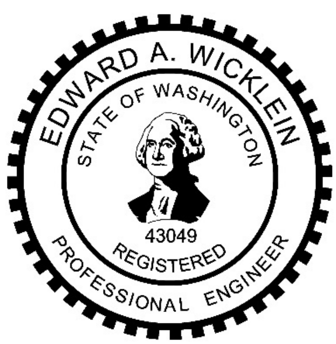
City of Tacoma
D-to-M Streets Track & Signal Surface Water
Hydraulic Analysis

Executive Summary
FLOODING REDUCTION
ALTERNATIVES ANALYSIS
AND
STORM AND SANITARY RECONFIGURATION

FINAL | November 2021

Digitally signed by Edward A. Wicklein
Contact Info: Carollo Engineers, Inc.
Date: 2021.12.01 14:12:44-08'00'



Contents

Executive Summary

Tables

Figures

EXECUTIVE SUMMARY

ES.1 Introduction

In 2012, Sound Transit (ST) completed the D-to-M Streets Track & Signal Project (Project), an expansion effort of a regional rail line in Western Washington that reconstructed a 19-acre portion of the City of Tacoma (City) from South “D” Street to South “M” Street, installed new rail bed, and regraded an existing rail bed. The Project relocated over 4,000 linear feet (LF) of the City’s stormwater system’s pipes, replacing piping in the area with new assets ranging from 12 to 72 inches in diameter. This system drains to the Thea Floss Waterway via two 96-inch outfalls, Outfalls A and B, approximately 2,000 feet northeast of the Project Area. Figure 1 locates the Project Area and the Thea Foss Waterway.

Figure 1 Project Location Map

The Project’s rail line alignment crossed numerous City roadways, including Pacific Avenue near its intersection with South 26th Street. To accommodate this crossing, the Project constructed a rail line bridge and also lowered the elevation of this intersection’s grade surface to allow for adequate vehicle clearance; as a result, reconstructed storm drain manholes (MHs) and catch basin (CB) rims were installed up to 18 feet below their pre-construction elevations. Following construction, MHs within this area have excessively surcharged and flooded the lowered roadway during large storm events, particularly at the intersection of Pacific Avenue and South 26th Street where flooding has been documented to depths of approximately 10 feet.

Carollo Engineers, Inc. (Carollo) conducted uniform flow and backwater analyses of the Project Area, which revealed that the relocated and reconstructed stormwater system is likely to flood under a 25-year storm and even more severely so under a 100-year event. These conditions indicate that the system does not meet the trunk conveyance design criteria detailed in the City's *2008 Surface Water Management Manual* (TSWMM), against which the Project had been held. A conceptual design was developed that would meet the original TSWMM design requirements through the Project Area. However, this conceptual design would require extensive construction in an area that was heavily disrupted during the initial project. Therefore, a less disruptive option was developed that provided additional system benefits beyond reconfiguring the stormwater system through the Project Area.

To alleviate current flooding within the Project Area, scenarios were evaluated to develop a conceptual design alternative that meets the TWSMM's design requirements. Potential conflicts with other known utilities were identified and incorporated into the conceptual design, which required reconfiguring the current alignments of both the sanitary sewer and stormwater systems downstream of the Project Area. This ancillary work is required to support the effectiveness of the recommended alternative under the City's design standards for storm and sanitary systems, while also resolving conflicts between the two systems.

ES.2 Flooding-Reduction Scenario Analysis

This section reviews the methodology and results of the alternatives analysis completed to evaluate the flooding-reduction scenarios within the Project Area, which included increased conveyance and peak attenuation through storage options. Each alternative scenario was tested in the City's Mike Urban model using design storms described in Section ES.2.1. Then, the alignment and sizing of all viable scenarios were further refined to consider conflicts with the sanitary sewer system's piping in the Project Area and to remain robust against the effects of future climate change, which include higher tide levels at the two outfalls and shorter, more intense rainfall events.

ES.2.1 Analysis Methodology

The scenarios were evaluated against design storms, which are modeled rainfall events that dictate the capacity basis for sizing new infrastructure and analyzing the performance of existing infrastructure. This analysis employed the following two design storms:

- **MGS 3-hour design storm**: A synthetic, short-duration, high-intensity event with 24-hour rainfall of 1.05 inches that was recently developed for the City by MGS Engineering Consultants, Inc. (MGS).
- **December 2019 storm**: A historical, recorded event from December 2019 with 24-hour rainfall of 3.52 inches that caused observed flooding in the Basin.

The December 2019 has a similar 24-hour rainfall to the current TSWMM design storm, but uses an actual observed hydrograph. The MGS 3-hour storm has less overall rainfall than the current TSWMM design storm, but is a higher intensity event and under consideration to add as TSWMM design storm. The high-intensity MGS 3-hour design storm was used to refine the scenarios to withstand the effects of climate change while the December 2019 storm's characteristics served as the controlling rainfall parameters against which the scenarios were modeled, assessed, and initially sized. As mentioned, this event caused considerable flooding in the Project Area.

Figure 2 identifies MHs within the Basin that have the potential to flood during a December 2019 storm while Figure 3 shows the calculated hydraulic profile through the Project Area, along with photographs of historical flooding documented at MHs during the actual December 2019 event.

Note that for this figure and all subsequent hydraulic profile figures, the green line represents the ground level, the black lines represent infrastructure including the top and bottom of pipes and MHs, and the blue line represents the peak hydraulic grade. If appropriate hydraulic grade lines (HGLs) are being maintained, the blue line should be below the green line, otherwise flooding is likely.

ES.2.2 Recommended Project Area Flooding-Reduction Scenario

A structural rehabilitation of an abandoned pipe that travels under the Project Area was identified to be the most viable and cost-effective flooding-reduction method within the Project Area (i.e., requires the least construction and new piping while maximizing capacity).

To minimize new pipe construction in the Project Area, the preferred scenario rehabilitates an abandoned, City-owned pipeline from upstream of Puyallup Avenue (i.e., MH 6765510 to MH 6765361, shown in Figure 4 by purple vertical lines) to convey a portion of the flow from the trunk near South 26th Street and Pacific Avenue to Outfall B. As the hydraulic profiles of the abandoned pipe to Outfall B and existing pipe to Outfall A shown in Figure 4 and Figure 5, this recommended and preferred scenario eliminates flooding in the Project Area under a simulated December 2019 storm.

Overall, the preferred scenario effectively eliminates flooding in the Project Area while also minimizing traffic disruptions along Pacific Avenue and South Tacoma Way/26th Street during construction and benefiting existing local users who have lateral inputs to the abandoned pipe. The pipe size and grade downstream from Puyallup Avenue (i.e., MH 6765361 to MH 6777414, shown in Figure 4 by red vertical lines) needs to be upsized and regraded while avoiding conflicts with other utilities such as the sanitary system as further discussed in the next section.

