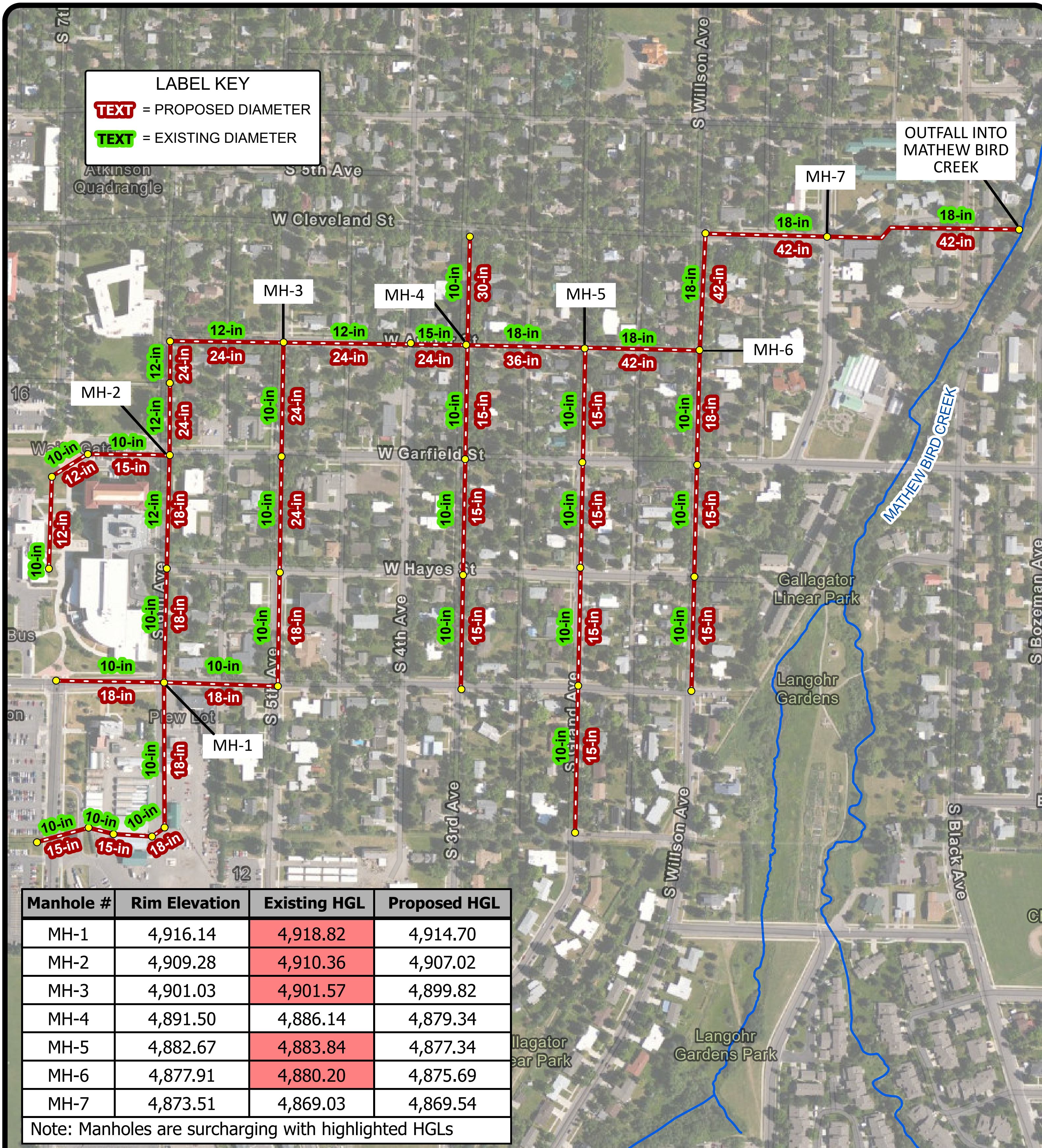
FIGURE 5

UPSIZED SYSTEM FOR 2-YEAR LEVEL OF SERVICE

Existing Pipe
Proposed Pipe
Stormwater Manhole

0 125 250 500 Feet

N



Manhole #	Rim Elevation	Existing HGL	Proposed HGL
MH-1	4,916.14	4,918.82	4,914.70
MH-2	4,909.28	4,910.36	4,907.02
MH-3	4,901.03	4,901.57	4,899.82
MH-4	4,891.50	4,886.14	4,879.34
MH-5	4,882.67	4,883.84	4,877.34
MH-6	4,877.91	4,880.20	4,875.69
MH-7	4,873.51	4,869.03	4,869.54

Note: Manholes are surcharging with highlighted HGLs

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W ARTHUR STREET IMPROVEMENTS

FIGURE 6

UPSIZED SYSTEM FOR 2-YEAR LEVEL OF SERVICE

Existing Pipe
Proposed Pipe
Stormwater Manhole

0 100 200 400 Feet

N

Another concern is the outlet pipe that discharges into Matthew Bird Creek, which passes through a 20-foot easement that may be encroached upon by nearby houses. To address these challenges, alternative methods of reducing the storm drain size should be considered. Potential solutions include incorporating infiltration galleries or adding an additional outfall to help manage stormwater and reduce the trunkline size.

This project replaces 11,500 feet of storm drain and 35 manholes. The estimated cost, including design and construction administration, is $11.3 million; more details are in Supplement C.

6.3.4 Recommendations

Evaluation of the planning-level model revealed three areas with undersized VCP storm drain systems: 8th and 9th Avenue, S Wallace Avenue, and W Arthur Street. To address the flooding at these locations, the City should plan for three capital improvement projects, totaling $20.6 million.

6.4 Bozeman Creek Tailwater Influences

The planning-level stormwater model was also used to evaluate the Bozeman Creek tailwater influences at four storm drain outfall locations, as shown in Figure 7 and Table 4. The water surface elevations (WSE) for the 10% and 4% annual exceedance probability (AEP) flood events were acquired from the Federal Emergency Management Agency (FEMA) Flood Insurance Study for Gallatin County, Montana, effective April 21, 2021 (FEMA, 2021) and Letter of Map Revision (LOMR) effective July 31, 2024 (NFHL_30031C). Profile plots for each outfall location are provided in Supplement C.

The evaluation of tailwater influences was conducted using the planning-level stormwater model, which reflects existing stormwater facilities. Many outfalls are associated with undersized upstream stormwater systems that surcharge during the 2-year storm event. Upsizing these systems would increase hydraulic loading on both the downstream system and the outfall locations. This analysis does not account for potential future improvements to the storm drain system. The combined effect of increased hydraulic loading and tailwater influences should be considered when designing future stormwater facilities.

6.4.1 Outfall 1 – W Cleveland Street

Outfall 1, near W Cleveland Street, is the W Arthur Street storm drain outfall and has a drainage area of approximately 140 acres. The storm drain is relatively flat before the final 650 feet of pipe, where it drops approximately 15 feet to discharge into Matthew Bird Creek, a tributary of Bozeman Creek. Due to this drastic change in elevation, tailwater from Matthew Bird Creek does not significantly impact the storm drain or any manholes at the 10% or 4% AEP flood events.

6.4.2 Outfall 2 – Rouse Avenue

Outfall 2 is the Rouse Avenue stormwater system outfall, which has a drainage area of approximately 310 acres. The 42-inch RCP trunkline has a flat slope of 0.2-0.5% before discharging into the creek. However, there is not a significant amount of tailwater from Bozeman Creek at this location; therefore, the system is not drastically impacted. At the 4% AEP event, tailwater extends up into the storm drain 430 feet and through one manhole; however, it does not surcharge the pipe, and the system retains sufficient capacity to convey surface runoff from a 2-year storm event.

6.4.3 *Outfall 3 – Peach Street*

Outfall 3 is located along Peach Street and has an east and west storm drain system associated with it. Based on the effective FIS, Bozeman Creek overtops Peach Street at the 2% AEP event. The eastern storm drain system consists of approximately 520 feet of 12–15-inch pipe with a drainage area of approximately 10 acres. All storm drains are located below the 10% AEP WSE. As a result, pipes are surcharged, and the four manholes within this system are impacted. All manhole rim elevations are higher than the 4% AEP WSE; however, two of the manholes have less than one foot of freeboard. The system has little to no capacity to handle runoff from a storm event at the 10% and 4% AEP flood events. Under these conditions, water will pond approximately 1 foot deep at the intersection of Peach Street and Church Avenue before spilling north down Church Avenue.

The western storm drain system consists of 24-27-inch RCPs with a drainage area of approximately 57 acres. One thousand four hundred sixty feet of storm drain is located below the 4% AEP WSE, surcharging several pipe segments. All manholes have rim elevations higher than the 4% AEP WSE; however, the system has little capacity to convey surface runoff if a rain event were to occur during these floods. The system collects runoff from a large area; therefore, there is the potential for significant surcharging and flooding along the Peach Street corridor if a rain event were to occur in conjunction with elevated WSE on Bozeman Creek. Under these conditions, water will generally follow the curb and gutter along Peach Street, flowing east towards the Peach Street and Rouse Avenue intersection or north down N Bozeman Avenue or N Montana Avenue. The LiDAR does not indicate any low points that would result in significant ponding.

6.4.4 *Outfall 4 – Tamarack Street*

Outfall 4 is located along Tamarack Street and has an eastern and western storm drain associated with it. According to the effective FIS, Bozeman Creek does not overtop this crossing at the 0.2% AEP flood event. The eastern storm drain system consists of a 30-inch trunkline that collects runoff from approximately 49 acres. Tailwater extends up 860 feet of storm drain during the 4% AEP event; however, it does not surcharge any pipes or manholes. The storm drain has sufficient capacity to handle a 2-year storm event under these conditions. If surface flooding occurs along this road corridor, water will pool at the intersection of N Wallace Avenue and Tamarack Street, reaching a depth of approximately 1 foot before spilling north and flowing along the curb and gutter of N Wallace Avenue.

The western storm drain consists of a 30-36-inch trunkline and has an 85-acre drainage area. Tailwater extends through 1,470 feet of storm drain and three manholes at the 4% AEP flood event. All manhole rim elevations exceed the 4% AEP WSE of Bozeman Creek; however, three pipe segments are surcharged, limiting the system’s capacity to convey runoff. Due to the size of the drainage area, a significant amount of runoff is conveyed through this storm drain system. Significant surcharging along the Tamarack Street corridor is likely if a large rain event coincides with a flood event on Bozeman Creek. Under these conditions, water will pond at the intersection of Tamarack Street and Rouse Avenue, reaching a depth of approximately 1 foot before spilling north along the curb and gutter of Rouse Avenue.

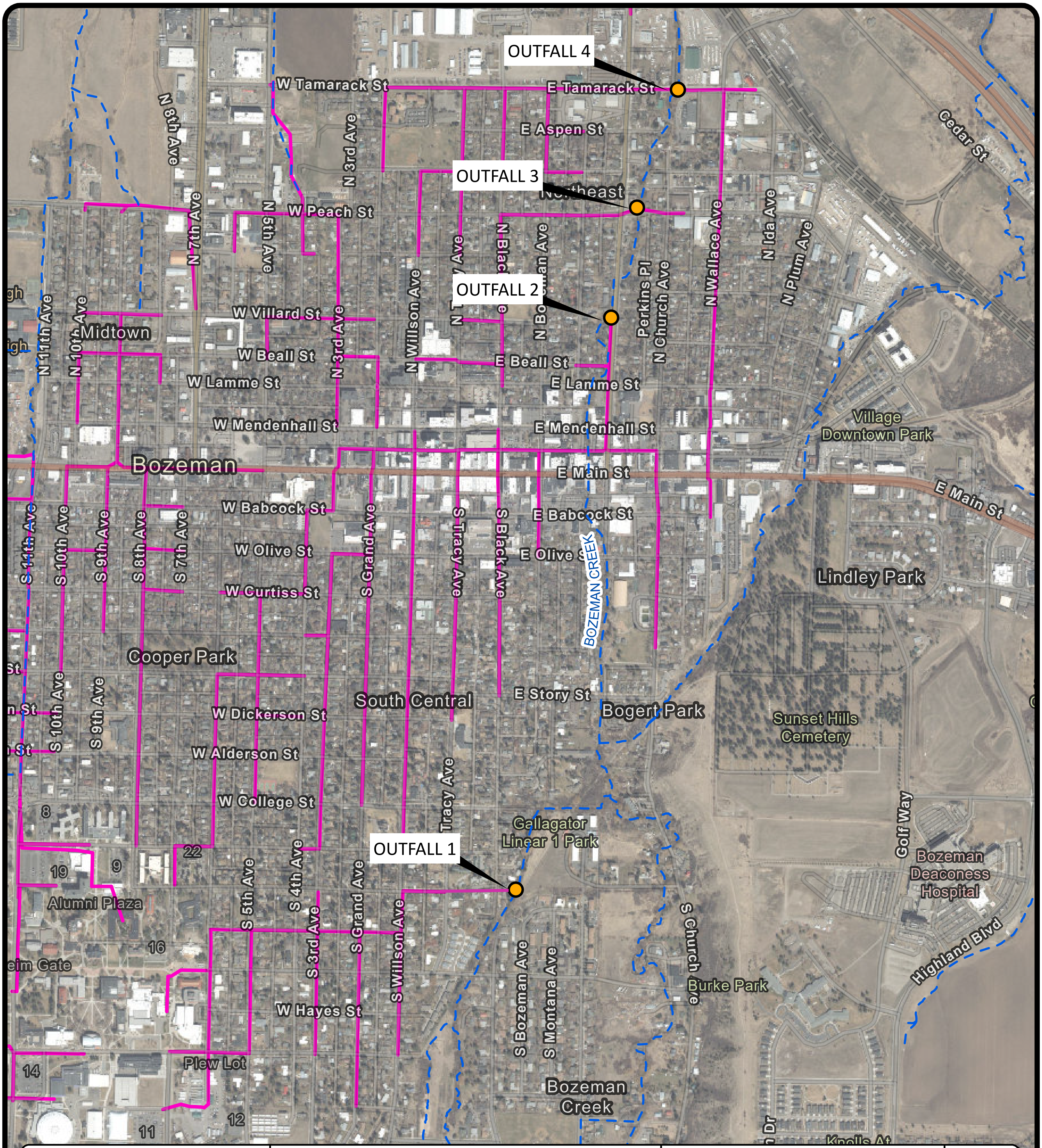
6.4.5 *Conclusion & Recommendation*

Outfalls 3 and 4 are affected by tailwater during flood events on Bozeman Creek; however, the tailwater does not reach levels that cause it to bubble out of manholes during the 4% AEP event. As a result, flap gates are not necessary. However, a rain event occurring simultaneously with a flood event on Bozeman Creek could lead to significant surface flooding in areas of the street nearest the outfalls. The eastern storm drain for Outfall 3, as well as the eastern and western storm drains for Outfall 4, could experience surface ponding up to 1 foot deep. Table 4 provides a summary of Bozeman Creek tailwater impacts on all four outfall locations.

Table 4: Bozeman Creek Tailwater Influences

Outfall[1]	Approximate Invert Elevation (ft)	Bozeman Creek WSE (ft)		Storm Drain Below Tailwater Elev (ft)		Manholes with Invert Below Tailwater Elev	
		10% AEP	4% AEP	10% AEP	4% AEP	10% AEP	4% AEP
1	4,852.23	4,856.50	4,856.79	170	190	0	0
2	4,786.00	4,786.38	4,787.51	130	330	0	1
3 (E)	4,776.00	4,779.61	4,780.59	420	420	4	4
3 (W)				1,250	1,360	6	6
4 (E)	4,755.74	4,763.15	4,763.64	820	860	4	4
4 (W)				1,390	1,470	3	3

[1] ”E” and “W” indicate the east and west storm drain systems



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PROPOSED STORMWATER IMPROVEMENTS

FIGURE 7

OUTFALL LOCATIONS

Gravity Mains
Waterways
Outfall Locations

0 250 500 1,000 Feet

N

7.0 DOWNTOWN STORMWATER STUDY

The downtown stormwater study detailed in the following section expands on the studies done in 2012 and 2021, detailed in Section 2. The SSA model and analysis completed in 2021 were used as the basis for a more detailed analysis of the infiltration galleries and bypass system alternatives to reduce hydraulic loading to the alleyway trunkline.

7.1 Soil Data Review

A soil data review of the downtown Bozeman study area was done to evaluate infiltration rates and determine if there are any patterns in soil layers and depths. The soil type and depth of soil layers in the downtown Bozeman study area were assessed using Montana Ground Water Information Center (GWIC) well log reports. The well log soil descriptions varied across reports; therefore, DOWL categorized soils into four categories: gravel, sand, clay, and other. The depth of each soil type was recorded.

Infiltration rates for various soil types were determined based on data from USCS Soils and conversations with DOWL geotechnical engineers. The results are presented in Table 5. Gravel soils have significantly higher infiltration rates than any of the other soils; therefore, infiltration galleries were targeted to be constructed in the gravel layer. Evaluation of the GWIC well log reports showed no clear patterns in soil layers, depths, or location, as shown in Figure 8. The gravel layer ranged from being at the surface to 16 feet deep.

Table 5. Soil Infiltration Rates

Soil Description	Range of Typical Infiltration Rates (in/hr)
Gravel	30
Poorly graded sandy gravel	10 - 15
Silty sand	1 - 2

7.2 Infiltration Gallery Conceptual Design

Two conceptual infiltration gallery designs were evaluated: an underground gallery and a rain garden gallery. Each gallery is connected to the storm drain system through a pipe set at a lower elevation than the trunkline, allowing the galleries to treat more than just localized surface runoff. Instead, they can infiltrate water already captured by the storm drain system, thereby reducing the overall hydraulic load. If water begins to accumulate in the gallery, it will overflow back into the storm drain system. This design significantly increases the volume of water the gallery can infiltrate compared to the rain garden gallery design assessed in the 2021 study.

The representative infiltration galleries were designed to accommodate most variations in gravel layer depth while remaining feasible for construction. The gallery depth, measured from the ground surface to the bottom of the infiltration gallery, was set at 12 feet. Potential locations for the infiltration galleries were identified by considering underground utilities, property lines, and other obstructions, such as trees and utility poles. Water, sewer, and stormwater gravity mains were avoided, though the locations of private utilities were unknown. Property lines and existing utilities constrained gallery widths. Galleries did not extend beyond the road's centerline to maintain access for construction and future utility installation. The length of the galleries was determined by the distance between intersections, tying into existing manholes. Various potential sites across downtown Bozeman were evaluated to determine the dimensions of the conceptual infiltration galleries, as shown in Table 6.

Connecting the infiltration gallery to the storm drain system would include installing a mechanical treatment unit upstream of each gallery. This unit prevents sediment and debris from accumulating in the gallery, thereby preserving its performance and infiltration capacity.

The rain garden design, in addition to infiltrating water from the underground storm drain system, captures surface runoff before it enters the infiltration gallery. This pre-treatment reduces sediment and improves water quality. However, the rain garden can only be placed in locations with vegetated boulevards adjacent to the road that experience significant surface runoff. The boulevard's added width allows for a larger infiltration and increased infiltration flow rates, as shown in Table 6. In contrast, the underground infiltration gallery is not limited to locations with vegetated boulevards, but it does not capture surface runoff.

The underground infiltration gallery design was chosen to simplify modeling in SSA. The downtown stormwater model does not account for curbs, gutters, or inlets, making it challenging to identify suitable locations for rain garden infiltration galleries based on surface runoff. A more detailed model that includes these features and more precise basin delineation would be needed to determine these locations.

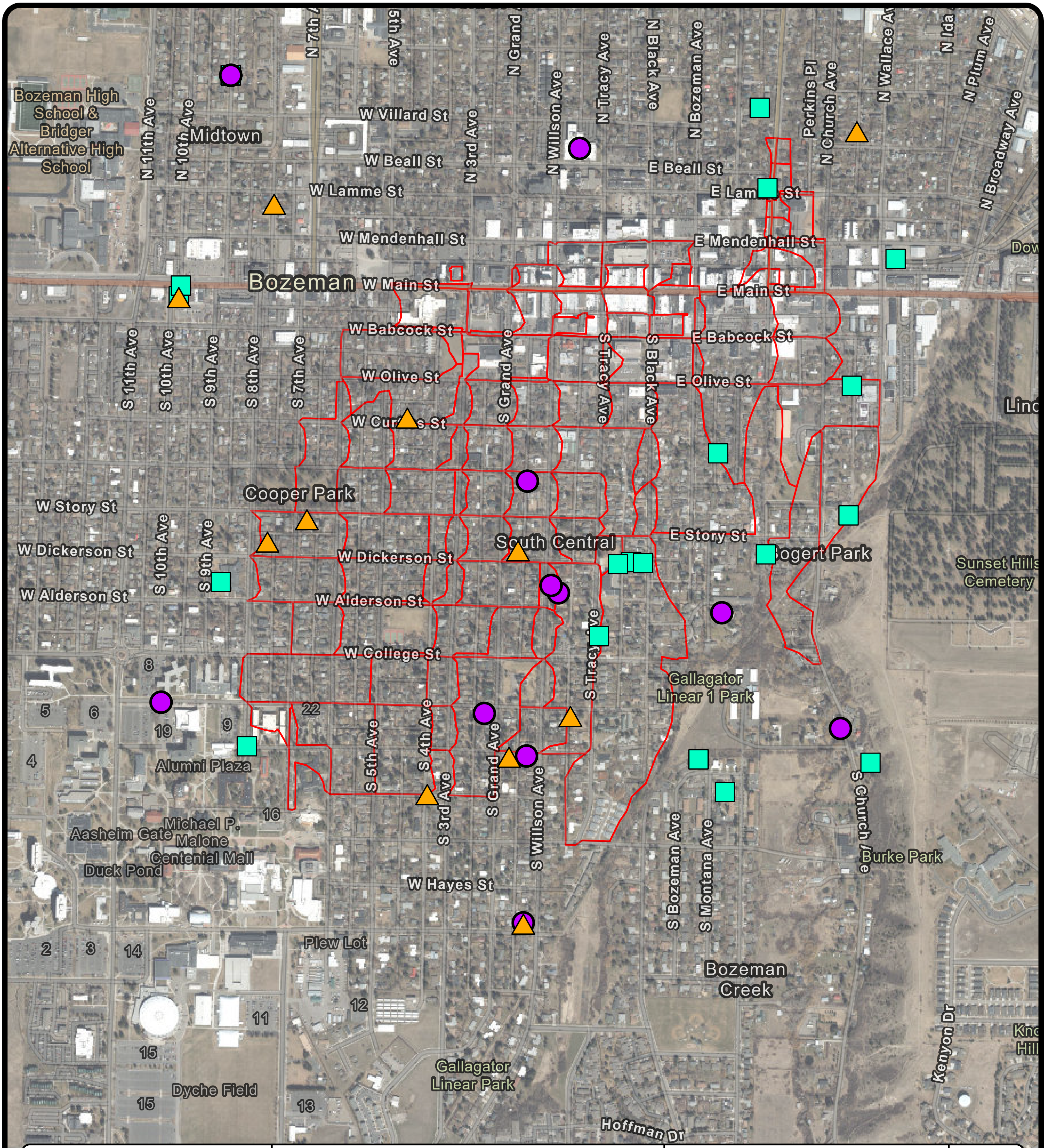
A storage pipe is embedded within the washed angular stone of the infiltration gallery to increase volumetric storage capacity. The storm drain system's hydraulic grade line determines the pipe diameter; for full utilization of the storage pipe's volume, the hydraulic grade line must extend above the top of the pipe. Following a review of multiple locations, a 4-foot diameter was identified as appropriate for most sites.

Infiltration galleries were modeled as storage nodes in SSA using a constant infiltration rate. A constant infiltration rate of 1.25 cfs was calculated using the length and width dimensions of the infiltration gallery and assuming a gravel soil layer. Calculations are shown below in Table 6. Infiltration gallery storage pipes were modeled as storage curves with a 150-foot barrel, a 12-inch stone base, and 40% stone voids.

Table 6: Infiltration Gallery Calculations

Type	Storage Pipe Diameter (ft)	Length (ft)	Width (ft)	Depth (ft)	Infiltration Rate (in/hr)	Constant Infiltration Rate (cfs)
Underground Gallery[1]	4	150	12	12	30	1.25
Rain Garden Gallery	4	150	20	12	30	2.08

[1] Infiltration gallery design modeled within SSA



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DOWNTOWN STORMWATER STUDY

FIGURE 8

GWIC WELL LOG GRAVEL DEPTHS

Gravel Depth 11-18 ft (11)
Gravel Depth 6-10 ft (12)
Gravel Depth 0-5 ft (30)
Downtown Subbasins

0 250 500 1,000 Feet

N

7.3 Design Alternatives

It is assumed that, in the future, all small VCP laterals—pipes connecting catch basins to the nearest manhole—and trunklines in the downtown area will be replaced with larger pipes measuring 15 inches or greater in diameter. However, upsizing these pipes increases hydraulic loading on the Mendenhall Street alleyway trunkline, causing surcharging at the 2-year storm event. Three design alternatives were developed to mitigate this impact and include the installation of infiltration galleries, the installation of a new storm drain bypass system, and a combination of both infiltration galleries and a bypass system.

Alternative 1 relies solely on infiltration galleries to prevent surcharging. The 2021 study determined that achieving a 2-year level of service would require 27 rain garden infiltration galleries, which only capture surface runoff before it enters the storm drain system. By contrast, the underground infiltration galleries in this design are connected directly to the storm drain system, allowing them to infiltrate a larger volume of runoff. Additionally, this analysis uses a higher infiltration rate based on the assumption that the galleries are installed in gravel. As a result, only four underground infiltration galleries are needed to prevent surcharging during the 2-year storm event, as shown in Figure 10. These infiltration galleries were strategically placed to reduce hydraulic loading and improve water quality in untreated areas. Additionally, six alternative locations were identified in case primary sites prove unfeasible due to unknown utilities or insufficient depth to the gravel layer. Site selection should also consider potential groundwater mounding and its impact on adjacent structures.

Alternative 2 is the bypass system recommended in the 2021 study (Alternative 4) and includes the new 24 to 30-inch storm drain trunkline extending down Olive St and S Bozeman Avenue to unload the upper reach of the alleyway trunkline. This alternative only addresses the capacity issues of the alleyway drainage and doesn't have the additional water quality benefits that the Alternative 1 infiltration galleries provide.

Alternative 3 is a combination of a bypass system and infiltration galleries. In this design, the bypass system is downsized from a 24 to 30-inch to an 18 to 24-inch system, with infiltration galleries added, as shown in Figure 9. Three infiltration galleries are still needed to prevent the alleyway trunkline from surcharging with a downsized. Unlike Alternative 2, this alternative provides additional water-quality treatment for untreated areas.

7.4 Cost Estimates

Cost estimates were prepared for each design alternative. The construction cost for a single infiltration gallery is estimated at $530,000, totaling approximately $2.1 million for Alternative 1. Bundling the installation of multiple galleries may yield additional cost savings. The standard bypass presented in Alternative 2 is estimated at $2.9 million. For Alternative 3, the downsized bypass system is estimated at $2.7 million, with the three required infiltration galleries adding $1.6 million, bringing the total to $4.3 million. Additional information is provided in Supplement C.

