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

Technical Memorandum
FLOODING REDUCTION ALTERNATIVES ANALYSIS

FINAL | November 2020

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Date: 2020.11.19 13:18:24-08'00'

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Abbreviations

AACE	Association for the Advancement of Cost Engineering
Basin	Thea Foss Basin
Carollo	Carollo Engineers, Inc.
Center	South Center Street
City	City of Tacoma
GIS	geographic information system
HGL	hydraulic grade line
I-705	Interstate 705
LF	linear feet
MG	million gallons
MGS	MGS Engineering Consultants, Inc.
MH	manhole
Pine	South Pine Street
Project	D-to-M Streets Track & Signal Project
RCP	Representative Concentration Pathways
ST	Sound Transit
TM	technical memorandum
TSWMM	City of Tacoma 2008 Surface Water Management Manual

Section 1

D-M MODELED ALTERNATIVES ANALYSIS

1.1 Introduction

The D-to-M Streets Track & Signal Project (Project) was completed by Sound Transit (ST) as part of a larger expansion of a regional rail line within Western Washington. This 19 acre portion of the expansion reconstructed City of Tacoma (City) streets from South 'D' Street to South 'M' Street and installed a new rail bed and regraded existing rail bed. The Project relocated over 4,000 linear feet (LF) of storm drainage pipe, replacing piping within the area with new pipe diameters ranging in size from 12 inches to 72 inches. Figure 1 shows a map identifying the Project area.

Figure 1 Project Location Map

The new stormwater system has been observed to flood in the project area during large rain events. Both a backwater[1] analysis (Task 2.1) and storm event analysis[2] (Task 2.3) using the City's Mike Urban conveyance model showed the system likely floods during 25-year storm(s),

[1] Final Technical Memorandum Stormwater Quantitative Analysis, Carollo Engineers, Inc., February 2019

[2] Draft Technical Memorandum Thea Foss Basin Event Evaluation, Carollo Engineers, Inc., March 2019

which does not meet City design guidelines outlined in the 2008 Surface Water Management Manual (TSWMM)[3] in place at the time of the Project.

1.2 Purpose

The purpose of this task is to evaluate potential solutions that meet TSWMM requirements to alleviate flooding 1) within the Project area as well as 2) approximately 2.2 miles upstream near the City's intersection of South Center Street (Center) and South Pine Street (Pine) that had previously led to property damage. This technical memorandum (TM) summarizes the potential solutions evaluated using the City's Mike Urban model (previously updated Task 2.3 - Event Evaluation) to address flooding within the Thea Foss Basin (Basin) including:

- Six scenarios in the Project area.
- Two storage scenarios in the upstream Center and Pine area. These two scenarios evaluated if the upstream flooding impacted the Project area flooding, and if upstream improvements could reduce Project area flooding.

Section 2
DESIGN STORMS

Design storms are rainfall events that dictate the capacity basis for sizing new infrastructure and analyzing the performance of the existing infrastructure.

2.1 Storm Selection

This task evaluated two design storms:

- Design Storm 1: a synthetic, short-duration high intensity event that has been recently developed for the City labeled as the MGS Engineering Consultants, Inc. (MGS)[4] 3-hour design storm
- Design Storm 2: a historical recorded event that caused observed flooding in the Basin and labeled as the December 2019 storm

Statistics for the two design storms are summarized in Table 1, and rainfall hyetographs for each event are presented in Figure 2. The synthetic MGS event was used to refine alternatives for climate change preparedness. However, the December 2019 storm characteristics exhibited the controlling rainfall parameters for assessing the storm system response for the alterative improvement scenarios.

[3] Surface Water Management Manual, City of Tacoma, September 22, 2008.
[4] Recommendations for Design Storms for Use in Hydraulic Modeling in Tacoma Washington, MGS Engineering Consultants, Inc. December 9, 2016

Table 1 Design Storm Comparison

Storm Event	Peak Hourly Rainfall (in/hr)	3-Hour Rainfall (in/3 hr)	24-Hour Rainfall (in/24 hr)
MGS 3 Hour Design Storm[1]	0.41	1.05	1.05
December 2019 Storm[2]	0.46	1.20	3.52

Notes:
Abbreviations: in – inch; hr – hour.
(1) Proposed design storm under consideration by the City for incorporation into the TSWMM.
(2) Actual recorded storm event that led to flooding.

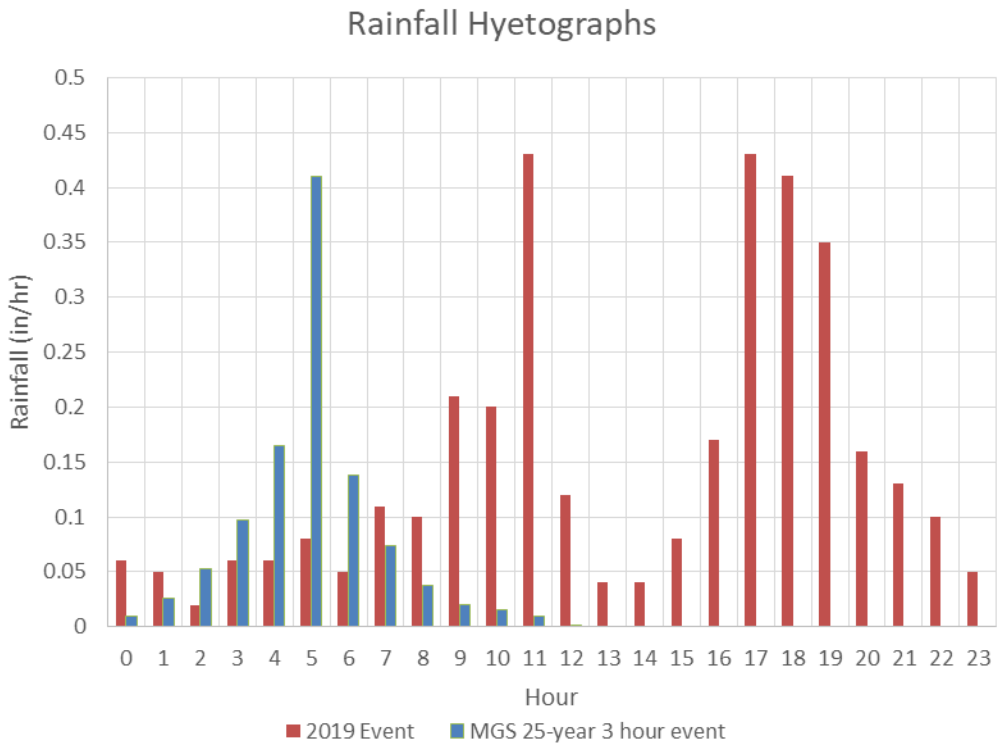


Figure 2 Rainfall Hyetographs

2.2 Model Comparison of December 2019 Flooding

The December 2019 storm event had a similar 24 hour rainfall (3.52 inches) volume as the TSWMM defined 25-year storm event (3.5 inches). As previously stated, this event resulted in considerable observed flooding within the Project area. The City's Mike Urban model run simulating the December 2019 event showed potential for flooding in the Project area as identified in Figure 3. Although no significant events that led to road closures were recorded elsewhere in the Basin, the simulation projected potential flooding throughout other areas of the Thea Foss Basin as well. For reference, the Center and Pine area has also been identified in Figure 3 as there has been recorded historically flooding in this intersection.

Figure 4 is a closer view of the downstream end of Basin through the Project vicinity identifying potentially flooding manholes, starting at manhole (MH) 6779068 and continuing downstream to the east. The calculated hydraulic profile through the 26th and Pacific intersection and vicinity is

shown in Figure 5 and paired with historical photos taken while those manholes were flooding during the storm event. For this pipe profile figure, and all subsequent hydraulic profile figures, the ground level is the green line, the black lines are the infrastructure including top and bottom of pipe, as well as MHs, and the blue line is peak hydraulic grade.

Figure 6 shows the peak hydraulic profile through the primary interceptor in the Basin starting at Center and Pine area going from west to east through the D-M Project area and discharging at Outfall A. There is a secondary outfall (Outfall B) that discharges flow collected from another interceptor that runs from south to north through the eastern side of the basin. Although the piping between the two outfalls is not intentionally interconnected, a single old pipe (that currently does not carry much flow and was classified as abandoned) connects the two outfall areas.

As the model closely matched the storm conditions near 26th & Pacific for the December 2019 rainfall event, this storm was used for initial evaluation for sizing system improvements in the Project area.