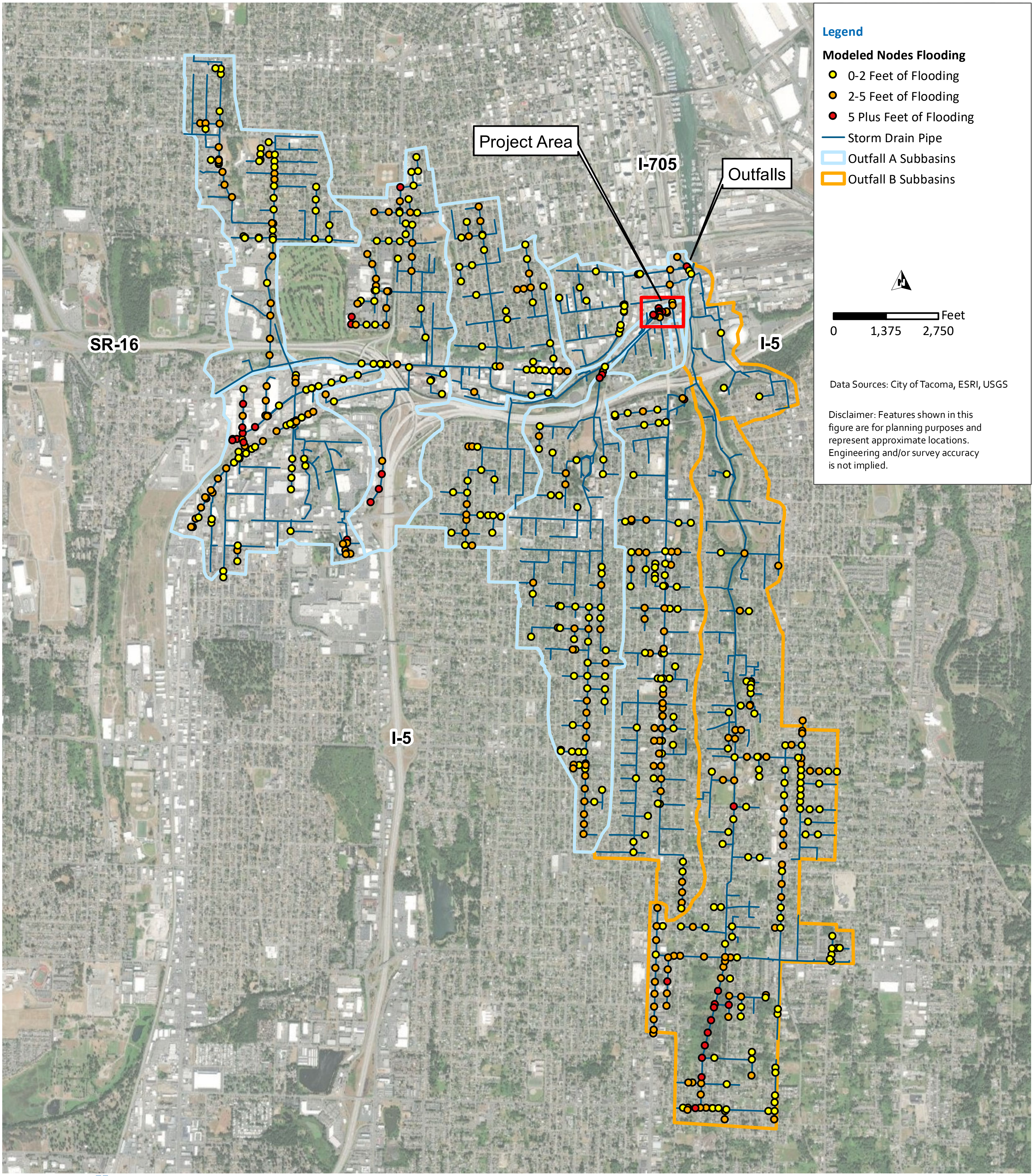


Figure 2 December 2019 Event Overview of Thea Foss Basin

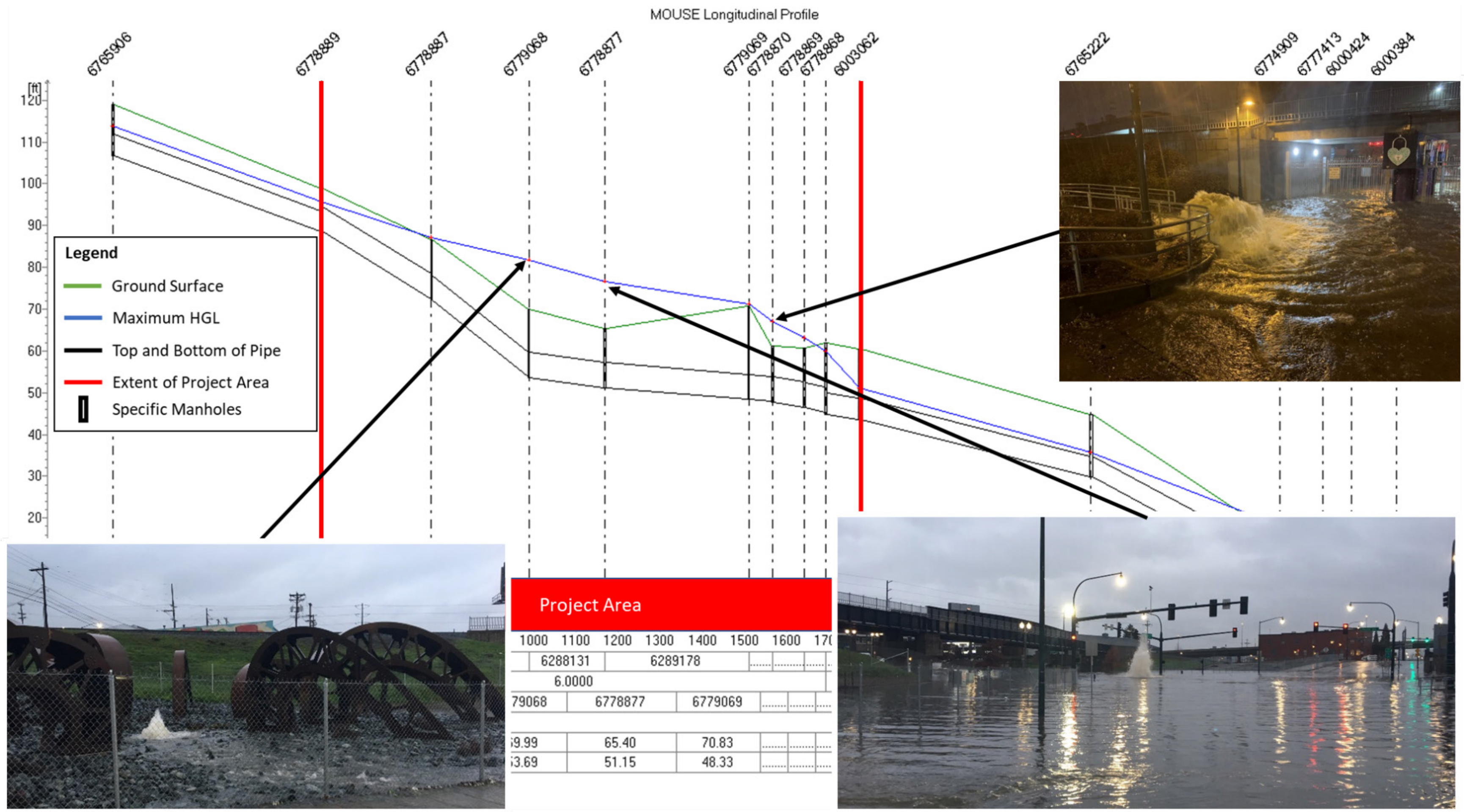


Figure 3 December 2019 Event Profile of Project Area