7.5 Recommendation

Alternative 3 is not a viable option as there is still a significant cost to install the downsized bypass system and not enough savings with the removal of one infiltration gallery. Alternative 1 is the recommended capital improvement project to pursue for unloading the alleyway trunkline. This alternative provides the least costly alternative while providing additional water quality benefits. It is recommended that this project be phased for final design with an initial phase including utility locations and subsurface geotechnical investigation at all 10 infiltration sites to help understand limitations and verify the assumptions made in our preliminary modeling. For budget planning purposes, the City should consider budgeting this project for the storm drain bypass system only just in case there are not four viable sites out of the 10 identified.

8.0 FUTURE MODEL DEVELOPMENT AND MAINTENANCE

The SSA planning-level model has room for further development and refinement. Currently, the model assumes "direct to outlet" internal routing for all subbasins, a conservative approach that typically overestimates peak flows. Revisiting the internal routing for each subbasin and updating the model accordingly could yield lower peak flow estimates and provide a more accurate representation of the level of service for the storm drain facilities.

Additionally, the model does not account for baseflow within the south-to-north open channels. Identifying and incorporating baseflow into the model would offer a more comprehensive understanding of tailwater influences at various outfalls and the capacity of the open channels. This enhancement would improve the overall accuracy of the model and its ability to inform system performance assessments.

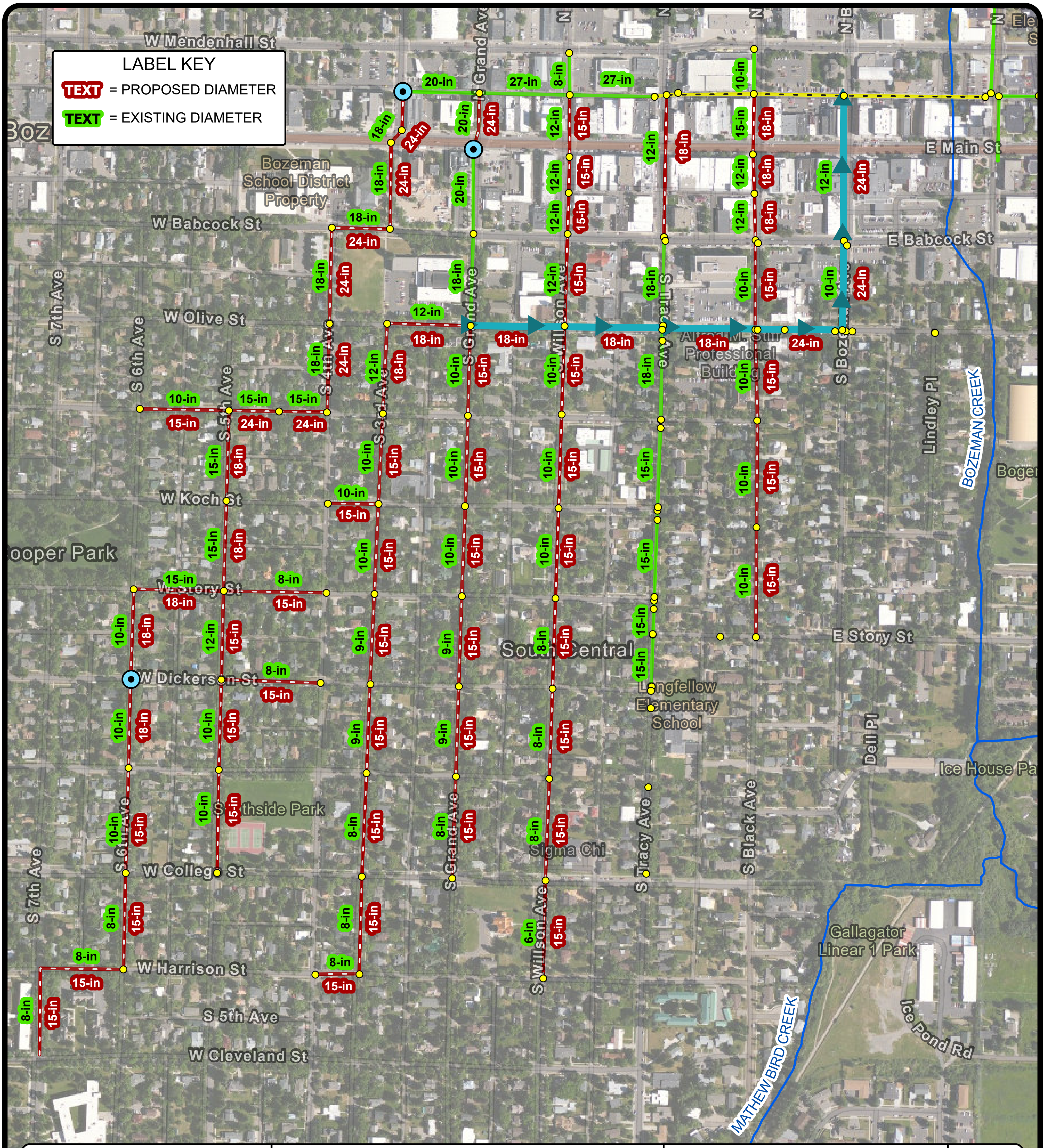
Detention ponds were incorporated into the model in locations where they influenced the performance of the downstream storm drain system, as detailed in Section 6.1.4. Each pond was modeled with a functional storage type using a constant surface area derived from aerial imagery, with invert and maximum elevations estimated based on LiDAR data. Further refinement of the model could include the addition of more detention ponds and the development of storage curves for each pond to improve accuracy.

As additional storm drain data is collected and storm drain improvement projects are completed, both the SSA planning-level and downtown stormwater models should be updated accordingly. These updates may involve incorporating detention ponds and infiltration galleries, revising storm drain inverts, sizes, materials, and rim elevations, updating the impervious area for basins, and adding new storm drain systems. Model refinement should be conducted on an as-needed basis to address emerging needs. In some areas, incorporating inlets, laterals, or subdividing larger subbasins into smaller ones may offer additional benefits and improve the model's precision.

Both models are valuable tools for evaluating capacity constraints within the study areas and supporting capital improvement planning. They can be used to assess the sizes of replacement pipes for the Historic Pipe Replacement Program and to determine the appropriate dimensions of stormwater treatment devices for installation under the Mechanical Stormwater Treatment Phase 4 CIP project.

Additionally, several stormwater planning studies, including the West Bozeman—South and Lower Bozeman Creek planning studies, have been recommended for future development. The planning-level and downtown stormwater models provide a robust framework that can guide the development of these and other future studies.

A comprehensive summary of the CIP and planning study recommendations is available in the 2025 Bozeman Stormwater Facilities Report.



DOWL

DOWNTOWN STORMWATER SYSTEM

- Stormwater Manhole
- Infiltration Gallery
- CIPP
- Existing Pipe
- Proposed Pipe
- Bypass System

N

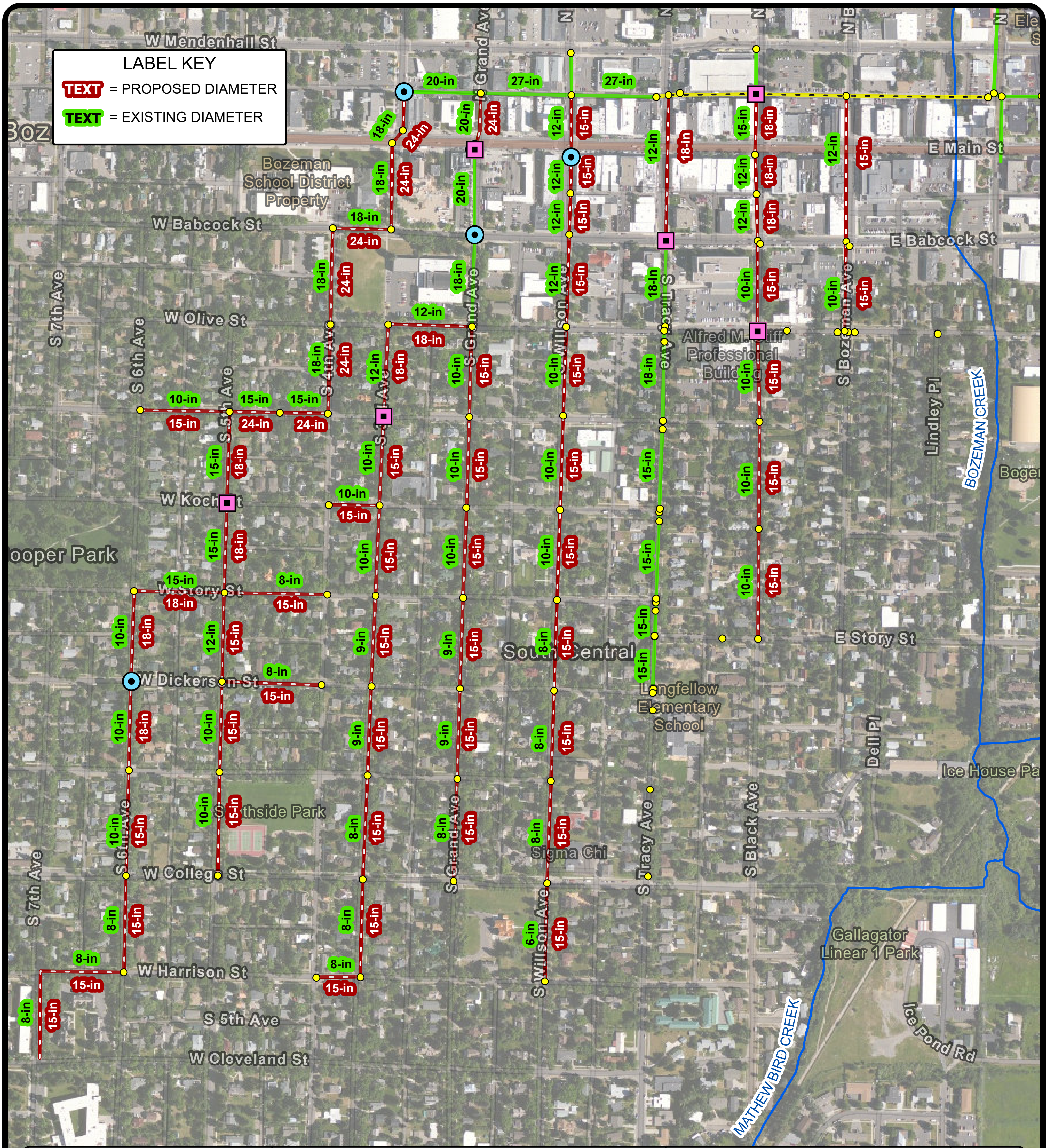
1283 N. 14th Ave. Suite 101
Bozeman, Montana 59715
406-586-8834

FIGURE 9

INFILTRATION GALLERY LOCATIONS WITH BYPASS

0 125 250 500 Feet

PROJECT: 4036.21888.02 DATE: 3/5/2025



DOWL	**DOWNTOWN STORMWATER SYSTEM**	Infiltration Gallery; Alternative Gallery Location; Stormwater Manhole; CIPP; Existing Pipe; Proposed Pipe
1283 N. 14th Ave. Suite 101 Bozeman, Montana 59715 406-586-8834 PROJECT: 4036.21888.02 DATE: 3/5/2025	FIGURE 10 INFILTRATION GALLERY LOCATIONS WITHOUT BYPASS	0 125 250 500 Feet

N

9.0 REFERENCES

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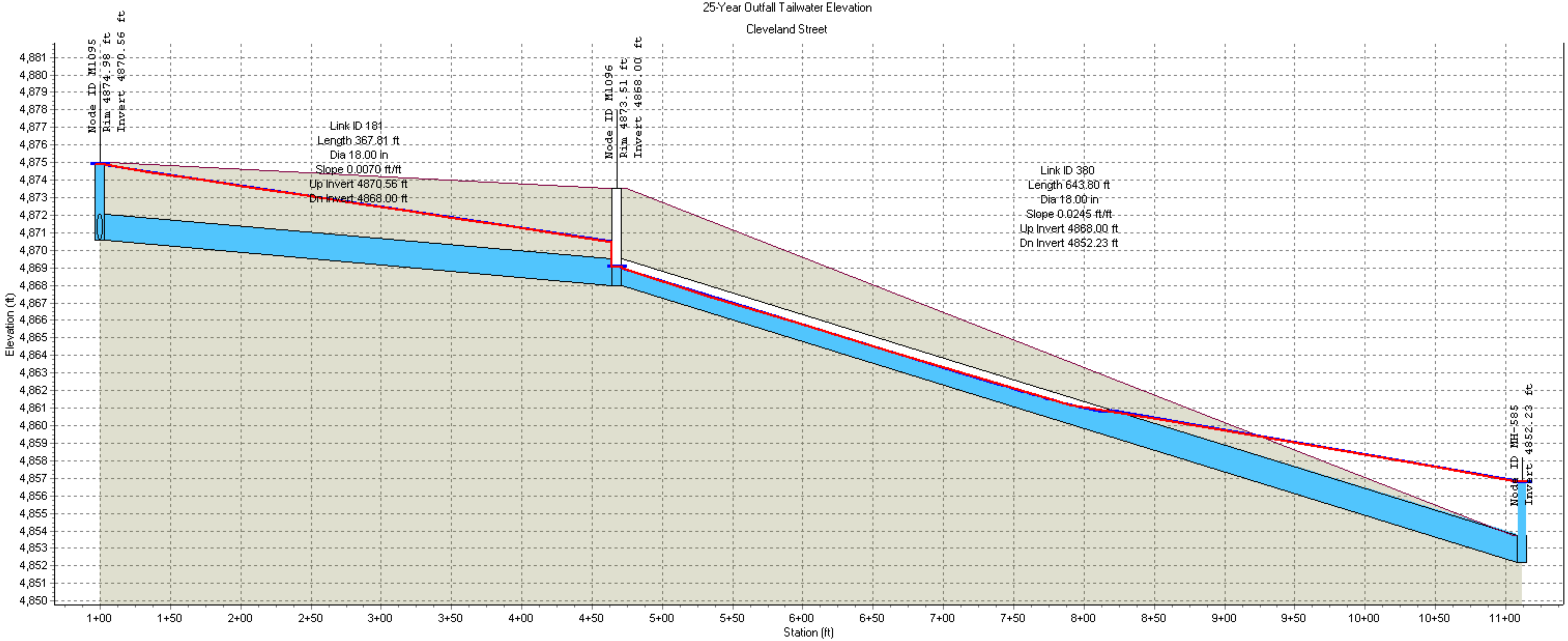
SUPPLEMENT A: REPRESENTATIVE STORM EVENTS

City of Bozeman Representative Actual Storm Events						
Storm date	Storm Duration (hrs)	Total Storm Depth (in)	Max Rainfall Intensity (in/hr)	Frequency at End of Storm	Max Freqency of Storm	Data Source (NCDC Gallatin Field vs MSU ORSL)
Representative 2-year Storms						
4/30/1951	19.0	1.09	0.45	2-yr	6-yr (6.0-hr)	Gallatin Field
6/17/1979	2.0	0.50	0.49	2-yr	2-yr (2.5-hr)	Gallatin Field
6/26/1963	1.0	0.45	0.45	2.1-yr	2.1-yr (1.0-hr)	Gallatin Field
6/12/2017	33.1	1.50	10.8	2.5-yr	3.7-year (24-hr)	ORSL
6/16/2019	0.7	0.38	11.4	1.5-yr	3.2-yr (10-min)	ORSL
Representative 5-year Storms						
6/29/2013	0.9	0.70	13.2	7.4-yr	7.4-yr (1-hr)	ORSL
8/14/2017	27.0	0.67	9	4.9-yr	5.2-yr (30-min)	ORSL
5/21/2004	3.0	0.76	0.56	5.9-yr	7.2-yr (2-hr)	Gallatin Field
6/5/2007	35.0	1.89	0.15	7.1-yr	7.1-hr (18-hr)	Gallatin Field
Representative 10-year Storms						
5/7/1965	1.0	0.79	0.79	10.9	10.9-yr (1-hr)	Gallatin Field
6/9/1969	19.0	1.50	0.59	10.1	10.7-yr (18-hr)	Gallatin Field
4/22/2018	18.0	1.48	2.4	10.7	10.7-yr (18-hr)	ORSL
Representative 25-year Storm						
6/24/1969	45.0	2.95	0.15	30.1	34.7-yr (36-hr)	Gallatin Field
Representative 50-year Storms						
5/12/1970	1.0	1.13	1.13	56.2	56.2-yr (1-hr)	Gallatin Field
5/26/2019	13.0	1.54	0.31	35.2	51.8-yr (6-hr)	Gallatin Field

SUPPLEMENT B: OUTFALL PROFILE PLOTS

25-Year Outfall Tailwater Elevation

Cleveland Street

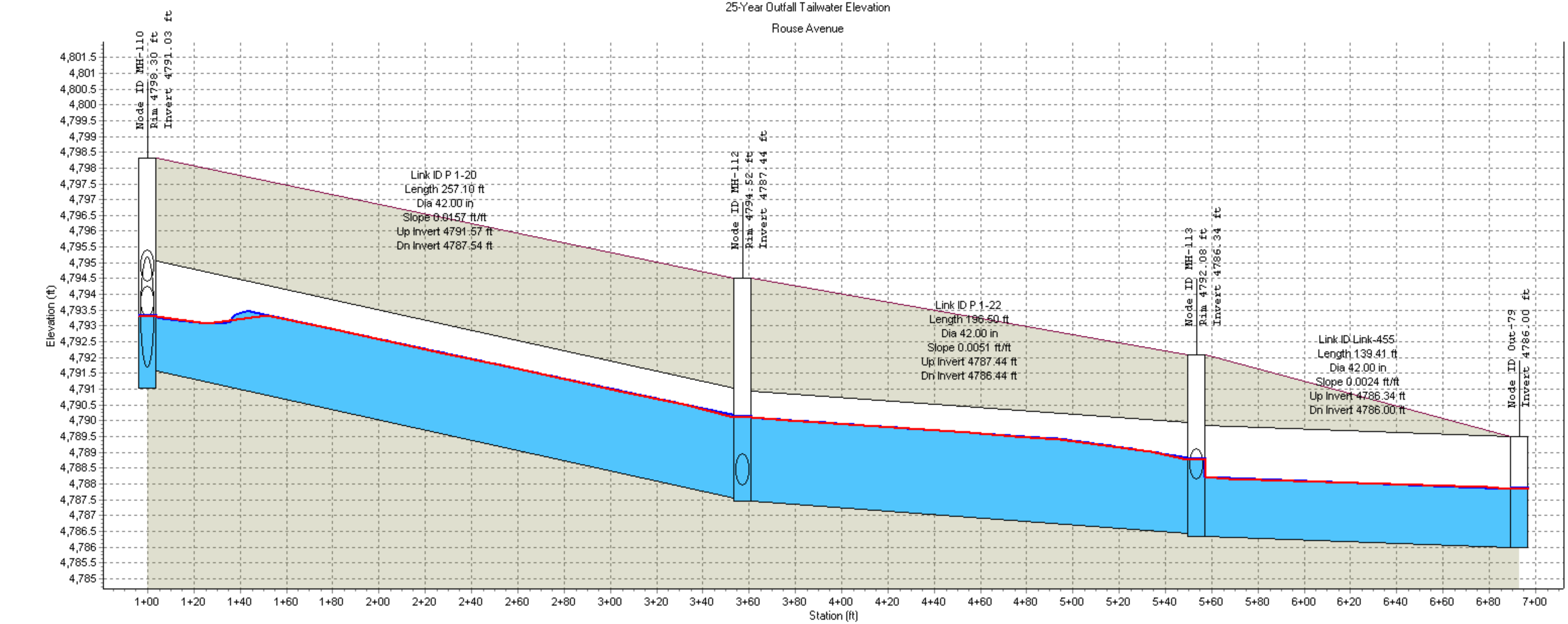


Node ID:	M1095	M1096	MH-585
Rim (ft):	4874.98	4873.51	
Invert (ft):	4870.56	4868.00	4852.23
Min Pipe Cover (ft):	2.92	4.01	
Max HGL (ft):	4874.98	4869.04	4856.79

Link ID:	181	380
Length (ft):	367.81	643.80
Dia (in):	18.00	18.00
Slope (ft/ft):	0.0070	0.0245
Up Invert (ft):	4870.56	4868.00
Dn Invert (ft):	4868.00	4852.23
Max Q (cfs):	12.56	13.52
Max Vel (ft/s):	7.89	8.46
Max Depth (ft):	1.27	1.27

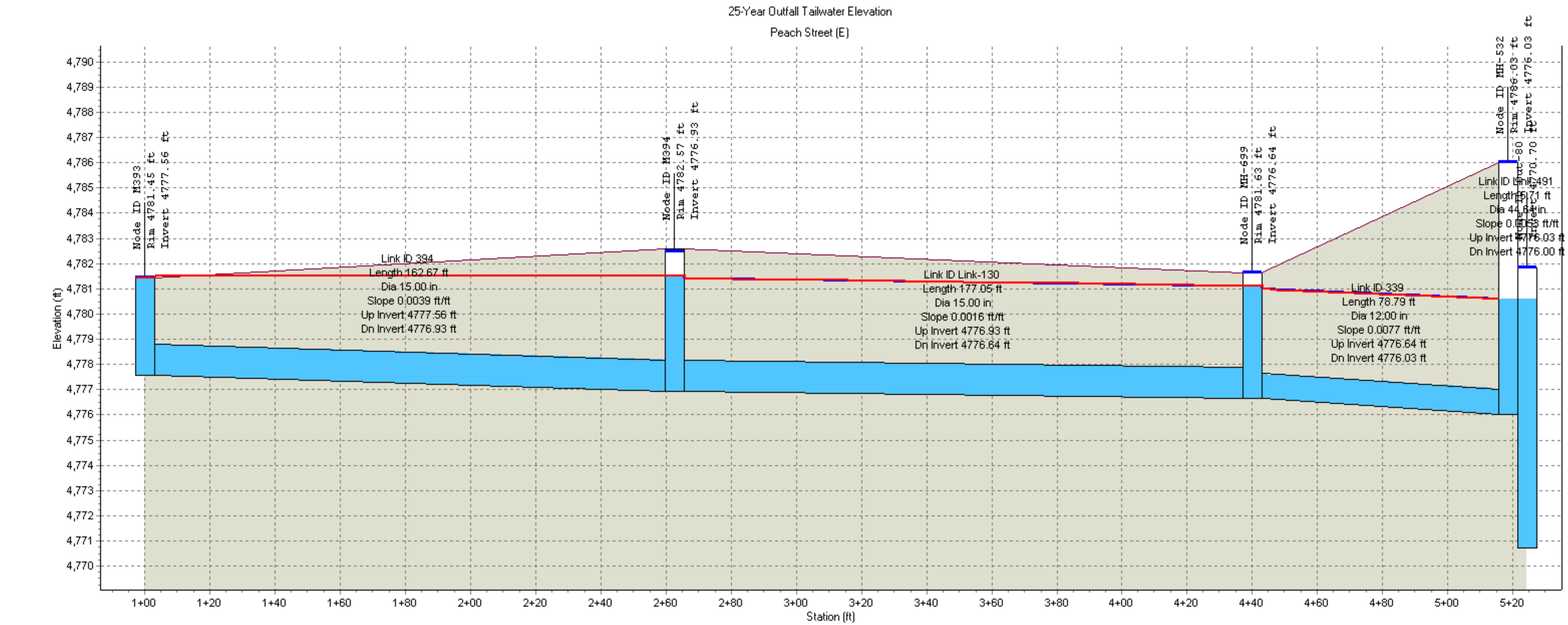
25-Year Outfall Tailwater Elevation

Rouse Avenue



Node ID:	MH-110	MH-112	MH-113	Out-79
Rim (ft):	4798.30	4794.52	4792.08	
Invert (ft):	4791.03	4787.44	4786.34	4786.00
Min Pipe Cover (ft):	2.90			
Max HGL (ft):	4793.31	4790.12	4788.77	4787.85

Link ID:	P 1-20	P 1-22	Link-455
Length (ft):	257.10	196.50	139.41
Dia (in):	42.00	42.00	42.00
Slope (ft/ft):	0.0157	0.0051	0.0024
Up Invert (ft):	4791.57	4787.44	4786.34
Dn Invert (ft):	4787.54	4786.44	4786.00
Max Q (cfs):	50.77	50.91	35.54
Max Vel (ft/s):	8.25	6.92	5.77
Max Depth (ft):	2.16	2.50	2.14

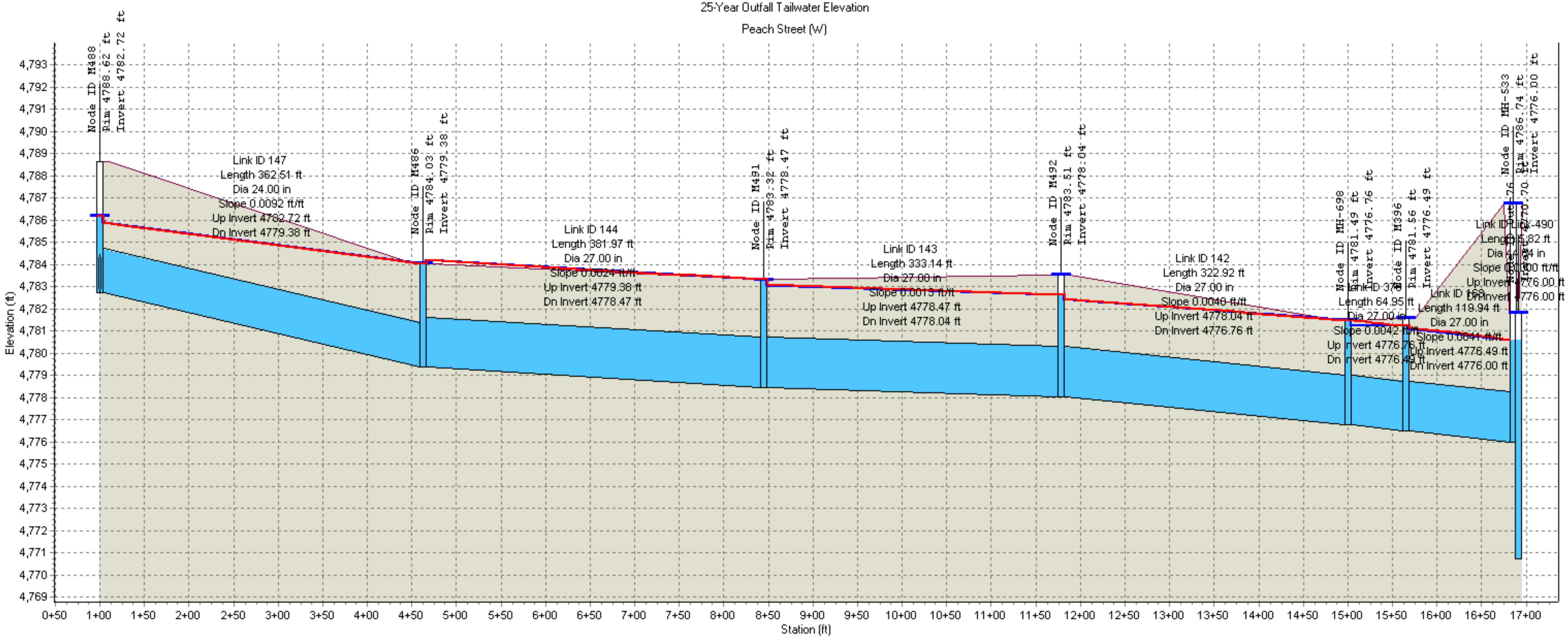


Node ID:	M393	M394	MH-699	MH-5[illegible]-80
Rim (ft):	4781.45	4782.57	4781.63	4786.03
Invert (ft):	4777.56	4776.93	4776.64	477[illegible]0.70
Min Pipe Cover (ft):	2.64	4.39	3.74	6.28
Max HGL (ft):	4781.45	4782.57	4781.63	478[illegible]1.84