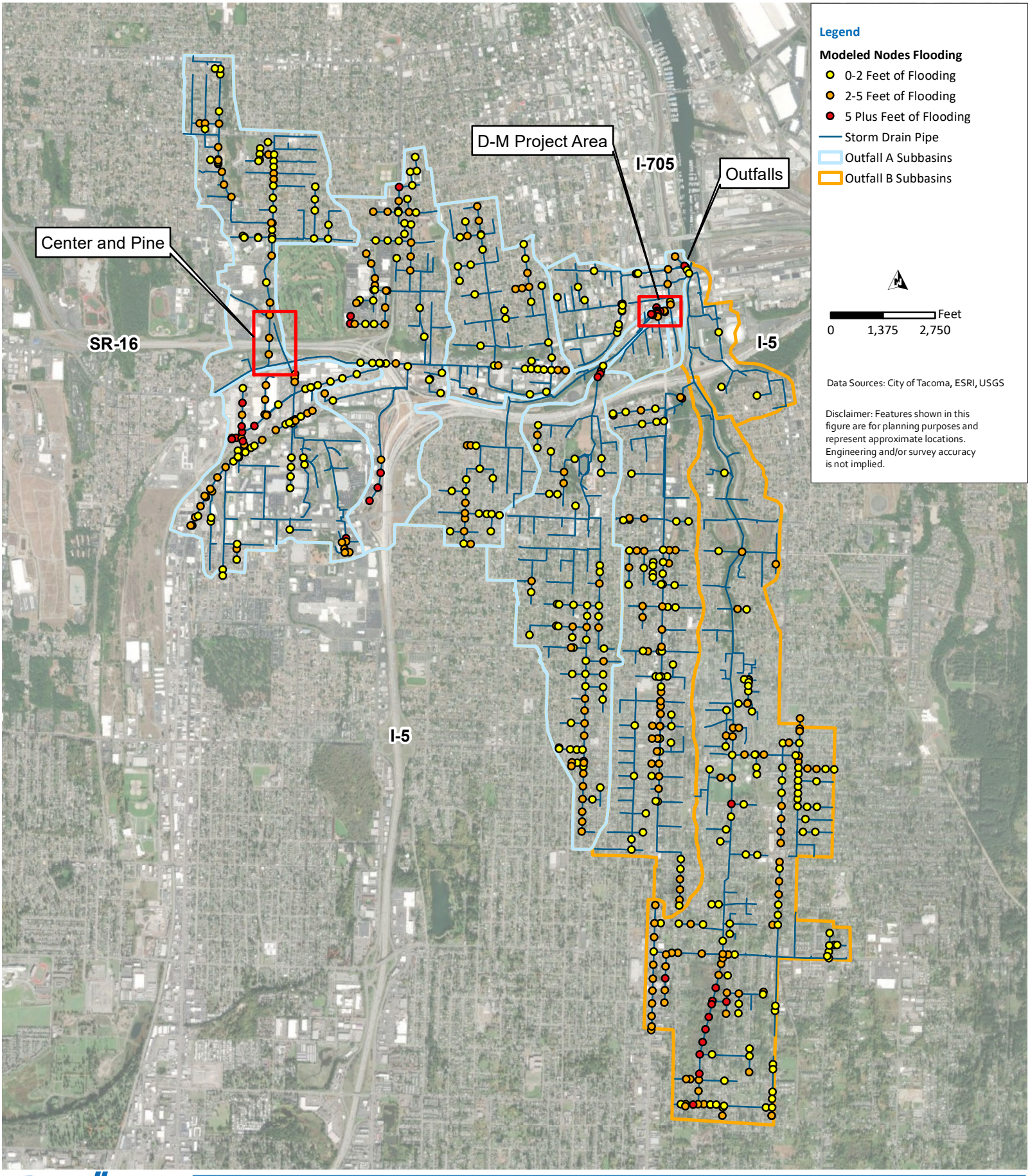


Figure 3 December 2019 Event Overview of Thea Foss Basin

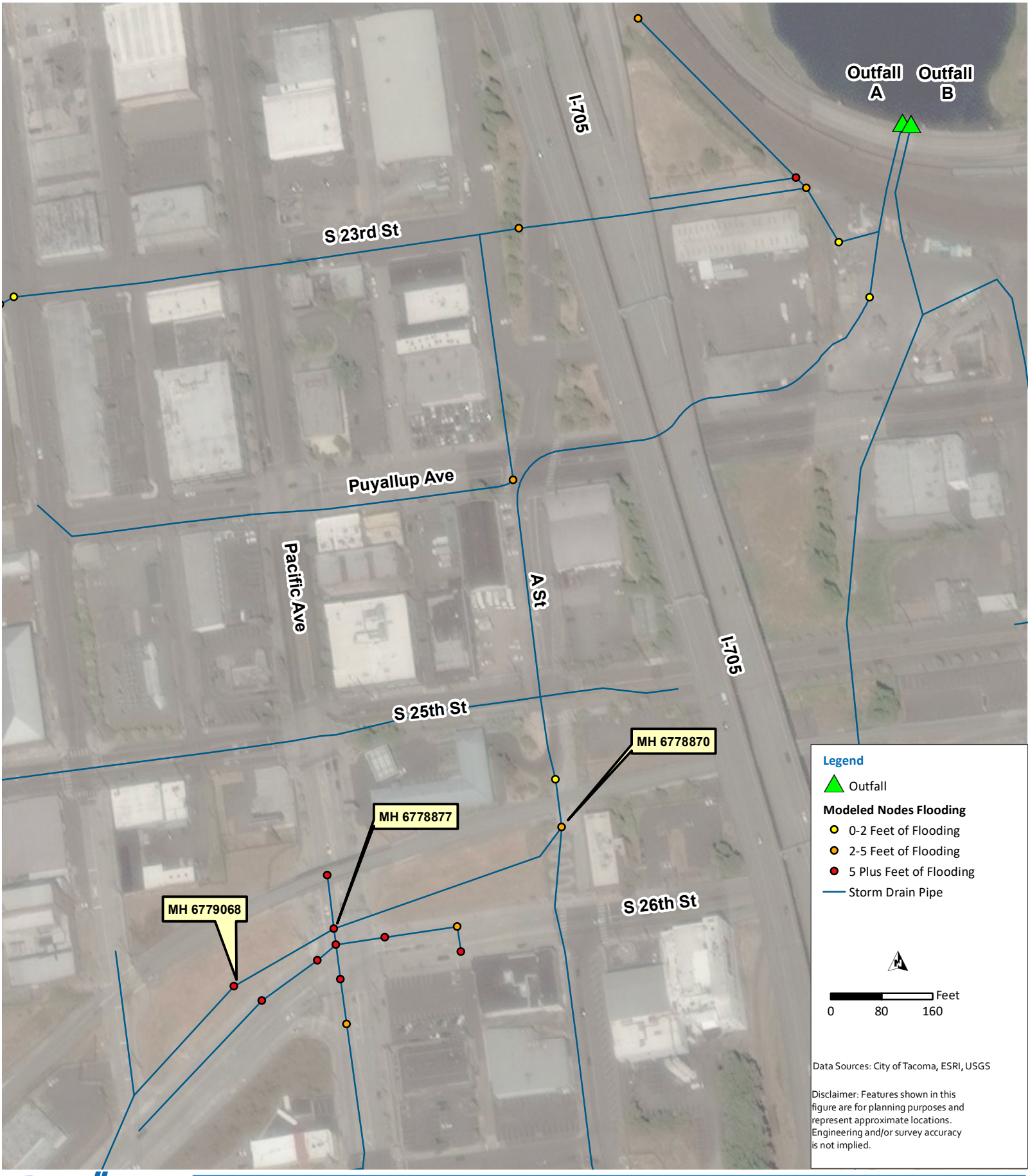


Figure 4 Project Area Overview During December 2019 Event

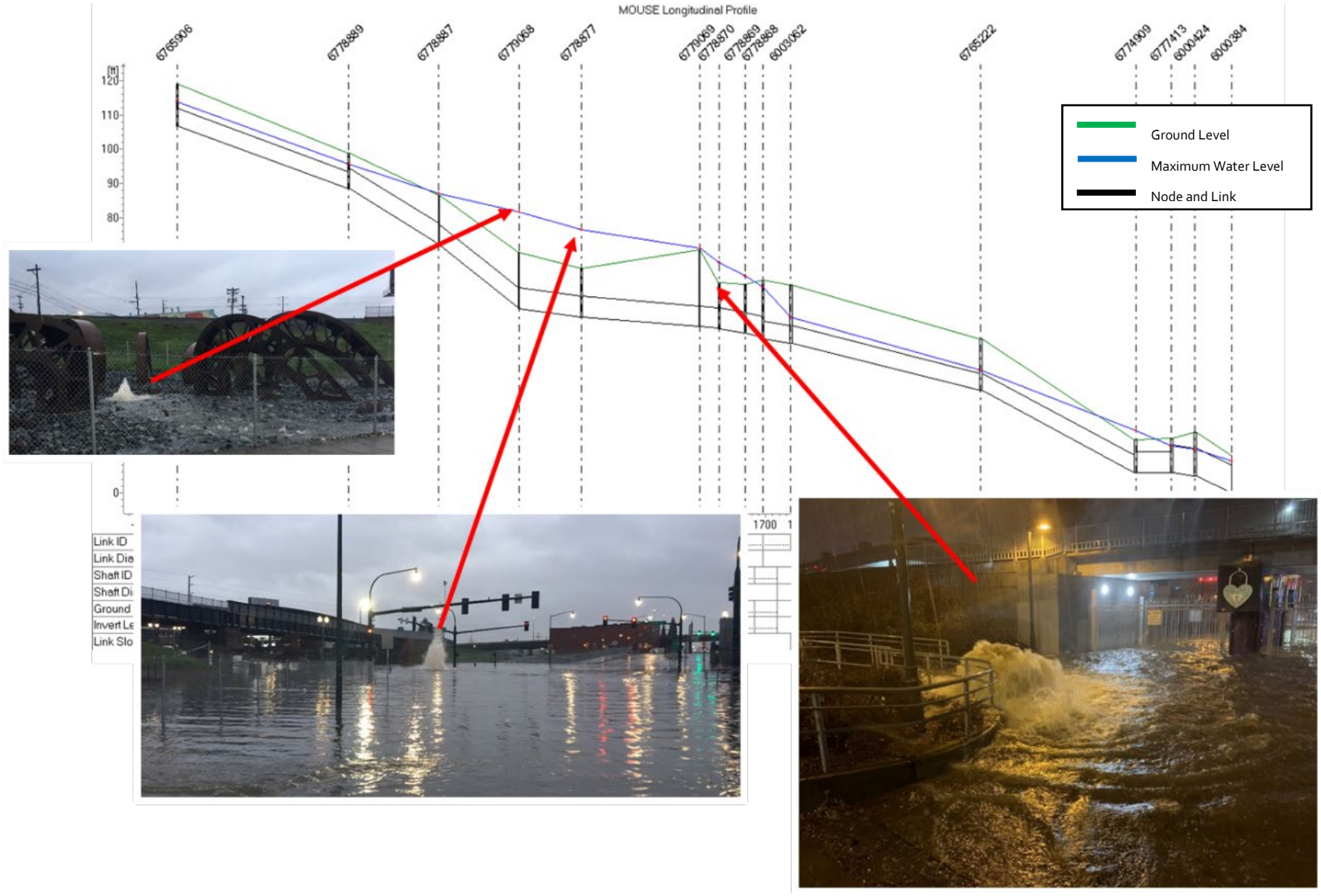


Figure 5 December 2019 Event Profile of Project Area

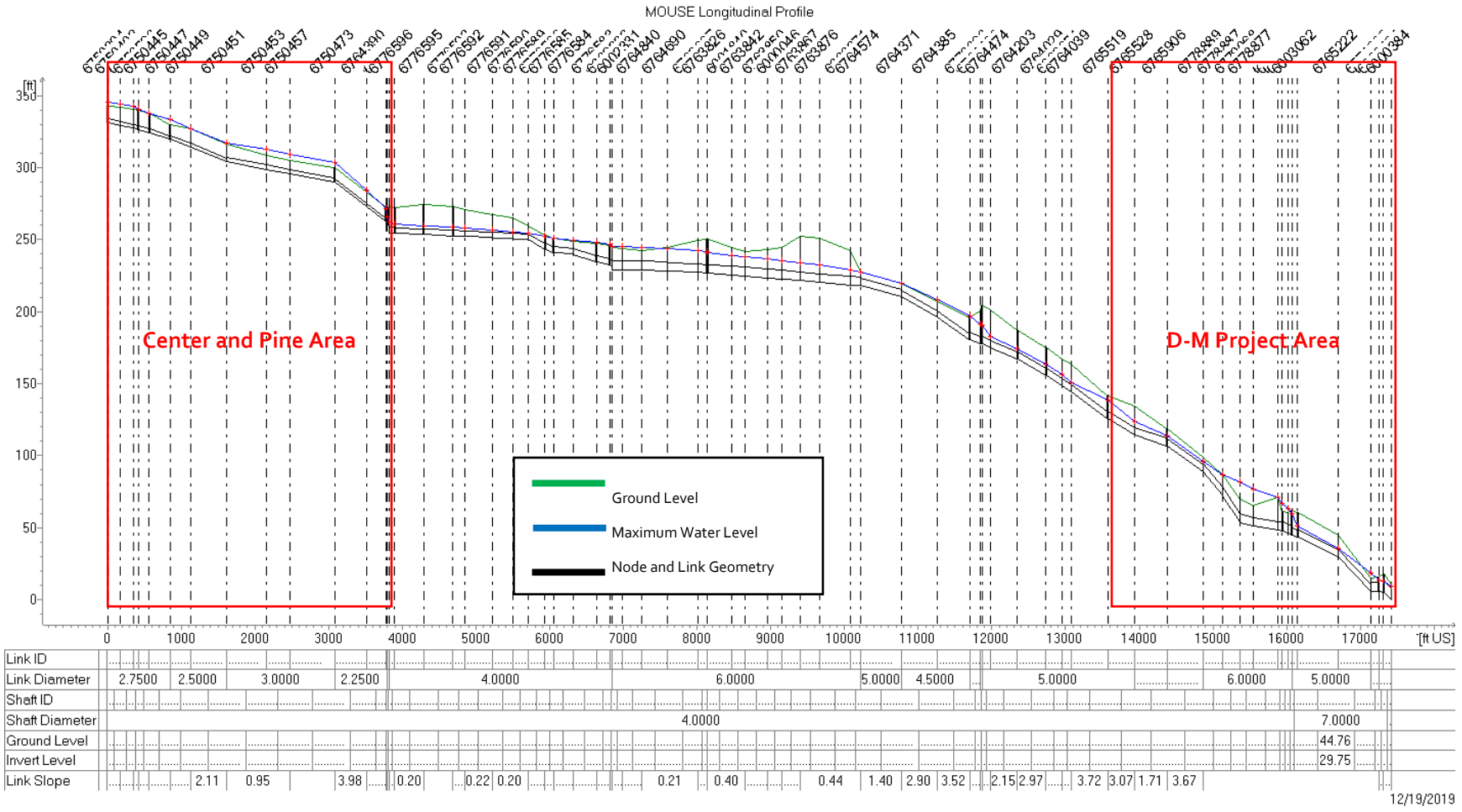


Figure 6 Peak Hydraulic Profile along Primary Interceptor to Outfall A

Section 3

FLOODING ALTERNATIVES ANALYSIS

Peak flows are generally managed either through sufficient conveyance capacity or storage attenuation of peaks. Options evaluated to eliminate flooding in the Project area are reviewed in Section 3.1. Section 3.2 evaluates options to reduce flooding at Center and Pine, as well tests further for any flooding relationship between the two areas.

3.1 Project Area Improvements Scenarios

Six improvement scenarios, as summarized in Table 2, were developed and tested using the model. These options consisted of adding a parallel piping to enhance the system capacity from the Project area to as far downstream as Outfall A, rehabilitation of abandoned piping to Outfalls A or B, a new pipe to outfall B, and storage. Figure 7 shows the locations and geometry of each scenario improvement.

Table 2 Modeled Scenario Summary for Project Area

Scenario	New Infrastructure Description	Additional Pipe Length (LF)	Pipe Diameter (inches)	Storage (MG)
1	Parallel piping within Project area	1,095	72	---
2	Parallel piping from Project area to Puyallup Ave and I-705	1,600	72	---
3	Rehabilitate abandoned Pipe to Outfall B	3,362	60, 63, and 72	---
4	Rehabilitate abandoned pipe and reconnect to Outfall A	3,106	60, 63, and 72	---
5	Storage	---	---	Up to 48 MG
6	Pipe to Outfall B	1,761	60	---

Note:
Abbreviations: MG – million gallons; I-705 – Interstate 705.

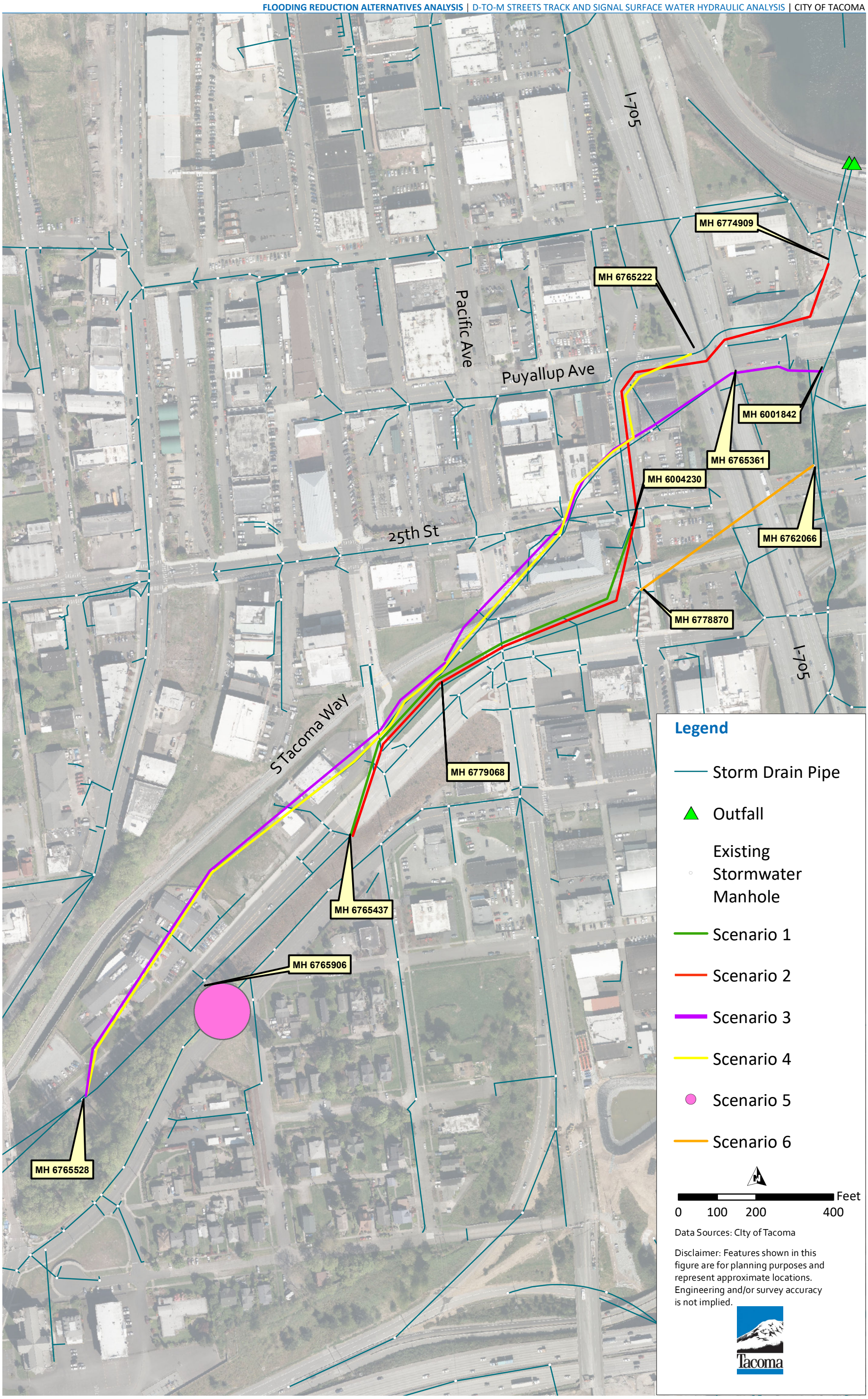


Figure 7 Project Area Improvement Scenario Alignments

3.1.1 Scenario 1

Supplementing the storm water interceptor in the Project area with a new 72-inch diameter parallel interceptor was presented previously in Task 6.1[5] as a potential solution to increasing capacity through the Project area. This previous effort assumed upstream and downstream conditions were ideal and met the TSWMM conditions, with the new parallel pipe installed between MH 6765437 and MH 6004230.

Adding the proposed parallel piping to the City's Mike Urban model and simulating the December 2019 event showed 1) flooding was significantly reduced but would still occur with the supplemental parallel pipe and 2) no flooding in the existing pipe. The flooding with the TSWMM sized parallel pipe was identified with the introduction of the more complete dynamic storm simulation, which captured the complete system hydraulics in the Basin and accounted for existing downstream restrictions. The calculated peak hydraulic profile is shown in Figure 8 for the parallel pipe (the existing pipe is not shown) with the three flooding MHs circled in red.

3.1.2 Scenario 2

To fully alleviate the remaining flooding issues from Scenario 1, Scenario 2 extends the length of the 72-inch parallel interceptor over 500 ft downstream to MH 6774909 to lower the hydraulic grade line (HGL) at MH 6004230, and match the assumed conditions from the Task 6.1 TM. By adding capacity to the downstream segment, flooding during the December 2019 event is eliminated in both the existing (Figure 9) and proposed (Figure 10) parallel pipe in the Project area. The downstream parallel piping size and route were assumed to be a generally viable alternative. However, there could be conflicts with the sanitary system between Puyallup Avenue and the outfall that would need to be fully considered with possible realignment or grade reconfiguration of the sanitary system in this area.

3.1.3 Scenario 3

Scenario 3 and 4 both evaluate rehabilitating an abandoned 96-inch pipeline owned by the City to limit the extent of new pipe construction. The abandoned pipe section was added to the model from the City's GIS records. For Scenario 3, the abandoned pipe would be rehabilitated from upstream of Puyallup Ave (MH 6765528 to MH 6765361) and resized at a new grade downstream from Puyallup Ave (MH 6765361 to MH 6001842) to increase capacity. The abandoned pipe connects to Outfall B, which diverts some of the existing flow away from Outfall A. Figure 11 shows no flooding in the existing pipe to Outfall A and Figure 12 shows no flooding occurs for the hydraulic profiles through the abandoned pipe to outfall B when simulating the December 2019 storm. This option would require 2,796 feet of rehabilitated pipe and 566 feet of upsized or regraded pipe. Similar to Scenario 2, the downstream new and upsized piping could have conflicts with the sanitary system between Puyallup Avenue and the outfall. The sanitary system may also require realignment or grade reconfiguration in this area.

[5] Technical Memorandum Stormwater Conceptual Design Report (Full Buildout), Carollo Engineers, Inc., February 2020