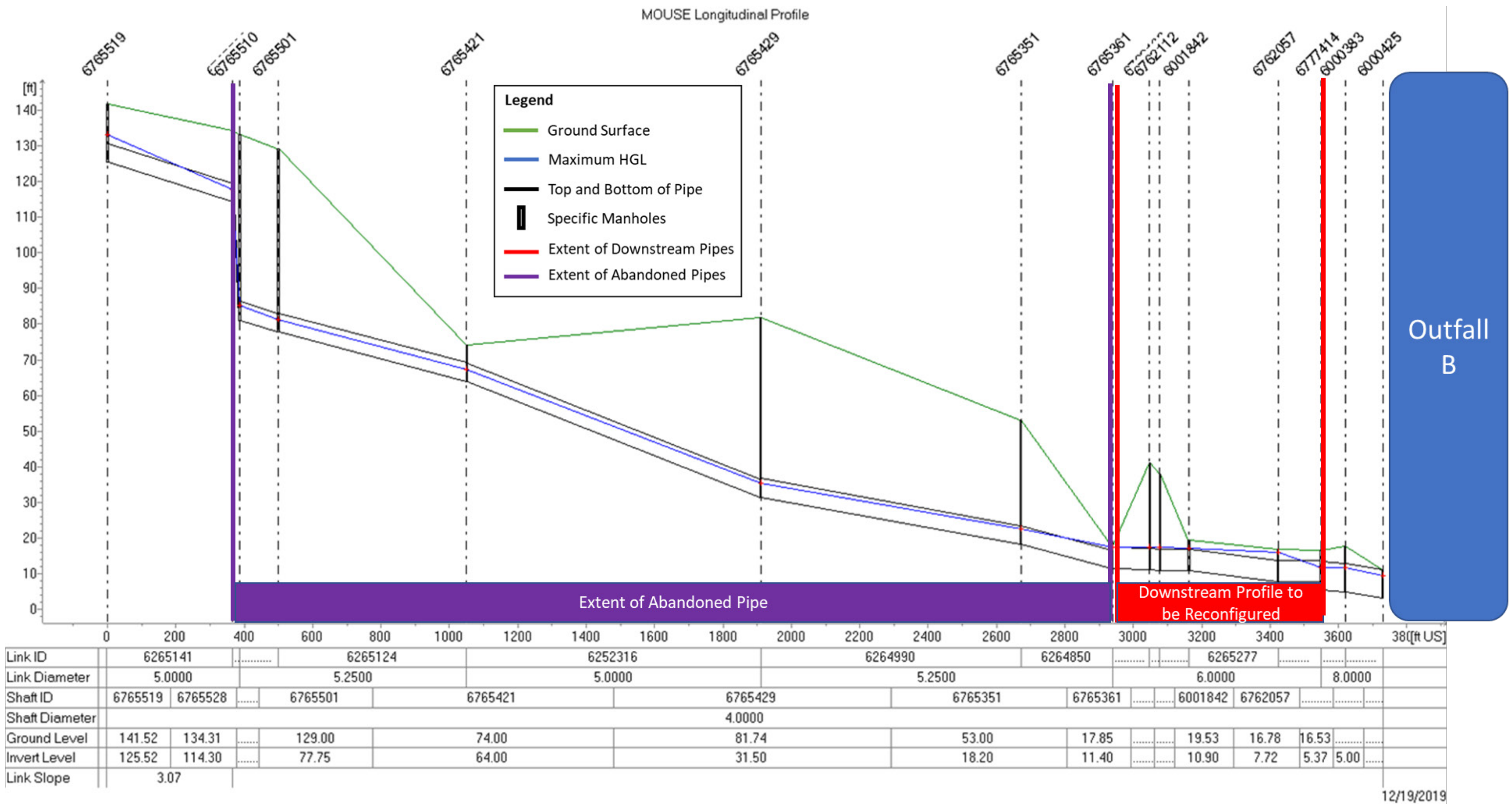


Figure 4 Preferred Scenario Profile for the Abandoned Pipe to Outfall B with the December 2019 Storm HGL