Link ID:	394	Link-130	339	Link-491
Length (ft):	162.67	177.05	78.79	5.71
Dia (in):	15.00	15.00	12.00	44.64
Slope (ft/ft):	0.0039	0.0016	0.0077	0.0053
Up Invert (ft):	4777.56	4776.93	4776.64	4776.03
Dn Invert (ft):	4776.93	4776.64	4776.03	4776.00
Max Q (cfs):	3.21	4.26	10.15	17531.18
Max Vel (ft/s):	2.96	3.63	12.92	50.00
Max Depth (ft):	1.25	1.25	1.00	5.82

25-Year Outfall Tailwater Elevation

Peach Street (W)

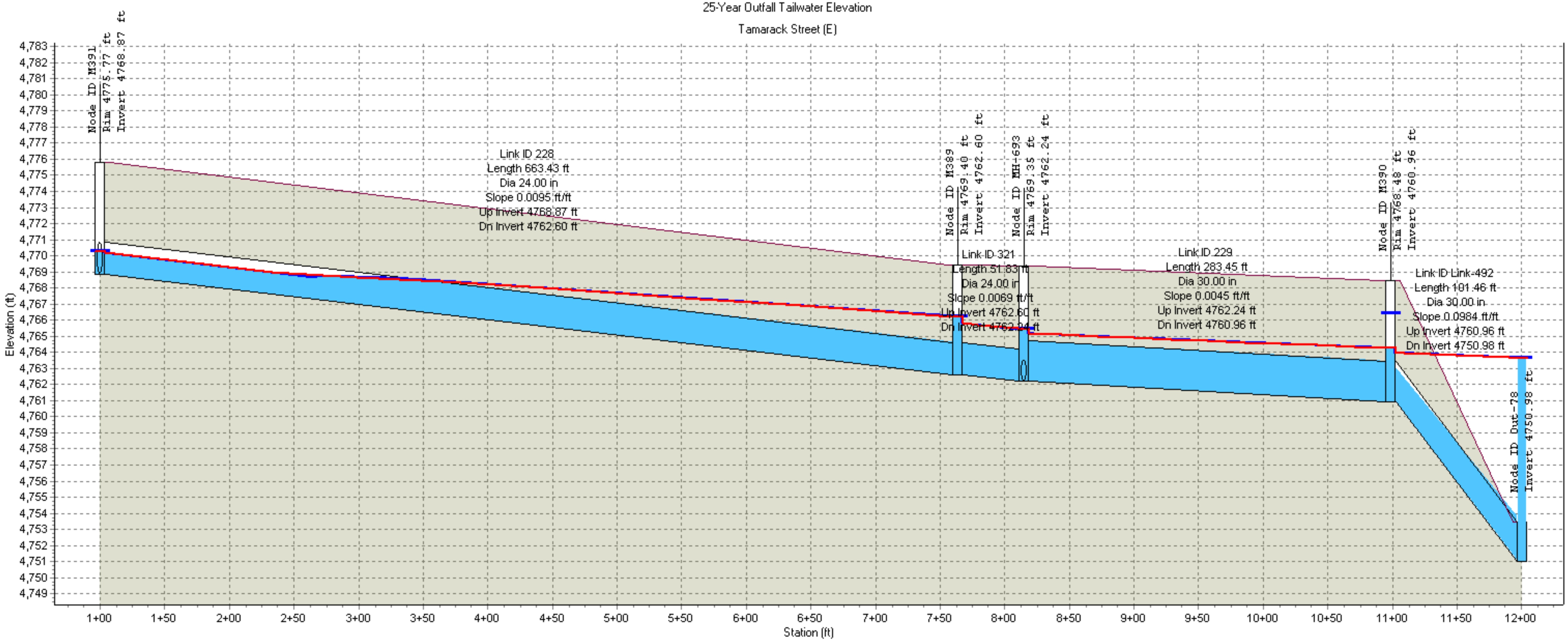


Node ID:	M488	M486	M491	M492	MH-698	M396	MH-533
Rim (ft):	4788.62	4784.03	4783.32	4783.51	4781.49	4781.56	4786.74
Invert (ft):	4782.72	4779.38	4778.47	4778.04	4776.76	4776.49	4776.00
Min Pipe Cover (ft):	3.90	2.40	2.60	3.22	2.48	2.82	7.02
Max HGL (ft):	4788.62	4784.03	4783.32	4783.51	4781.49	4781.56	4786.74

Link ID:	147	144	143	142	378	168	Link-490
Length (ft):	362.51	381.97	333.14	322.92	64.95	119.94	5.32
Dia (in):	24.00	27.00	27.00	27.00	27.00	27.00	44.64
Slope (ft/ft):	0.0092	0.0024	0.0013	0.0040	0.0042	0.0041	0.0000
Up Invert (ft):	4782.72	4779.38	4778.47	4778.04	4776.76	4776.49	4776.00
Dn Invert (ft):	4779.38	4778.47	4778.04	4776.76	4776.49	4776.00	4776.00
Max Q (cfs):	14.13	11.08	12.30	14.61	26.81	28.44	18170.50
Max Vel (ft/s):	4.50	2.79	3.09	3.67	7.60	9.39	50.00
Max Depth (ft):	2.00	2.25	2.25	2.25	2.25	2.25	5.32

25-Year Outfall Tailwater Elevation

Tamarack Street (E)

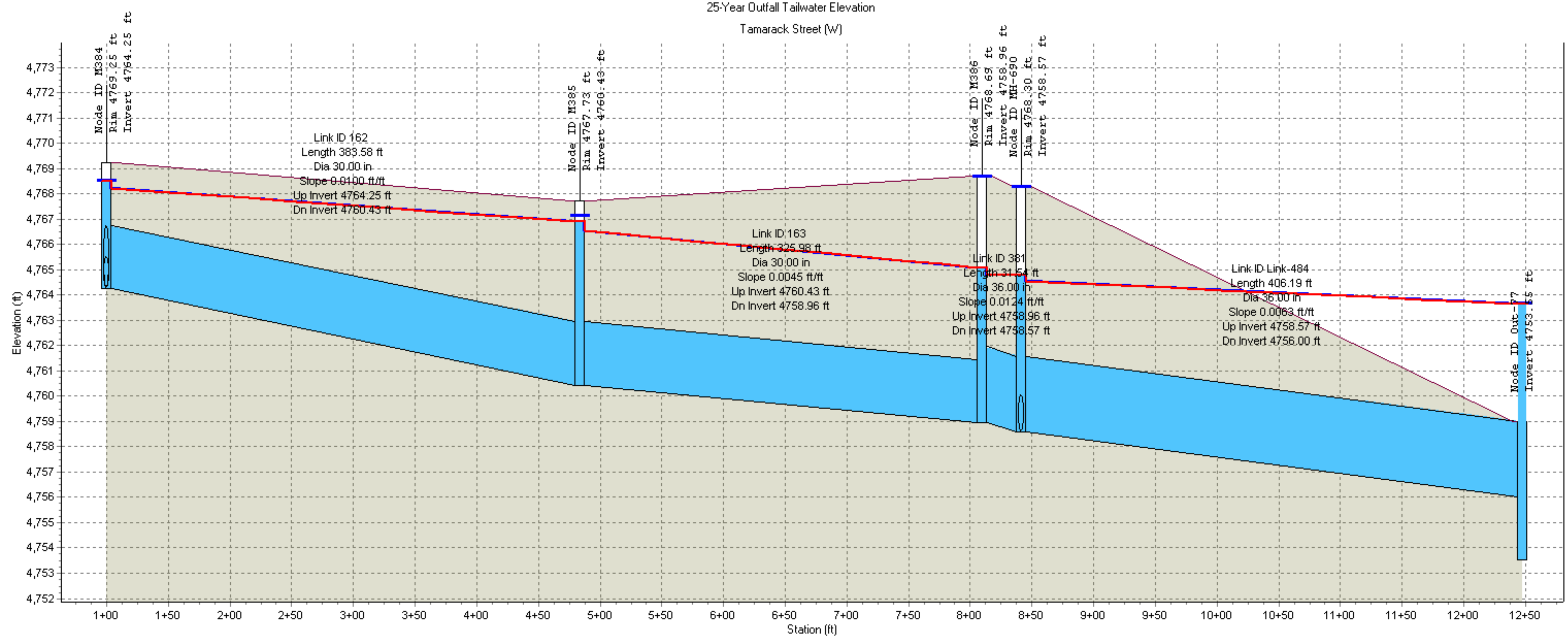


Node ID:	M391	M389	MH-693	M390	Out-78
Rim (ft):	4775.77	4769.40	4769.35	4768.48	
Invert (ft):	4768.87	4762.60	4762.24	4760.96	4750.98
Min Pipe Cover (ft):	4.90	4.80	4.61	5.02	
Max HGL (ft):	4770.28	4769.40	4769.22	4767.32	4763.64

Link ID:	228	321	229	Link-492
Length (ft):	663.43	51.83	283.45	101.46
Dia (in):	24.00	24.00	30.00	30.00
Slope (ft/ft):	0.0095	0.0069	0.0045	0.0984
Up Invert (ft):	4768.87	4762.60	4762.24	4760.96
Dn Invert (ft):	4762.60	4762.24	4760.96	4750.98
Max Q (cfs):	14.85	16.51	20.24	24.58
Max Vel (ft/s):	5.24	5.25	4.12	5.72
Max Depth (ft):	1.70	2.00	2.50	2.50

25-Year Outfall Tailwater Elevation

Tamarack Street (W)



Node ID:	M384	M385	M386	MH-690	Out-77
Rim (ft):	4769.25	4767.73	4768.69	4768.30	
Invert (ft):	4764.25	4760.43	4758.96	4758.57	4753.55
Min Pipe Cover (ft):	2.50	4.80	6.73	6.73	
Max HGL (ft):	4769.25	4767.73	4768.69	4768.30	4763.64

Link ID:	162	163	381	Link-484
Length (ft):	383.58	325.98	31.54	406.19
Dia (in):	30.00	30.00	36.00	36.00
Slope (ft/ft):	0.0100	0.0045	0.0124	0.0063
Up Invert (ft):	4764.25	4760.43	4758.96	4758.57
Dn Invert (ft):	4760.43	4758.96	4758.57	4756.00
Max Q (cfs):	21.20	23.75	90.92	45.08
Max Vel (ft/s):	4.32	4.84	12.86	6.76
Max Depth (ft):	2.50	2.50	3.00	3.00

SUPPLEMENT C: COST ESTIMATES

8th and 9th Avenue Improvements					
ITEM DESCRIPTION	ADDITIONAL INFORMATION	QUANTITY	UNIT	UNIT COST	TOTAL
TRAFFIC CONTROL	$14/LF	1	LS	$ 92,680	$ 92,680
RCP 12 IN		700	LNFT	$ 100	$ 70,000
RCP 15 IN		2130	LNFT	$ 150	$ 319,500
RCP 18 IN		730	LNFT	$ 200	$ 146,000
RCP 24 IN		1290	LNFT	$ 250	$ 322,500
RCP 30 IN		290	LNFT	$ 265	$ 76,850
RCP 36 IN		1480	LNFT	$ 300	$ 444,000
REMOVE STORM DRAIN		6620	LNFT	$ 45	$ 297,900
REMOVE MANHOLE		21	EA	$ 1,400	$ 29,400
ASPHALT RESTORATION		16600	SQYD	$ 90	$ 1,494,000
MANHOLE STRUCTURE BASE 60 IN		15	EA	$ 15,000	$ 225,000
MANHOLE STRUCTURE BASE 72 IN		5	EA	$ 15,500	$ 77,500
MANHOLE STRUCTURE BASE 84 IN		1	EA	$ 16,000	$ 16,000
					$ -
				SUBTOTAL	**$ 3,611,330**
			CONTINGENCIES & UNLISTED ITEMS	***30%***	$ 1,083,399
				SUBTOTAL	**$ 4,694,729**
			MOBILIZATION	***15%***	$ 704,209
				SUBTOTAL	**$ 5,398,938**
			DESIGN	***20%***	$ 1,079,788
				SUBTOTAL	**$ 6,478,726**
			CONSTRUCTION ADMINISTRATION	***15%***	$ 809,841
				TOTAL	**$ 7,288,567**

Wallace Street Improvements					
ITEM DESCRIPTION	ADDITIONAL INFORMATION	QUANTITY	UNIT	UNIT COST	TOTAL
TRAFFIC CONTROL	$14/LF	1	LS	$ 27,860	$ 27,860
RCP 12 IN		800	LNFT	$ 100	$ 80,000
RCP 15 IN		350	LNFT	$ 150	$ 52,500
RCP 24 IN		840	LNFT	$ 250	$ 210,000
REMOVE STORM DRAIN		1990	LNFT	$ 45	$ 89,550
REMOVE MANHOLE		7	EA	$ 1,400	$ 9,800
ASPHALT RESTORATION		4870	SQYD	$ 90	$ 438,300
MANHOLE STRUCTURE BASE 60 IN		7	EA	$ 15,000	$ 105,000
					$ -
				SUBTOTAL	**$ 1,013,010**
			CONTINGENCIES & UNLISTED ITEMS	***30%***	$ 303,903
				SUBTOTAL	**$ 1,316,913**
			MOBILIZATION	***15%***	$ 197,537
				SUBTOTAL	**$ 1,514,450**
			DESIGN	***20%***	$ 302,890
				SUBTOTAL	**$ 1,817,340**
			CONSTRUCTION ADMINISTRATION	***15%***	$ 227,167
				TOTAL	**$ 2,044,507**

Arthur Street Improvements					
ITEM DESCRIPTION	ADDITIONAL INFORMATION	QUANTITY	UNIT	UNIT COST	TOTAL
TRAFFIC CONTROL	$14/LF	1	LS	$ 160,440	$ 160,440
RCP 12 IN		440	LNFT	$ 100	$ 44,000
RCP 15 IN		3820	LNFT	$ 150	$ 573,000
RCP 18 IN		2610	LNFT	$ 200	$ 522,000
RCP 24 IN		2060	LNFT	$ 250	$ 515,000
RCP 30 IN		350	LNFT	$ 265	$ 92,750
RCP 36 IN		400	LNFT	$ 300	$ 120,000
RCP 42 IN		1780	LNFT	$ 380	$ 676,400
REMOVE STORM DRAIN		11500	LNFT	$ 45	$ 517,500
REMOVE MANHOLE		35	EA	$ 1,400	$ 49,000
ASPHALT RESTORATION		19750	SQYD	$ 90	$ 1,777,500
MANHOLE STRUCTURE BASE 60 IN		30	EA	$ 15,000	$ 450,000
MANHOLE STRUCTURE BASE 72 IN		3	EA	$ 15,500	$ 46,500
MANHOLE STRUCTURE BASE 84 IN		2	EA	$ 16,000	$ 32,000
					$ -
				SUBTOTAL	**$ 5,576,090**
			CONTINGENCIES & UNLISTED ITEMS	***30%***	$ 1,672,827
				SUBTOTAL	**$ 7,248,917**
			MOBILIZATION	***15%***	$ 1,087,338
				SUBTOTAL	**$ 8,336,255**
			DESIGN	***20%***	$ 1,667,251
				SUBTOTAL	**$ 10,003,505**
			CONSTRUCTION ADMINISTRATION	***15%***	$ 1,250,438
				TOTAL	**$ 11,253,944**

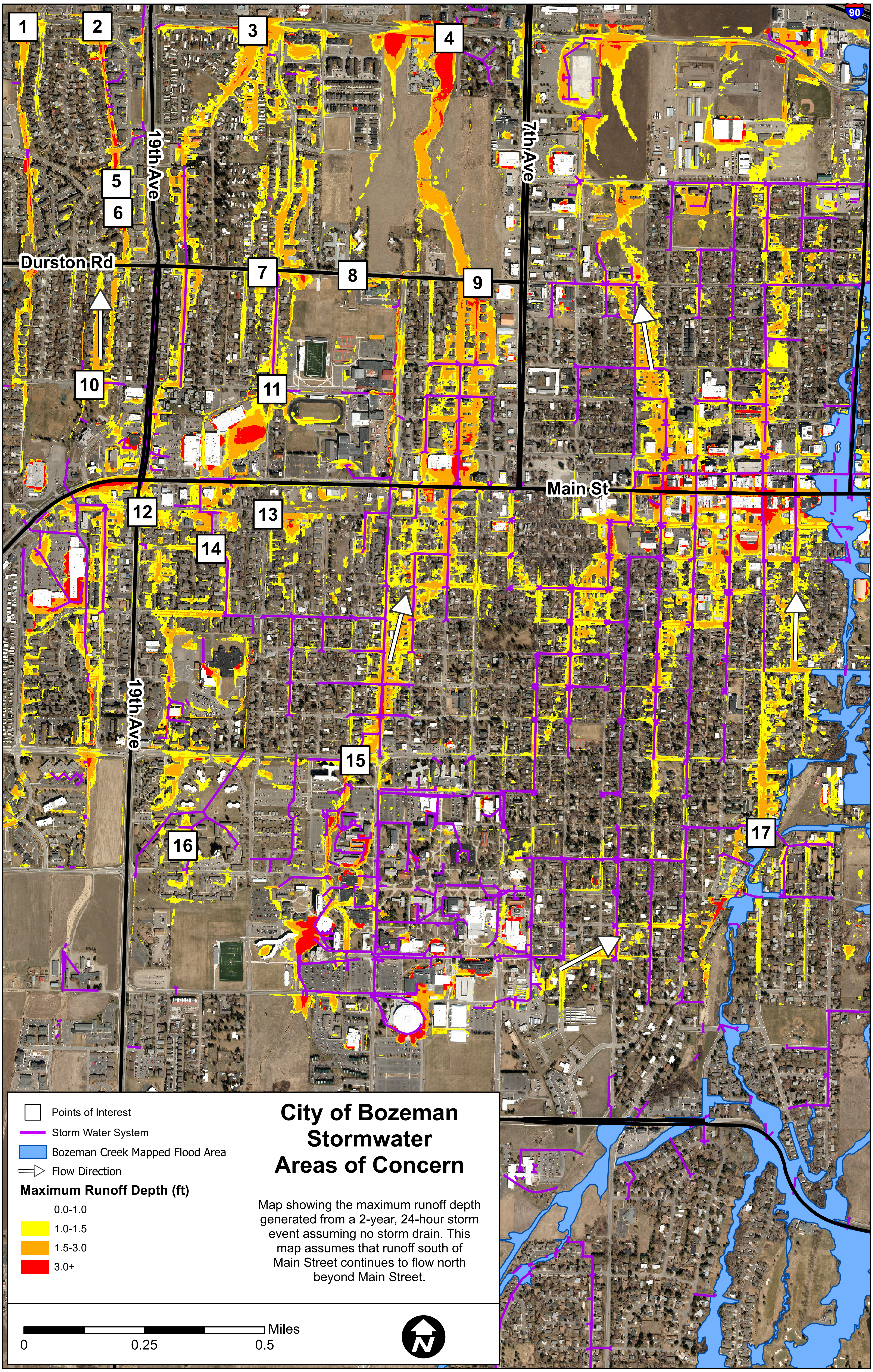
Single Infiltration Gallery					
ITEM DESCRIPTION	ADDITIONAL INFORMATION	QUANTITY	UNIT	UNIT COST	TOTAL
TRAFFIC CONTROL		1	LS	$ 10,000	$ 10,000
DRAINAGE PIPE 48 IN	48" PERFORATED STORAGE PIPE	150	LNFT	$ 400	$ 60,000
CURB AND GUTTER-CONC	CURB AND GUTTER REPLACEMENT	150	LNFT	$ 85	$ 12,750
ASPHALT RESTORATION	160'x24'	430	SQYD	$ 90	$ 38,700
MANHOLE STRUCTURE BASE 60 IN		2	EA	$ 15,000	$ 30,000
CDS UNIT MANHOLE	6' STORMWATER TREATMENT DEVICE	1	EA	$ 25,000	$ 25,000
DRAIN AGGREGATE	WASHED ANGULAR STONE	670	CUYD	$ 110	$ 73,700
SEPARATION GEOTEXTILE - HIGH		800	SQYD	$ 3	$ 2,400
RCP 18 IN		40	LNFT	$ 200	$ 8,000
					$ -
					$ -
				SUBTOTAL	**$ 260,550**
			CONTINGENCIES & UNLISTED ITEMS	***30%***	$ 78,165
				SUBTOTAL	**$ 338,715**
			MOBILIZATION	***15%***	$ 50,807
				SUBTOTAL	**$ 389,522**
			DESIGN	***20%***	$ 77,904
				SUBTOTAL	**$ 467,427**
			CONSTRUCTION ADMINISTRATION	***15%***	$ 58,428
				TOTAL	**$ 525,855**

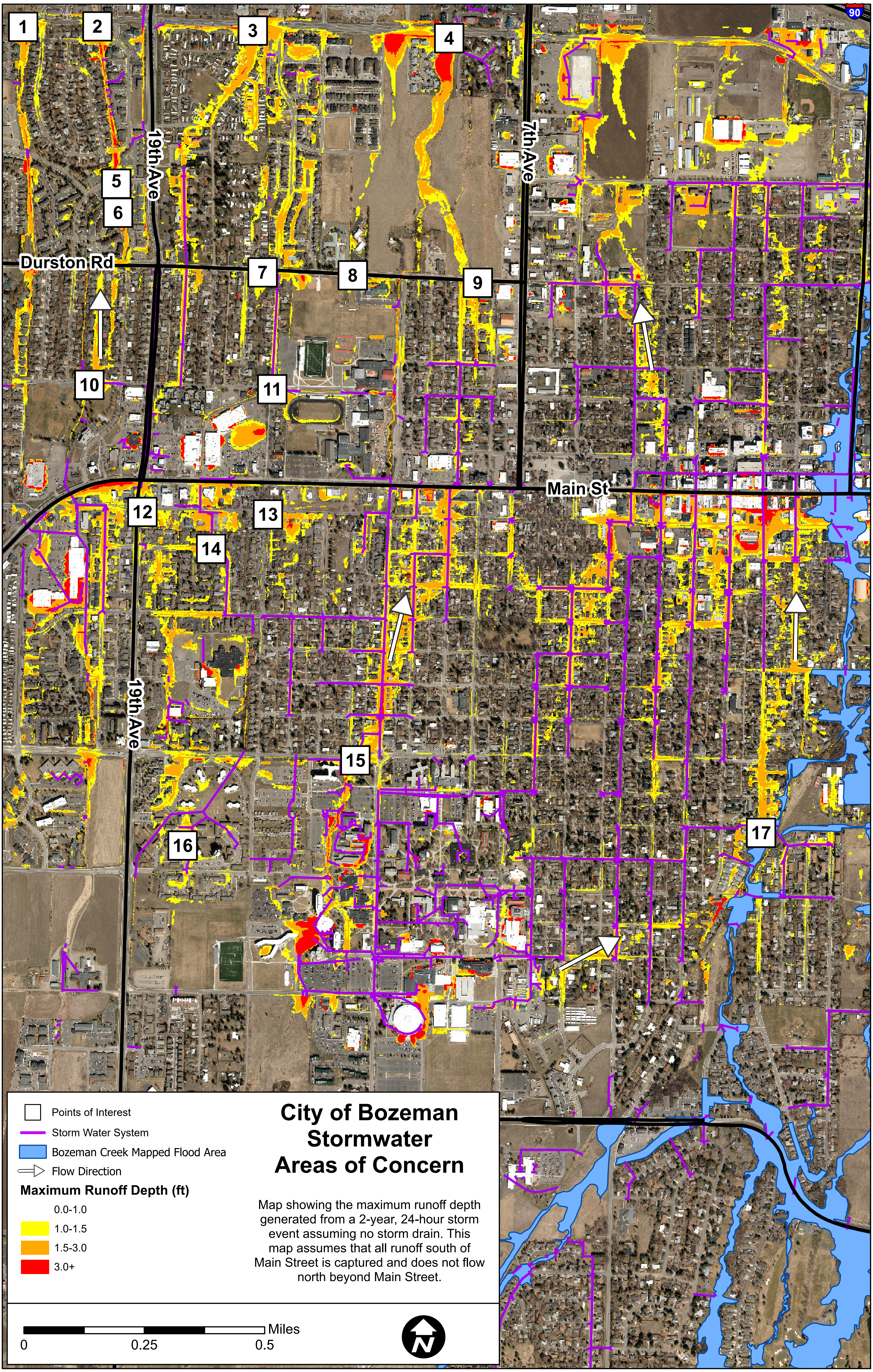
Standard Bypass System					
ITEM DESCRIPTION	ADDITIONAL INFORMATION	QUANTITY	UNIT	UNIT COST	TOTAL
TRAFFIC CONTROL	$14/LF	1	LS	$ 34,020	$ 34,020
RCP 24 IN		1140	LNFT	$ 250	$ 285,000
RCP 30 IN		1290	LNFT	$ 265	$ 341,850
ASPHALT RESTORATION		6200	SQYD	$ 90	$ 558,000
MANHOLE STRUCTURE BASE 60 IN		13	EA	$ 15,000	$ 195,000
MANHOLE STRUCTURE BASE 72 IN		1	EA	$ 15,500	$ 15,500
					$ -
					$ -
				SUBTOTAL	**$ 1,429,370**
			CONTINGENCIES & UNLISTED ITEMS	***30%***	$ 428,811
				SUBTOTAL	**$ 1,858,181**
			MOBILIZATION	***15%***	$ 278,727
				SUBTOTAL	**$ 2,136,908**
			DESIGN	***20%***	$ 427,382
				SUBTOTAL	**$ 2,564,290**
			CONSTRUCTION ADMINISTRATION	***15%***	$ 320,536
				TOTAL	**$ 2,884,826**