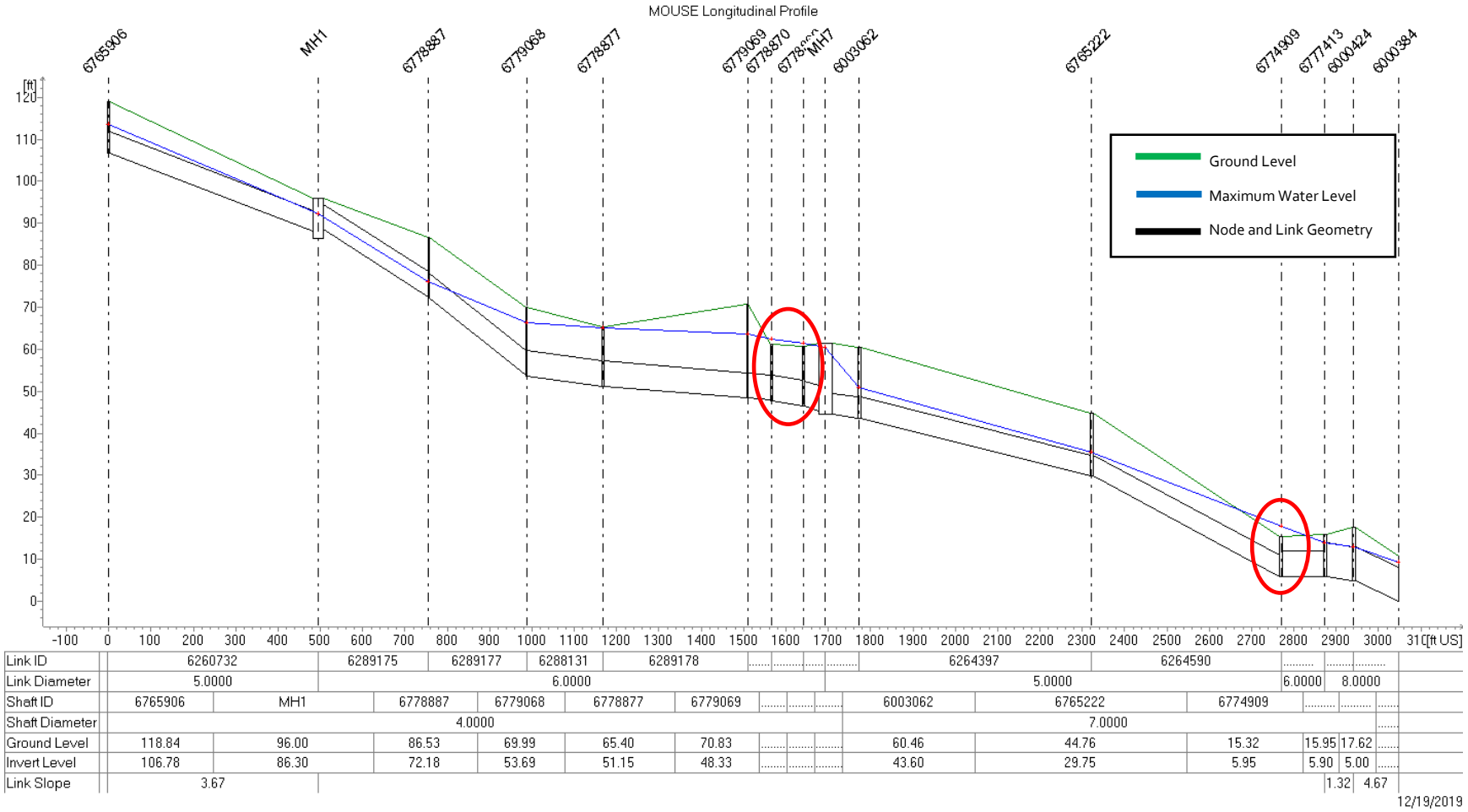


Figure 8 Scenario 1 Profile in Task 6.1 Parallel Pipe

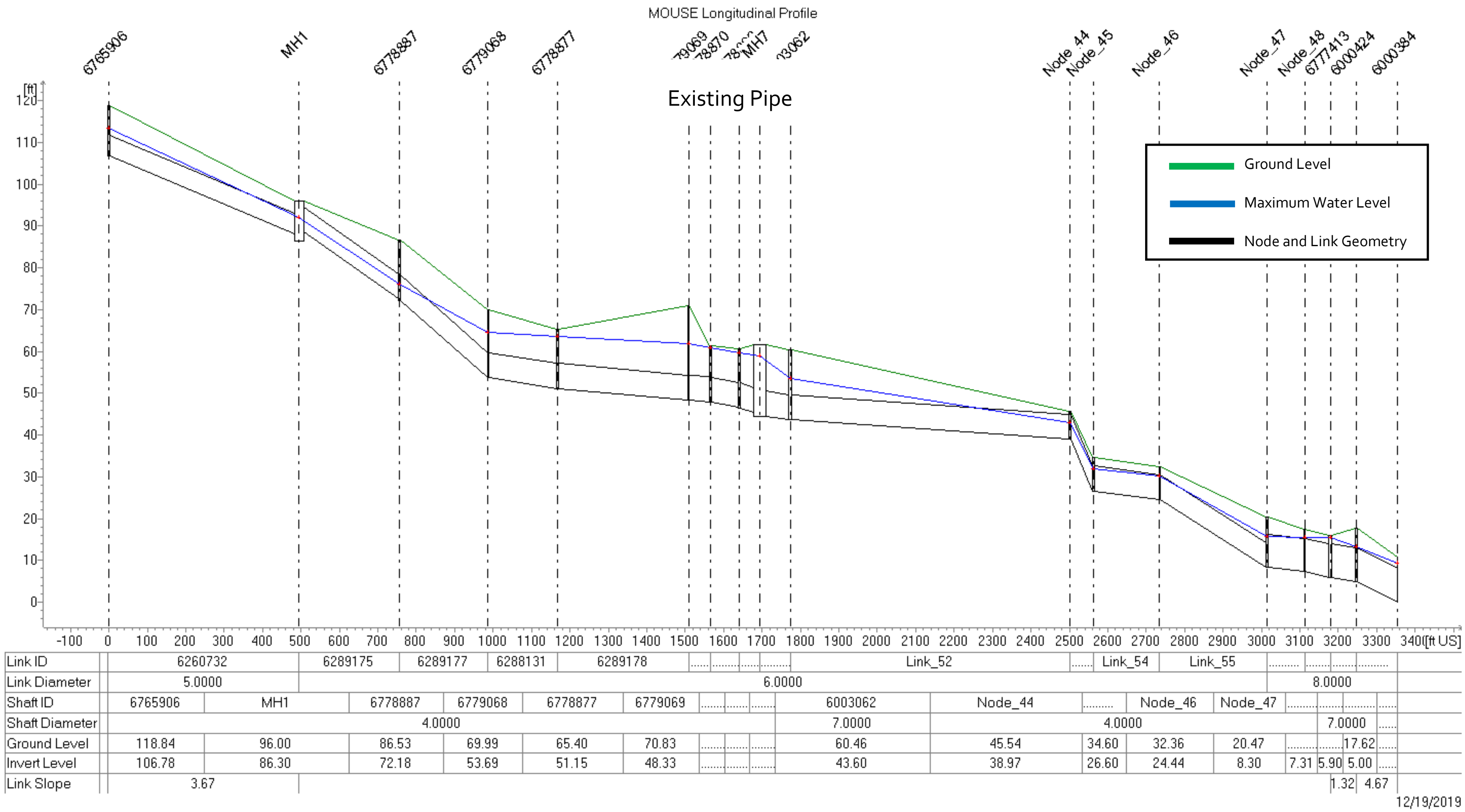
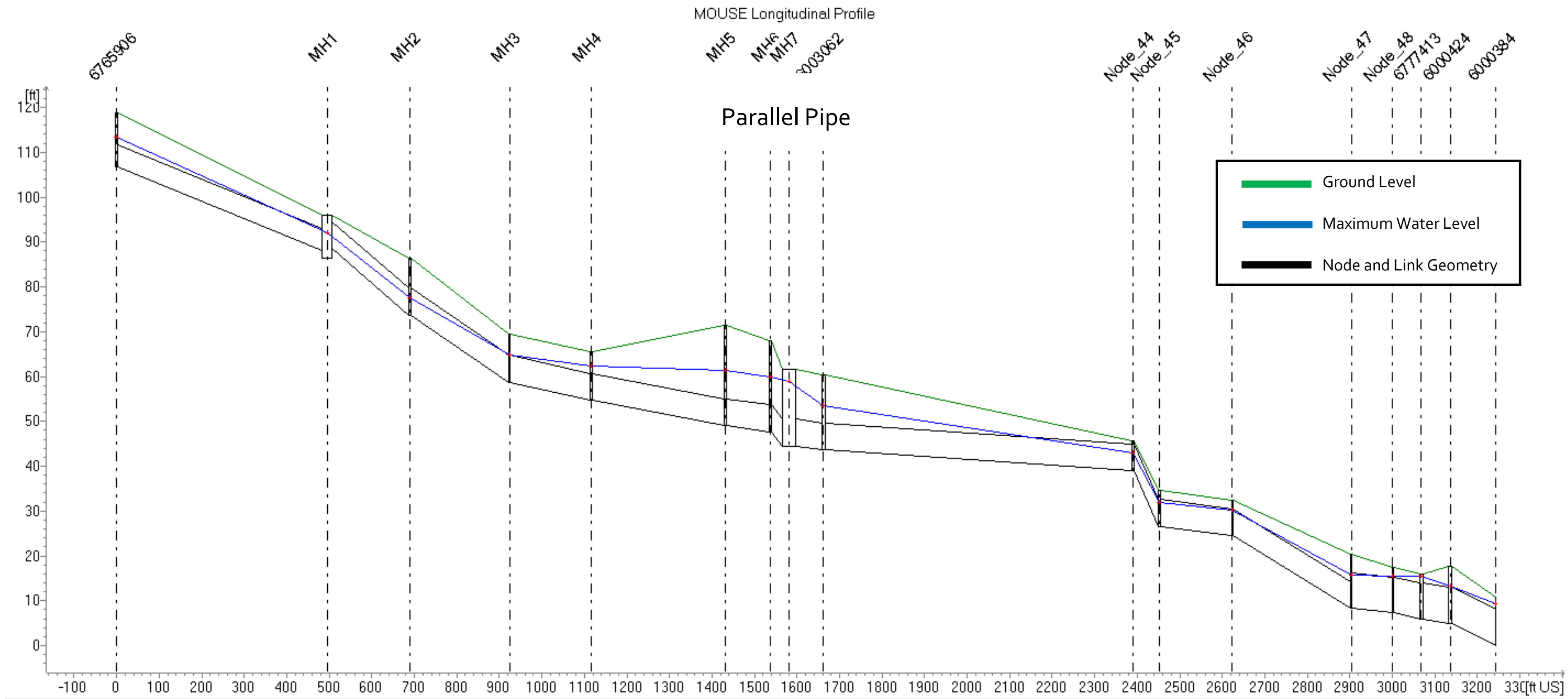


Figure 9 Scenario 2 Existing Pipe Profile



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Shaft ID	6765906	MH1	MH2	MH3	MH4	MH5	MH6	....	6003062	Node_44	....	Node_46	Node_47	....	....	....	.....
Shaft Diameter	4.0000	7.0000	4.0000	7.0000	.....											
Ground Level	118.84	96.00	86.50	69.50	65.50	71.50	....	....	60.46	45.54	34.60	32.36	20.47	17.33	....	17.62	.....
Invert Level	106.78	86.30	73.70	58.68	54.71	49.05	....	....	43.60	38.97	26.60	24.44	8.30	7.31	5.90	5.00	.....
Link Slope	3.67	1.32	4.67													

12/19/2019

Figure 10 Scenario 2 Parallel Pipe Profile

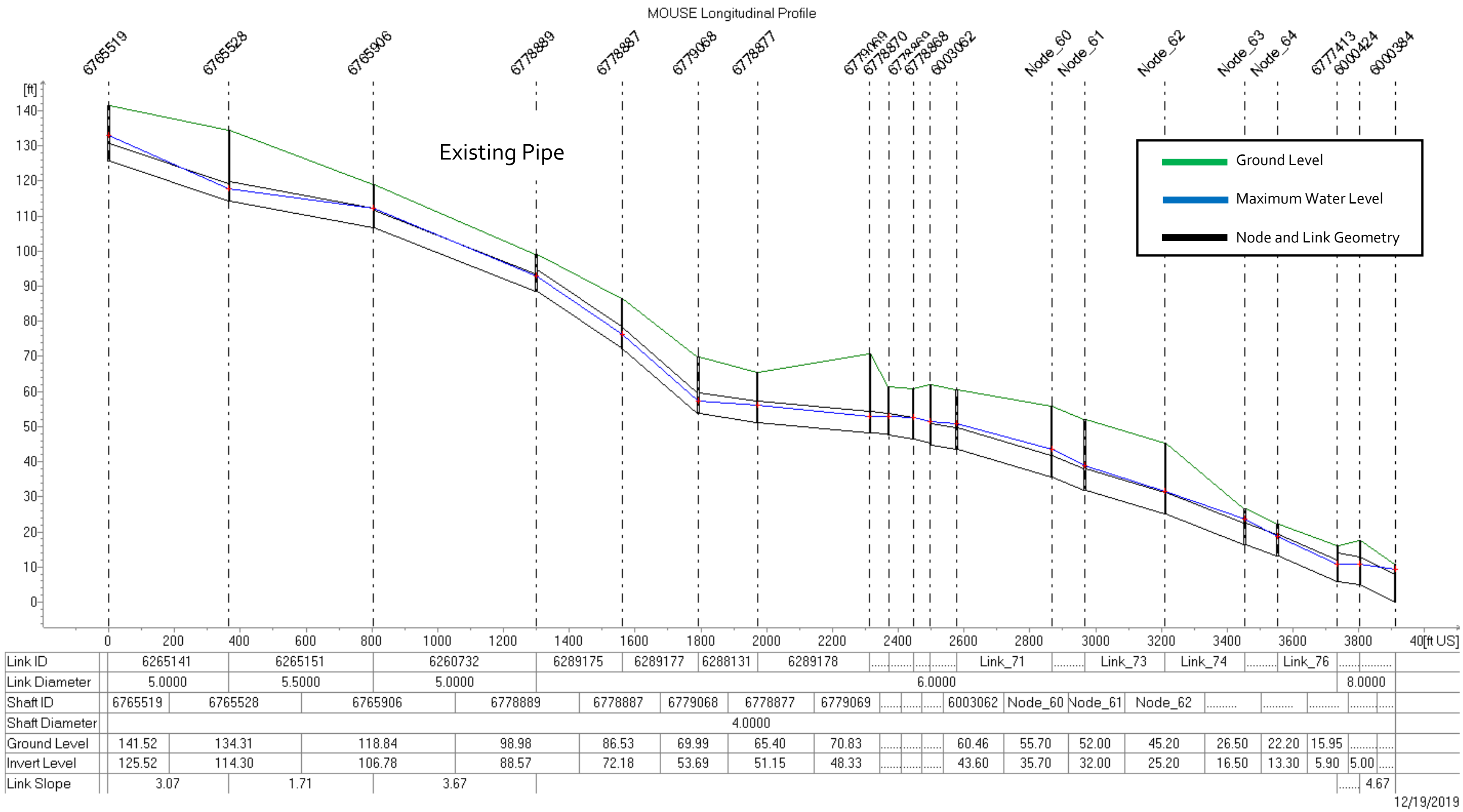
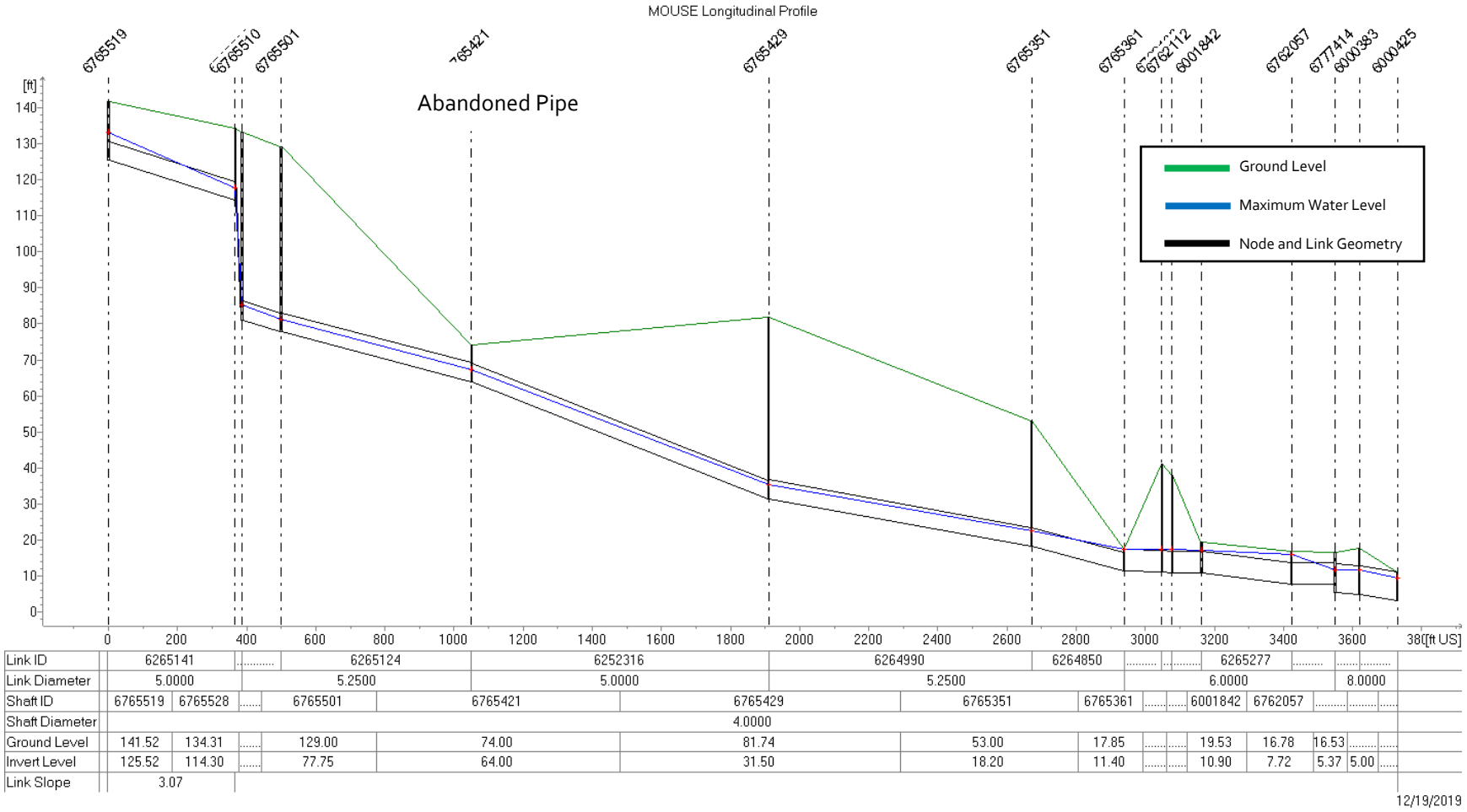


Figure 11 Scenario 3 Profile for Existing Pipe



Link ID	6265141			6265124		6252316		6264990		6264850			6265277									
Link Diameter	5.0000			5.2500		5.0000		5.2500					6.0000				8.0000					
Shaft ID	6765519	6765528		6765501		6765421		6765429		6765351		6765361			6001842	6762057						
Shaft Diameter	4.0000																					
Ground Level	141.52	134.31		129.00		74.00		81.74		53.00		17.85			19.53	16.78	16.53					
Invert Level	125.52	114.30		77.75		64.00		31.50		18.20		11.40			10.90	7.72	5.37	5.00				
Link Slope	3.07																					

Figure 12 Scenario 3 Profile for Abandoned Pipe

3.1.4 Scenario 4

Scenario 4 is very similar to Scenario 3, in that it makes use of the abandoned pipe. However, instead of diverting flows to Outfall B at MH 6765361, a new pipe would be installed from the abandoned pipe to connect back to Outfall A at MH 6765222. Similar to Scenario 3, some downstream upsizing (MH 6774909 to MH 6777413) is needed to increase capacity. The HGL in Figures 13 and 14 show flows could be conveyed without flooding impacts during the December 2019 event with the new upsized pipe.