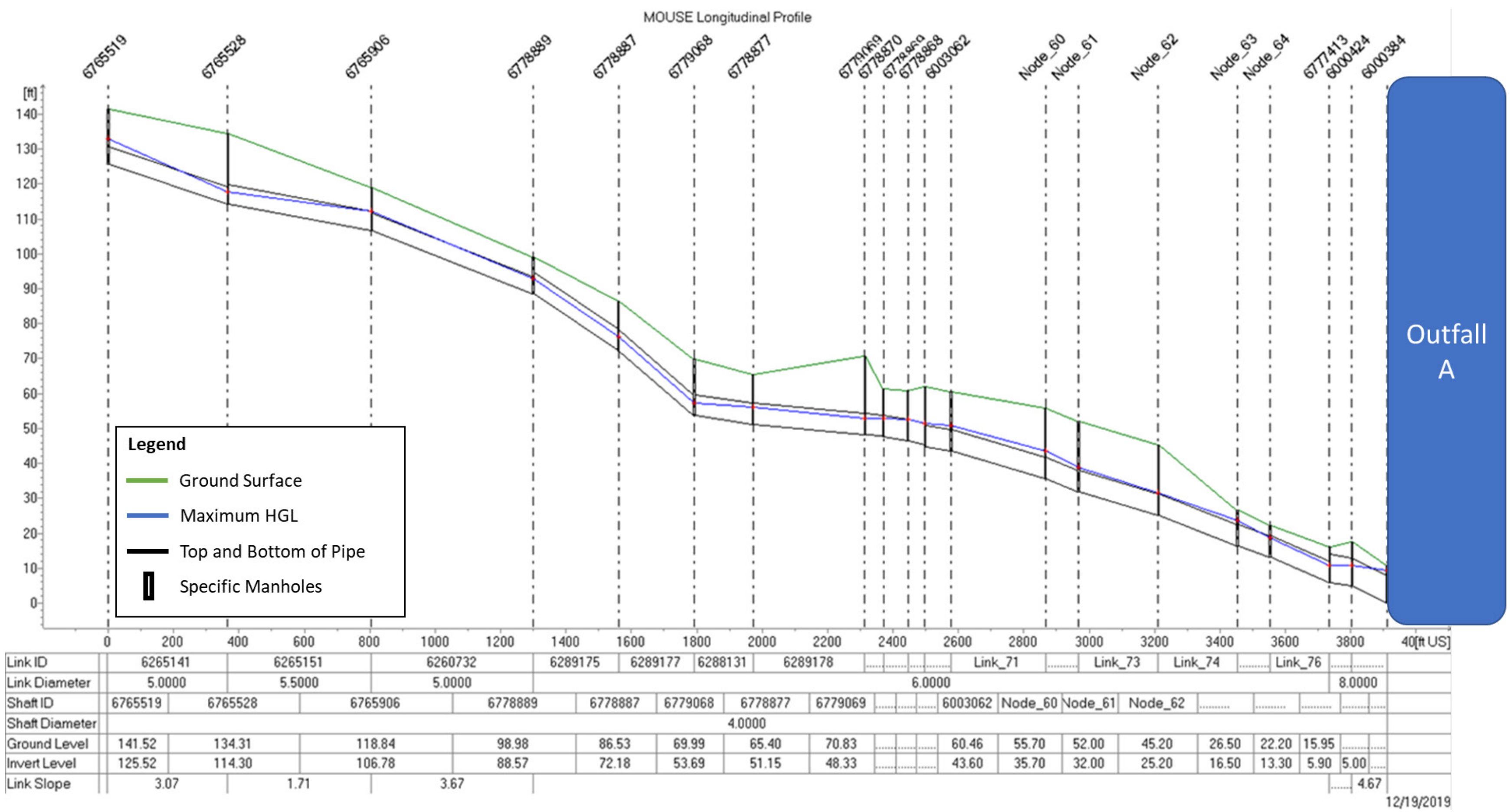


Figure 5 Preferred Scenario Profile for the Existing Pipe to Outfall A with the December 2019 Storm HGL

ES.3 Stormwater and Sanitary Sewer Reconfiguration

To successfully implement the preferred scenario while meeting hydraulic requirements downstream of the Project Area, the following two issues must be addressed:

- Ensure that flows from the City's various design storms are efficiently conveyed out of the Project Area and away from City streets, stormwater piping just upstream of both Outfalls A and B along Puyallup Avenue and Dock Street Yard must be upsized.
- Several conflicts between new and upsized downstream stormwater piping and the sanitary sewer system were identified between Puyallup Avenue and the outfalls. Portions of the sanitary sewer system are not only aging and require rehabilitation but also may not meet the City's current specific design criteria during the design storms.

To resolve these issues, the current pipeline alignments of the downstream sanitary sewer and stormwater systems are recommended to be completely reconfigured along Puyallup Avenue and East 26th Street. Existing pipes will be abandoned or removed and replaced with larger pipelines that lower the risk of flooding in both systems. This joint approach ensures that the two gravity systems meet the City's design criteria while avoiding conflicts between them.

The following sections hydraulically model the new, proposed alignments and recommend improvements that are required to achieve this reconfiguration. These downstream improvements integrate with the preferred scenario's solution and holistically address flooding within the Basin.

ES.3.1 Hydraulic Modeling Methodology and Design Criteria

Proposed improvements to the downstream sanitary sewer and stormwater systems were evaluated using the City's Central Treatment Plant (CTP) collection system model, which was updated in 2020 using the City's GIS data and the calibration verified for this present effort.

The proposed alignments of the two systems were first developed to avoid property line conflicts, minimize utility crossings, remain within the right-of-way wherever possible, and keep conveyance to the existing downstream sanitary pipes and stormwater outfalls. The alignments were then imported into the calibrated hydraulic model, which was used to determine the invert elevations and pipe diameters required to convey flows while keeping the HGLs in criteria for the City's design standards. Note that these are two separate systems, and each have their own design criteria, which are tested under different design storms.

Design standards for the sanitary sewer system measure the system's ability to handle or withstand the peak wet weather flow (PWWF) of a 20-year design event called the November 2003 storm. The following two criteria were used to evaluate and size the buildout sanitary sewer system's pipes during such an event within the City's Mike Urban Model:

- **Criterion A**: New pipes' maximum depth-of-flow-to-pipe-diameter ratio (d/D) must be lower than 0.8 under PWWF.
- **Criterion B**: The maximum allowable HGL for existing system piping during PWWF is 1 foot above pipe crown but less than 3 feet below the MH rim.

Meanwhile, design criteria for the stormwater system evaluate the system's ability to handle or withstand the peak flow rate of the MGS 3-hour design storm and December 2019 storm as well as a 24-hour, 25-year event using a Soil Conservation Services (SCS) Type 1A hydrograph, as required by the City's current 2016 TSWMM.

The following three criteria for new stormwater piping from the most recent 2016 TSWMM for backwater flow conditions delineates:

- Under a 25-year event, there shall be a minimum of 0.5 feet of freeboard between the water surface and the top of any MH or CB.
- Under a 100-year event, overtopping of the pipe conveyance system may occur. However, the additional flow shall not extend half the width of the traveled way's outside lane of or exceed 4 inches in depth at its deepest point.
- All conveyance systems shall be designed for fully developed conditions, which shall be derived from the percentages of proposed and existing impervious areas within the Project site.

These TSWMM requirements formed the basis to establish following pass/fail conditions for this analysis:

- **Condition 1**: Peak HGL of 0.5 feet or greater below an MH's rim elevations during a TSWMM 25-year, 24-hour event.
- **Condition 2**: Peak HGL of 4 inches above an MH's rim during a 100-year, 24-hour event.
- **Condition 3**: No flooding occurs during the MGS 3-hour design storm.
- **Condition 4**: No flooding occurs during the simulation of a December 2019 storm.

ES.3.2 Modeling Results

Implementing the recommended scenario and simultaneously reconfiguring the downstream sanitary sewer and stormwater systems will significantly reduce the risk of flooding at South 26th Street and Pacific Avenue under all design storms while also eliminating conflicts between the two systems, improving the sanitary sewer system's conveyance, and minimizing construction disruptions. With the improvements introduced in the following sub-sections, both systems' new piping will uphold the City's design criteria and performance goals.

Figure 6 shows the recommended layout for the sanitary sewer and stormwater systems. Existing, undersized pipes are shown in purple and proposed to be abandoned. Meanwhile, the proposed gravity sanitary sewer alignment is shown in light blue and the proposed stormwater alignments are shown in yellow.