Downsized Bypass System					
ITEM DESCRIPTION	ADDITIONAL INFORMATION	QUANTITY	UNIT	UNIT COST	TOTAL
TRAFFIC CONTROL	$14/LF	1	LS	$ 34,020	$ 34,020
RCP 18 IN		1140	LNFT	$ 200	$ 228,000
RCP 24 IN		1290	LNFT	$ 250	$ 322,500
ASPHALT RESTORATION		5920	SQYD	$ 90	$ 532,800
MANHOLE STRUCTURE BASE 60 IN		14	EA	$ 15,000	$ 210,000
					$ -
					$ -
				SUBTOTAL	**$ 1,327,320**
			CONTINGENCIES & UNLISTED ITEMS	***30%***	$ 398,196
				SUBTOTAL	**$ 1,725,516**
			MOBILIZATION	***15%***	$ 258,827
				SUBTOTAL	**$ 1,984,343**
			DESIGN	***20%***	$ 396,869
				SUBTOTAL	**$ 2,381,212**
			CONSTRUCTION ADMINISTRATION	***15%***	$ 297,652
				TOTAL	**$ 2,678,864**

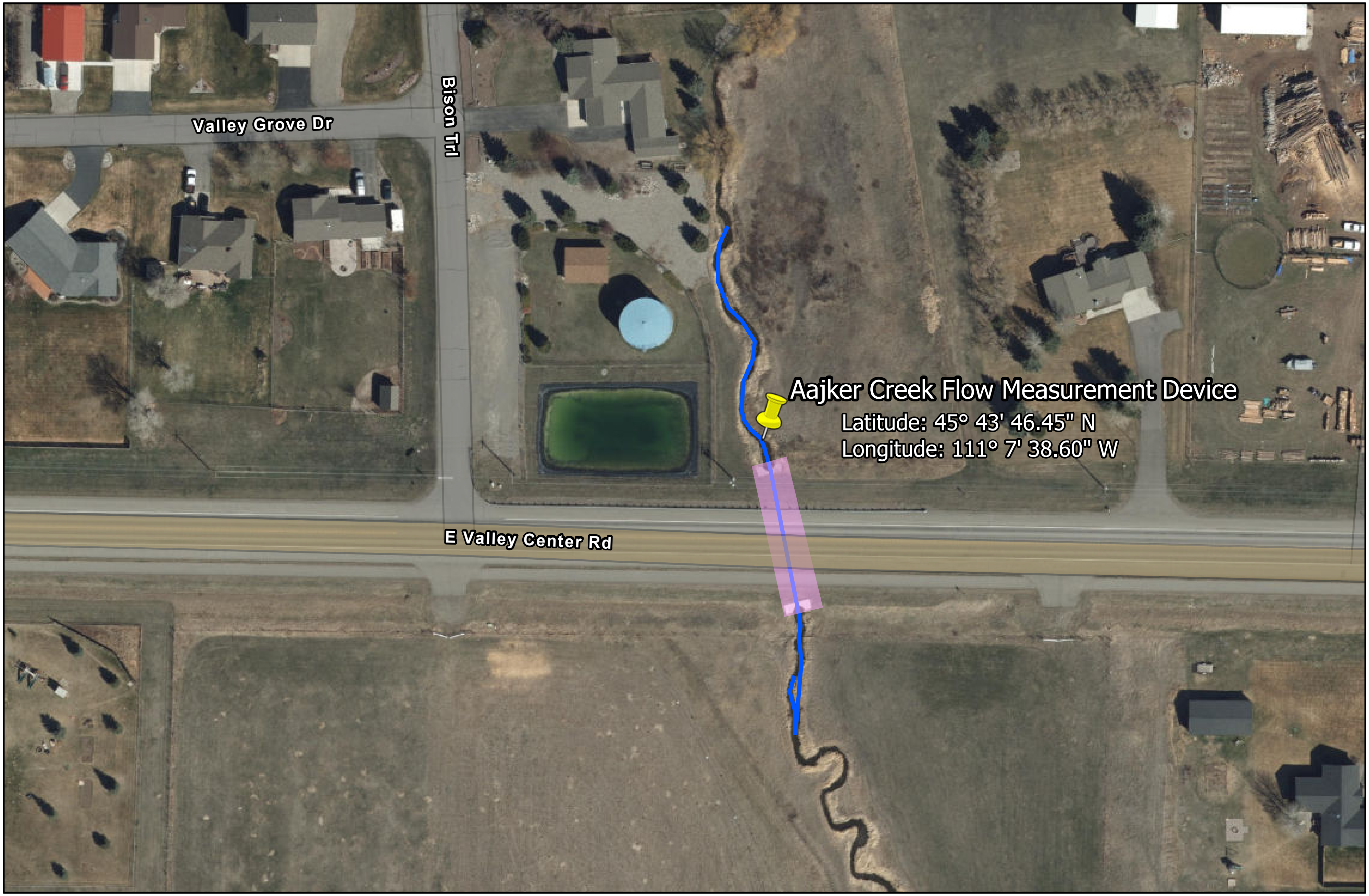
Alternatives					
Alternative	Description	QUANTITY	UNIT	UNIT COST	TOTAL
Alternative 1	Four Infiltration Galleries	4	EA	$ 525,855	**$ 2,103,420**
Alternative 2	Standard Bypass System	1	EA	$ 2,884,826	**$ 2,884,826**
Alternative 3	Three Infiltration Galleries	3	EA	$ 525,855	$ 1,577,565
	Downsized Bypass System	1	EA	$ 2,678,864	$ 2,678,864
				Total	**$ 4,256,429**

SUPPLEMENT D: RAIN-ON-GRID FIGURES


City of Bozeman
Stormwater
Areas of Concern
Map showing the maximum runoff depth generated from a 2-year, 24-hour storm event assuming no storm drain. This map assumes that runoff south of Main Street continues to flow north beyond Main Street.
Points of Interest
Storm Water System
Bozeman Creek Mapped Flood Area
Flow Direction
Maximum Runoff Depth (ft)
0.0-1.0
1.0-1.5
1.5-3.0
3.0+
Miles
0
0.25
0.5
N
Durston Rd
Main St
19th Ave
7th Ave
90
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

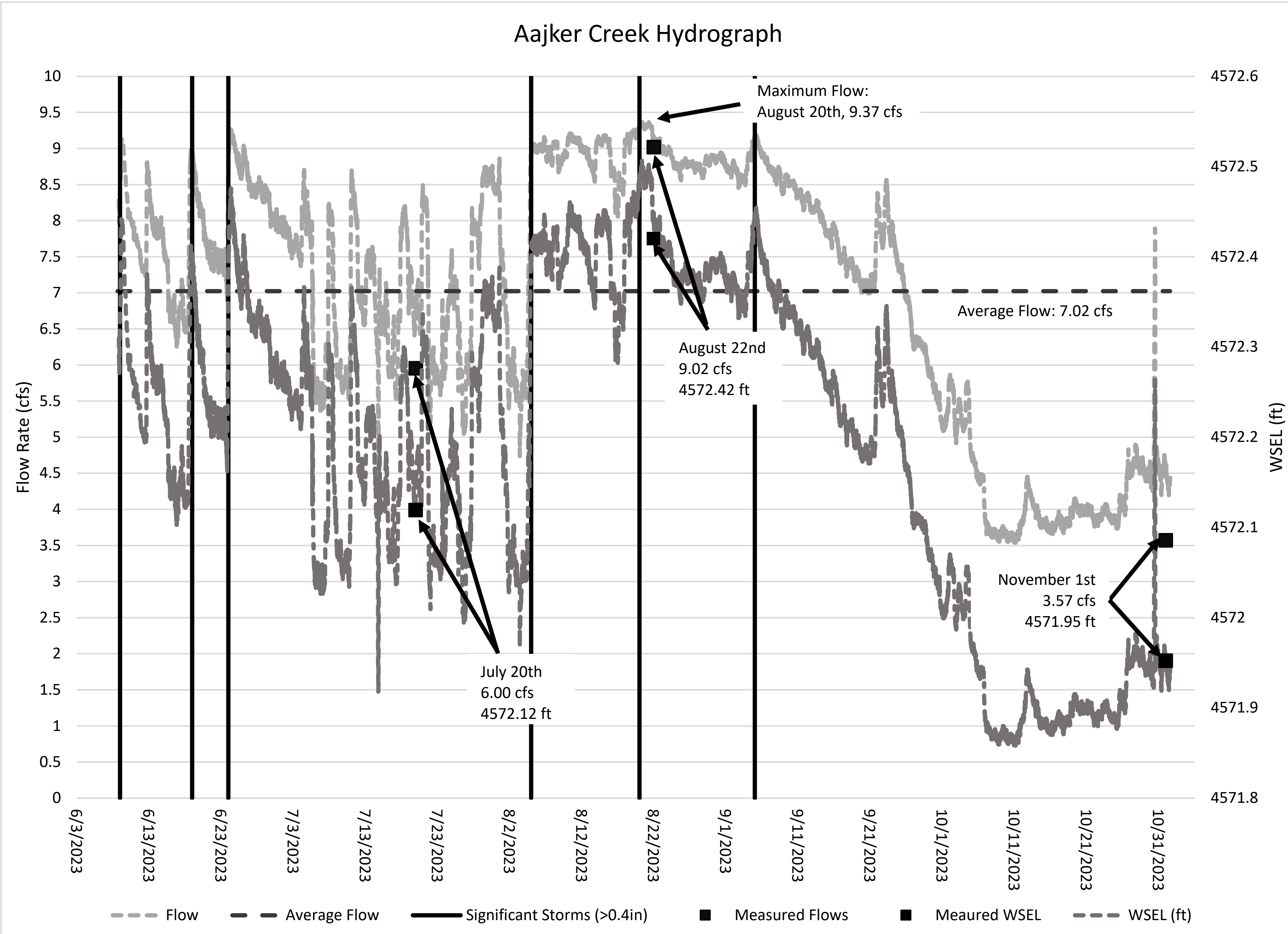

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
90
19th Ave
7th Ave
Durston Rd
Main St
City of Bozeman Stormwater Areas of Concern
Points of Interest
Storm Water System
Bozeman Creek Mapped Flood Area
Flow Direction
Maximum Runoff Depth (ft)
0.0-1.0
1.0-1.5
1.5-3.0
3.0+
Map showing the maximum runoff depth generated from a 2-year, 24-hour storm event assuming no storm drain. This map assumes that all runoff south of Main Street is captured and does not flow north beyond Main Street.
0
0.25
0.5
Miles
N

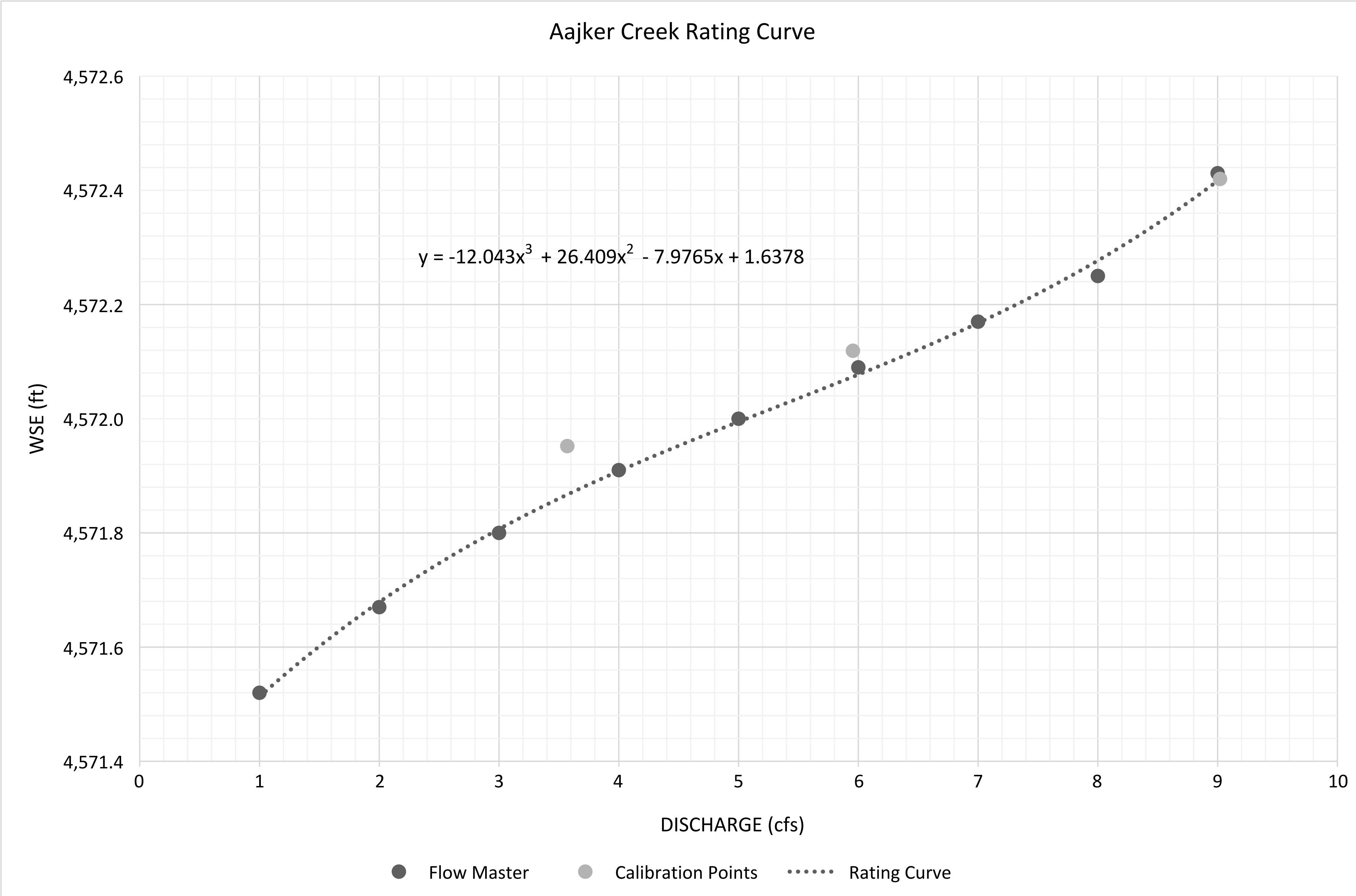
APPENDIX C: FLOW MEASUREMENT RATING CURVES



City of Bozeman	Projection: NAVD88 Units: Feet Scale: 1 INCH EQUALS 100 ft Date: March 2025	Feet 0 50 100	DOWL	**Aajker Creek Flow Sensor Location**

\\dowl.com\j\Projects\36\21888-02\60GIS\20_APRXs_MXDs\BZNFigures_CS.aprx

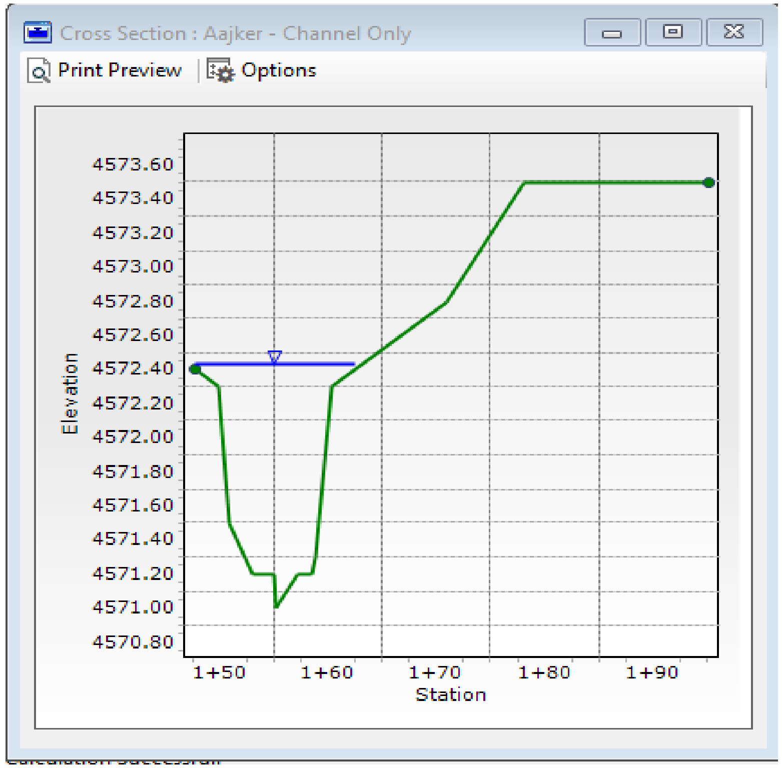

Aajker Creek Hydrograph
Maximum Flow: August 20th, 9.37 cfs
Average Flow: 7.02 cfs
August 22nd
9.02 cfs
4572.42 ft
July 20th
6.00 cfs
4572.12 ft
November 1st
3.57 cfs
4571.95 ft
Flow Rate (cfs)
WSEL (ft)
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4572.6
4572.5
4572.4
4572.3
4572.2
4572.1
4572
4571.9
4571.8
6/3/2023
6/13/2023
6/23/2023
7/3/2023
7/13/2023
7/23/2023
8/2/2023
8/12/2023
8/22/2023
9/1/2023
9/11/2023
9/21/2023
10/1/2023
10/11/2023
10/21/2023
10/31/2023
Flow
Average Flow
Significant Storms (>0.4in)
Measured Flows
Meaured WSEL
WSEL (ft)

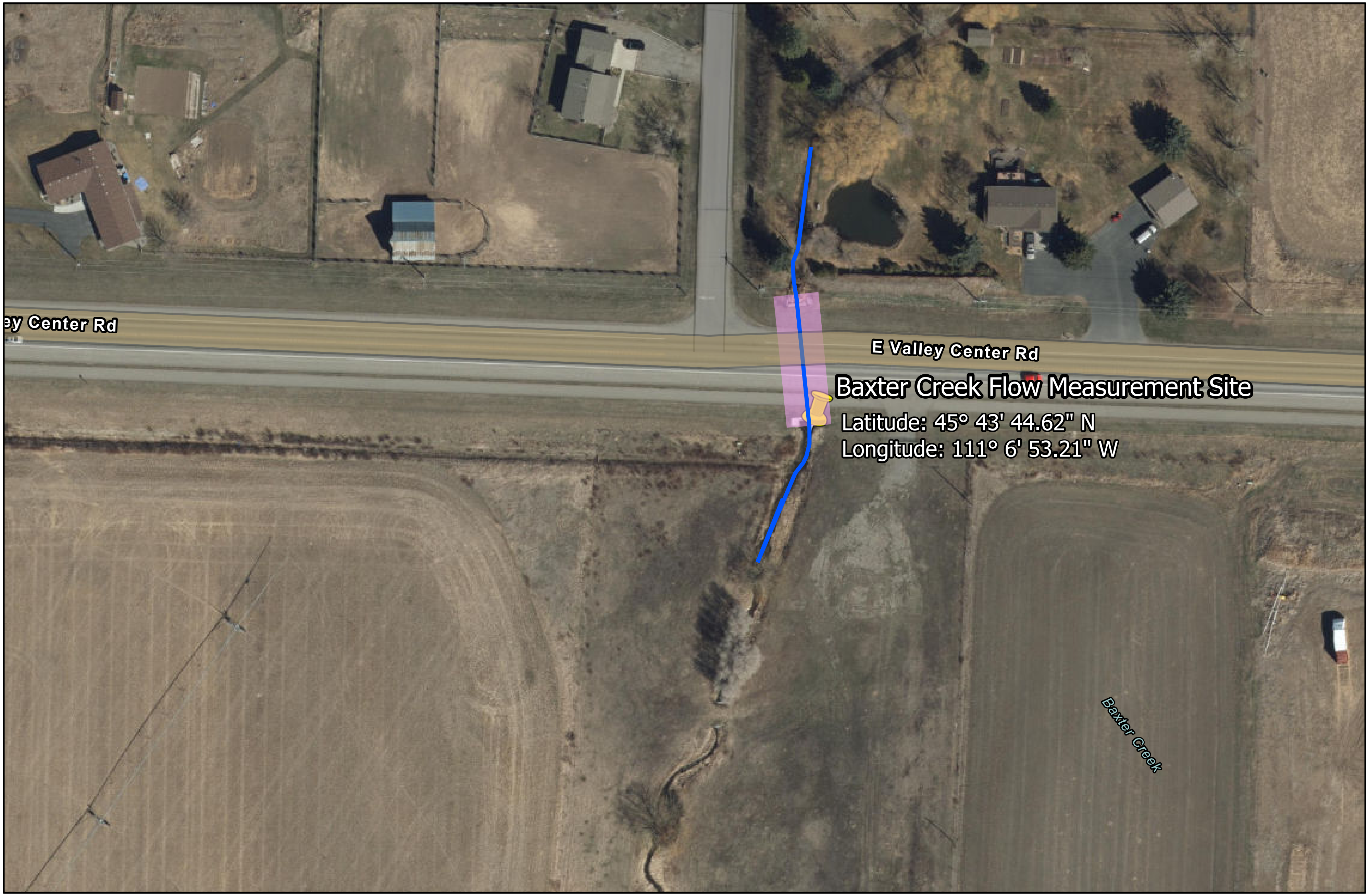

Aajker Creek Rating Curve
y = -12.043x3 + 26.409x2 - 7.9765x + 1.6378
WSE (ft)
4,572.6
4,572.4
4,572.2
4,572.0
4,571.8
4,571.6
4,571.4
0
1
2
3
4
5
6
7
8
9
10
DISCHARGE (cfs)
Flow Master
Calibration Points
Rating Curve

Date	Sensor Depth Reading (ft)	Discharge (cfs)	Measured WSE (ft)	Calculated WSE n=0.16	Difference in WSE n=.16
7/20/2023	0.84	6.0	4572.12	4572.07	0.05
8/22/2023	1.14	9.0	4572.42	4572.42	0.00
11/1/2023	0.67	3.6	4571.95	4571.87	0.09

PVC Elevation	Slope
4571.28	0.011
Max WSEL 4572.4 ft	

Flow Master Rating Data - Channel Only		
Flow (cfs)	WSE (ft) (n=.16)	Depth (ft) (n=.16)
1	4,571.52	0.24
2	4,571.67	0.39
3	4,571.80	0.52
4	4,571.91	0.63
5	4,572.00	0.72
6	4,572.09	0.81
7	4,572.17	0.89
8	4,572.25	0.97
9	4,572.43	1.15





City of Bozeman	Projection: NAVD88 Units: Feet Scale: 1 INCH EQUALS 100 ft Date: March 2025	N 0 50 100 Feet	DOWL	**Baxter Creek Flow Sensor Location**

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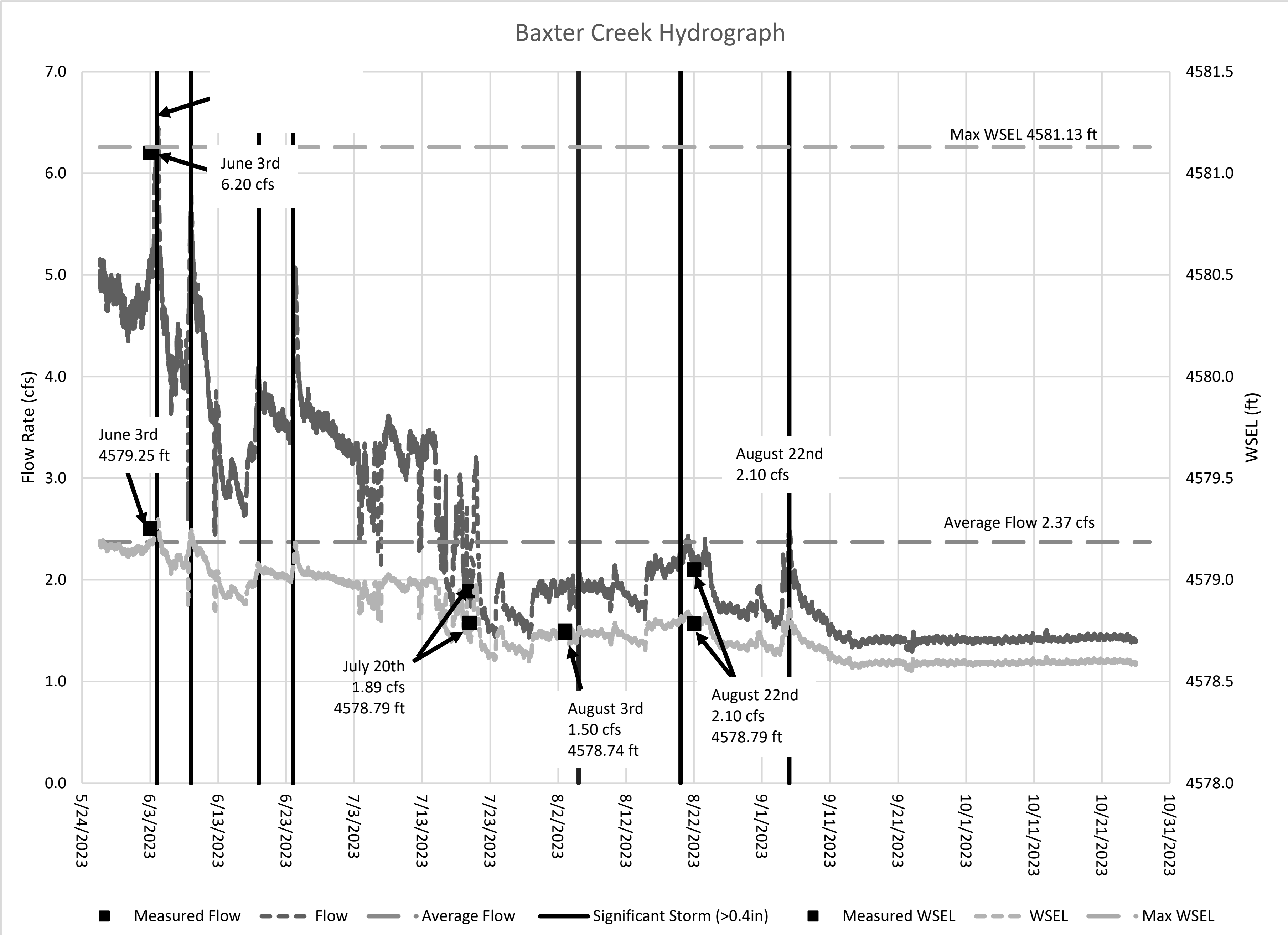
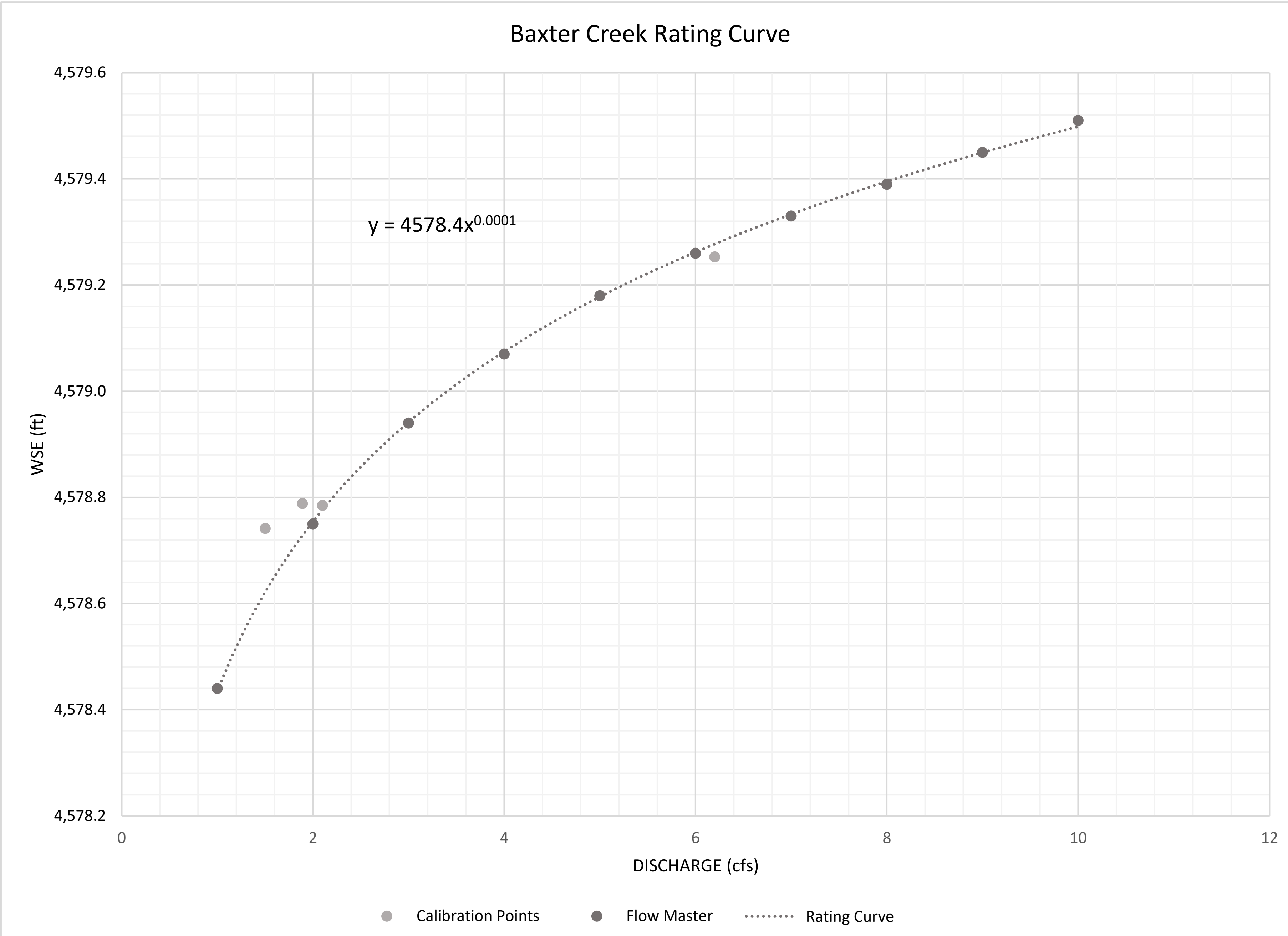