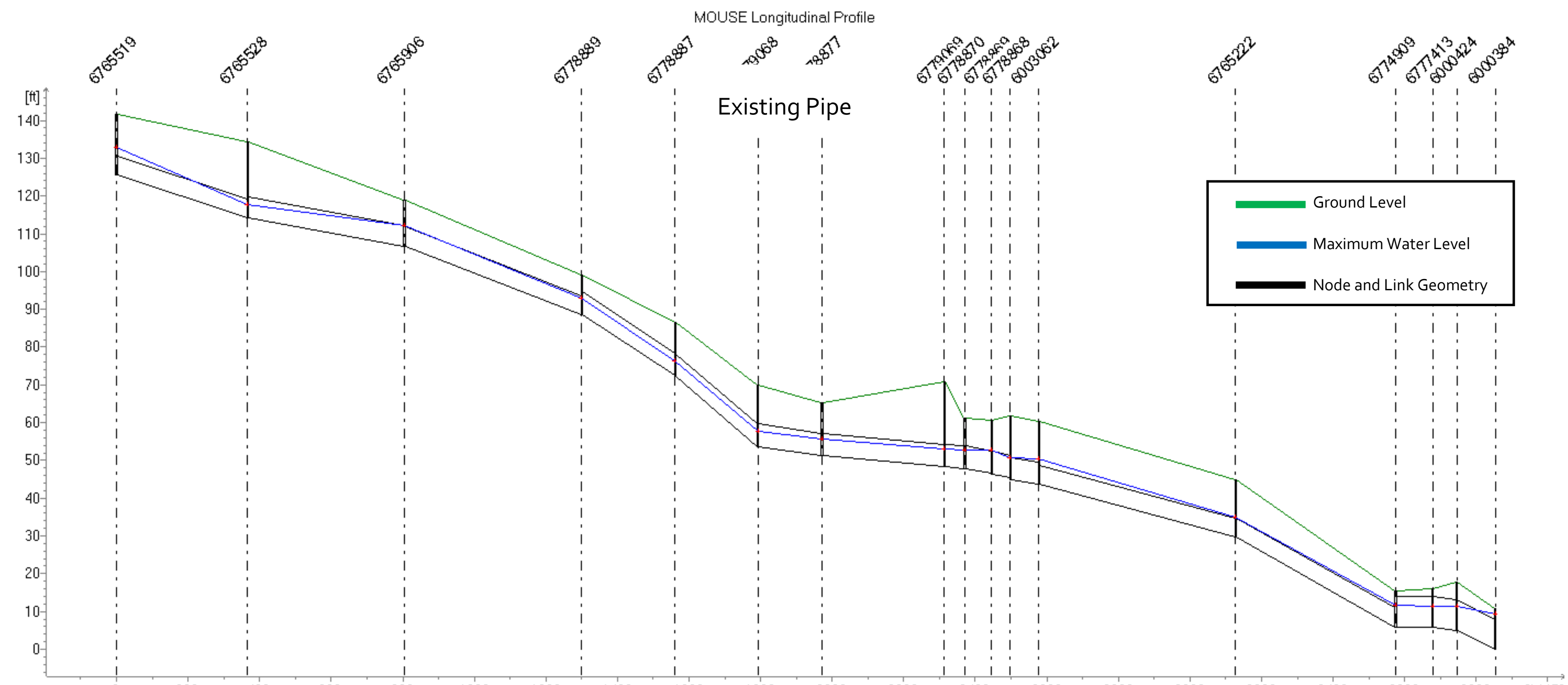
While this modeled scenario eliminates flooding, construction of these pipe would be slightly more significant than Scenario 3, as 1) 2,573 ft of pipe would need to be rehabbed, 2) 350 ft would need to be constructed new, and 3) 183 ft would need to be regraded or upsized. The downstream piping would have conflicts with the sanitary system between Puyallup Avenue and Outfall A that would need to be considered with possible realignment or grade reconfiguration in this area.

3.1.5 Scenario 5

Scenario 5 evaluated the total storm water storage volume needed to lower the peak HGL below the ground level to eliminate flooding in the City's Mike Urban model. For modeling purposes, the storage was added just upstream of MH 6765906 and results indicate that a total 48 MG of storage was needed to eliminate flooding during the December 2019 event. The profile of this scenario is shown in Figure 15. While 48 MG of storage eliminates the flooding and could be distributed between several sites, it is a significant volume that would be costly and impactful to locate in this urban environment. Therefore, Scenario 5 is not recommended for further consideration.

3.1.6 Scenario 6

Scenario 6 is similar to Scenario 3, but proposes a new pipe between MH 6778870 and 6762066 instead of utilizing the abandoned pipe to transport flows to Outfall B. The profiles from the new and existing pipes to outfalls B and A, respectively, are shown in Figures 16 and 17. This option would require 550 ft of new pipe between MH 6778870 and MH 6762066, with an additional 1,211 LF of pipe upsized to 96-inches in diameter between MH 6779068 and MH 6777414. The new pipe that would be constructed would cross under I-705. Given the pipe size and installation location, tunneling could be required to install the pipe. However, there are numerous wastewater utility conflicts making this a more complicated and expensive option relative to the other scenarios. Therefore, Scenario 6 is not recommended for further consideration.



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Shaft Diameter	4.0000																
Ground Level	141.52	134.31	118.84	98.98	86.53	69.99	65.40	70.83	......	......	......	60.46	44.76	15.32	....	....	.....
Invert Level	125.52	114.30	106.78	88.57	72.18	53.69	51.15	48.33	......	......	......	43.60	29.75	5.95	5.90	5.00	.....
Link Slope	3.07	1.71	3.67	....	4.67												

12/19/2019

Figure 13 Scenario 4 Profile for Existing Pipe

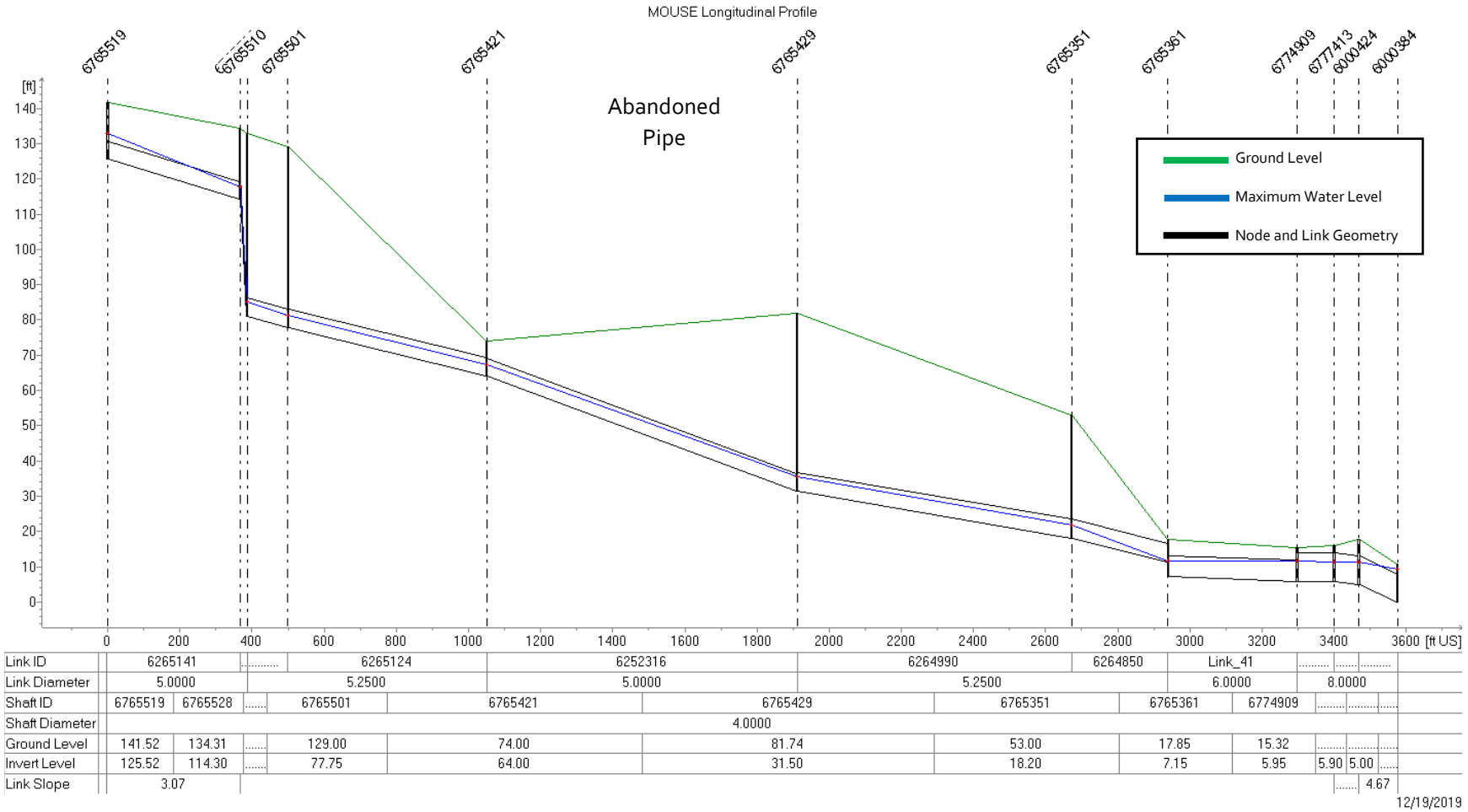
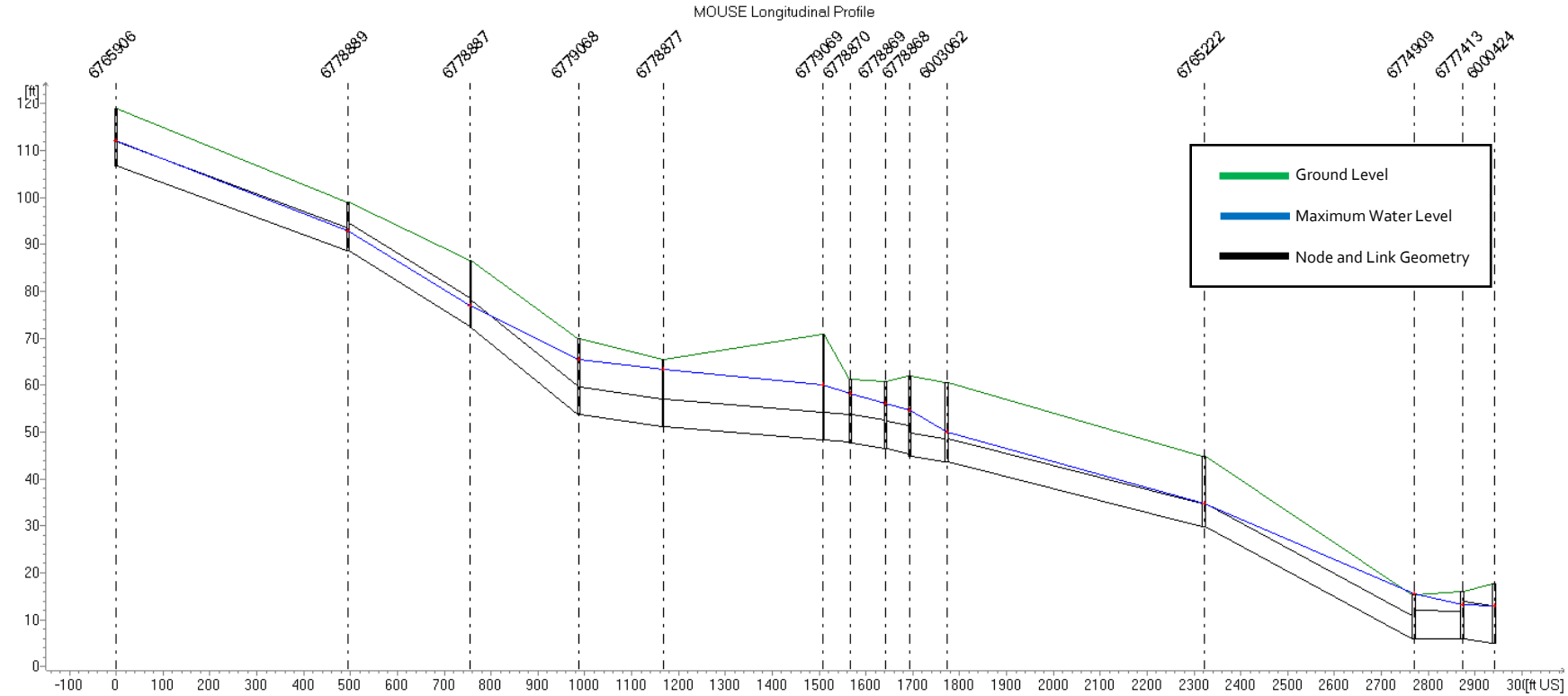


Figure 14 Scenario 4 Profile for Abandoned Pipe



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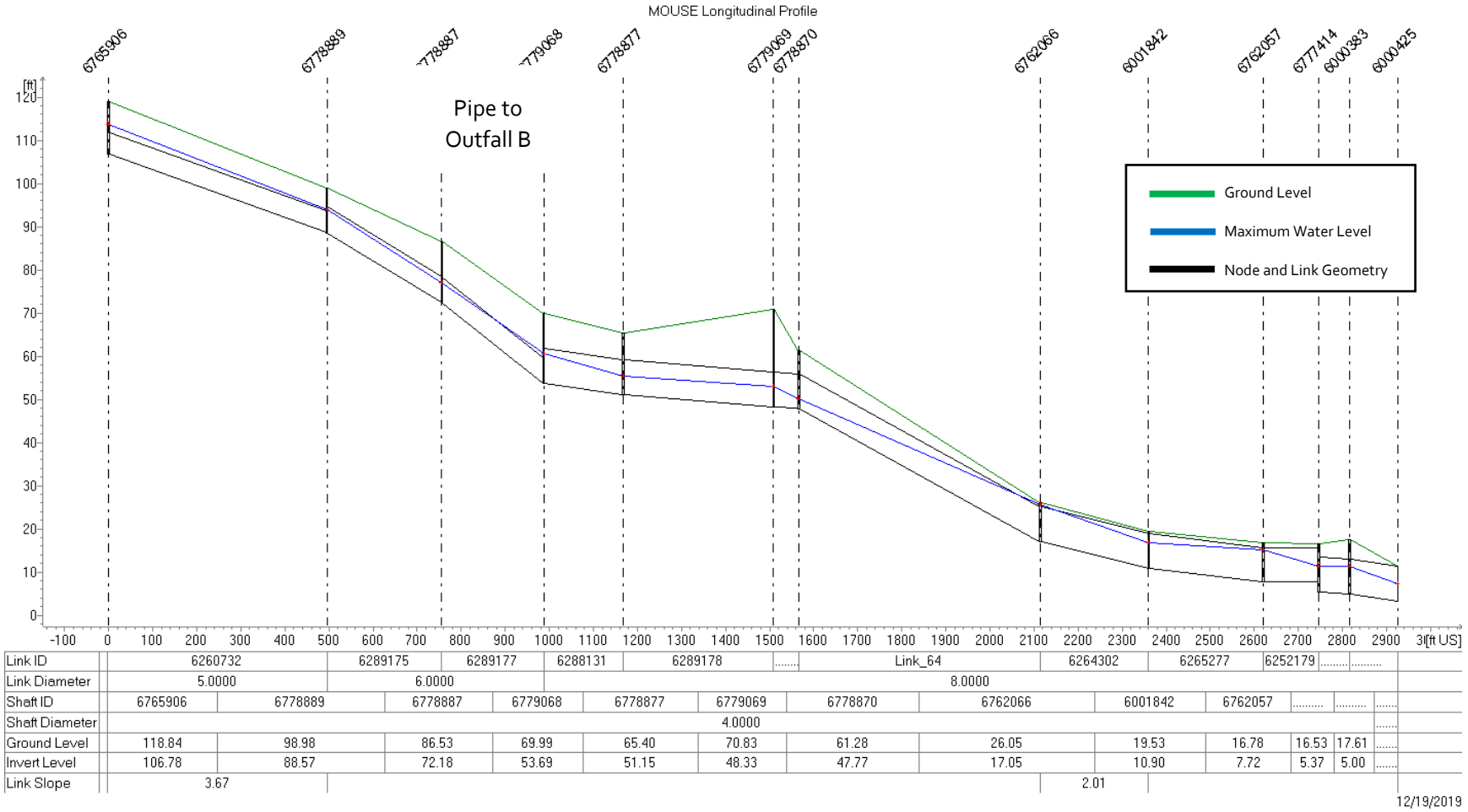
Shaft ID	6765906	6778889	6778887	6779068	6778877	6779069				6003062	6765222	6774909	
Shaft Diameter	4.0000									7.0000			
Ground Level	118.84	98.98	86.53	69.99	65.40	70.83				60.46	44.76	15.32	15.95
Invert Level	106.78	88.57	72.18	53.69	51.15	48.33				43.60	29.75	5.95	5.90
Link Slope	3.67												1.32

12/19/2019

Figure 15 Scenario 5 Profile



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Shaft ID	6765906	6778889	6778887	6779068	6778877	6779069	6778870	6762066		6001842	6762057	.....	.....	.....	
Shaft Diameter	4.0000														
Ground Level	118.84	98.98	86.53	69.99	65.40	70.83	61.28	26.05		19.53	16.78	16.53	17.61	.....	
Invert Level	106.78	88.57	72.18	53.69	51.15	48.33	47.77	17.05		10.90	7.72	5.37	5.00	.....	
Link Slope	3.67								2.01						