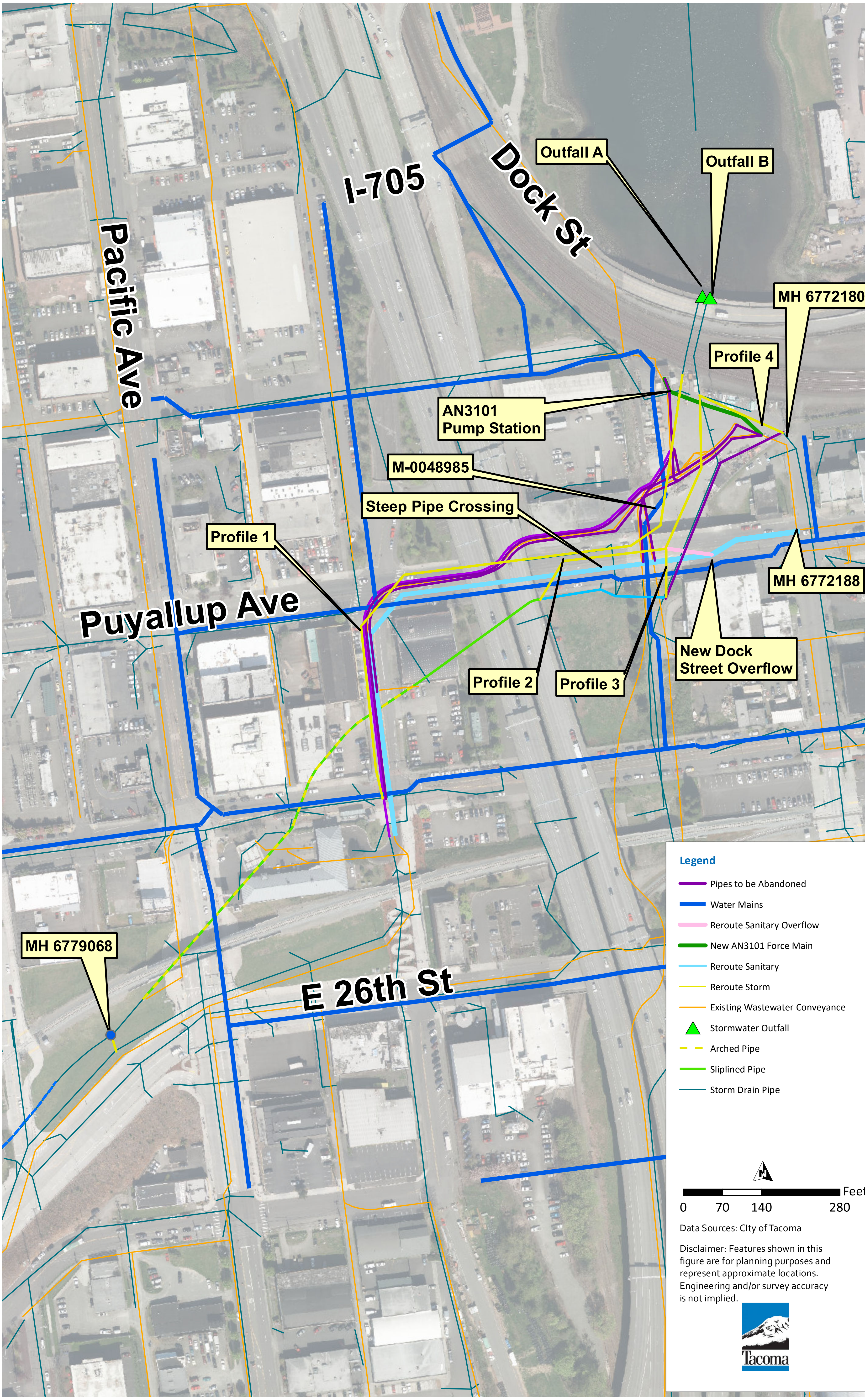


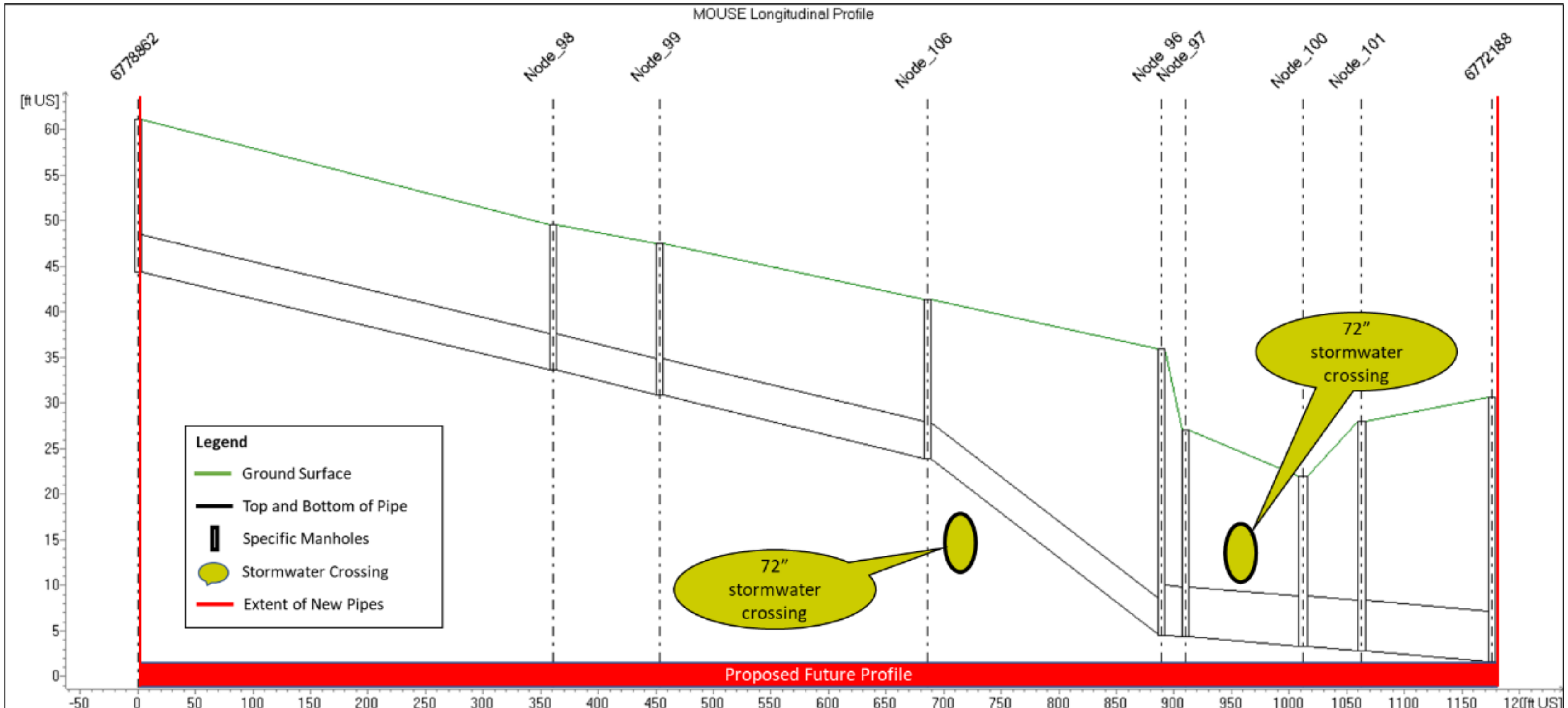
Figure 6 Recommended Stormwater and Sanitary Sewer System Improvements