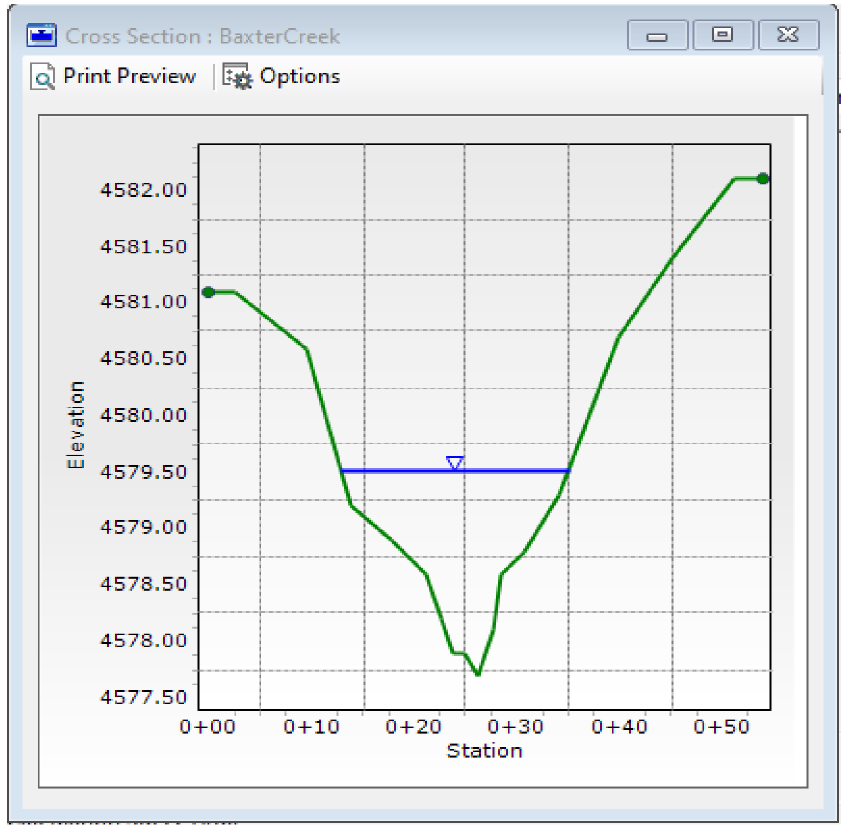
Baxter Creek Hydrograph
Flow Rate (cfs)
WSEL (ft)
Max WSEL 4581.13 ft
June 3rd
6.20 cfs
June 3rd
4579.25 ft
August 22nd
2.10 cfs
Average Flow 2.37 cfs
July 20th
1.89 cfs
4578.79 ft
August 3rd
1.50 cfs
4578.74 ft
August 22nd
2.10 cfs
4578.79 ft
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
4581.5
4581.0
4580.5
4580.0
4579.5
4579.0
4578.5
4578.0
5/24/2023
6/3/2023
6/13/2023
6/23/2023
7/3/2023
7/13/2023
7/23/2023
8/2/2023
8/12/2023
8/22/2023
9/1/2023
9/11/2023
9/21/2023
10/1/2023
10/11/2023
10/21/2023
10/31/2023
Measured Flow
Flow
Average Flow
Significant Storm (>0.4in)
Measured WSEL
WSEL
Max WSEL


Baxter Creek Rating Curve
y = 4578.4x^0.0001
WSE (ft)
4,579.6
4,579.4
4,579.2
4,579.0
4,578.8
4,578.6
4,578.4
4,578.2
0
2
4
6
8
10
12
DISCHARGE (cfs)
Calibration Points
Flow Master
Rating Curve

Date	Sensor Depth Reading (ft)	Discharge (cfs)	Measured WSE	Calculated WSE n=0.12	Difference in WSE n=0.12
6/3/2023	1.08	6.2	4579.25	4578.47	0.79
7/20/2023	0.61	1.9	4578.79	4578.21	0.58
8/3/2023	0.56	1.5	4578.74	4578.17	0.57
8/22/2023	0.61	2.1	4578.79	4578.21	0.58

PCV Elevation	Slope
4578.18	0.002
Max WSE 4581.13	

Flow Master Rating Data		
Flow (cfs)	WSE (ft) (n=0.12)	Depth (ft) (n=0.12)
1	4,578.44	0.26
2	4,578.75	0.57
3	4,578.94	0.76
4	4,579.07	0.89
5	4,579.18	1.00
6	4,579.26	1.08
7	4,579.33	1.15
8	4,579.39	1.21
9	4,579.45	1.27
10	4,579.51	1.33



City of Bozeman

Projection: NAVD88
Units: Feet
Scale: 1 INCH EQUALS 100 ft
Date: March 2025

N

0 50 100 Feet

DOWL

Farmer's Canal DS Flow Sensor Location

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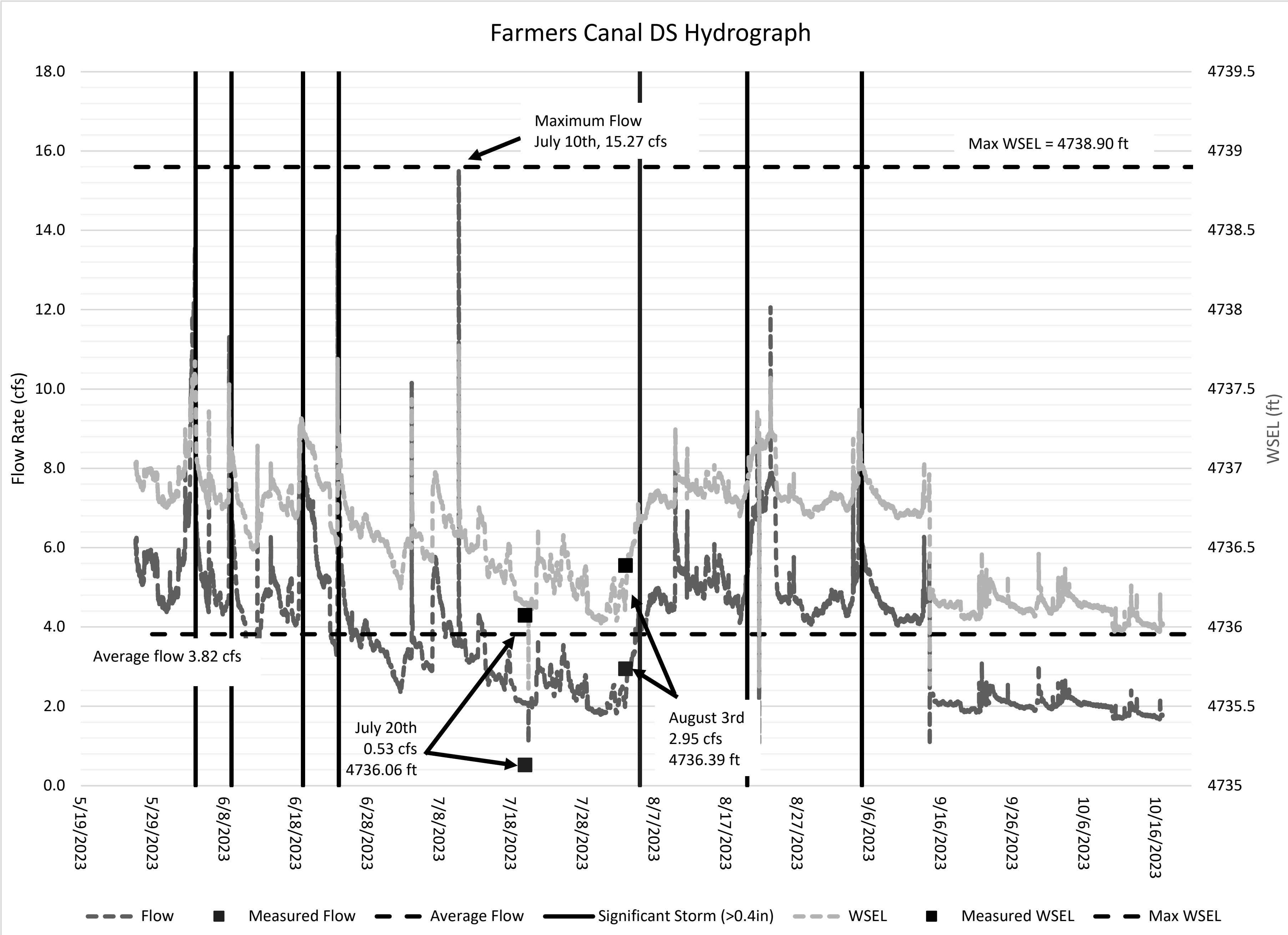
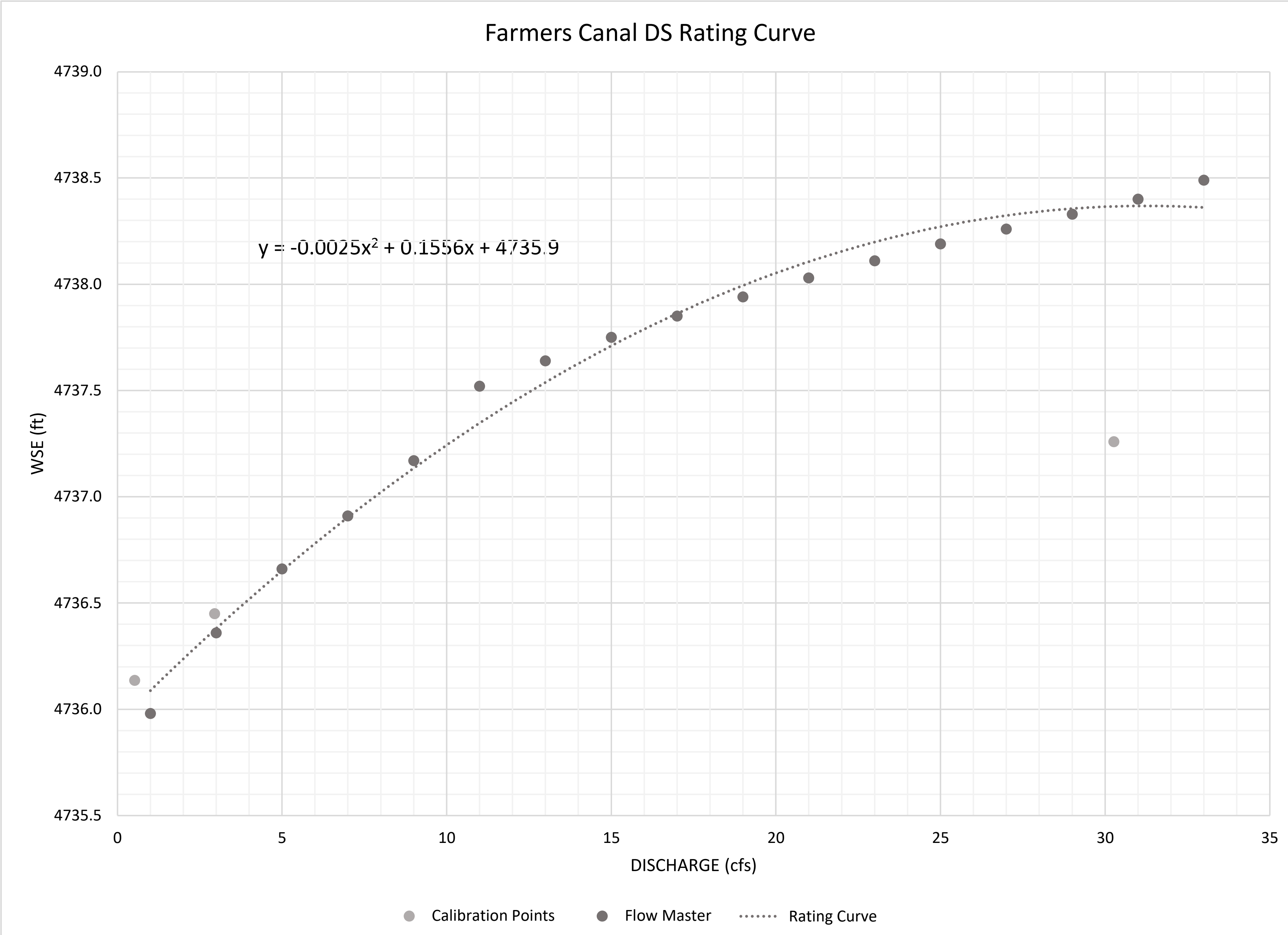
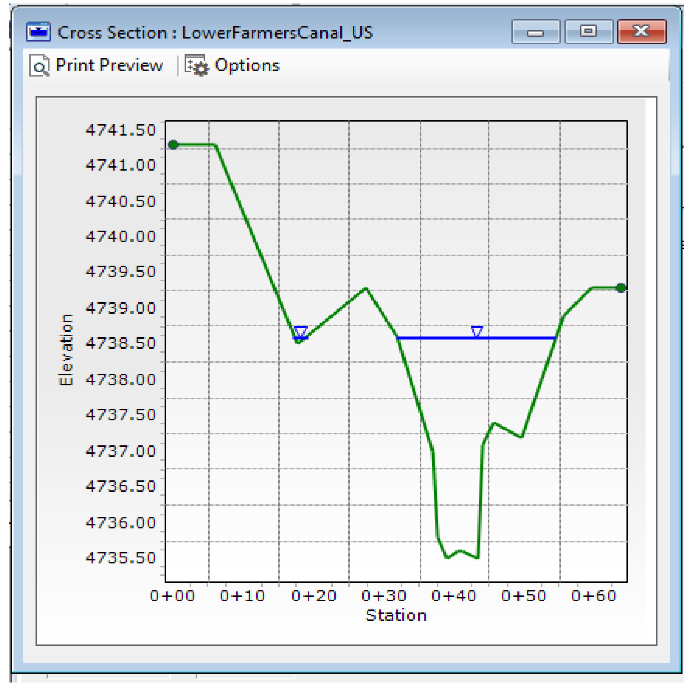

Farmers Canal DS Hydrograph
Flow Rate (cfs)
WSEL (ft)
Maximum Flow
July 10th, 15.27 cfs
Max WSEL = 4738.90 ft
Average flow 3.82 cfs
July 20th
0.53 cfs
4736.06 ft
August 3rd
2.95 cfs
4736.39 ft
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4739.5
4739
4738.5
4738
4737.5
4737
4736.5
4736
4735.5
4735
5/19/2023
5/29/2023
6/8/2023
6/18/2023
6/28/2023
7/8/2023
7/18/2023
7/28/2023
8/7/2023
8/17/2023
8/27/2023
9/6/2023
9/16/2023
9/26/2023
10/6/2023
10/16/2023
Flow
Measured Flow
Average Flow
Significant Storm (>0.4in)
WSEL
Measured WSEL
Max WSEL

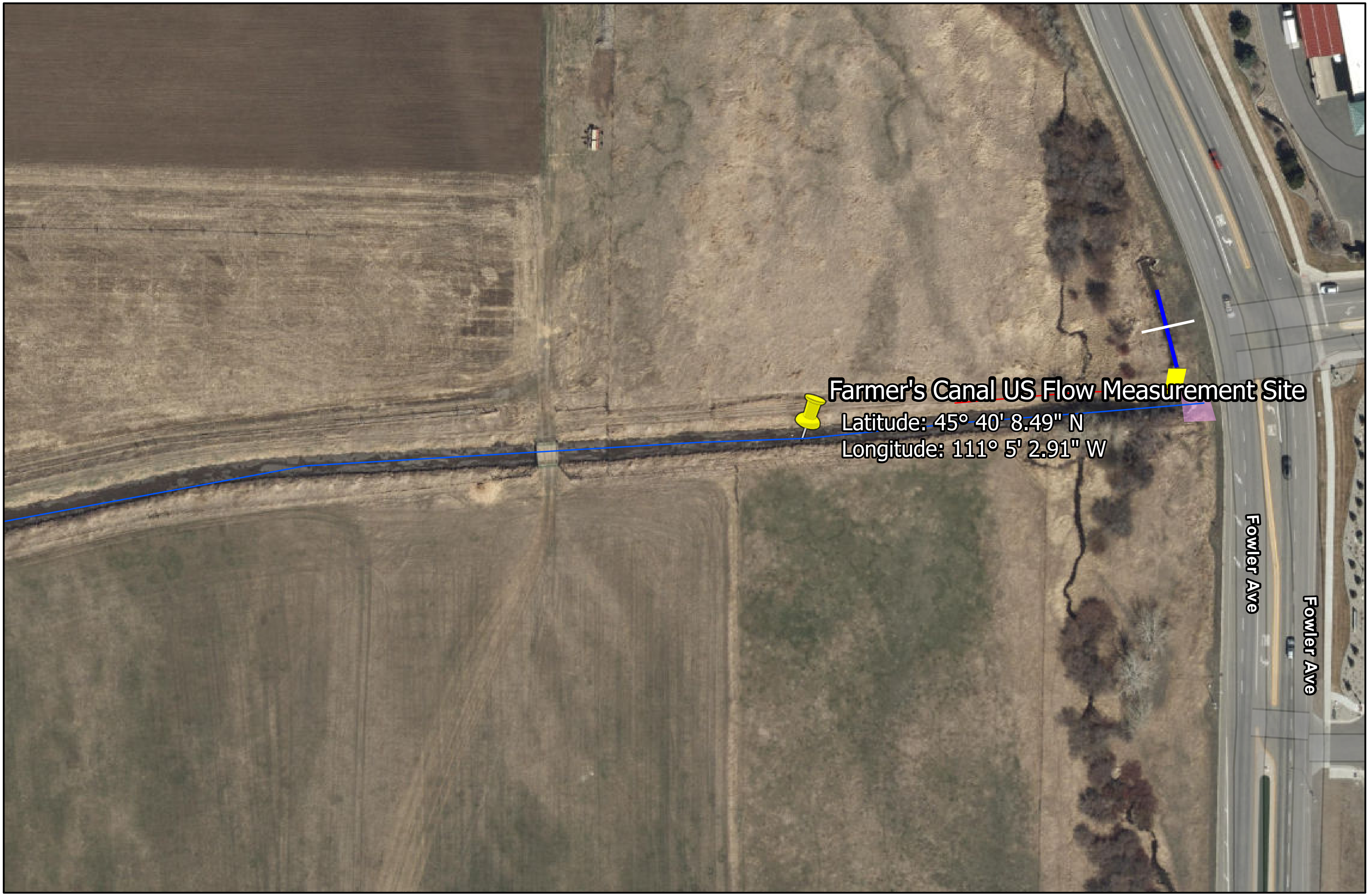

Farmers Canal DS Rating Curve
y = -0.0025x² + 0.1556x + 4735.9
WSE (ft)
4739.0
4738.5
4738.0
4737.5
4737.0
4736.5
4736.0
4735.5
0
5
10
15
20
25
30
35
DISCHARGE (cfs)
Calibration Points
Flow Master
Rating Curve

Date	Sensor Depth Reading (ft)	Flow (cfs)	Measured WSE	WSE at US Cross Section Location	Calculated WSE n=0.11	Calculated WSE n=0.11	Difference in WSE n=0.11 US
7/20/2023	0.61	0.5	4736.07	4736.14	4735.84	4735.64	0.30
8/3/2023	0.93	3.0	4736.39	4736.45	4736.10	4735.83	0.35
8/21/2023	1.74	30.3	4737.20	4737.26	4737.95	4737.64	-0.69

Flow Master Rating Data US	
Flow (cfs)	WSE (ft) (n=.11)
1	4,735.98
3	4,736.36
5	4,736.66
7	4,736.91
9	4,737.17
11	4,737.52
13	4,737.64
15	4,737.75
17	4,737.85
19	4,737.94
21	4,738.03
23	4,738.11
25	4,738.19
27	4,738.26
29	4,738.33
31	4,738.40
33	4,738.49

PCV Elevation	Slope	Adjusted PVC Elevation US
4735.46	0.004	4735.52
Max WSE 4739.4		





City of Bozeman

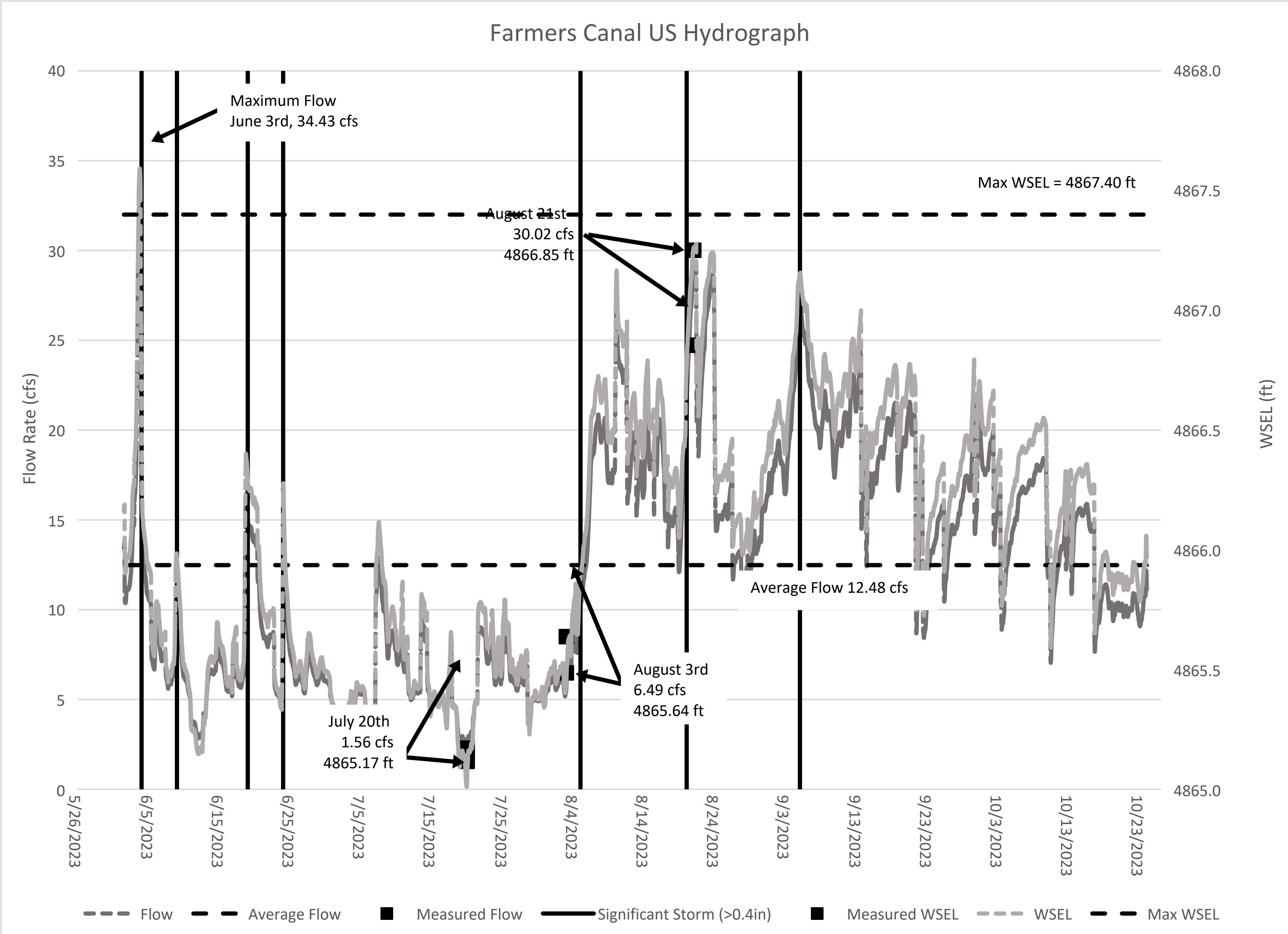
Projection: NAVD88
Units: Feet
Scale: 1 INCH EQUALS 100 ft
Date: March 2025