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Figure 16 Scenario 6 Profile to Outfall B

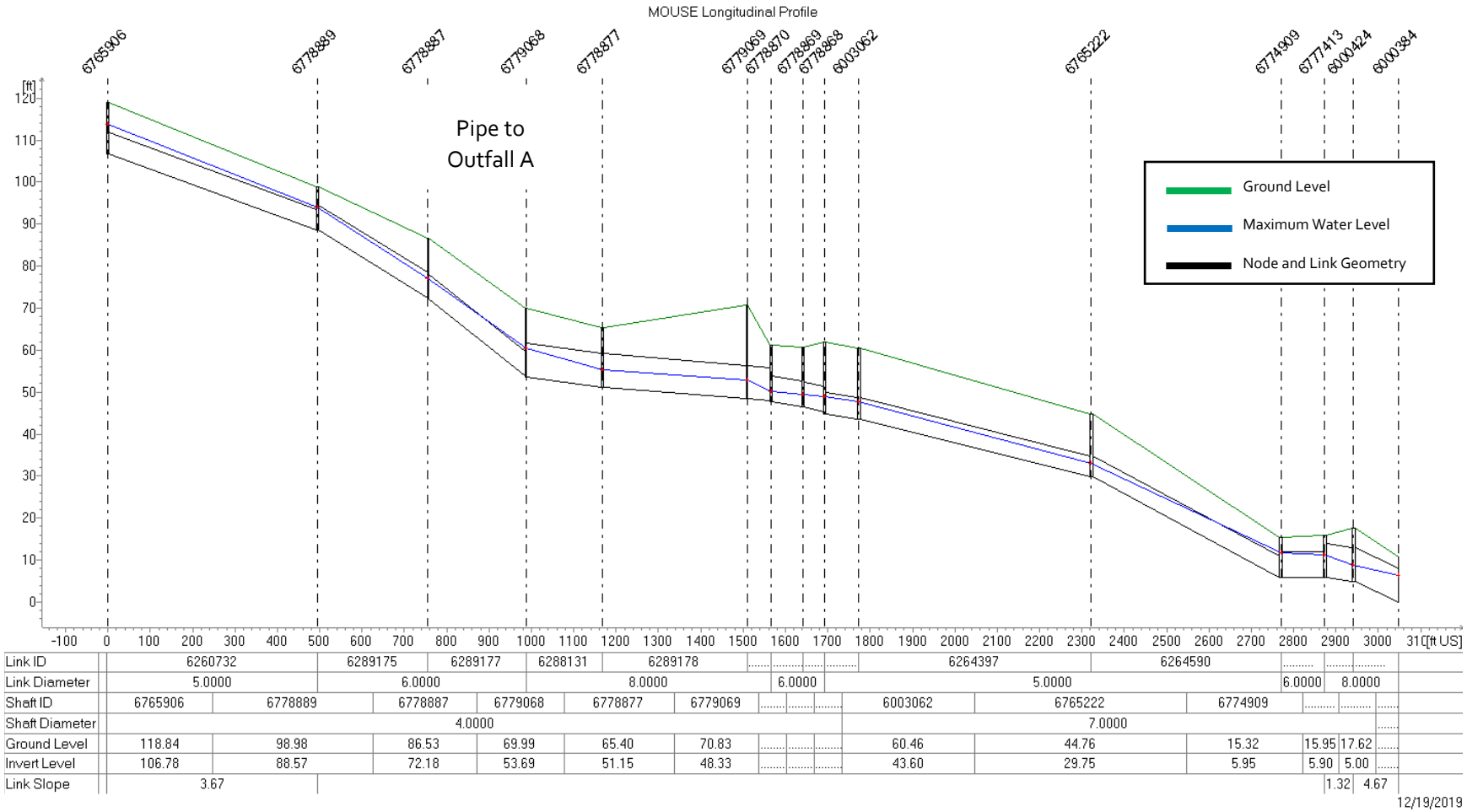


Figure 17 Scenario 6 Profile to Outfall A

3.2 Center & Pine Area Analysis

Localized flooding has been observed upstream in the Basin near Center and Pine, which is also apparent in the City's Mike Urban model results. The location of the flooding during the December 2019 event is shown in Figure 18. The peak flows of the event are very short, therefore storage options may be more viable than parallel piping.

The storage operations evaluated at Center and Pine addressed local flooding, but did not appear to impact the flooding in the Project area. The HGL breaks between many of the sites with potential flooding, therefore areas of flooding in other parts of the system are likely independent from the hydraulic restrictions in the D-M area.

3.2.1 Scenarios 7 and 8

For the purposes of modeling, two storage options were evaluated to eliminate flooding in the model for the December 2019 event. A full system analysis was not performed for this area that considered pipe sizing and routing. The storage option was focused on how much volume would need to be managed through surface ponds within the hydraulic profile of the storm system that could fill and drain via gravity. The first option (Scenario 7) consists of one large upstream storage facility while the second (Scenario 8) consists of a smaller total storage volume split into two smaller facilities, one upstream and one downstream of Center and Pine. The potential location of the facilities is shown in Figure 19. Scenario 7 places all the storage at potential site A, and Scenario 8 splits the storage between potential sites A and B. In order to lower the hydraulic grade with a single storage facility, a 265 foot radius structure is needed. There may not be sufficient land available for a facility of this size at the potential site A. The second option consists of two 80 foot radius storage facilities potentially at the northwest and southwest ends of the privately owned Allenmore Golf Course. Distributing the storage is likely more constructible and still adequately lowered the grade, as shown in Figure 20.

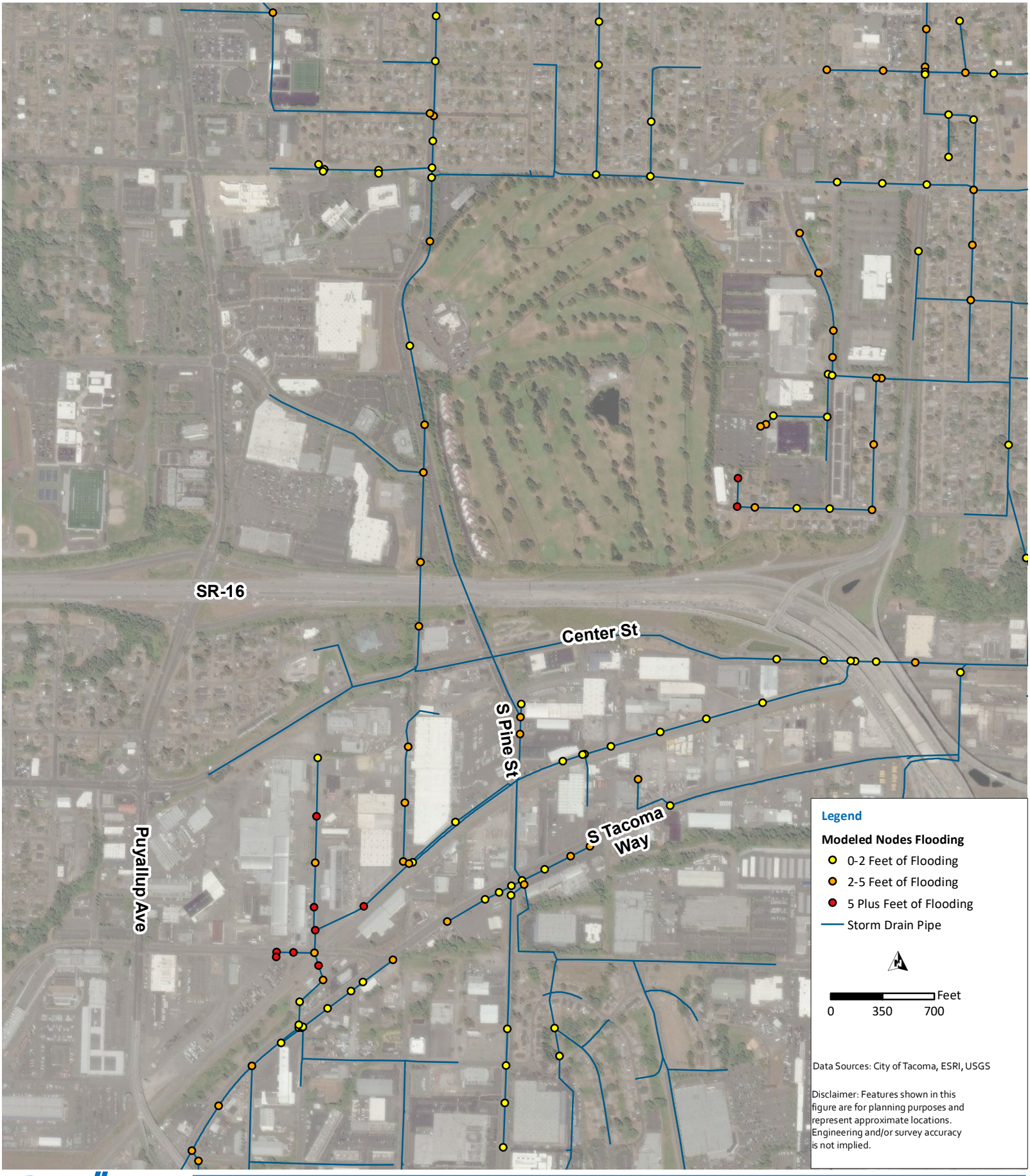


Figure 18 Center and Pine December 2019 Modeled Flooding

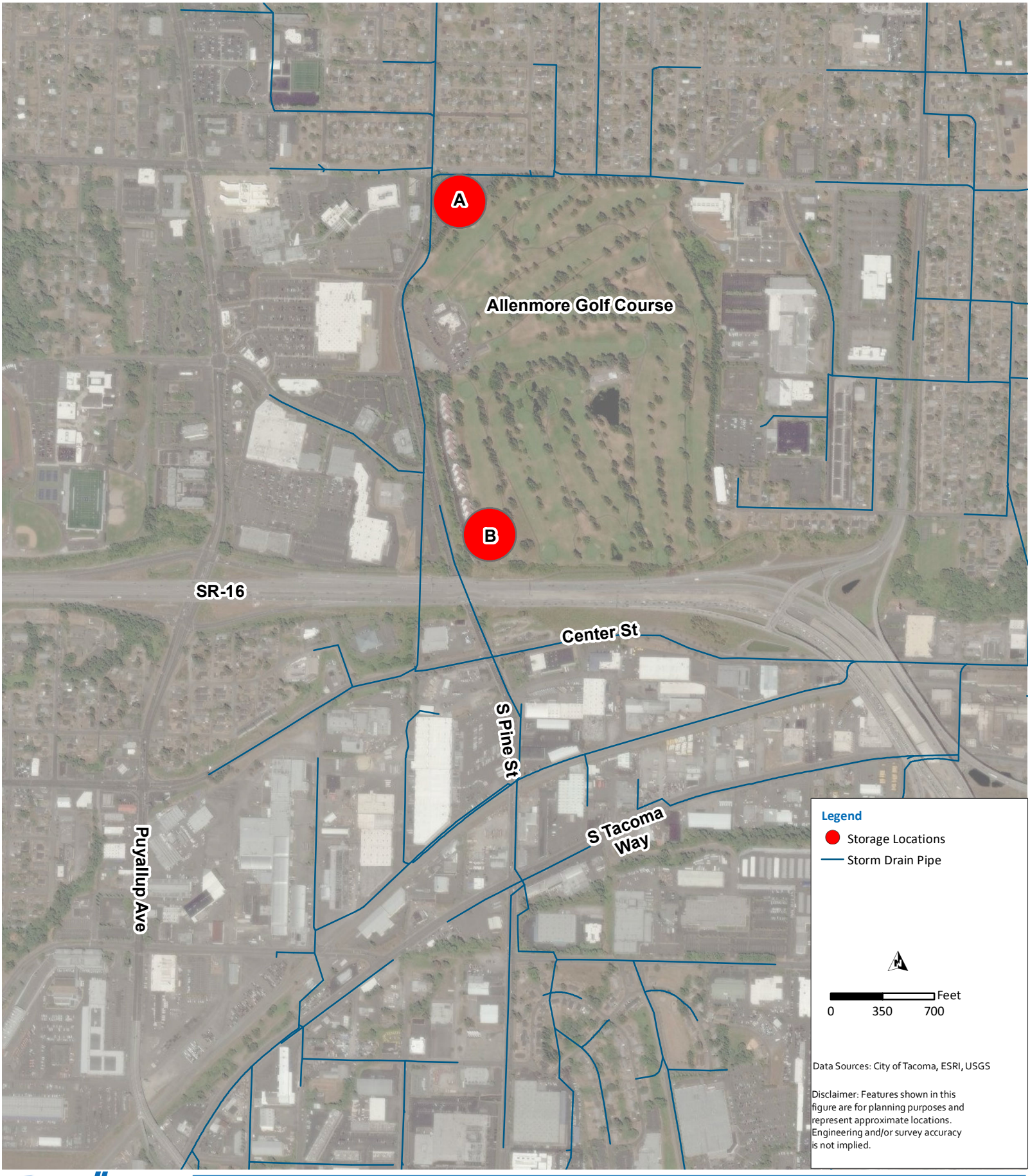


Figure 19 Center and Pine Proposed Storage Scenario 7 and 8

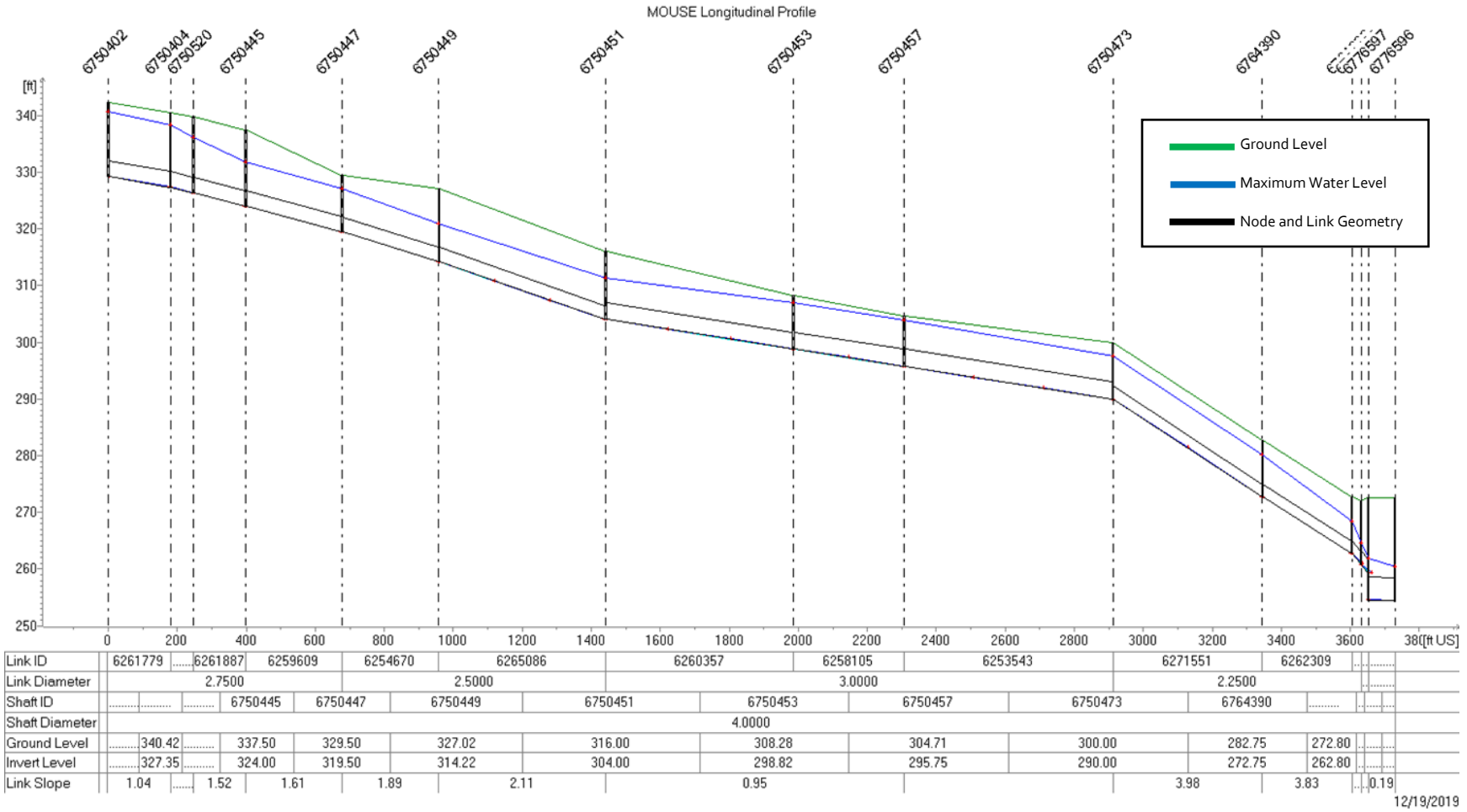


Figure 20 Center and Pine Profile for Scenario 8

3.3 Summary of All Scenarios Tested

The scenarios tested in the model are summarized in Table 3. Scenarios 2, 3, 4, 5, and 6 all eliminated modeled flooding within the Project area and Scenarios 7 and 8 eliminated flooding at Center and Pine during the December 2019 event.