ES.3.2.1 Improvements to the Sanitary Sewer System

To reconfigure the aging sanitary sewer system between Puyallup Avenue and East 26th Street and achieve the new alignment shown in Figure 6, the following tasks must be completed:

- **Move the AN3101 discharge force main to a new MH**: A new 24-inch-diameter force main is proposed from the AN3101 to MH 6772180, extending an estimated 209 LF. In Figure 6, the relocated discharge force main is shown in dark green.
- **Relocate the Dock Street overflow structure**: The existing structure is Dock Street's controlled overflow point. Modeling shows that this structure must be relocated from MH 6771568 to a newly constructed manhole, upstream from MH 6772188 to avoid flooding the sanitary sewer system downstream of the Project Area during a November 2003 storm. Shown in pink in Figure 6, the new structure was sized with a 7-foot-long weir with a crest elevation of 8.3 feet and a height of 5 feet and connects to the stormwater system using an estimated 86 LF in 48-inch-diameter piping. With these improvements, the new overflow structure conveys a similar peak flow out of the collection system during a November 2003 storm as current overflow is expected to. Even with this flow added as inflow to the stormwater system, Figure 8 shows that the City's stormwater HGL criteria are upheld.
- **Replace the Puyallup Avenue bridge with a fill and retaining wall**: As a part of this project the existing Puyallup Avenue bridge will be removed. The Puyallup Avenue alignment should be completely regraded with fill and a new retaining wall should be constructed on the north side of the street. The new road replacing the bridge will have a similar layout to the existing roadway. The location of this bridge is called out in Figure 6.
- **Steep pipe crossing**: The new sanitary alignment conflicts with the new storm sewer system at two points. Existing up and downstream infrastructure, large diameter pipes for capacity, and ground level elevations limit the options for the sanitary alignment. To avoid interferences with the stormwater system, a steep pipe is recommended so the sanitary system can cross above the stormwater system in the upstream crossing and below the sanitary system at the downstream crossing. Figure 7 shows the sanitary profile and steep pipe along with the stormwater crossing elevations.

Table 1 summarizes all of the improvements required to replace the aging sanitary sewer piping while maintaining system performance and meeting the City's design criteria for new piping.



Link ID	Link_129		Link_130	Link_131	Link_139		Link_133	Link_134	Link_135
Link Diameter	4.0000					5.5000			
Shaft ID	6778862	Node_98	Node_99	Node_106	Node_96	Node_97	Node_100	Node_101	6772188
Shaft Diameter	6.0000						8.0000	6.0000	
Ground Level	61.13	49.50	47.50	41.36	36.00	27.00	22.00	28.00	30.66
Invert Level	44.43	33.60	30.84	23.86	4.54	4.33	3.31	2.80	1.67
Link Slope									

Figure 7 Sanitary System Alignment at Steep Pipe Crossing

Table 1 Sanitary System Improvements Summary

Type	Diameter (inches)	LF / Number of Manholes
Gravity	48	941
Gravity	66	287
Force Main	24	209
Dock Street Overflow	48	86
Dock Street Overflow Structure	120	1
Manholes	84	3
Manholes	96	6

To verify the sanitary system changes do not pose adverse effects, the November 2003 storm (20-year sanitary design storm) was run in the hydraulic model under the Basin's buildout conditions with the original and proposed alignments. Modeling showed that, even with improvements, the risk of flooding remains approximately the same at certain sites outside of the Project Area; however, the proposed alignment will not exacerbate current conditions and, though minimally, still lowers the HGL.

At this time, the HGL cannot be lowered any further without reconfiguring the CTP's headworks, which, under peak flows, is currently limited by hydraulic restrictions. Such a task is beyond the scope of this present effort. The peak HGL through the proposed sanitary alignment with other local system changes is shown in Figure 8 during a 20-year sanitary design storm.