Feet
0 50 100

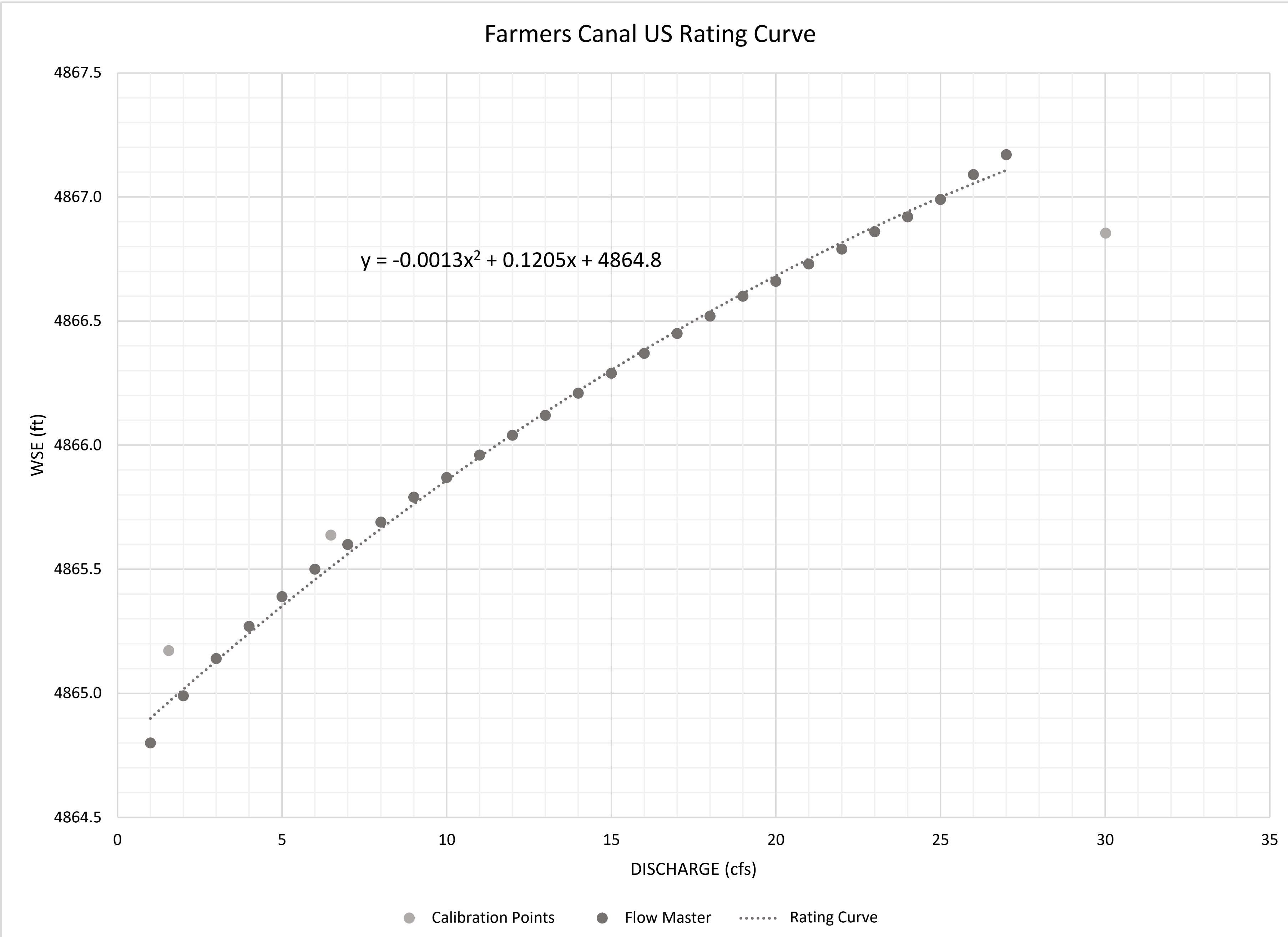
DOWL

Farmer's Canal US Flow Sensor Location

\\dowl.com\j\Projects\36\21888-02\60GIS\20_APRXs_MXDs\BZNFigures_CS.aprx



Farmers Canal US Hydrograph
Flow Rate (cfs)
WSEL (ft)
Maximum Flow
June 3rd, 34.43 cfs
Max WSEL = 4867.40 ft
August 21st
30.02 cfs
4866.85 ft
Average Flow 12.48 cfs
August 3rd
6.49 cfs
4865.64 ft
July 20th
1.56 cfs
4865.17 ft
40
35
30
25
20
15
10
5
0
4868.0
4867.5
4867.0
4866.5
4866.0
4865.5
4865.0
5/26/2023
6/5/2023
6/15/2023
6/25/2023
7/5/2023
7/15/2023
7/25/2023
8/4/2023
8/14/2023
8/24/2023
9/3/2023
9/13/2023
9/23/2023
10/3/2023
10/13/2023
10/23/2023
Flow
Average Flow
Measured Flow
Significant Storm (>0.4in)
Measured WSEL
WSEL
Max WSEL

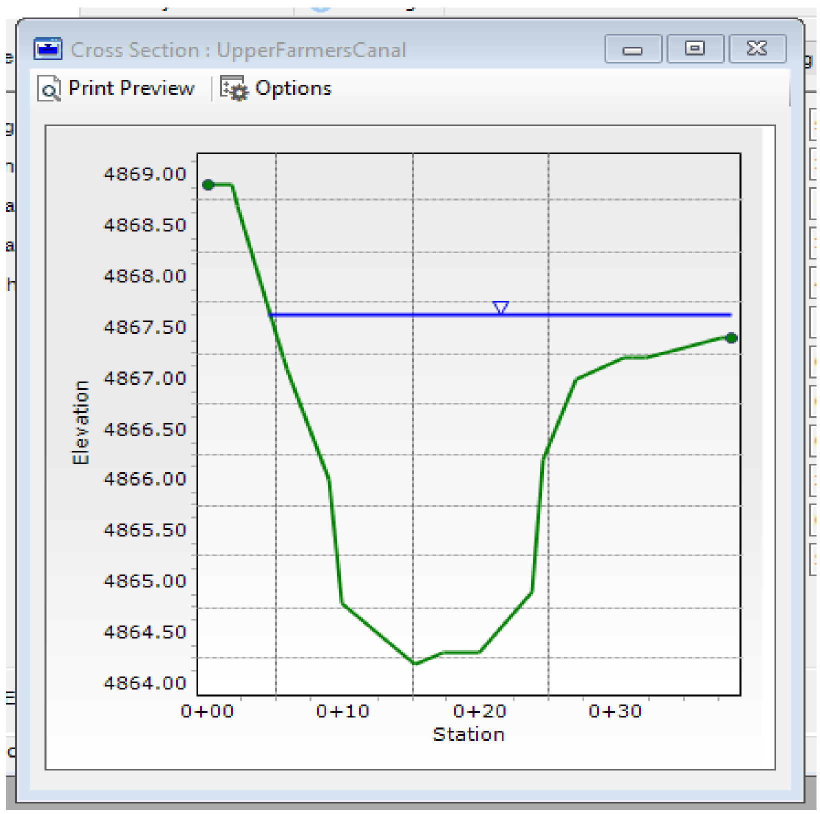


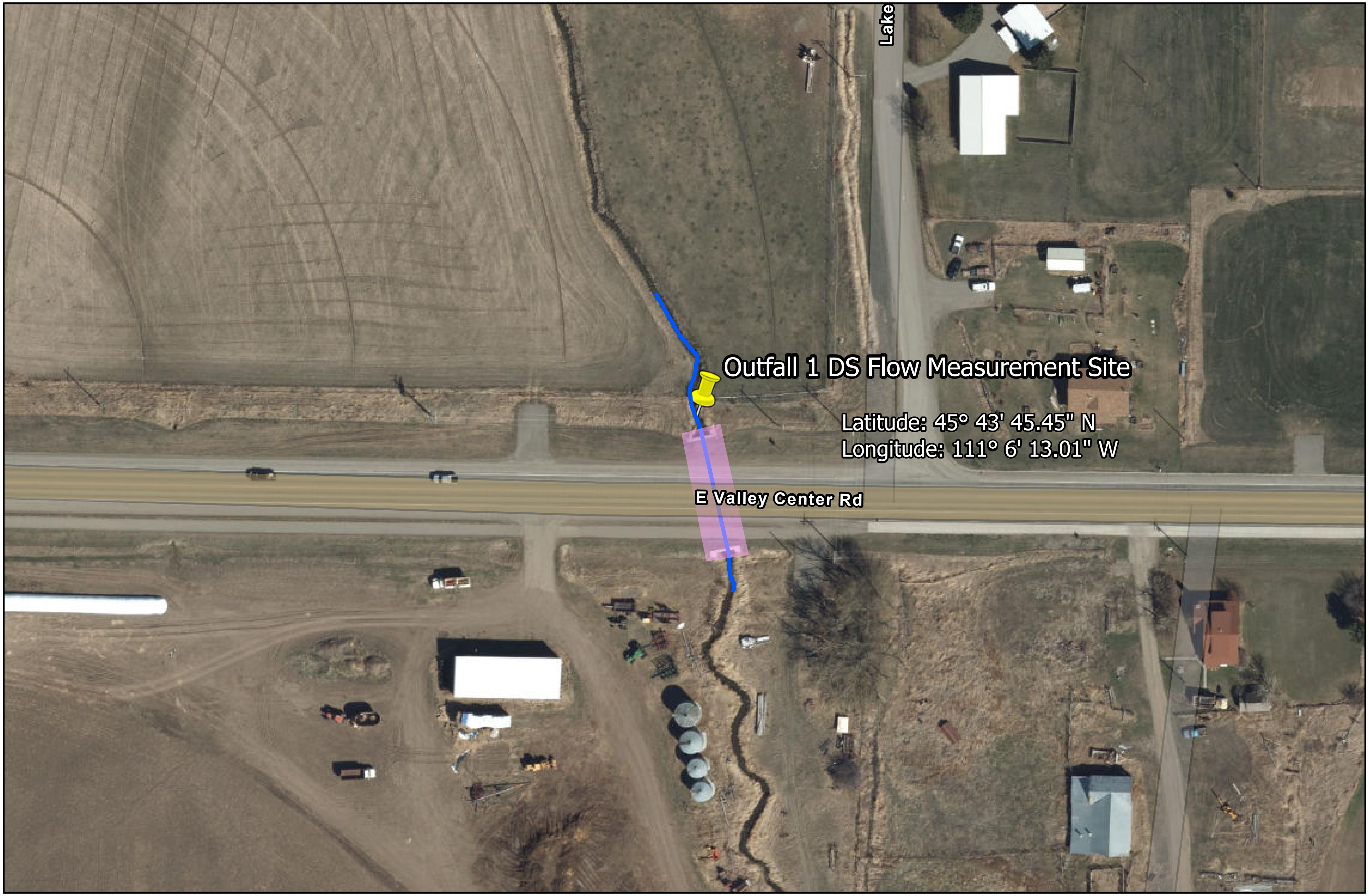
Farmers Canal US Rating Curve
y = -0.0013x² + 0.1205x + 4864.8
WSE (ft)
4867.5
4867.0
4866.5
4866.0
4865.5
4865.0
4864.5
0
5
10
15
20
25
30
35
DISCHARGE (cfs)
Calibration Points
Flow Master
Rating Curve

Date	Sensor Depth Reading (ft)	Flow (cfs)	Measured WSE	Calculated WSE n=0.11	Difference in WSE n=0.11
7/20/2023	0.07	1.6	4865.17	4864.97	0.21
8/3/2023	0.53	6.5	4865.64	4865.51	0.13
8/21/2023	1.75	30.0	4866.85	4867.23	-0.37

Flow Master Rating Data	
Flow (cfs)	WSE (ft) (n=.11)
1	4,864.80
2	4,864.99
3	4,865.14
4	4,865.27
5	4,865.39
6	4,865.50
7	4,865.60
8	4,865.69
9	4,865.79
10	4,865.87
11	4,865.96
12	4,866.04
13	4,866.12
14	4,866.21
15	4,866.29
16	4,866.37
17	4,866.45
18	4,866.52
19	4,866.60
20	4,866.66
21	4,866.73
22	4,866.79
23	4,866.86
24	4,866.92
25	4,866.99
26	4,867.09
27	4,867.17

PCV Elevation	Distance from PVC to XS	Slope	Adjusted PVC Elevation
4865.13	23	0.001	4865.11
Max WSEL	4867.40		





City of Bozeman	Projection: NAVD88 Units: Feet Scale: 1 INCH EQUALS 100 ft Date: March 2025	Feet 0 50 100	DOWL	**Outfall 1 DS Flow Sensor Location**

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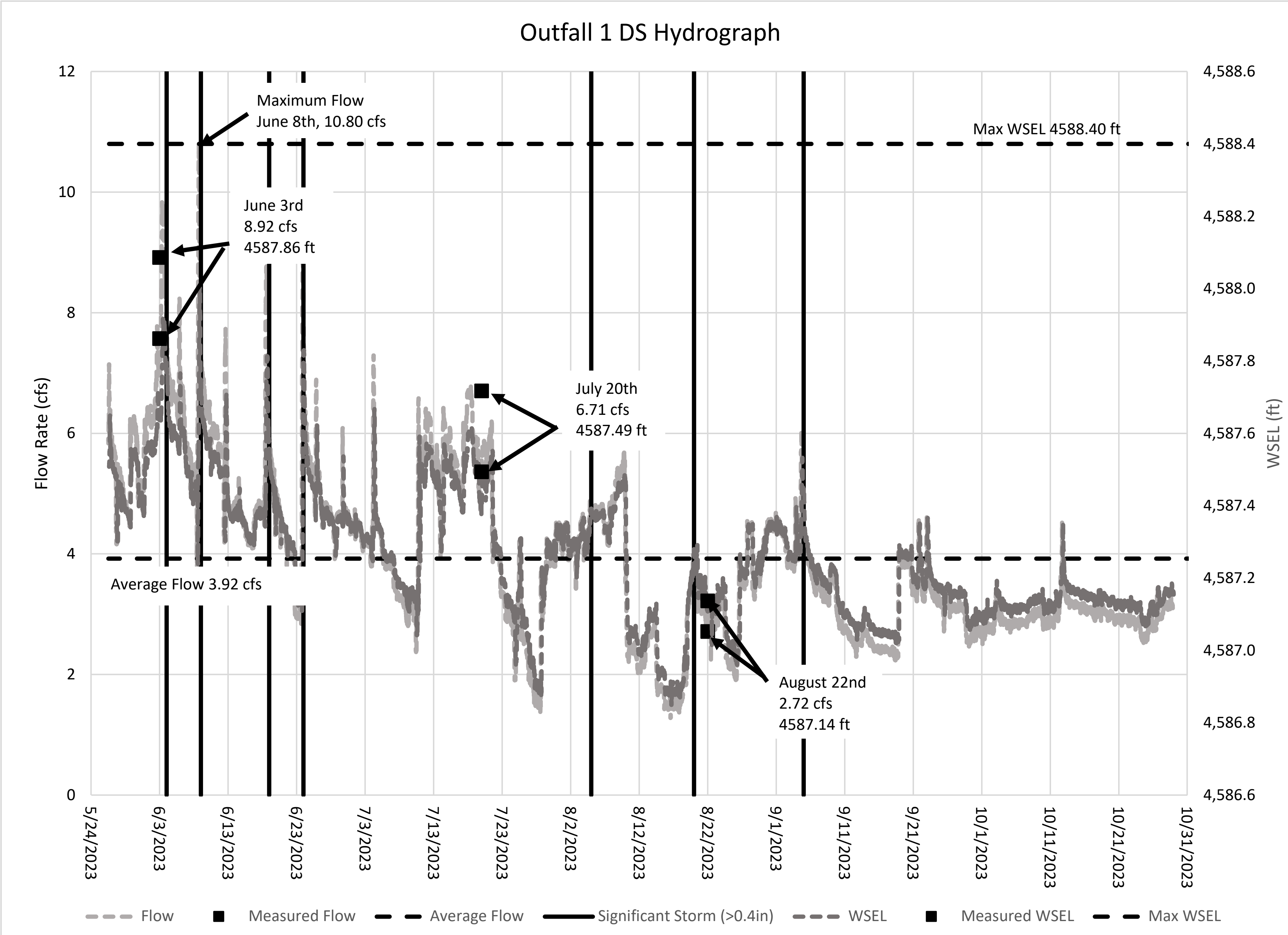
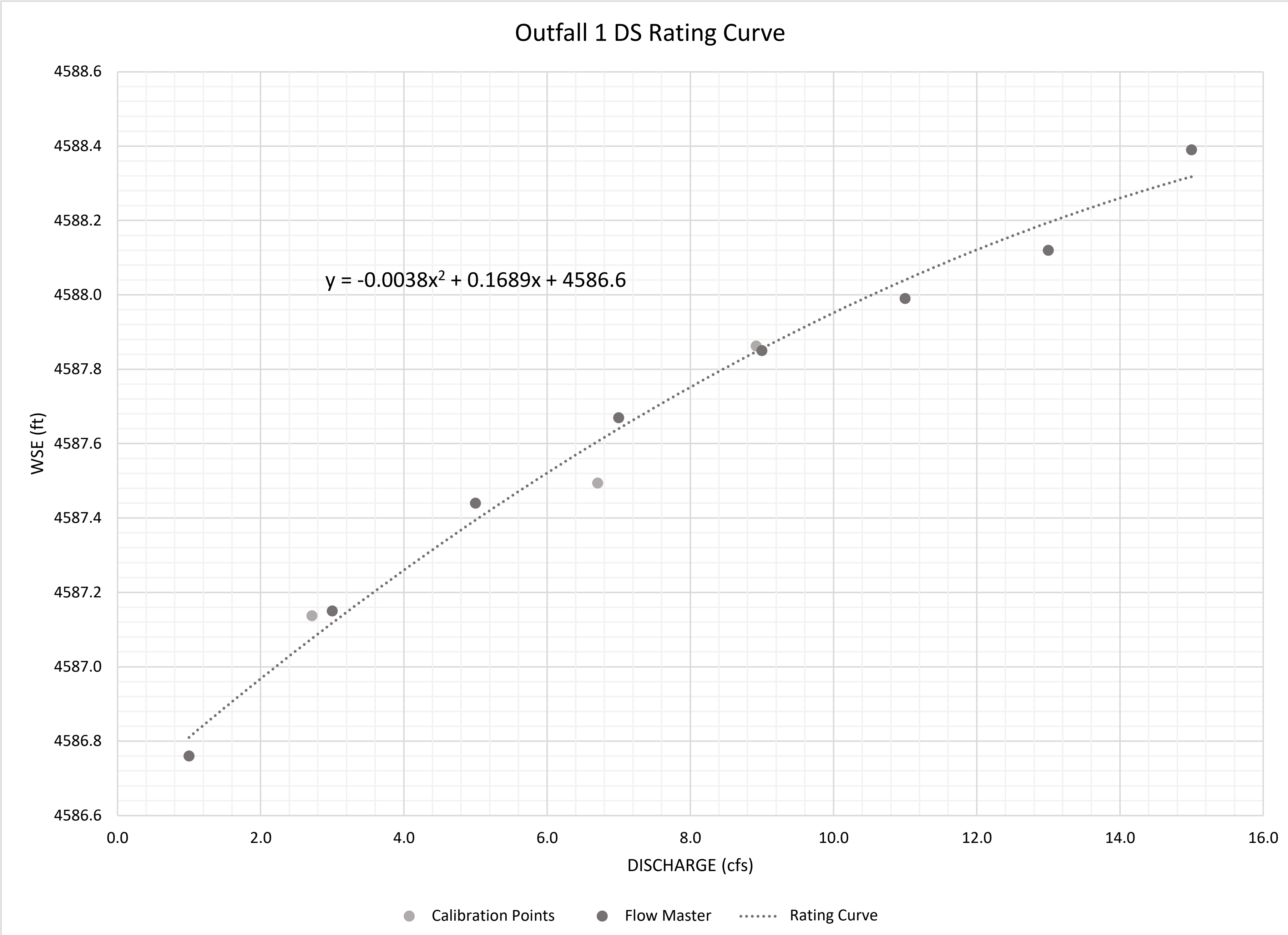


Outfall 1 DS Hydrograph
Maximum Flow
June 8th, 10.80 cfs
Max WSEL 4588.40 ft
June 3rd
8.92 cfs
4587.86 ft
July 20th
6.71 cfs
4587.49 ft
Average Flow 3.92 cfs
August 22nd
2.72 cfs
4587.14 ft
Flow Rate (cfs)
WSEL (ft)
12
10
8
6
4
2
0
4,588.6
4,588.4
4,588.2
4,588.0
4,587.8
4,587.6
4,587.4
4,587.2
4,587.0
4,586.8
4,586.6
5/24/2023
6/3/2023
6/13/2023
6/23/2023
7/3/2023
7/13/2023
7/23/2023
8/2/2023
8/12/2023
8/22/2023
9/1/2023
9/11/2023
9/21/2023
10/1/2023
10/11/2023
10/21/2023
10/31/2023
Flow
Measured Flow
Average Flow
Significant Storm (>0.4in)
WSEL
Measured WSEL
Max WSEL

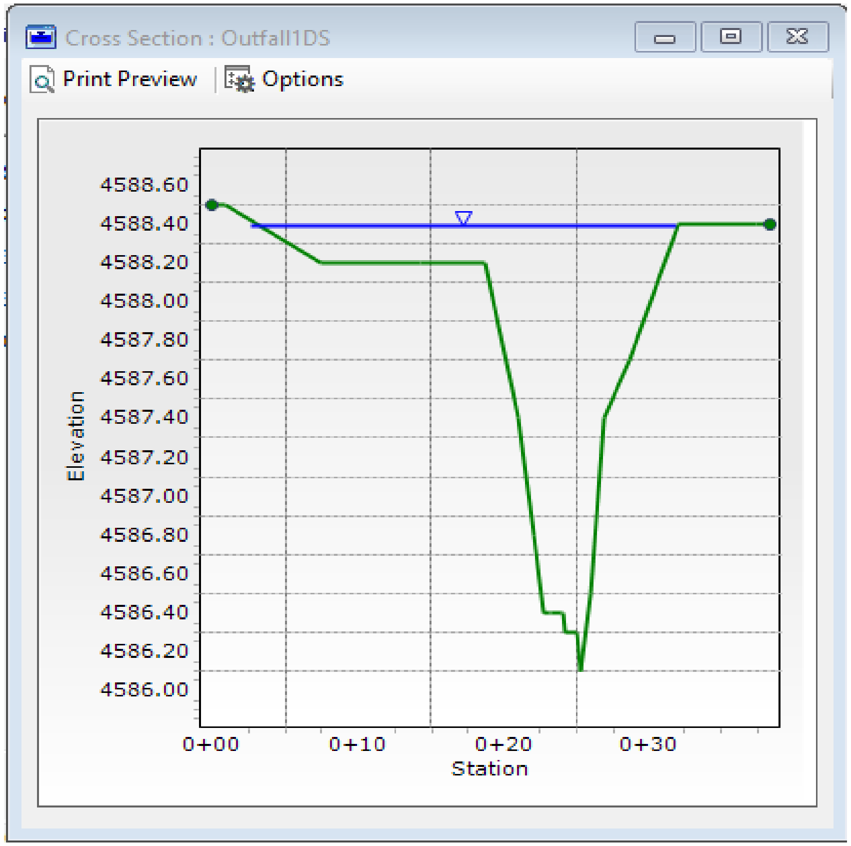


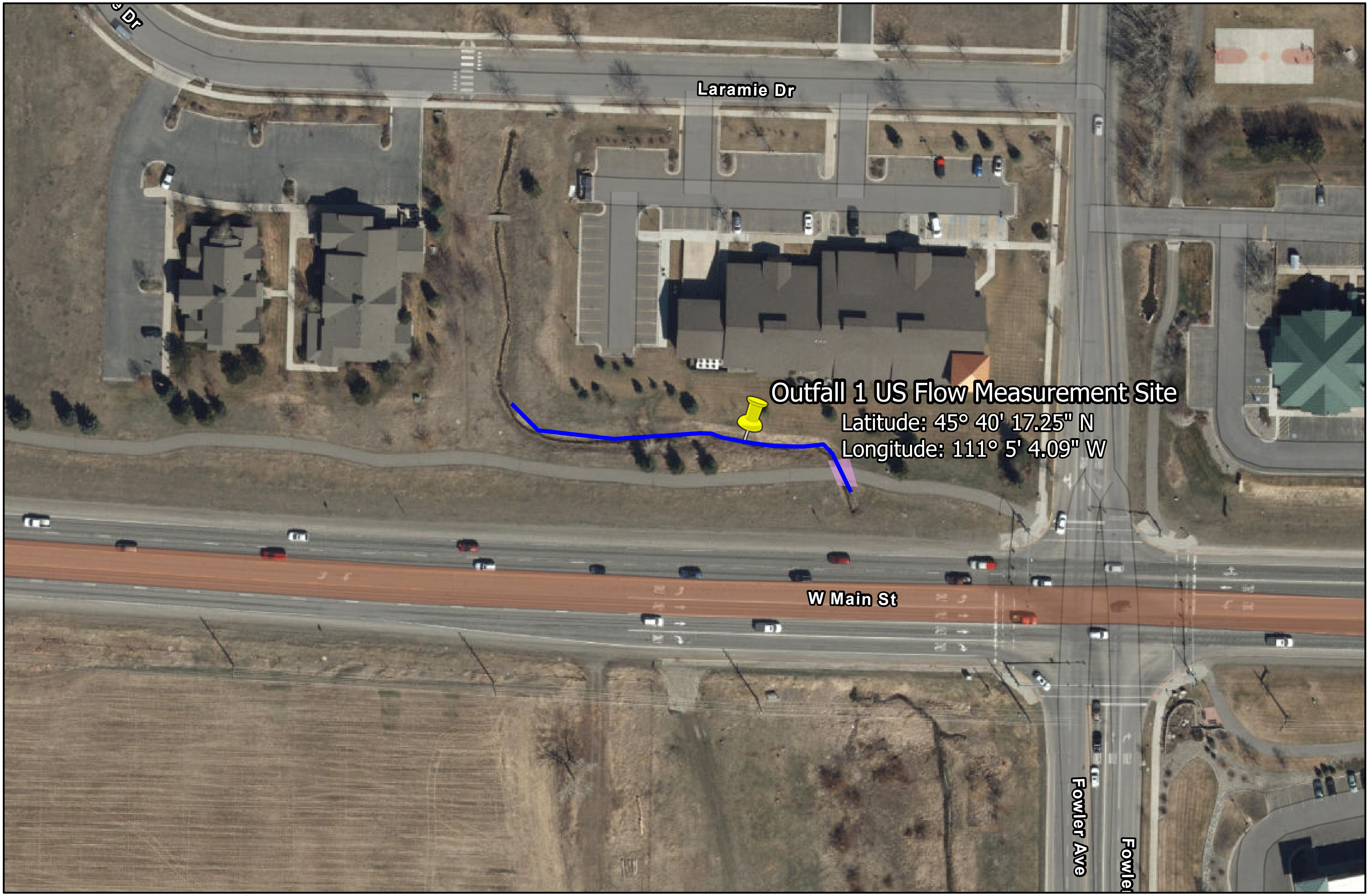
Outfall 1 DS Rating Curve
4588.6
4588.4
4588.2
4588.0
4587.8
4587.6
4587.4
4587.2
4587.0
4586.8
4586.6
WSE (ft)
y = -0.0038x2 + 0.1689x + 4586.6
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
DISCHARGE (cfs)
Calibration Points
Flow Master
Rating Curve