Table 3 Summary of All Tested Scenarios

Scenario	Location	Description	Length of Upsized / Regraded Pipe (LF)	Length of New / Rehabbed Pipe (LF)	Diameter (ft)	Additional Storage (MG)	Viable Solution?
1	Project Area	Parallel Piping (StormShed3G)	0	1,095	6	0	No
2	Project Area	Parallel Piping StormShed3G + Extended	80	2,350	6, 8	0	Yes
3	Project Area	Rehab Abandoned Pipe to Outfall B	0	3,219	5, 6	0	Yes
4	Project Area	Rehab Abandoned Pipe and Reconnect to Outfall A	0	3,156	5, 5.25, and 6	0	Maybe
5	Project Area	Storage	0	0	0	48	Unlikely
6	Project Area	New Pipe to Outfall B	1,211	550	6, 8	0	Unlikely
7	Center and Pine	1 Storage Tank	0	0	0	8.2	Maybe
8	Center and Pine	2 Storage Tanks	0	0	0	1.5	Yes

Of the two rehabilitation options Scenario 3 and 4, Scenario 3 appears more viable as there are fewer piping conflicts, less new piping, and Outfall B has more available capacity. Therefore Scenario 2 and Scenario 3 are most viable options to eliminate flooding in the Project area. Improvements at Center & Pine do not appear to significantly alter flooding in the Project area. Therefore Scenarios 2 and 3 were further developed, assuming no changes at Center and Pine, verifying all conveyance requirements were met for these two scenarios for all key storms and possible climate variability.

Section 4

SCENARIO 2 AND 3 REFINEMENT

Scenarios 2 and 3 appear to be the most viable options to reduce flooding in the Project Area. Both options require piping construction through a congested piping corridor from Puyallup Avenue North through Dock Street Yard with numerous potential conflicts with other storm pipes, as well as large sanitary pipes. The alignment and sizing of these two scenarios were revised and tested for sensitivity to future climate change, assuming the routes through Puyallup and Dock Street yard.

4.1 Geometry Refinement

Both Scenario 2 and Scenario 3 have conflicts with the sanitary system from just west of I-705 on Puyallup Avenue to the outfalls. To avoid these conflicts, two possible system reconfigurations were considered, realigning along 23rd Ave, and the Puyallup Street alignment shown in Figure 21. Adjusting the downstream configuration, the Puyallup Ave alignment would create the least work and align with the City's plans for wastewater infrastructure changes and known soil issues in the vicinity of 23rd street.

Scenario 3 initially was estimated to involve rehabbing 2,796 LF of pipe, with an additional 566 ft of piping replaced. CCTV of the abandoned pipe section showed significant structural deficiencies, arched sections and partially collapsed sections. The upstream connection point was revised to MH 6779068 from MH 6765528. This allows connection downstream of the partially collapsed section of the abandoned pipe, and decreases the linear feet of rehab to 1,115 required to eliminate D-M flooding. As the downstream section could have similar risks, the abandoned pipe will need to be slip lined to offer the necessary structural improvements to ensure integrity of the pipe. If the downstream piping is rehabilitated to convey the higher flows, it would be an opportunity to rehabilitate the upstream piping for the current existing flows. Figure 22 shows the revised Scenario 3. The piping transitions from circular to arch pipe at MH 6765351, however the MH would not need to be accessed from the surface for the sliplining installation.

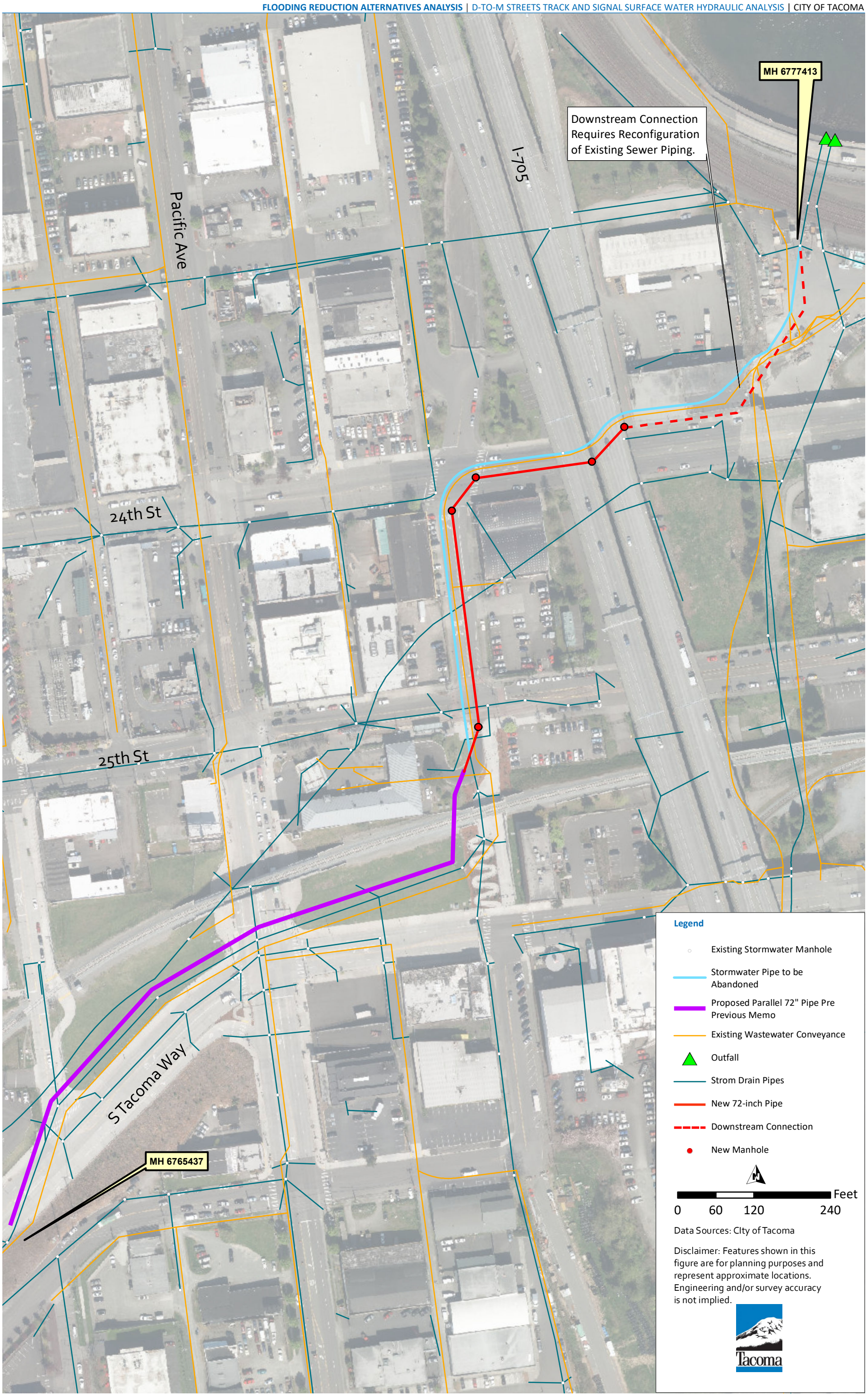


Figure 21 Parallel Piping: Puyallup St Realignment

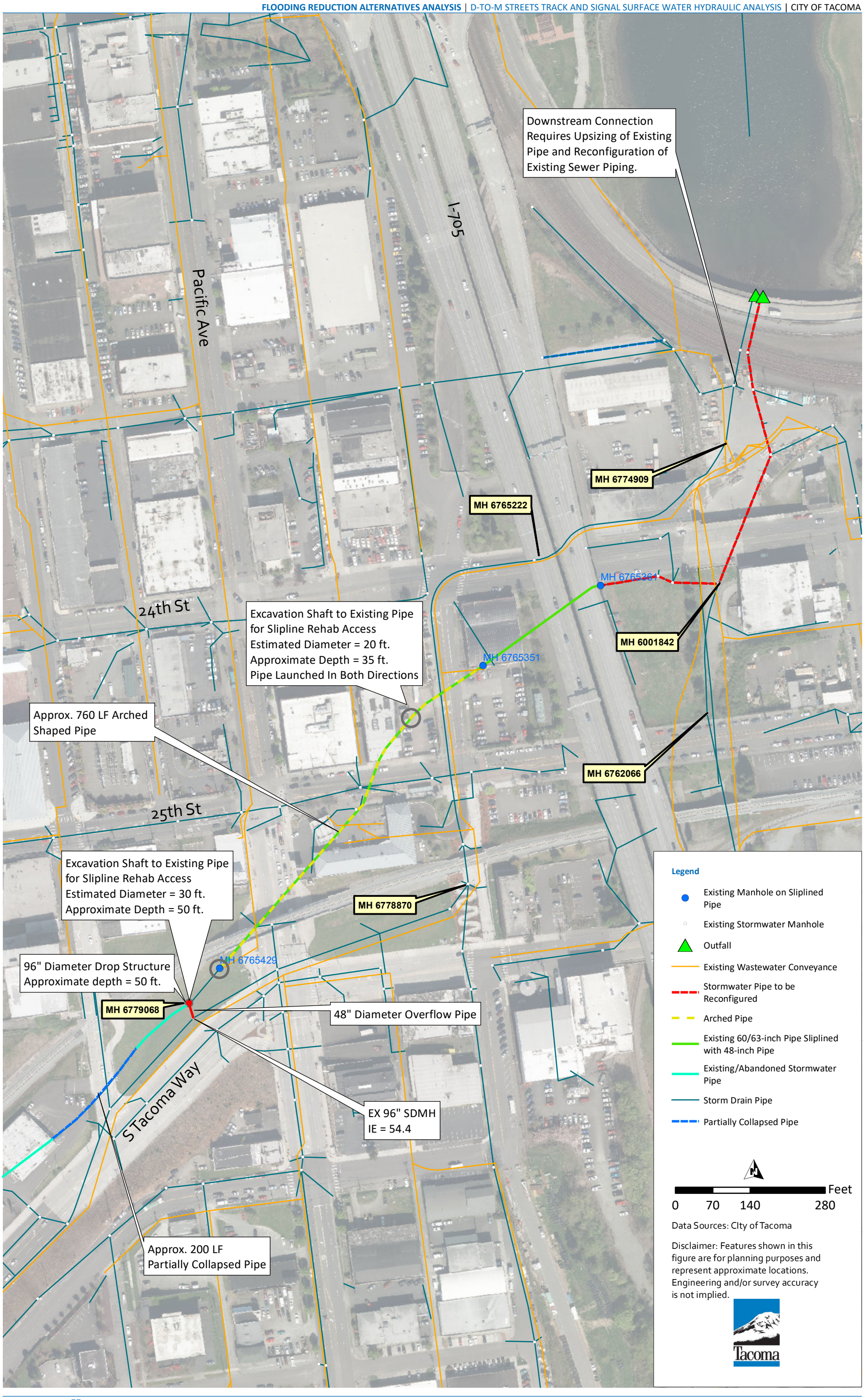


Figure 22 Existing Abandoned Pipe Rehabilitation Alternative

4.2 Climate Change Sensitivity

The potential climate change impacts on the system include increased rainfall and sea level rise. Future rainfall could be characterized by shorter and more intense events. The MGS Recommendations for Design Storms for Use in Hydraulic Modeling in Tacoma Washington TM indicates a possible 10 percent to 15 percent increase in rainfall magnitude. The MGS design storm was increased by 10 percent to evaluate system impacts and verify sizing for Scenarios 2 and 3.

Additionally, tidal influences were increased by 3.1 feet[6] to reflect modeled sea level rise for a 50 percent criteria for probability of exceedance in 2120 (100 year life) using Representative Concentration Pathways (RCP) 8.5 (the more conservative of the two climate change models). Therefor the TSWMM design mean high tide of +4.64 feet City datum was increased to +7.74 feet.

To account for the higher tide levels at the outfall and the more intense MGS storm, additional downstream upsizing was needed to avoid flooding or significant surcharging for both scenarios. To pass the storm for Scenario 2 without flooding or significant surcharging, pipe 6265029 was further upsized to 8 feet. While some minor surcharging occurs the depth of pipe is not significant enough to warrant further upsizing without full consideration of the sanitary piping conflicts. The finalized profile to Outfalls A and B is shown below in Figures 23 and 24.

To pass the storm for Scenario 3 without flooding or significant surcharging pipes downstream of MH 6001842 were upsized as shown in Figure 20. The ground elevation for MH 6765421 was also revised to match the City's on-line geographic information system (GIS) and Google Earth ground elevations.

The 2120 tide levels only caused flooding at with the last section of pipe, where sea level is above the current ground elevation. Piping improvements will not change this type of flooding as it is not conveyance related, the ground level would need to be raised near the outfall by 2120.

[6] http://wacoastalnetwork.com/chrn/research/sea-level-rise/

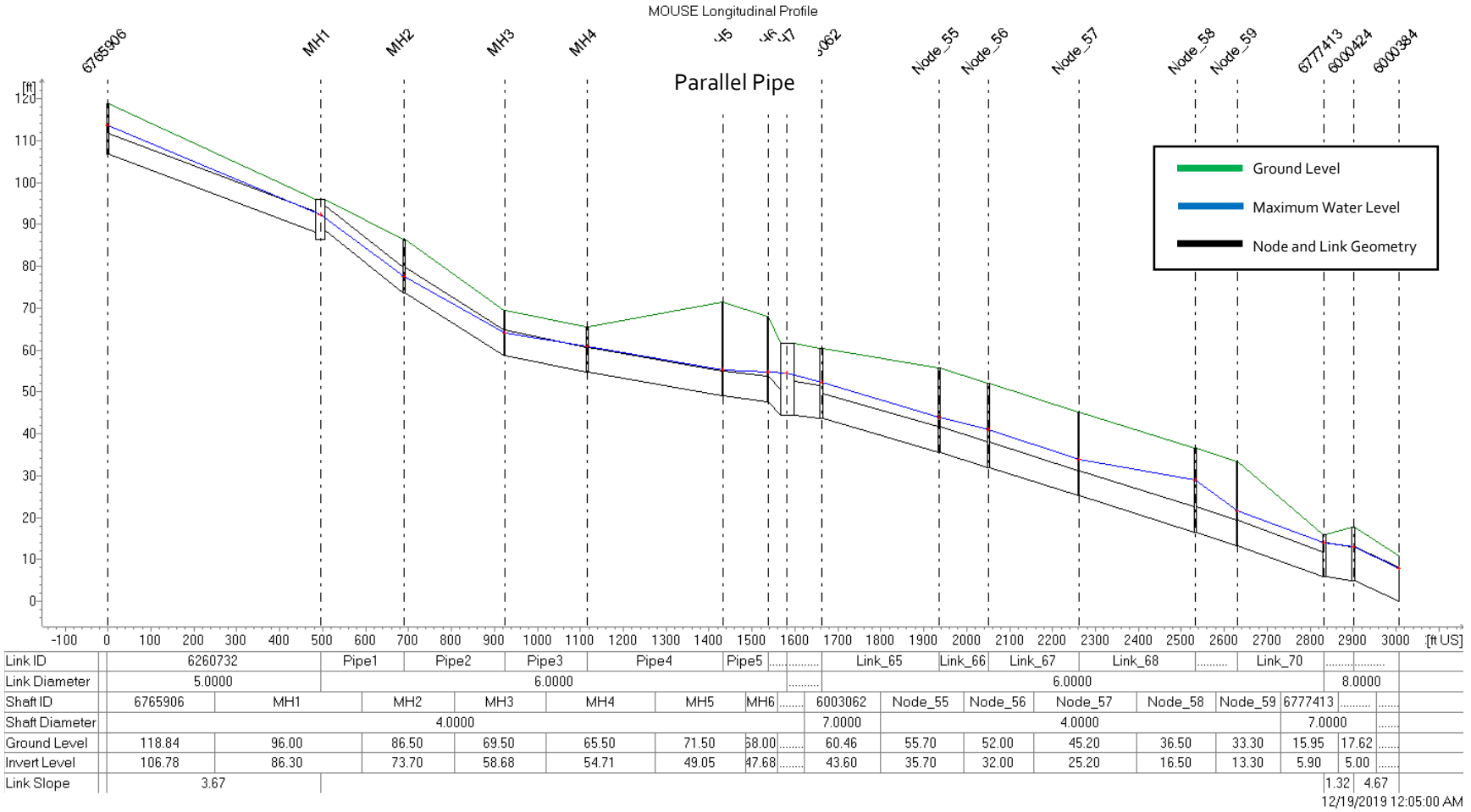


Figure 23 HGL through Scenario 2 Profile in Parallel Pipe with Possible Climate Change