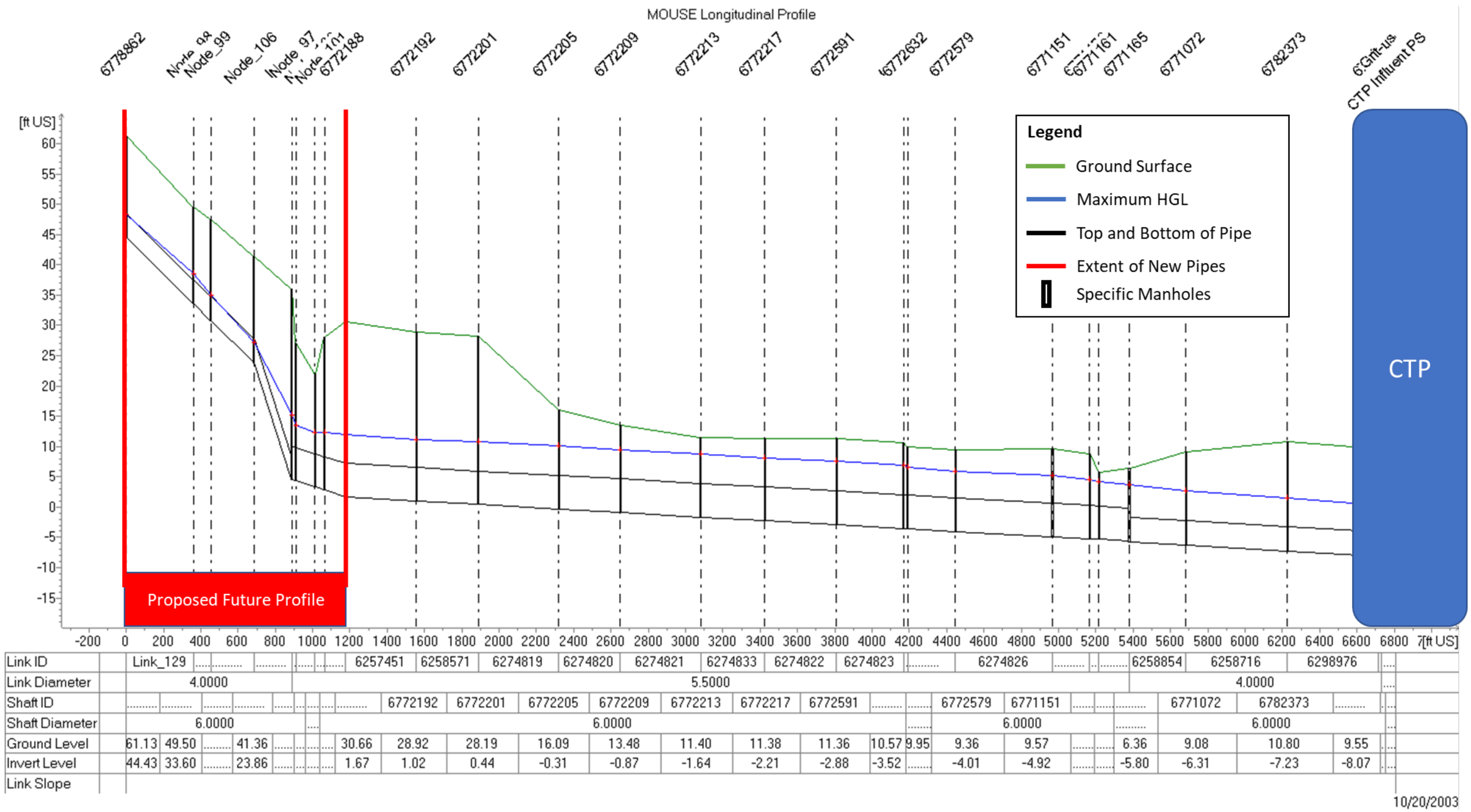


Figure 8 Sanitary Profile and HGL during the 20-year design storm

ES.3.2.2 Improvements to the Stormwater System

As introduced in Section ES.3.1, stormwater piping just upstream of Outfalls A and B must be replaced and reconfigured to increase the stormwater system's capacity to convey flow out of the Project Area, through the collection system, and to each outfall.

The stormwater reconfiguration effort was broken into four separate profiles, each of which is called out and colored yellow in Figure 6: Profile 1 is upstream of Outfall A and referred to as reroute #1, and Profiles 2, 3, and 4 are upstream of Outfall B, collectively referred to as reroute #2. The proposed alignments run into several water main crossings; however, only one downstream crossing with the 12-inch water main M-0048985 must be relocated to avoid conflicts with new stormwater piping. In all other cases, sufficient clearance for pipelines is available without the need for relocation.

Table 2 summarizes the pipelines and MHs needed to improve the four profiles.

Table 2 Stormwater Improvement Summary

Profile	Type	Diameter (in)	LF / Number of Manholes
1	Pipe	72	911
1	Pipe	84	330
1	Manhole	96	4
1	Manhole	108	3
2	Pipe	72	262
2	Pipe	96	284
2	Manhole	96	2
2	Manhole	108	3
3	Pipe	72	90
3	Manhole	96	1
4	Pipe	24	163
4	Manhole	48	1
Upstream of 2 and 3	Slip lining	60/63	1,115 downstream (up to 1,338 LF upstream(1))

Note:

(1) A portion of line upstream from the Project Area should be rehabilitated for existing customers on the segment, the extent required will have to be determined during design.

Modeling results show that, with these improvements, the reconfigured profiles eliminate flooding in the stormwater system under an MGS 3-hour design storm, which was the high-intensity storm used to size the new alignments and other stormwater assets. Even during a TSWMM 24-hour, 25-year event and a December 2019 storm, the proposed configuration maintained appropriate HGLs and met the City's criteria.

Figures 9 and 10 show the entire stormwater profile throughout the Project Area to Outfalls A and B, respectively, with the max HGL from the MGS storm.

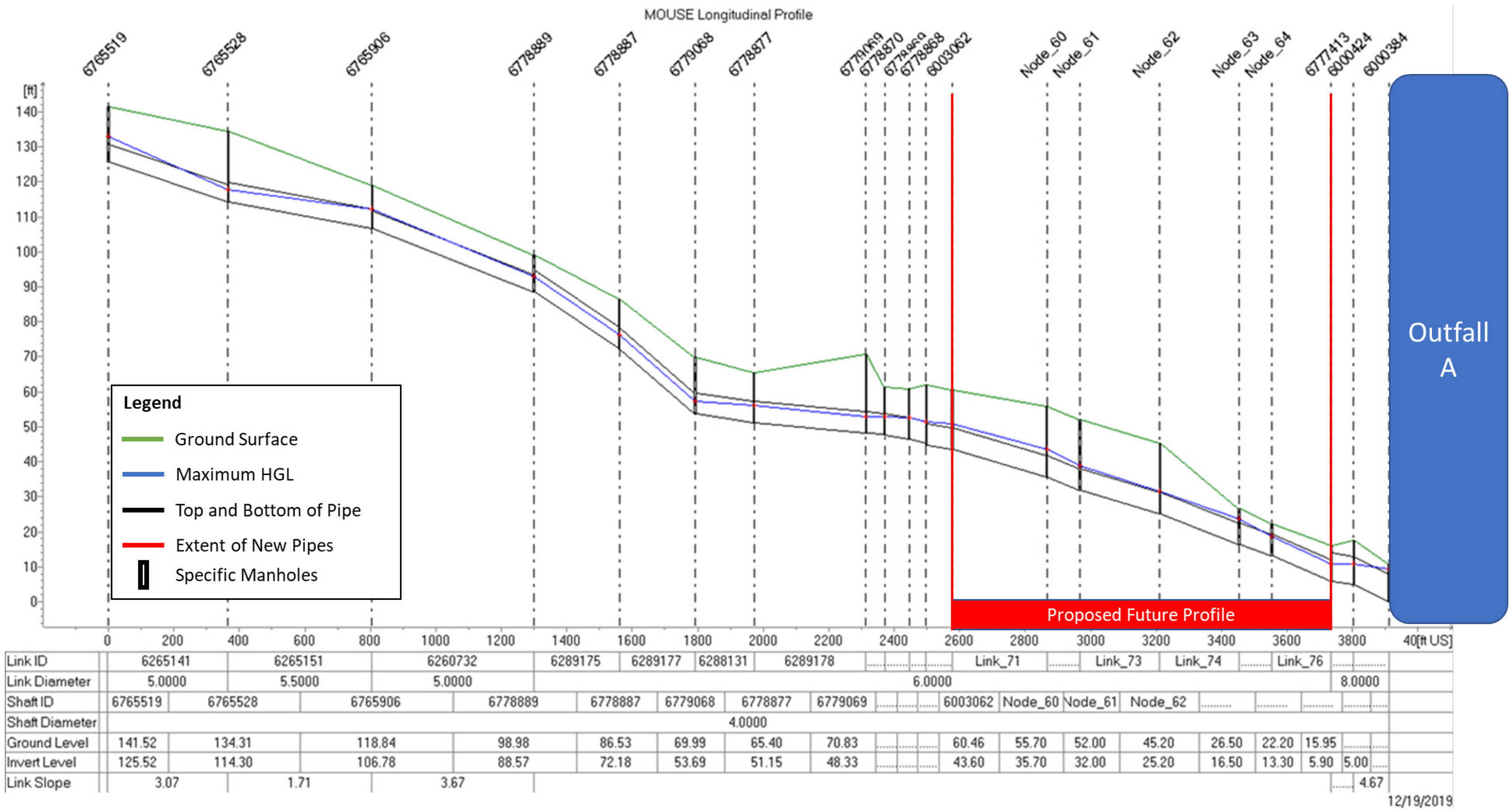


Figure 9 Peak Stormwater HGL with Proposed Piping Improvements to Outfall A for MGS Storm