Date	Sensor Depth Reading (ft)	Flow (cfs)	Measured WSE	WSE n=0.105	Difference in WSE n=0.105
6/3/2023	1.45	8.9	4587.86	4587.85	0.01
7/20/2023	1.08	6.7	4587.49	4587.61	-0.11
8/22/2023	0.73	2.7	4587.14	4587.08	0.06

Bottom of PVC Elevation	Slope
4586.41	0.008
Max WSE 4588.40 ft	

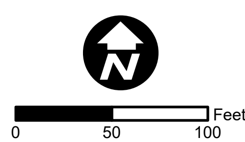
Flow Master Rating Data	
Flow (cfs)	WSE (ft) (n=0.105)
1	4586.76
3	4587.15
5	4587.44
7	4587.67
9	4587.85
11	4587.99
13	4588.12
15	4588.39





City of Bozeman

Projection: NAVD88
Units: Feet
Scale: 1 INCH EQUALS 100 ft
Date: March 2025



DOWL

Outfall 1 US Flow Sensor Location

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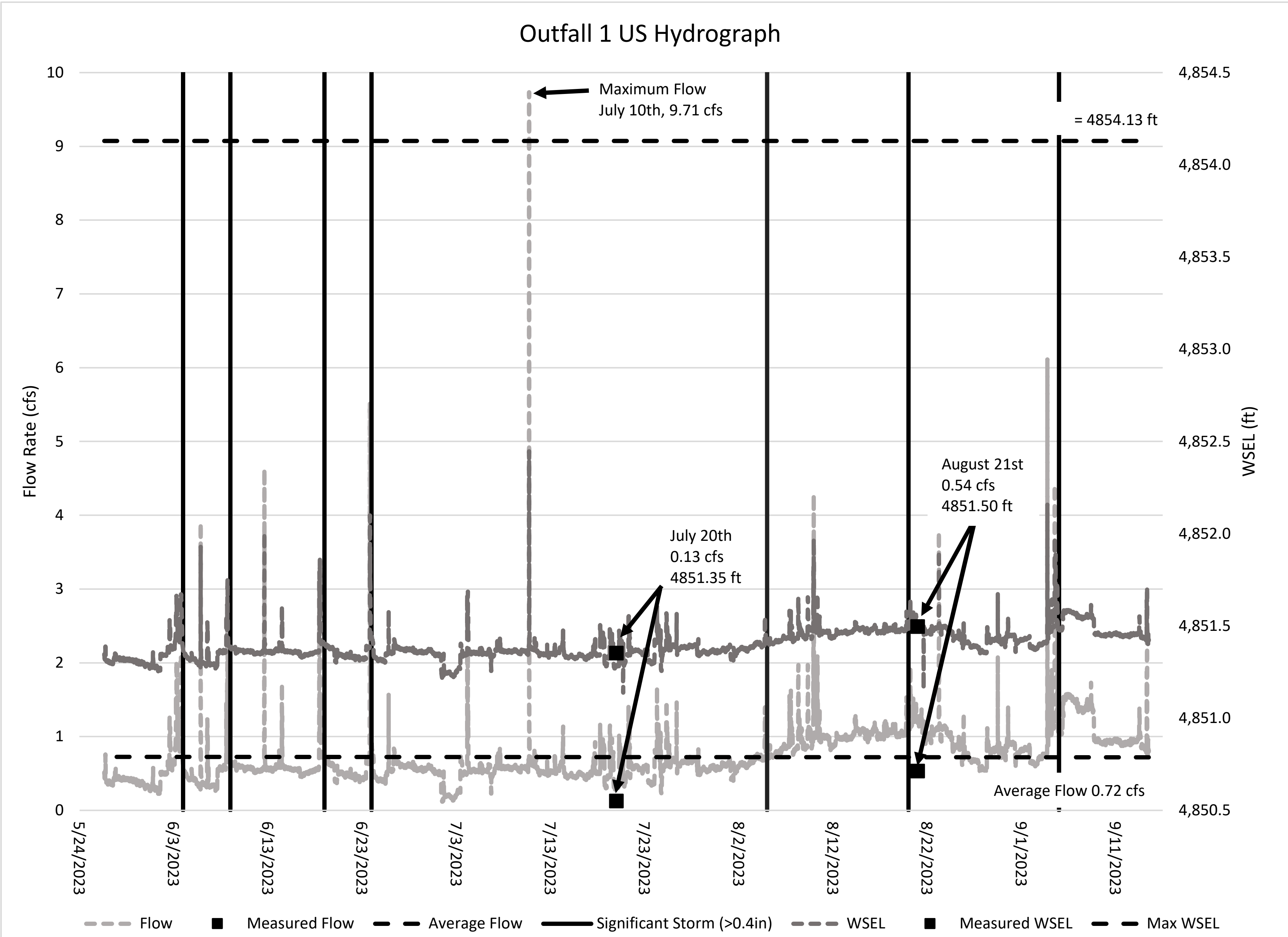
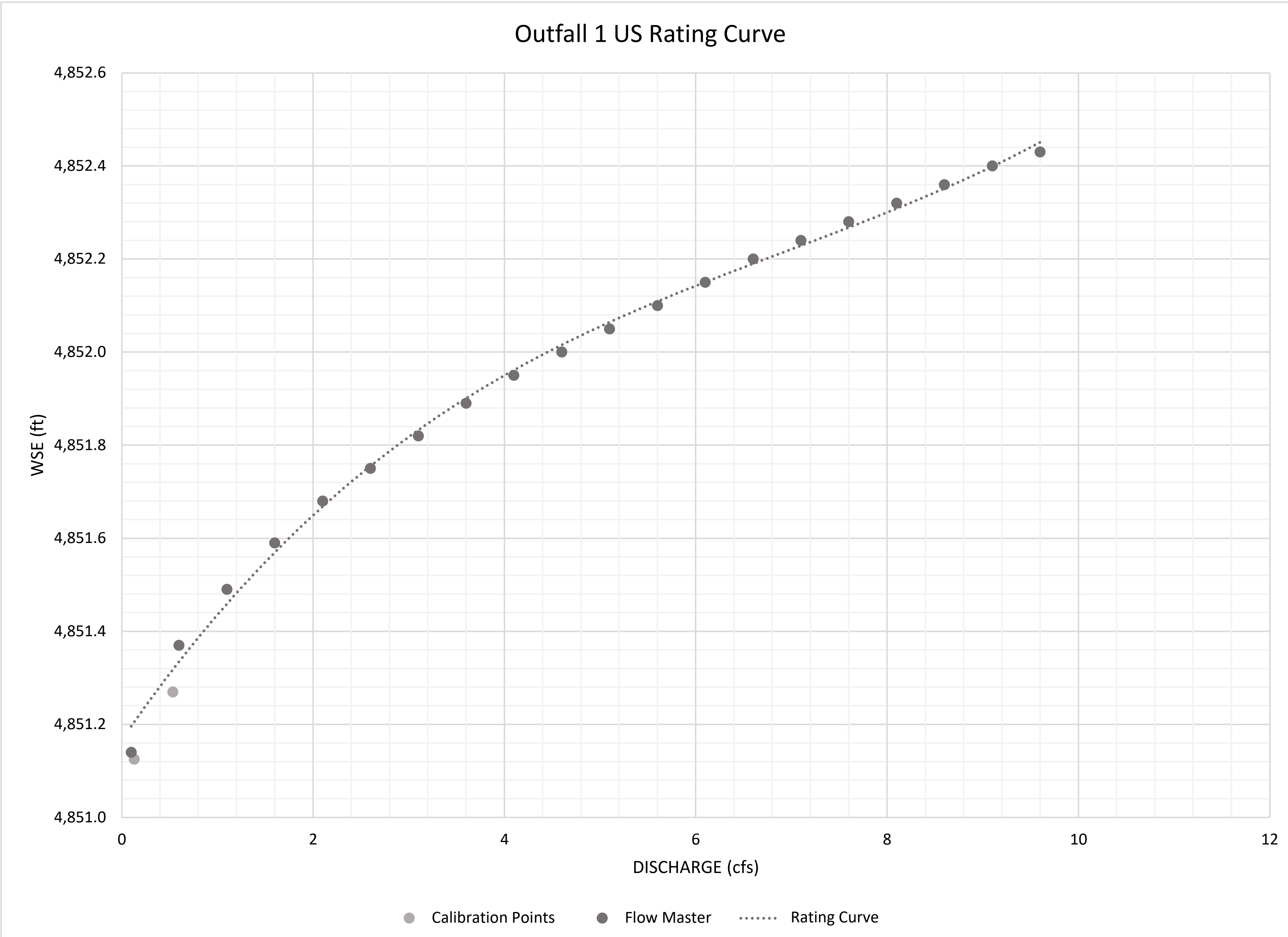


Outfall 1 US Hydrograph
Flow Rate (cfs)
WSEL (ft)
10
9
8
7
6
5
4
3
2
1
0
4,854.5
4,854.0
4,853.5
4,853.0
4,852.5
4,852.0
4,851.5
4,851.0
4,850.5
Maximum Flow
July 10th, 9.71 cfs
= 4854.13 ft
July 20th
0.13 cfs
4851.35 ft
August 21st
0.54 cfs
4851.50 ft
Average Flow 0.72 cfs
5/24/2023
6/3/2023
6/13/2023
6/23/2023
7/3/2023
7/13/2023
7/23/2023
8/2/2023
8/12/2023
8/22/2023
9/1/2023
9/11/2023
Flow
Measured Flow
Average Flow
Significant Storm (>0.4in)
WSEL
Measured WSEL
Max WSEL

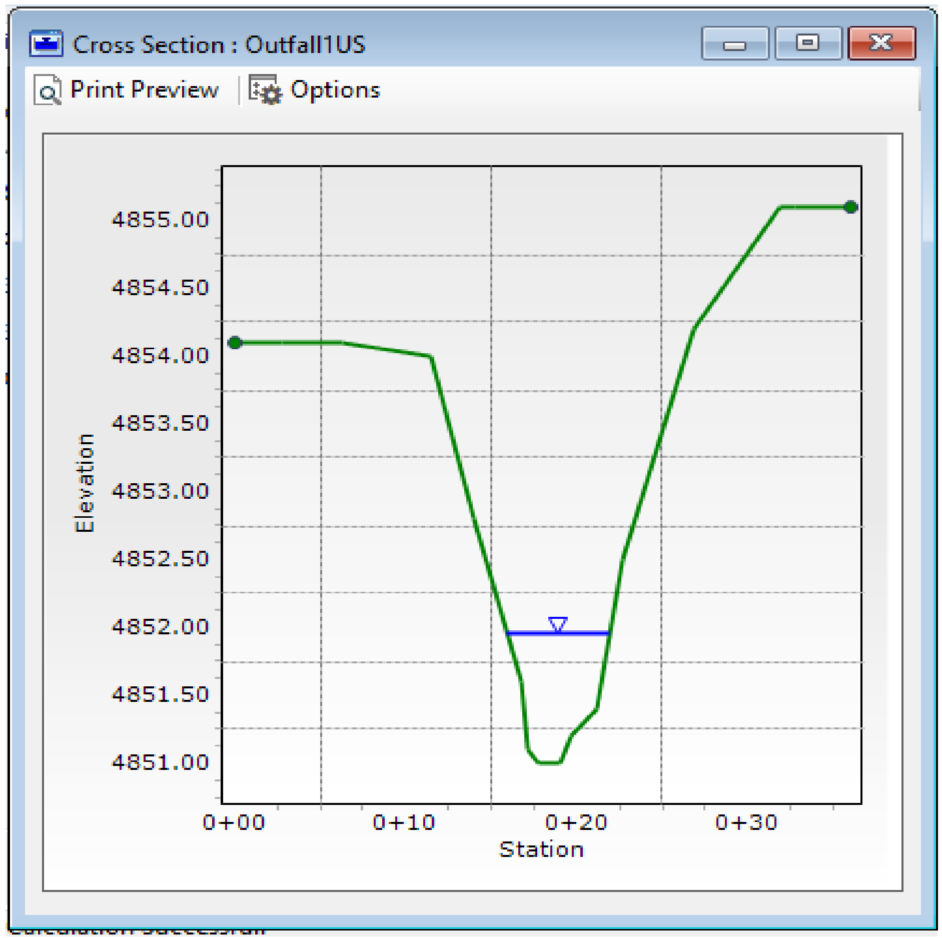


Outfall 1 US Rating Curve
4,852.6
4,852.4
4,852.2
4,852.0
4,851.8
4,851.6
4,851.4
4,851.2
4,851.0
WSE (ft)
0
2
4
6
8
10
12
DISCHARGE (cfs)
Calibration Points
Flow Master
Rating Curve

Date	Sensor Depth Reading (ft)	Flow (cfs)	Measured WSE	WSE Adjusted US	Calculated WSE n=0.11	Difference in WSE n=0.11 US
7/20/2023	0.17	0.13	4851.13	4851.35	4851.15	0.20
8/21/2023	0.32	0.54	4851.27	4851.50	4851.30	0.19

PCV Elevation	Slope	Adusted PVC Elevation for US
4850.95	0.01	4851.18
Max WSE 4854.13		

Flow master	
Flow	WSE (ft) (n=.11)
0.1	4,851.14
0.6	4,851.37
1.1	4,851.49
1.6	4,851.59
2.1	4,851.68
2.6	4,851.75
3.1	4,851.82
3.6	4,851.89
4.1	4,851.95
4.6	4,852.00
5.1	4,852.05
5.6	4,852.10
6.1	4,852.15
6.6	4,852.20
7.1	4,852.24
7.6	4,852.28
8.1	4,852.32
8.6	4,852.36
9.1	4,852.40
9.6	4,852.43



APPENDIX D: WATER QUALITY CAPITAL PROJECTS

Outfalls For Water Quality Treatment Assessment

Background:

Bozeman's modern stormwater water quality standards came into existence in 1980. Prior to 1980, development projects did not include post-construction BMPs designed to meet water quality standards. As a result, numerous sub-watersheds exist that do not provide the same level of service as those developed post-1980. Increasing the water quality level of service of pre-1980 sub-watersheds to a modern standard can be accomplished using BMPs whose primary function is treatment, infiltration, or a combination of both. Sediment removal BMPs should be prioritized due to Bozeman and Mandeville Creek impairments (TMDL info).

As of 2024, the City has completed 29 water quality projects, providing treatment to 594 acres within pre-1980 sub-watersheds. The majority of projects consist of hydrodynamic separators installed in-line with existing infrastructure, with a primary function of sediment removal. Several infiltration-based projects have been completed, with a primary function of flood control with a sediment removal co-benefit.

To increase the water quality level of service provided by pre-1980 sub-watersheds, the following have been completed;

- Delineation of pre-1980 sub-watersheds,
- Identification of sub-watersheds with a completed water quality improvement project,
- Identification of sub-watersheds without water quality improvements,
- Hydrologic and hydraulic (????) analysis of sub-watersheds,
- Sub-watershed description and potential project identification, and
- Budget estimates for most appropriate project type.

We will discuss with DOWL and select which will be carried forward through planning-level design per Scope 2.4.5.

Water Quality Improvements Projects:

Project Location: S. 11th Ave and Koch St.

Sub-Watershed Size: 32.3 Acres

Land Use: Residential

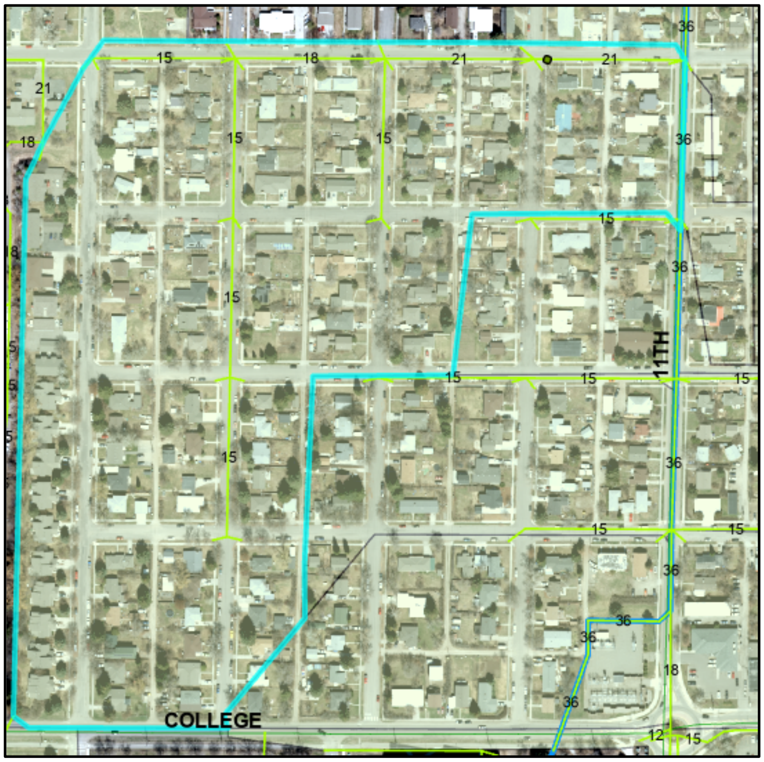
Sub-Watershed Description: This residential sub-watershed is a 32.3-acre area of mostly single-family residential land use. The existing infrastructure consists of curb and gutter with 21 standard inlets leading to a 21" outfall to Mandeville Creek where it is piped beneath S. 11th Ave. There is not currently any treatment within this watershed. It is a candidate for a mechanical separator as it has a single main line leading to the creek and apparent space between utilities in Koch Street. Trees only occupy about half or so of boulevard areas that could be used for infiltration if geotechnical and utilities allow.

Hydrologic & Hydraulic Analysis: The planning level model shows the outlet storm drain pipe with a peak flow of 12.17 cfs during the 2-year, 24-hr synthetic storm with the storm drain surcharging through the manholes. If there is an option to put in an infiltration gallery, that would be helpful to increase the service level on the SD system.

Project Identification: Installing a hydrodynamic separator first would allow staff to test function. If it is regularly being overwhelmed, infiltration could be added to assist in keeping flow rates low.

Budget Estimate:

Traffic Control		1	LS	$14,000	$14,000
Mobilization		1	LS	$18,000	$18,000
Taxes, Bonds, Insurance		1	LS	$9,000	$9,000
Connection to Existing		2	LNFT	$12,000	$24,000
Concrete Restoration			20	$25	$0
Asphalt Restoration	dimensions	100	SQYD	$75	$7,500
Curb and Gutter Restoration		30	LNFT	$40	$1,200
Pretreatment Unit	CDS 8'	1	EA	$145,000	$145,000
Removal and Disposal Material		20	CUYD	$250	$5,000
Miscellaneous		1	EA	$10,000	$10,000
Pipe	21"	30	LNFT	$240	$7,200
				Subtotal	$240,900
				Design	$48,180
				Construction Admin	$36,135
				Total	$325,215



Project Location: Arthur Watershed

Sub-Watershed Size: 131 Acres

Land Use: Residential / Institutional

Sub-Watershed Description: This watershed discharges to Matthew Bird Creek via a single 18" outfall. Half of the pipe in this drainage is VCP material and susceptible to tree root intrusion. While none of this watershed was originally built with water quality standards in place, some areas of MSU campus have redeveloped. Several more upgrades are underway which should reduce the flows and pollution to this outfall. The location that first seems to be the place to install water quality treatment is in the unpaved portion of South Black Avenue. Because of grades and the water level at the creek, this may be a challenging location to install. Just east of Willson, the right-of-way has few utilities and significant depth to groundwater.

Hydrologic & Hydraulic Analysis: The planning level stormwater model is showing that the whole pipe system through this area is undersized with surcharging through the manholes occurring at the 2-year, 24-hr event. The peak flow that is discharged into Matthew Bird Creek is 13.53 cfs though it is likely more than that due to the surcharged manholes. Unless infiltration galleries are incorporated into this SD system to help offload it, slip lining is not an option for pipe renewal.

Project Identification: Reducing volume to this outfall may be a beneficial strategy in additional ways that simply addressing water quality with mechanical separation would not affect. If the current pipe size can be maintained, slip lining becomes an option for pipe renewal. There is recent evidence of the pipe surcharging at the bottom of the hill by South Black Ave. Infiltration-based solutions would reduce quantity, although there are limited spaces to site them between the mature trees and utilities.

Multiple cross streets have potential space for infiltration because they lack water or sewer mains. It may be best to put a smaller infiltration project on each branch before it collects in Arthur. Additional savings would be realized at pipe replacement, where slip lining would save approximately half of the cost of dig-and-replace methods for 2000 feet of pipe. Estimate for 5 smaller structures.

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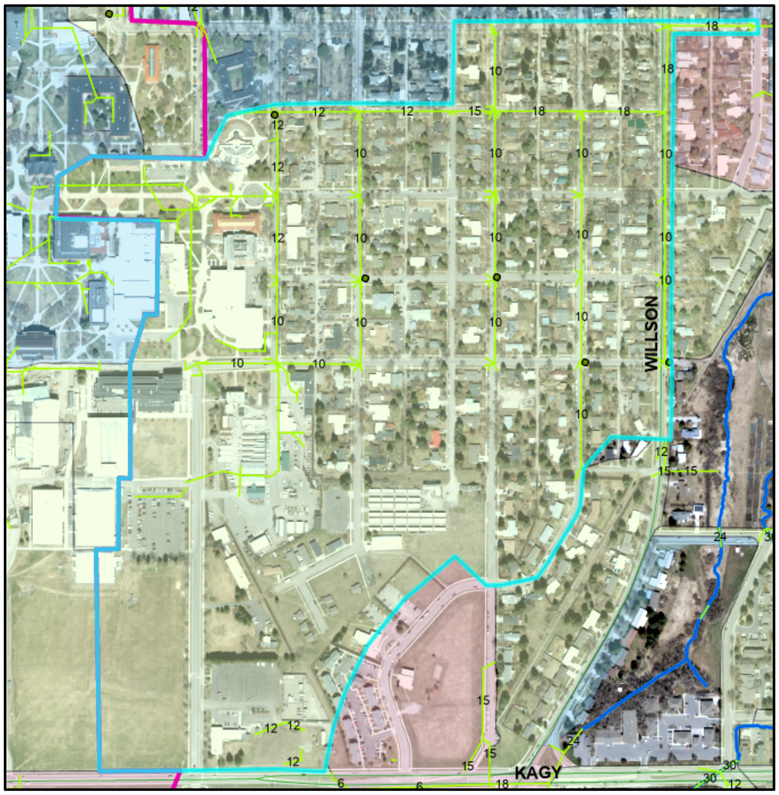
Budget Estimate:

Traffic Control		1	LS	$12,000	$12,000
Mobilization		1	LS	$15,000	$15,000
Taxes, Bonds, Insurance		1	LS	$5,000	$5,000
Perf Pipe	48" storage	400	LNFT	$85	$34,000
Concrete Restoration		500	SQFT	$25	$12,500
Asphalt Restoration	dimensions	450	SQYD	$90	$40,500
Manhole Structures	6x6	5	EA	$15,500	$77,500
Pretreatment Unit	SAFL Baffle	5	EA	$6,000	$30,000
Bedding	washed rock	670	CUYD	$100	$67,000
Separation Geotextile		800	SQYD	$4	$3,200
Pipe	12"	200	LNFT	$180	$36,000
				Subtotal	$332,700
				Design	$66,540
				Construction Admin	$49,905
				Total	$449,145



Project Location: Willson Watershed 7c

Sub-Watershed Size: 38.6 Acres

Land Use: Residential / Commercial

Sub-Watershed Description: This sub-watershed is 38.6 Acres and lies in the Bozeman Creek watershed. This sub-watershed ranges from single-family residential, multi-family residential, and commercial use. This watershed is mostly lined with curb and gutter and has no treatment before discharging into the downtown trunk line and then Bozeman Creek. Neighboring sub-watersheds have mechanical separator units before hitting the trunk line. Mature trees limit boulevard space, and asphalt was redone a few years ago. At most, there may be space to install 4 drywells, it is unlikely that a more typical infiltration boulevard would fit anywhere in this watershed. The hydraulic analysis from the Trunk Line project suggested that 5 infiltration galleries would be needed. Story, Koch, and Curtiss are cross streets which lack water and sewer mains. Curtiss is the best location without having survey data.

Hydrologic & Hydraulic Analysis: The planning level stormwater model shows a peak discharge of 4.86 cfs from the lateral during the 2-year, 24-hour storm though the system does surcharge through the manholes. This is a storm drain system we are recommending an underground infiltration gallery be installed on because the service level of the storm drain is so low. Earlier analysis suggested upsizing this entire stormwater main to City minimum of 15” when the clay tile is removed. Reducing flow would alleviate downstream issues, but would likely not allow us to reduce pipe size in the pipe rehab effort.

Project Identification: This outfall is a good opportunity to address quality and quantity at the same time with infiltration. A mechanical separator near the outfall point north of Main Street would address quality, but not quantity.

Budget Estimate:

Single Infiltration Gallery					
ITEM DESCRIPTION	ADDITIONAL INFORMATION	QUANTITY	UNIT	UNIT COST	TOTAL
TRAFFIC CONTROL		1	LS	$ 10,000	$ 10,000
DRAINAGE PIPE 48 IN	48" PERFORATED STORAGE PIPE	150	LNFT	$ 400	$ 60,000
CURB AND GUTTER-CONC	CURB AND GUTTER REPLACEMENT	150	LNFT	$ 85	$ 12,750
ASPHALT RESTORATION	160'x24'	430	SQYD	$ 90	$ 38,700
MANHOLE STRUCTURE BASE 60 IN		2	EA	$ 15,500	$ 31,000
CDS UNIT MANHOLE	6' STORMWATER TREATMENT DEVICE	1	EA	$ 25,000	$ 25,000
DRAIN AGGREGATE	WASHED ANGULAR STONE	670	CUYD	$ 110	$ 73,700
SEPARATION GEOTEXTILE - HIGH		800	SQYD	$ 3	$ 2,400
RCP 18 IN		40	LNFT	$ 200	$ 8,000
					$ -
					$ -
				SUBTOTAL	$ 261,550
			CONTINGENCIES & UNLISTED ITEMS	*30%*	$ 78,465
				SUBTOTAL	$ 340,015
			MOBILIZATION	*15%*	$ 51,002
				SUBTOTAL	$ 391,017
			DESIGN	*20%*	$ 78,203
				SUBTOTAL	$ 469,221
			CONSTRUCTION ADMINISTRATION	*15%*	$ 58,653
				TOTAL	$ 527,873

Project Location: Basin 25

Sub Watershed Size: 128.7 Acres

Land use type: Mixed-use residential and commercial

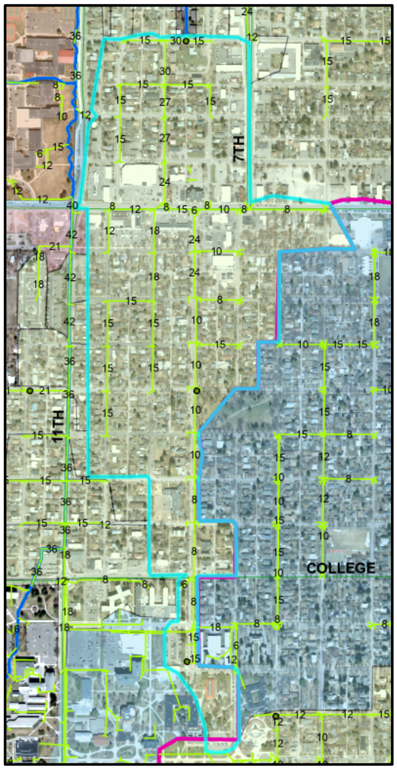
Sub-Watershed Description: This sub-watershed has a 13-block run with no treatment before outfalling into Tributary - SWWW_00053 that ultimately flows into Mandeville Creek. It is a good candidate for treatment as there is a single outfall on Villard that could host a mechanical separator unit. A capital project scheduled for FY29 at the outfall area would replace the sanitary sewer and presumably the ditch section. The area of this capital item is known to flood into yards during high-intensity events. A severe bottleneck also exists at 8th and Main Street. There are open boulevard sections without trees, with the most options available along 9th Avenue. This watershed could also be broken into several sub-watersheds.