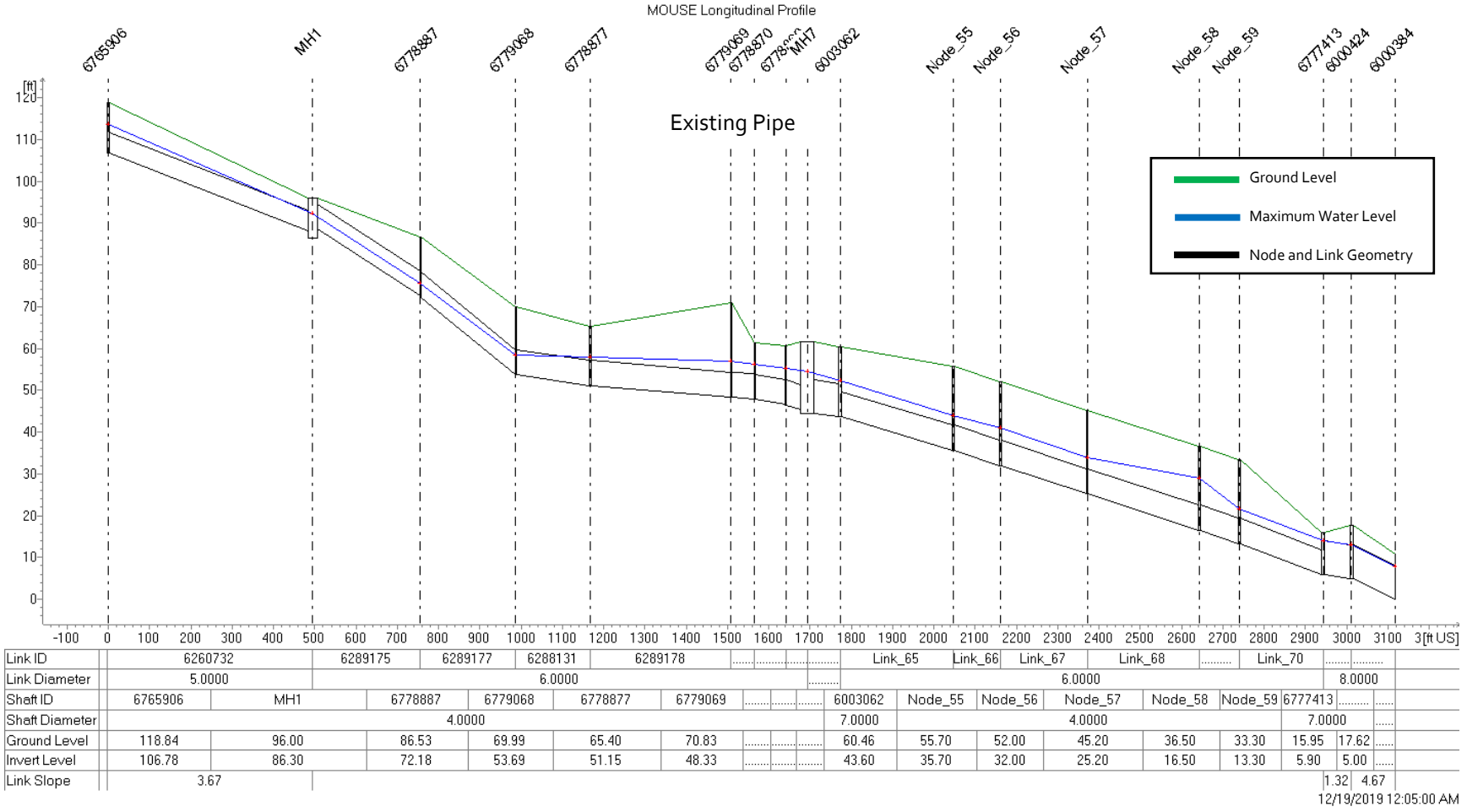


Figure 24 HGL through Scenario 2 Profile in Existing Pipe with Possible Climate Change

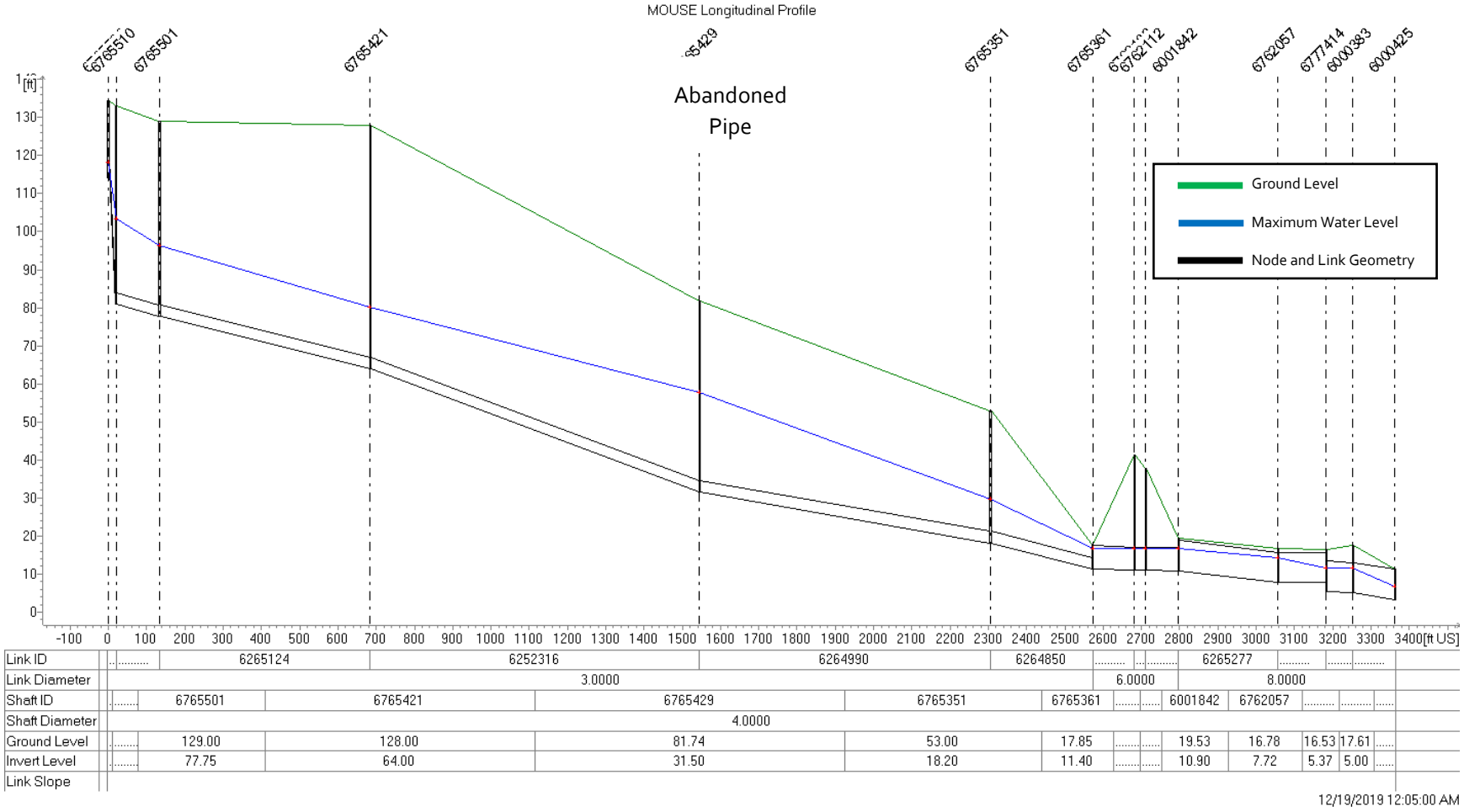
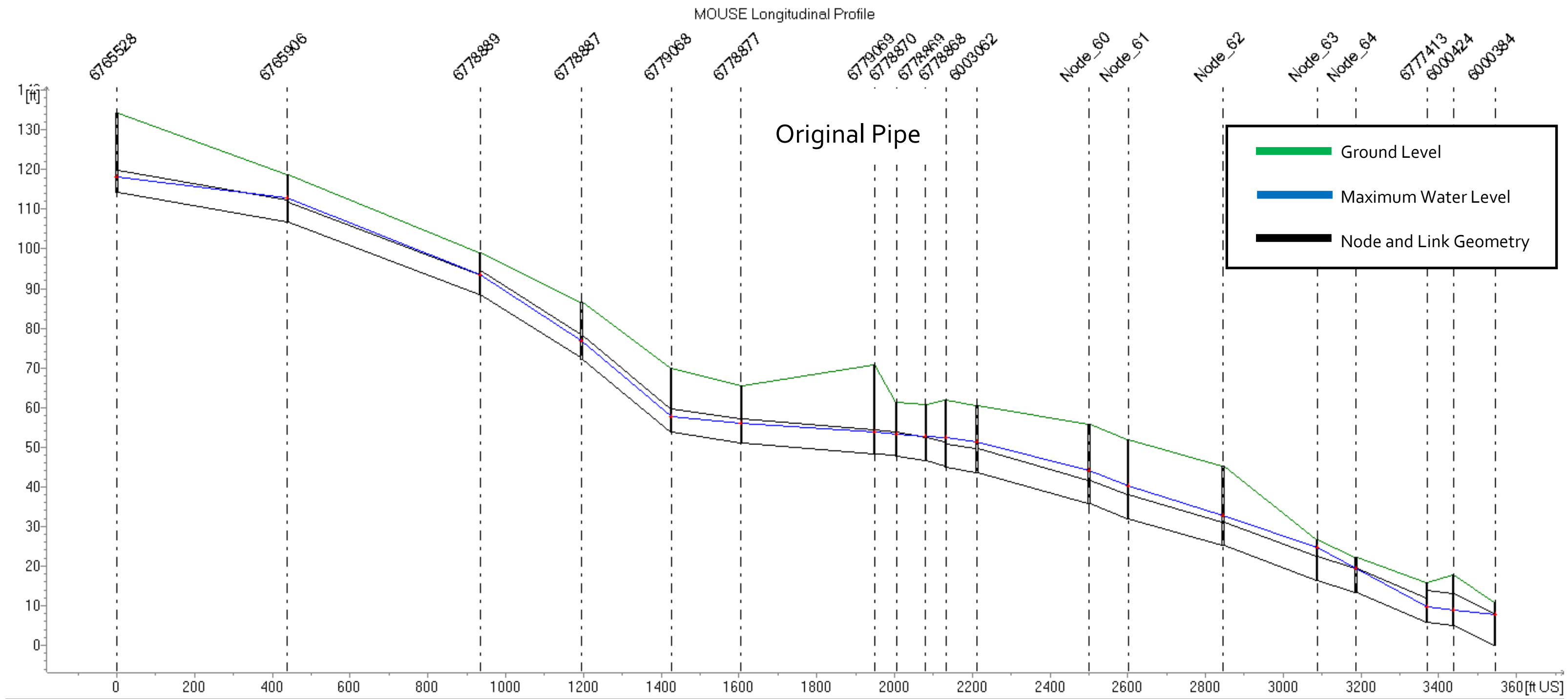


Figure 25 HGL through Scenario 3 Profile in Abandoned Pipe with Possible Climate Change



Link ID	6265151	6260732	6289175	6289177	6288131	6289178	......	......	......	......	Link_71	......	Link_73	Link_74	......	Link_76	......	......	
Link Diameter	5.5000	5.0000	6.0000	8.0000															
Shaft ID	6765528	6765906	6778889	6778887	6779068	6778877	6779069	......	......	......	6003062	Node_60	Node_61	Node_62	Node_63	......	......	......	......
Shaft Diameter	4.0000																		
Ground Level	134.31	118.84	98.98	86.53	69.99	65.40	70.83	......	......	......	60.46	55.70	52.00	45.20	26.50	22.20	15.95	......	......
Invert Level	114.30	106.78	88.57	72.18	53.69	51.15	48.33	......	......	......	43.60	35.70	32.00	25.20	16.50	13.30	5.90	5.00	......
Link Slope	1.71	3.67	1.32	4.67															

12/19/2019 12:05:00 AM

Figure 26 HGL through Scenario 3 Profile in Existing Pipe with Possible Climate Change

4.3 Summary of Potential Solutions for Project Area

Both Scenarios 2 and 3 can be improved to reduce flooding risk from future climate change scenarios. Both scenarios would require additional work to avoid sewer pipe conflicts in the downstream sections. The project costs were estimated for the Section upstream from Puyallup Avenue, assuming the downstream sections would have similar costs as there were similar conflicts with sanitary system between Puyallup Ave and the outfalls. The final recommendations and estimated costs for the two best alternatives are summarized in Table 4. The details of cost development are summarized in Appendix A, with the cost estimate for Scenario 2 summarized in Appendix B, and the cost estimate for Scenario 3 in Appendix C.

Table 4 Summary and Cost of Most Viable Options

Scenario	Description	Length of Slip lined Pipe (LF)	Length of Parallel Pipe (LF)	Length of Pipe to be Reconfigured (LF)	Estimated Project Cost ($ in millions)(1,2,3)
2	Parallel Piping to Puyallup Ave(4)	0	750	1,500	6,200,000 to 13,300,000
3	Rehab Abandoned pipe to Puyallup Ave(4)	1,115	0	0	4,400,000 to 9,500,000

Notes:
(1) Costs estimated to Puyallup Ave, downstream costs are expected to be similar between Scenarios and not included in this estimate. Refer to Appendices A - C for estimating assumptions and details.
(2) The expected level of accuracy for this cost opinion follows the Recommended Practice 18R 97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 4" estimate.
(3) The cost estimate herein is based on 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 Engineers, Inc. (Carollo) have no control over variances in the cost of labor, materials, equipment; nor 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) Additional pipe will be needed from Puyallup Ave to Outfalls. The cost is likely similar for both options due to similar sanitary sewer conflicts.

Section 5
SUMMARY AND RECOMMENDATIONS

Scenario 3, rehabilitation of the abandoned line, is recommended as 1) the construction risk of slip lining the abandoned pipe is likely lower, 2) the abandoned pipe is currently in need of rehabilitation for the local existing users, and 3) construction will likely be less disruption to traffic on both Pacific Avenue and South Tacoma Way/26th Street, all major traffic corridors within the City.

However, the sanitary system improvements should be simultaneously evaluated and developed with the final downstream storm pipe route and sizing to finalize the proposed layout that will eliminate flooding within the Project area. This joint approach will ensure that both gravity systems meet performance criteria and construction disruptions on Puyallup Avenue and Dock Street Yard will be minimized.

Appendix A

BASIS OF AACE CLASS 4 COST ESTIMATE FOR PIPE REHABILITATION & PARALLEL PIPE EXTENSION ALTERNATIVES

PROJECT MEMORANDUM

D-TO-M STREETS TRACK & SIGNAL PROJECT SURFACE WATER HYDRAULIC ANALYSIS

City of Tacoma

Date: November 18, 2020
Project No.: 10964A00

Prepared By:	Brian Sliger, PE
Reviewed By:	Erik Waligorski, PE & Susanna Leung, PE
Subject:	Task 7.1: Basis of AACE Class 4 Cost Estimate for Pipe Rehabilitation & Parallel Pipe Extension Alternatives

Background and Purpose

The D-to-M Streets Track & Signal Project (Project) was completed by Sound Transit (ST) as part of a larger expansion of a regional rail line within Western Washington. This 19-acre portion of the expansion reconstructed City of Tacoma (City) streets from South 'D' Street to South 'M' Street, installed a new rail bed, and regraded an existing rail bed. The Project relocated over 4,000 linear feet of storm drainage pipe, replacing piping in the area with new pipes having diameters ranging in size from 12 inches to 72 inches. These relocations were performed to allow for the lowering of the roadway grade and the installation of a railway bridge over the roadway. Following construction, multiple storm manholes within the Project area have surcharged and flooded the lowered roadway during large storm events.

The Project was located within the Thea Foss Waterway basin (Basin) and therefore was subject to meeting the requirements of the City's 2008 Surface Water Management Manual (TSWMM). Carollo Engineers, Inc. (Carollo) has independently completed an alternatives analysis that identified two viable solutions that comply with the TSWMM requirements within the Project area. The initial analysis analyzed the installation of a new parallel trunk main to convey flows in access of the existing pipe's capacity. An additional alternatives analysis has now been completed to look at the rehabilitation of an existing abandoned stormwater main to convey the necessary flows. This alternatives analysis and cost opinion are provided in separate, accompanying documents. The purpose of this project memorandum is to summarize the basis of cost opinion for the potential alternative for rehabilitation of the existing stormwater trunk main and to expand on the previously developed parallel trunk main alternative for comparison of these two alternatives.

The rehabilitation alternative cost opinion prepared reflects the installation of a new 48-inch pipe sliplined through the existing 60/63-inch stormwater trunk main. Two large pit excavations would be required for access to the existing trunk main at two points along its alignment. Major components of the Project include:

- Approximately 2,550 feet of 48-inch diameter pipe sliplined through the existing 60/63-inch trunk main.
- Approximately 30-feet diameter and 50-foot deep access shaft to perform sliplining.

- A new 48-inch diameter overflow pipe and drop structure for conveying flows from the existing D-to-M trunk main to the newly rehabilitated trunk main.
- One (1) new 96-inch manholes.

The parallel pipe extension alternative cost opinion prepared reflects the installation of new trenched 72-inch pipe continuing from the end point of the original parallel pipe alternative. Major components of the Project include:

- Approximately 750 feet of 72-inch diameter reinforced concrete pipe (RCP) installed via trenching.
- Five (5) new 96-inch manholes.

Both these alternatives assume that the installed pipe connects to a similar location in Puyallup Ave, just West of Interstate 705. The conveyance further downstream was not finalized as it will require extensive sewer improvements. Therefore costing of this downstream conveyance was not completed and it is assumed that both alternatives would require similar costs for any necessary improvements to the existing downstream conveyance.