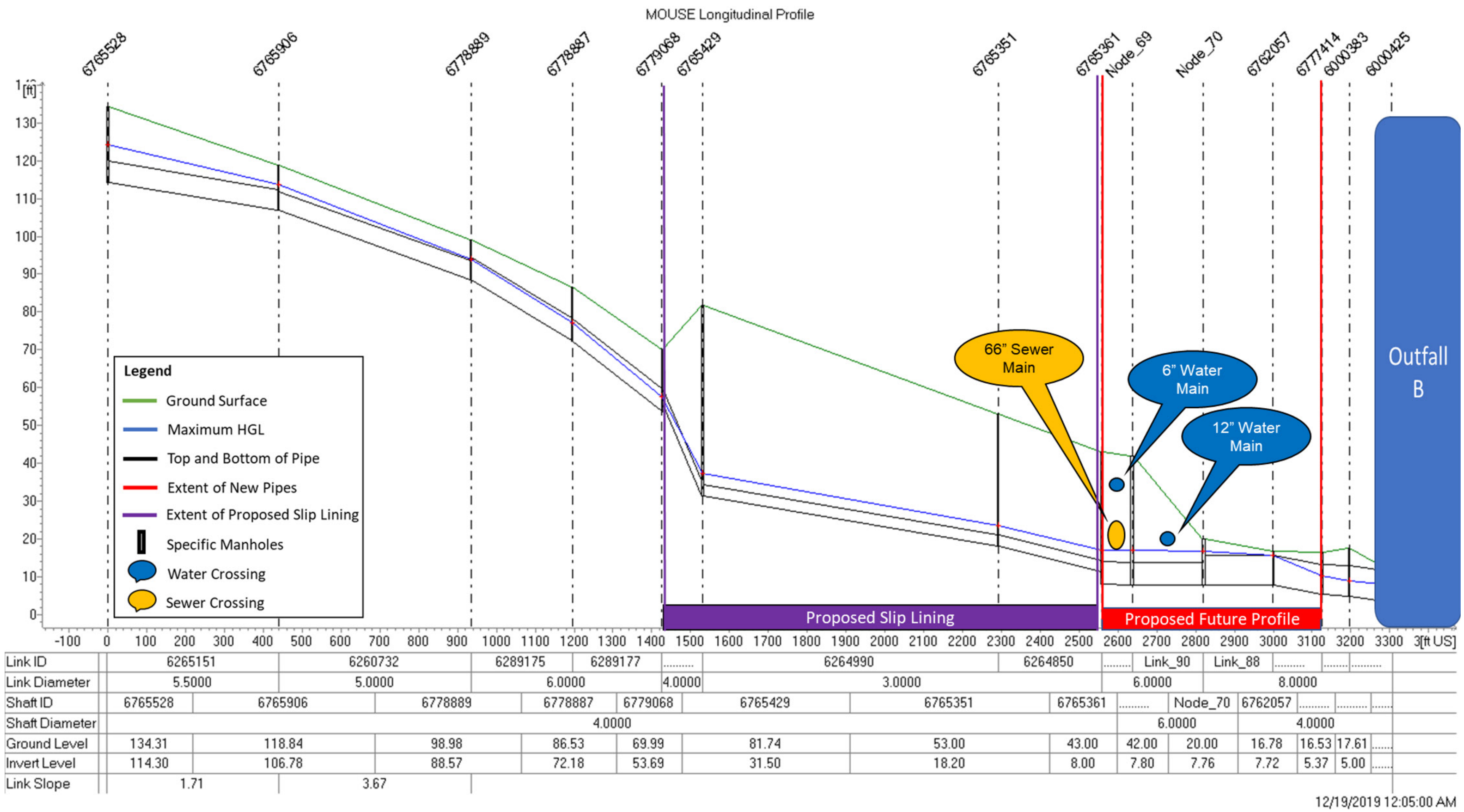


Figure 10 Peak Stormwater HGL with Proposed Piping Improvements to Outfall B for MGS Storm

ES.4 Cost Estimation for the Preferred Scenario and System Reconfiguration

Table 3 presents cost opinions to reconfigure the sanitary sewer and stormwater systems and implement the preferred scenario, which, together, cost an estimated $35.3 million for the total project. These cost opinions follow the Association for the Advancement of Cost Engineering's (AACE) Class 4 designation, which, per *Recommended Practice 18R-97 Cost Estimate Classification System for the Process Industries* (1998), has an expected level of accuracy of -30 percent to +50 percent of the cost presented. Estimations are in 2020 dollars, consistent with the Seattle Engineering News-Record (ENR) value of 12840. Depending on the cost of labor, materials, and equipment and the final design, these costs would have been subject to change. Note that rehabilitation costs were not developed for the section of abandoned pipe upstream from the Project Area, the line should be repaired to the most upstream connection.

Table 3 Cost Opinion of Recommended Improvements by Utility System (in 2020 dollars)

Description	Cost ($ in millions)	Cost Accuracy Range ($ in millions)[4]	
Stormwater System Improvements Project Cost [1,2,3,6]	$15.1	$10.6	$22.7
Sanitary Sewer System Improvements Project Cost [1,2,3,7]	$8.0	$5.6	$12.0
Miscellaneous Shared Work Project Cost [1,2,3,5]	$12.2	$8.6	$18.3
Total Project Cost [1,2,3]	$35.3	$24.8	$53.0

Notes:

(1) Includes a 30 percent design contingency.

(2) Includes engineering, legal, and administration fees and the Owner's reserve for change orders.

(3) The cost estimate herein was developed according to our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo has no control over variances in the cost of labor, materials, or equipment; services provided by others; contractor's means and methods of executing the work or of determining prices; competitive bidding or market conditions; practices; or bidding strategies. Carollo cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown.

(4) The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (AACE, 1998) designation as a "Class 4" estimate with a level of accuracy range (-30 percent to +50 percent).

(5) Includes work that must be completed to facilitate both the storm system and sanitary system improvements. Individual cost items include traffic control, bypass system, and the Puyallup Ave Bridge Removal and Re-Grade.

(6) Costs include storm reroute #1, storm reroute #3, 12-inch watermain relocation, and Task 7.1 Scenario 3 pipeline rehab.

(7) Costs include 24-inch force main replacement, sanitary reroute, and New Dock Street overflow.