Hydrologic & Hydraulic Analysis: The peak flow discharging into the tributary at the 2-year, 24-hr event is 27.92 cfs although much of this system surcharges through the manholes. Raingarden or underground infiltration galleries could be a could option to help increase the service of the SD system.

Project Identification: Infiltration should be installed upstream of the bottleneck at Main Street to alleviate quantity issues in addition to quality. South 8th Avenue at Koch St. lacks sewer and water mains, this might be a good location. There is likely a boulevard near MSU where we could add a raingarden component to capture a portion of the upper watershed and gain the benefit of education and a visible stormwater feature. Estimate includes one infiltration facility and one boulevard rain garden.

Budget Estimate:

Traffic Control		1	LS	$15,000	$15,000
Mobilization		1	LS	$8,000	$8,000
Taxes, Bonds, Insurance		1	LS	$10,000	$10,000
Perf Pipe	48" storage	300	LNFT	$85	$25,500
Concrete Restoration		500	SQFT	$25	$12,500
Asphalt Restoration	dimensions	400	SQYD	$90	$36,000
Manhole Structures	6x6	1	EA	$15,500	$15,500
Flow Control Structure		1	EA	$16,000	$16,000
Pretreatment Unit	SAFL Baffle	1	EA	$6,000	$6,000
Bedding	washed rock	670	CUYD	$100	$67,000
Separation Geotextile		800	SQYD	$4	$3,200
Pipe	12"	60	LNFT	$150	$9,000
Boulevard Rain Garden	5x40	200	SQFT	$500	$100,000
Pipe	18"	100	LNFT	$200	$20,000
				Subtotal	$343,700
				Design	$68,740
				Construction Admin	$51,555
				Total	$463,995



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Project Location: Cherry Drive

Sub Watershed Size: 12 Acres represents roughly half of the sub-watershed reaching the tributary. This area includes the right-of-way and some residential front yards which lead a single inlet; the other half is in an open space area.

Land Use: Residential, Open Space

Hydrologic & Hydraulic Analysis: N/A

Sub-Watershed Description: This sub-watershed has a single curb inlet at the bottom of a hill that receives a lot of traction sand application in winter. Stormwater receives treatment afterward by traveling through grassy swales; capture of the first flush would aid maintenance and function at the inlet location. Estimate is for four drywells along the curbline at the top of the hill, and the beginning of the cul-de-sac.

Project Identification: Infiltration via dry-wells.

Budget Estimate:

Traffic Control		1	LS	$5,000	$5,000
Mobilization		1	LS	$6,000	$6,000
Taxes, Bonds, Insurance		1	LS	$9,000	$9,000
Perf Pipe	48" storage	0	LNFT	$85	$0
Concrete Restoration		500	20	$25	$12,500
Asphalt Restoration	dimensions	40	SQYD	$90	$3,600
Drywell with stone	+fabric, casting, 5'	4	EA	$18,000	$72,000
				Subtotal	$108,100
				Design	$21,620
				Construction Admin	$16,215
				Total	$145,935

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Project Location: Langhor Ave.

Sub-Watershed Size: 48.5 Acres + 42 Acres

Land Use: Residential

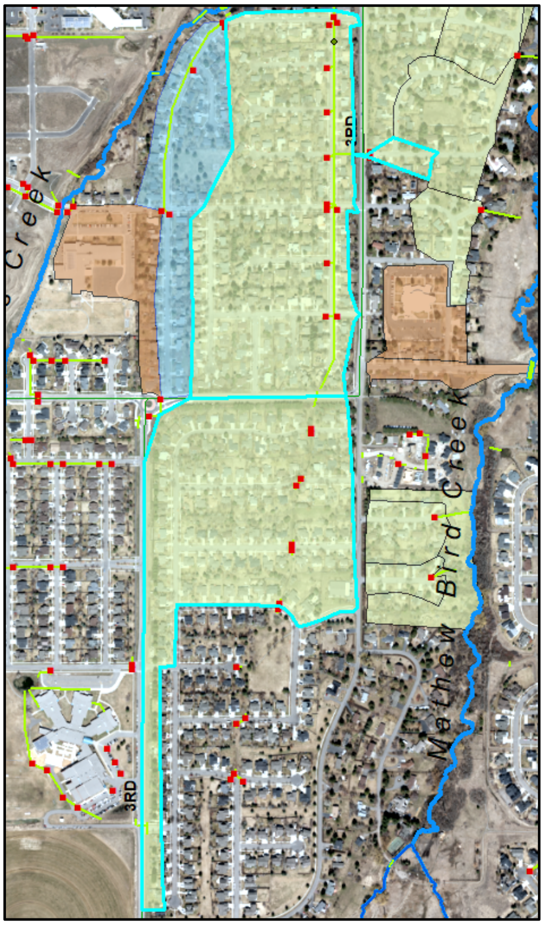
Sub-Watershed Description: The northern end is a good candidate for a separator as the pipe system collects a large area with no treatment before entering Figgins Creek, a direct tributary to Bozeman Creek. Infiltration may be possible in boulevards, but groundwater might interfere in a deeper installation.

Hydrologic & Hydraulic Analysis: N/A

Project Identification: The watershed directly to its southern border drains into this system through an open grassy swale, adding an additional 42 acres of residential stormwater runoff which is not built to modern standards but does have some detention for medium sized storm events. There are boulevards without continuous trees, but many areas lack curb and gutter or a typical boulevard, ruling out boulevard infiltration.

Budget Estimate:

Traffic Control		1	LS	$14,000	$14,000
Mobilization		1	LS	$18,000	$18,000
Taxes, Bonds, Insurance		1	LS	$9,000	$9,000
Connection to Existing		2	LNFT	$12,000	$24,000
Concrete Restoration		45	SQYD	$25	$1,125
Asphalt Restoration	dimensions	100	SQYD	$75	$7,500
Curb and Gutter Restoration		60	LNFT	$25	$1,500
Pretreatment Unit	CDS 8'	1	EA	$145,000	$145,000
Removal and Disposal Material		20	CUYD	$250	$5,000
Miscellaneous		1	EA	$10,000	$10,000
Pipe	30"	30	LNFT	$285	$8,550
				Subtotal	$243,675
				Design	$48,735
				Construction Admin	$36,551
				Total	$328,961



Project Location: W. Olive/ S.16th/ W. Babcock

Sub Watershed Size: 40 Acres

Land Use: Multi-Family/ Commercial

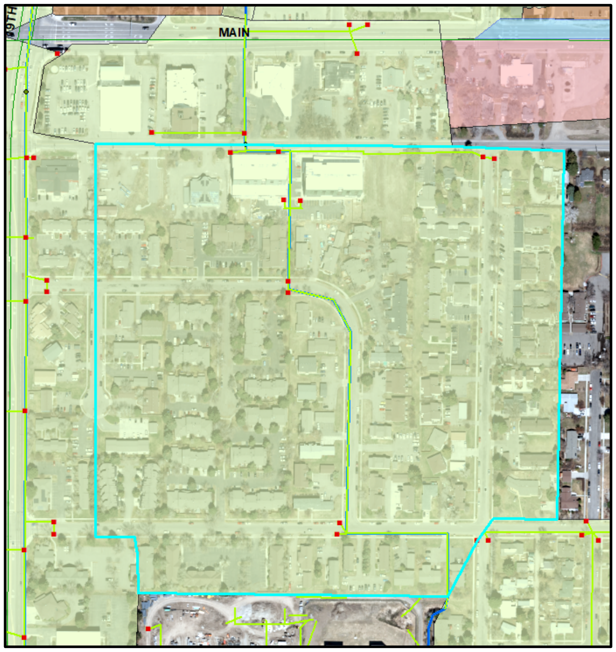
Sub-Watershed Description: This ditch discharges to Mandeville Creek in large events only. The area to the north is a controlled groundwater area, so reducing the amount of stormwater through this area could be beneficial. A separator wouldn't work well in this location due to Middle Creek Ditch and the size of the separator that would be required.

Hydrologic & Hydraulic Analysis: N/A

Project Identification: Recommended action is to wait for Babcock and College street projects to arrive, and bring those contributing areas up to modern standard. If flow reaching Mandeville Creek is observed after that time, consider adding rain gardens in boulevards.

Budget Estimate:

Traffic Control		1	LS	$12,000	$12,000
Mobilization		1	LS	$8,000	$8,000
Taxes, Bonds, Insurance		1	LS	$10,000	$10,000
Perf Pipe	48" storage	100	LNFT	$85	$8,500
Concrete Restoration		500	SQFT	$25	$12,500
Asphalt Restoration	dimensions	120	SQYD	$90	$10,800
Dry Well	5'	1	EA	$15,500	$15,500
Bedding	washed rock	350	CUYD	$100	$35,000
Separation Geotextile		400	SQYD	$4	$1,600
Boulevard Rain Garden	5x40	200	SQFT	$500	$100,000
				Subtotal	$213,900
				Design	$42,780
				Construction Admin	$32,085
				Total	$288,765



Project Location: E. Cleveland St. / E. Garfield St.

Sub-Watershed Size: 31 Acres

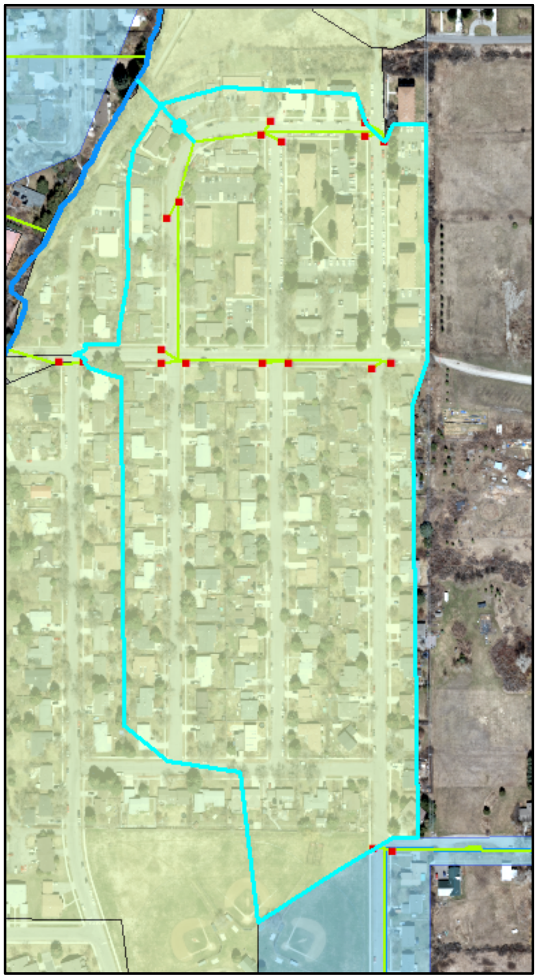
Land Use: Single-family and multi-family Residential

Sub-Watershed Description: This will be a difficult area to site a mechanical separator due to utility layout and trees at the downstream end of the watershed. It discharges 31 acres of stormwater runoff directly into Matthew Bird Creek, which joins with Bozeman Creek shortly thereafter. There are some boulevard areas where infiltration might be possible. The main has some baseflow.

Hydrologic & Hydraulic Analysis: N/A

Project Identification: Check feasibility for installing a wet detention watershed near the Galligator Trail and discuss with Parks and Water Resources Engineering. If there is insufficient space or other barriers, consider a hydrodynamic separator on the west branch where there is more room to install it, and smaller boulevard infiltration on the east streets. Groundwater may be a limiting factor and boulevards will have to be relatively shallow.

Budget Estimate: N/A



Project Location: Kagy / Highland

Sub-Watershed Size: 29 Acres

Land Use: Single Family, Roadway

Sub-Watershed Description: This watershed drains directly into Bozeman Creek and has no treatment. A future road project in this location may be a good time to install new infrastructure. Some of the land is owned by MDT.

The median or park provide space, although the steeper slope may complicate grades and the typical layout. Waiting for a road or intersection project would make sure the design can work in the long term.

Hydrologic & Hydraulic Analysis: N/A

Project Description: This sub-watershed would be a great candidate for various treatment types as the storm main lies under a large boulevard/ median area.

Budget Estimate:

Traffic Control		1	LS	$25,000	$25,000
Mobilization		1	LS	$15,000	$15,000
Taxes, Bonds, Insurance		1	LS	$10,000	$10,000
Perf Pipe	48" storage	400	LNFT	$85	$34,000
Concrete Restoration		200	SQFT	$25	$5,000
Asphalt Restoration	dimensions	300	SQYD	$90	$27,000
Landscaped Restoration		200	SQYD	$60	$12,000
Manhole Structures	6x6	5	EA	$15,500	$77,500
Pretreatment Unit	SAFL Baffle	5	EA	$6,000	$30,000
Bedding	washed rock	670	CUYD	$100	$67,000
Separation Geotextile		800	SQYD	$4	$3,200
Pipe	15"	200	LNFT	$180	$36,000
				Subtotal	$341,700
				Design	$68,340
				Construction Admin	$51,255
				Total	$461,295

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Project Location: S. 20th Ave.

Sub-Watershed Size: 27 Acres

Land Use: Multi-Family, Commercial

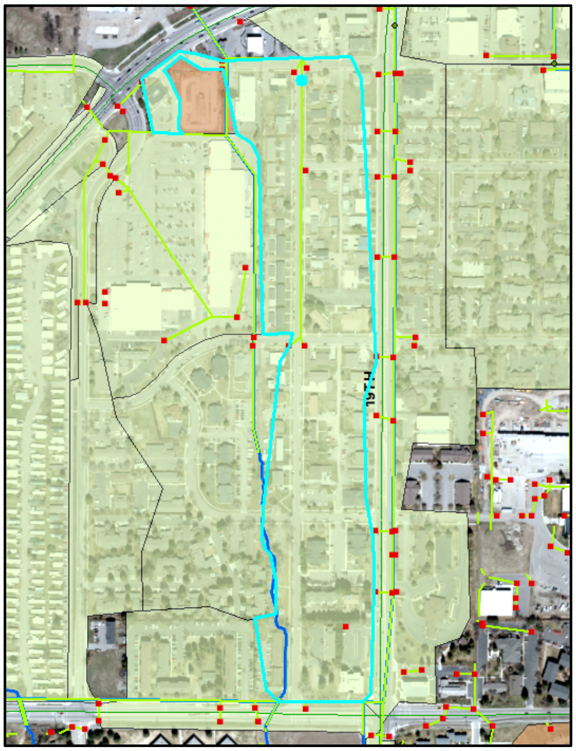
Sub-Watershed Description: In this high-density, 27-acre sub-watershed which drains into E. Fork Catron Creek, clearance to groundwater and utilities should be considered because the utility layout is not uniform in the roads.

Hydrologic & Hydraulic Analysis: N/A

Project Identification: A mechanical separator south of Babcock would be the simplest solution, although there are many boulevards without trees where we could install infiltration.

Budget Estimate:

Traffic Control		1	LS	$14,000	$14,000
Mobilization		1	LS	$18,000	$18,000
Taxes, Bonds, Insurance		1	LS	$9,000	$9,000
Connection to Existing		2	LNFT	$12,000	$24,000
Concrete Restoration		20	SQYD	$25	$500
Asphalt Restoration	dimensions	100	SQYD	$75	$7,500
Curb and Gutter Restoration		30	LNFT	$40	$1,200
Pretreatment Unit	CDS 8'	1	EA	$145,000	$145,000
Removal and Disposal Material		20	CUYD	$250	$5,000
Miscellaneous		1	EA	$10,000	$10,000
Pipe	18"	40	LNFT	$240	$9,600
				Subtotal	$243,800
				Design	$48,760
				Construction Admin	$36,570
				Total	$329,130



The following projects will not receive budget level estimates. After the higher priority projects from this list are completed, these should be considered for boulevard rain garden installation. These should accept drainage from smaller areas of around 0.5-2 acres.

Project Location: Babcock and Ferguson

Sub-Watershed Size: 26 Acres

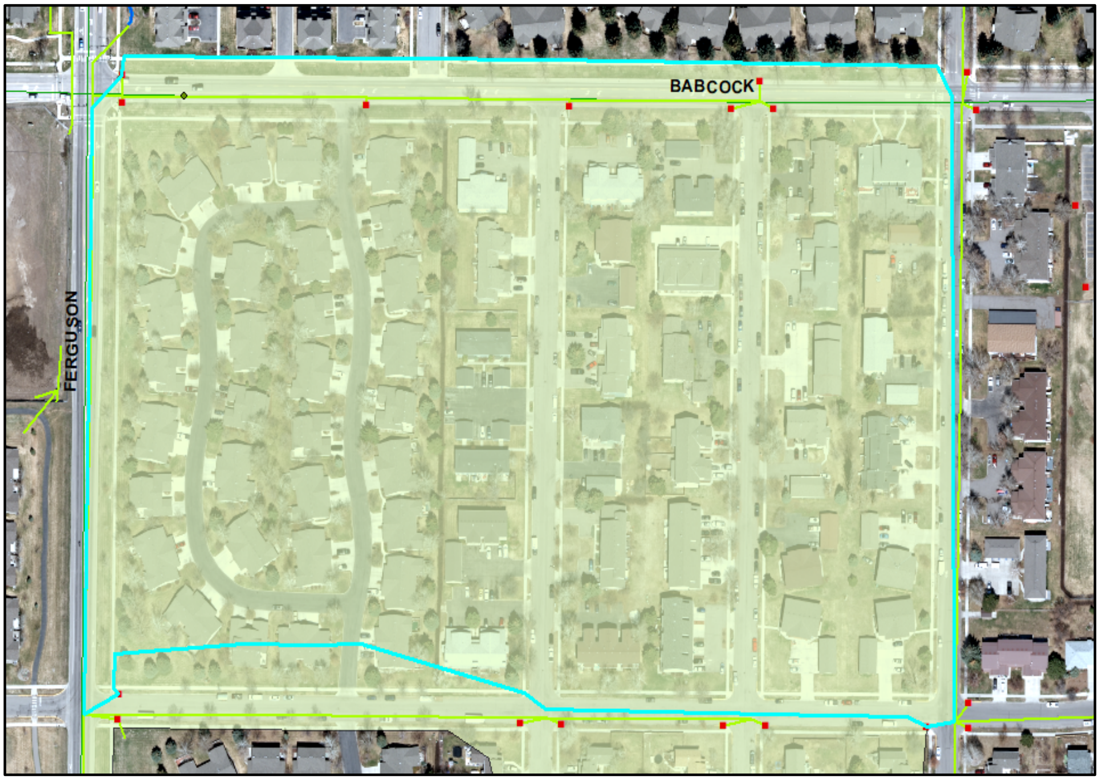
Land Use: Residential

Sub-Watershed Description: This residential area drains into Tributary - SWWW_00007, which drains to West Gallatin Canal and has the potential for multiple types of treatment to be installed. The future buildout of Babcock should be considered. About a third of this watershed is treated via a detention pond. A good bit of pervious area, we may have better options available.

Hydrologic & Hydraulic Analysis: N/A

Project Identification: N/A

Budget Estimate: N/A



Project Location: Durston and Meagher Ave.

Sub-Watershed Size: 22 Acres

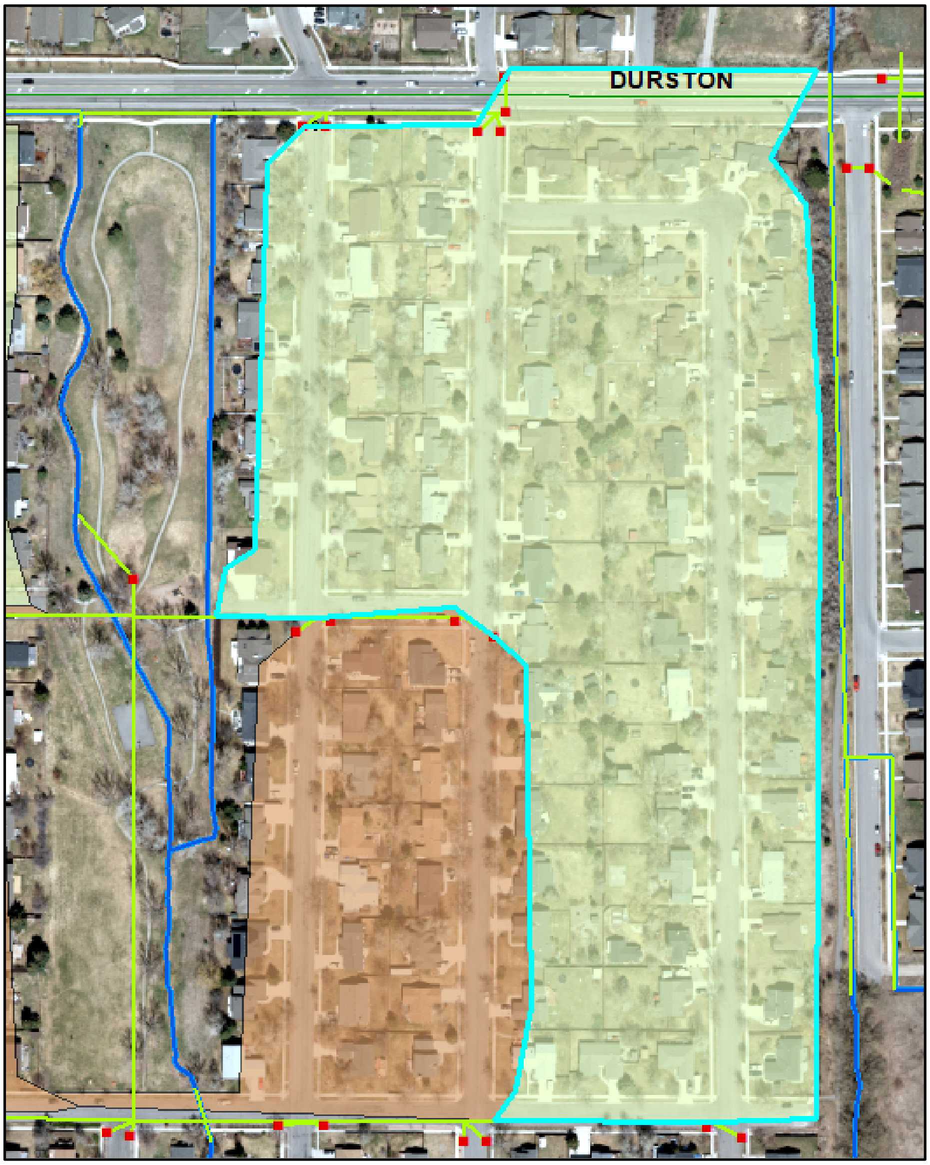
Land Use: Residential

Sub-Watershed Description: This 22-acre sub-watershed has mature trees in most boulevard. The stormwater main that runs along the south of Durston may also be a good candidate for an inline treatment unit. It’s an option but with this being a residential subwatershed with a good bit of pervious area, we may have better options available.

Hydrologic & Hydraulic Analysis: N/A

Project Identification: Good candidate for an inline treatment unit

Budget Estimate: N/A



BOZEMAN MT
Stormwater Division

Project Location: 20th and Durston

Sub-Watershed Size: 19 Acres

Land Use: Residential/commercial

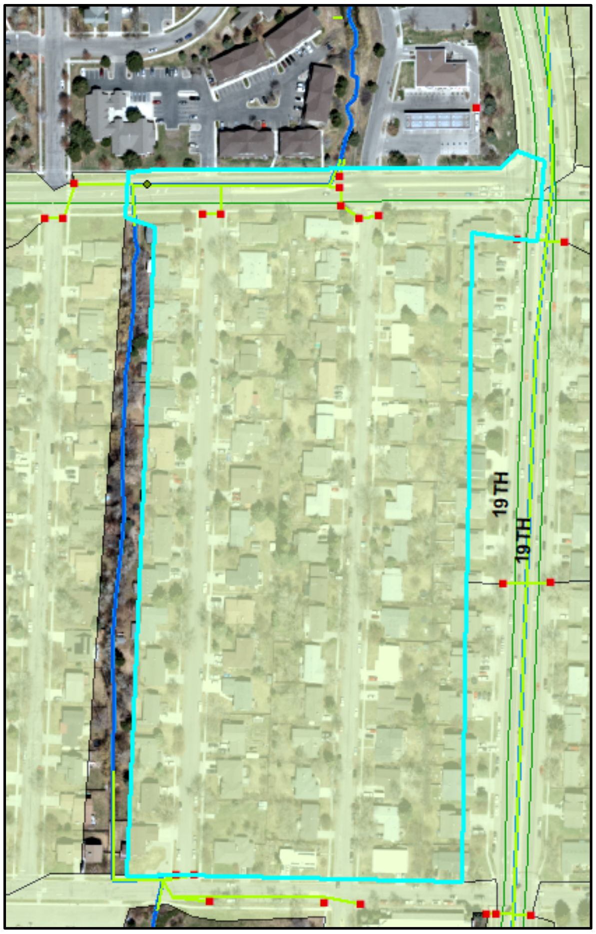
Sub-Watershed Description: This 19-acre sub-watershed drains into East Fork Catron Cr. at a single point with space to install a treatment unit. Most of the boulevard space is occupied with trees. The future alignment of Durston should be considered.

Hydrologic & Hydraulic Analysis: N/A

Project Identification: Install a treatment unit.

It's an option, but as this is a residential subwatershed with a good bit of previous area, we may have better options available. Baseflow from East Fork Catron Creek may be an issue.

Budget Estimate: N/A



The following three watersheds are in the approved capital plan and will be built over the next few years. Monitor projects for several years after installation and determine if additional boulevard rain gardens are needed to reduce the volume inputs.