Cost Basis

The expected level of accuracy for this cost estimate follows the Recommended Practice 18R-97 Cost Estimate Classification System for the Process Industries (Association for the Advancement of Cost Engineering [AACE], 1998) designation as a "Class 4" estimate with an expected level of accuracy of -30 percent to +50 percent of the cost presented. Estimated project costs are in April 2020 dollars, consistent with the Seattle Engineering News-Record (ENR) value of 12112. As the project design matures, cost estimates are subject to change, and the cost of labor, materials, and equipment may vary. Because the project timeline is unknown, costs were not adjusted to the mid-point of construction.

Carollo's Costing Model tool was utilized to prepare the cost opinions. This model compiles historical cost data for various project items to produce a unit cost representative of the costs expected to be encountered during the construction bidding process. This planning approach uses both major-item quantity estimates and percentage allowances based on experience with similar projects. The following narrative compliments the assumptions listed in the cost opinion worksheet.

General:

- Costs included in the estimate reflect the best understanding of planning level requirements, as they existed at the time the estimate was prepared. Any modifications to the present scope and/or alignment may have substantial cost impacts.
- Existing civil site conditions including pipe diameter, pipe slopes, and existing ground surface elevation are as reflected in the City of Tacoma's GIS system.[1]
- Construction activities and sequencing are not hampered by constrained site conditions (no reduced productivity). Work can be sequenced to minimize service and community interruptions.
- Pipe installation is completed within a single dry season.
- Groundwater table remains generally below the bottom of trenches during the dry season. Trench dewatering is limited to sump pumps.
- Shaft excavation for the rehabilitation alternative is sealed off from groundwater via a tremie slab.
- The existing estimated total direct cost for the D-to-M project area parallel pipe (less the features outlined in this estimate) was utilized for determining the total project cost for installing a parallel stormwater trunk main.[(2)]

Slipline Rehabilitation Access Excavation Shafts:

- Excavation shaft shoring consists of secant pile walls and tremie/concrete slabs at the bottom of each excavation.
- Shaft diameter is based upon conversation with contractors/suppliers and typical size needed to accommodate the proposed pipe size and associated equipment.
- Shoring and excavation costs were based on actual costs from similar installation on other Project(s).

Slipline Rehabilitation:

- Pipe was assumed to be centrifugally cast fiberglass reinforced polymer mortar (CCFRPM) pipe as manufactured by Hobas Pipe USA, Inc.
- The new pipe will have a 48-inch inside diameter (ID) and 50-inch outside diameter (OD). This pipe is larger than required for hydraulic needs but is maximized to reduce grouting costs.
- The cost for laser profiling of the existing 60/63-inch pipe to confirm its internal diameter and condition has been included as a construction cost. This would be required during the design phase and may not need to be repeated during construction, depending on the initial design inspection findings. Costs for this inspection are based on quotes from RedZone Robotics Inc. for similar Projects.
- Installation will be predominately carried out by the "carry" method where an in-pipe cart system is used to carry each pipe section into place.
- Minimal bends will be required along the alignment (2-22.5 degree bends).
- Grouting of the annular space between the existing pipe and the new pipe will be required.
- Existing manholes will not be replaced or rehabilitated. Two new manholes, however, will be installed at the proposed excavation shafts.
- Bypassing of the existing flows within the abandoned main will not be required.

72-Inch Reinforced Concrete Pipe (RCP) Installation:

- Excavation depth of the pipe is based on the weighted average invert depth along its alignment, using ground surface elevations from GIS and the proposed invert elevations.
- Trenches sized to allow for a sufficient work area within the pit including the installation of a 96-inch manhole and manhole connection following the pipe ram.
- Trenches are assumed to be backfilled completely with imported structural backfill, due to their proximity to roadways and/or bridge footings.
- All trench shoring is driven steel sheet piles with internal bracing.
- The new pipe material is RCP:
  - This pipe material remains more readily available and less expensive than other types of pipe that are suitable for an installation of this size and type.
  - Class III RCP Pipe using American Concrete Pipe Association standards[3], assuming a fill height of 15 feet and a Type 2 installation type.

Miscellaneous:

- Geotechnical conditions encountered at the site are adequate for the proposed excavations and pipe installations.
- Traffic Control:
  - Minimal traffic control will be required for the rehabilitation alternative due to the proposed locations of the work (predominately outside the roadway).
  - The parallel pipe alternative extension will require significant traffic control measures as it will be installed within the traveled right of way.

- Restoration:
  - Minimal restoration will be required for the rehabilitation alternative due to the proposed locations of the work (predominately outside the roadway and landscaped areas).
  - The parallel pipe alternative extension will require pavement replacement along its length (assumed to be one full lane width).

Exclusions

All potential items of cost which might be associated with the project but for which no costs have been included are listed below:

- Costs for unusual site conditions not currently identified within this memorandum.
- Costs for community impacts (e.g. disruption to surrounding businesses).
- Costs for temporary staging easements beyond the City's existing easements.
- Estimating allowances for City's indirect costs not specifically listed, including bid market, construction management and inspection, permitting, operations support, community outreach, environmental impacts, real estate acquisition and easements, and mitigation.
- Costs for any potential construction delays due to external interferences such as weather conditions, union strikes, pandemics, or emergency services.
- Costs for unknown or changing site conditions including, but not limited to, ground improvements and site developments beyond existing site conditions reflected in the City's GIS records.(1)
- Costs for additional scope beyond that as detailed in the current scope of work.

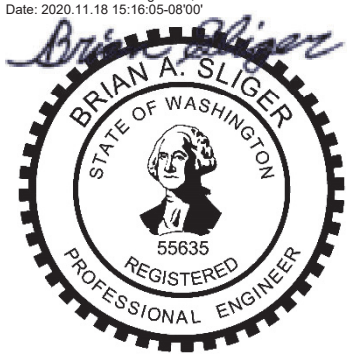
References

1. tacomeMAP, https://tmap.cityoftacoma.org/, City of Tacoma GIS, March 2020.
2. Stormwater Conceptual Design Report (Full Buildout), City of Tacoma, D-to-M Streets Track & Signal Project, Surface Water Hydraulic Analysis, Carollo Engineers, Inc., February 2019.
3. American Concrete Pipe Association – LRFD Fill Height Tables for Concrete Pipe: https://www.concretepipe.org/wp-content/uploads/FillHeightTables-1.pdf
4. Carollo Cost Estimating Manual
5. Carollo Conceptual Cost
6. Department of Ecology, Resource Protection Well Reports, Various Locations in Project Vicinity, https://appswr.ecology.wa.gov/wellconstruction/map/WCLSWebMap/default.aspx
7. City of Tacoma CCTV Records

Prepared by:

BAS:sm

Digitally signed by Brian A. Sliger
Contact Info: Carollo Engineers, Inc.
Date: 2020.11.18 15:16:05-08'00'



Appendix B

BASIS OF COST ESTIMATE FOR PARALLEL PIPING SCENARIO 2

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QUANTITY TAKEOFF WORKSHEET

Project: D-to-M Streets Track & Signal Project
Surface Water Hydraulic Analysis
Client: City of Tacoma
Location: Tacoma, WA
Zip Code: 98402
Element 01 Misc.

Date: May 21st, 2020
By : B. Sliger
Reviewed:
Format: MASTER FORMAT 50

MF50 / SPEC NO.	DRAWING # / DESCRIPTION	# of PLACES	Resulting UNIT	LENGTH in Feet	WIDTH, HEIGHT or DEPTH	THICKNESS in Feet	DIAMETER in Feet	LBS per LF	TOTAL QTY		NOTES	Item No. (Carollo Code)
	(Leave this row blank)											
33_05_13 / 02580	84" X 8' Deep Precast Manhole, No Ring, Cover, Earthwork, Top Or Bottom Slab	5.00	EA						5.00	EA		0258011015
33_05_13 / 02580	84" Precast Manhole, Xtra Depth Over 8'	5.00	VLF		7.00				35.00	VLF	Assumes average 15' depth.	0258011016
33_05_13 / 02580	36" Dia. X 1150 Lb Heavy Traffic Manhole Frame & Cover	5.00	EA						5.00	EA		0258013065
31_50_00 / 02260	Sheet Piling, 27#/Sf To 20' Deep, Drive, Pull & Salvage (Trenches Only)	1.00	SF	1,500.00	15.00				22,500.00	SF		0226023018
31_00_00 / 02300	Cat 235 Trackhoe 1.50Cy Bucket, Class B (Medium Digging), 0-20' D	1.00	CY	750.00	8.00	15.00			3,333.33	CY	Assumes 8' wide trench	0230025051
31_00_00 / 02300	Imported Pipe Bed & Zone/Confined Structure Backfill, Class B Material	1.00	CY	750.00	8.00	15.00			2,547.93	CY	Subtract Pipe volume	0230025062
31_00_00 / 02300	10 Cy Dump Truck, 10 Miles/Round Trip	1.00	CY	750.00	8.00	15.00			3,333.33	CY		0230027008
33_31_20 / 15261	72" Astm C-76 Class Iii Rcp In Open Trench	1.00	LF	750.00					750.00	LF		1526111017
32_12_15 / 02742	4" Ac Paving On 8" Abc	1.00	SY	750.00	12.00				1,000.00	SY	Assumes 12' wide lane replacement	0274243021
02_41_00 / 02220	Asphalt Pavement Cutting	2.00	INFT	750.00		0.50			9,000.00	INFT	Trench length x2	0222011001
02_41_00 / 02220	Remove 4"-6" Asphalt Pavement	1.00	SF	750.00	12.00				9,000.00	SF		0222011005

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DETAILED COST ESTIMATE

For Allowances, make sure "Spec No." is entered as TEXT.

Project: D-to-M Streets Track & Signal Project
Client: City of Tacoma
Location: Tacoma, WA
Element: 01 Misc.

Format: MASTER FORMAT 50
Date : May 21st, 2020
By : B. Sliger
Reviewed:

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL	COMMENTS	ITEM NO (Carollo Code)
33_05_13 / 02580	84" Precast Manhole, Xtra Depth Over 8'	35.00	VLF	$916.28	$32,070		+10% adder for 96-inch	0258011016
33_05_13 / 02580	84" X 8' Deep Precast Manhole, No Ring, Cover, Earthwork, Top Or Bottom Slab	5.00	EA	$7,036.24	$35,181		+10% adder for 96-inch	0258011015
33_05_13 / 02580	36" Dia. X 1150 Lb Heavy Traffic Manhole Frame & Cover	5.00	EA	$1,420.80	$7,104		MH Excavation included under pipe extension	0258013065
				Total	$74,355			
				$/EA	$14,871.02	**$ 15,000.00**	96-Inch Manholes	
31_00_00 / 02300	10 Cy Dump Truck, 10 Miles/Round Trip	3,333.33	CY	$8.00	$26,670			0230027008
31_00_00 / 02300	Imported Pipe Bed & Zone/Confined Structure Backfill, Class B Material	2,547.93	CY	$62.16	$158,377			0230025062
31_00_00 / 02300	Cat 235 Trackhoe 1.50Cy Bucket, Class B (Medium Digging), 0-20' D	3,333.33	CY	$3.19	$10,621			0230025051
31_50_00 / 02260	Sheet Piling, 27#/Sf To 20' Deep, Drive, Pull & Salvage (Trenches Only)	22,500.00	SF	$19.67	$442,483			0226023018
33_31_20 / 15261	72" Astm C-76 Class Iii Rcp In Open Trench	750.00	LF	$192.26	$144,198			1526111017
32_12_15 / 02742	4" Ac Paving On 8" Abc	1,000.00	SY	$56.50	$56,499			0274243021
02_41_00 / 02220	Remove 4"-6" Asphalt Pavement	9,000.00	SF	$.70	$6,328			0222011005
02_41_00 / 02220	Asphalt Pavement Cutting	9,000.00	INFT	$.66	$5,939			0222011001
	Dewatering Allowance	1.00	LS	$100,000.00	$100,000			
	Traffic Control	1.00	LS	$143,000.00	$143,000		15% of pipe instalaltion cost (Round up)	
	Utility Conflict (Minor)	1.00	LS	$25,000.00	$25,000		Estimated allowance based on installation in roadway	
	Utility Conflict (Major)	1.00	LS	$50,000.00	$50,000		Estimated allowance based on installation in roadway	
				Total	$1,169,114			
				$/LF	$1,558.82	**$ 1,560.00**	72-Inch Pipe Extension	
	Total Proposed D-to-M Parallel 72-Inch Pipe (Direct Cost)				$ 2,272,325.00		From previous estimate/memo.	
	Less Flow Convergance Vault				$ 100,000.00		From previous estimate/memo (vault not required with extension)	
				Total	$ 2,172,325.00	**$ 2,173,000.00**	Proposed D-to-M Parallel 72-Inch Pipe (Direct Cost)	

Appendix C

BASIS OF COST ESTIMATE FOR PIPE REHABILITATION SCENARIO 3

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QUANTITY TAKEOFF WORKSHEET

Project: D-to-M Streets Track & Signal Project
Surface Water Hydraulic Analysis
Client: City of Tacoma
Location: Tacoma, WA
Zip Code: 98402
Element 01 Misc.

Date: May 21st, 2020
By : B. Sliger
Reviewed:
Format: MASTER FORMAT 50

MF50 / SPEC NO.	DRAWING # / DESCRIPTION	# of PLACES	Resulting UNIT	LENGTH in Feet	WIDTH, HEIGHT or DEPTH	THICKNESS in Feet	DIAMETER in Feet	LBS per LF	TOTAL QTY		NOTES	Item No. (Carollo Code)
	(Leave this row blank)											
33_05_13 / 02580	84" X 8' Deep Precast Manhole, No Ring, Cover, Earthwork, Top Or Bottom Slab	1.00	EA						1.00	EA		0258011015
33_05_13 / 02580	84" Precast Manhole, Xtra Depth Over 8'	1.00	VLF		20.00				20.00	VLF		0258011016
33_05_13 / 02580	36" Dia. X 1150 Lb Heavy Traffic Manhole Frame & Cover	1.00	EA						1.00	EA		0258013065
40_05_36.01 / 15269	48" Reinforced Polymer Mortar Pipe, Sn 46 Psi	1.00	LF	1,115.00					1,115.00	LF		1526911011
40_05_36.01 / 15269	48" Fwc 22.5 Deg Elbow	2.00	EA						2.00	EA		1526911031
31_00_00 / 02300	Controlled Density Fill (Cdf)	1.00	CY	1,115.00			24.00		991.11	CY	Annulus X-sectional area x length (50" pipe OD x 60" receiving pipe ID)	0230025073
31_00_00 / 02300	Imported Trench Backfill/Unconfined Struct. BF, Class B Material	1.00	CY			50.00	30.00		1,309.00	CY		0230025065
31_00_00 / 02300	Imported Trench Backfill/Unconfined Struct. BF, Class B Material	1.00	CY			35.00	20.00		407.24	CY		0230025065

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DETAILED COST ESTIMATE

For Allowances, make sure "Spec No." is entered as TEXT.

Project: D-to-M Streets Track & Signal Project
Client: City of Tacoma
Location: Tacoma, WA
Element: 01 Misc.

Format: MASTER FORMAT 50
Date : May 21st, 2020
By : B. Sliger
Reviewed:

SPEC. NO.	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	TOTAL	COMMENTS	ITEM NO (Carollo Code)
33_05_13 / 02580	84" Precast Manhole, Xtra Depth Over 8'	20.00	VLF	$832.98	$16,660		Excavation included in shaft LS.	0258011016
33_05_13 / 02580	84" X 8' Deep Precast Manhole, No Ring, Cover, Earthwork, Top Or Bottom Slab	1.00	EA	$6,396.58	$6,397			0258011015
33_05_13 / 02580	36" Dia. X 1150 Lb Heavy Traffic Manhole Frame & Cover	1.00	EA	$1,420.80	$1,421			0258013065
				Total	$24,477			
				$/Each	$24,477	$ 25,000.00	96-Inch Manholes (Downstream)	
40_05_36.01 / 15269	48" Fwc 22.5 Deg Elbow	2.00	EA	$5,548.75	$11,098			1526911031
40_05_36.01 / 15269	48" Reinforced Polymer Mortar Pipe, Sn 46 Psi	1,115.00	LF	$224.62	$250,446			1526911011
31_00_00 / 02300	Controlled Density Fill (Cdf)	991.11	CY	$92.79	$91,965			0230025073
	Service Reinstatement	10.00	EA	$7,500.00	$75,000			
	Laser Profiling of Carrier Pipe	1.00	LS	$60,000.00	$60,000		Based on quote for similar project from Redzone Robotics.	
				Total	$488,509			
					$438	$440	Slipline of 60/63-Inch Pipe w/ 48-Inch Pipe	
31_00_00 / 02300	Imported Trench Backfill/Unconfined Struct. BF, Class B Material	1,309.00	CY	$109.37	$143,167		x2 Unit cost for depths and complexity	0230025065
	Excavation	1.00	LS	$200,000.00	$200,000		Based on similar 2015 Project	
	30-foot Diameter Secant Pile Wall, 50 foot Depth	1.00	LS	$ 250,000.00	$250,000		Based on similar 2015 Project	
	Tremie Slab Bottom	1.00	LS	$ 125,000.00	$125,000		Based on similar 2015 Project	
	Site Prep and Layout	1.00	LS	$ 125,000.00	$125,000		Based on similar 2015 Project	
	Site Restoration	1.00	LS	$8,000	$8,000			
31_00_00 / 02300	Imported Trench Backfill/Unconfined Struct. BF, Class B Material	407.24	CY	$69.43	$28,274		x2 Unit cost for depths and complexity	0230025065
	Excavation	1.00	LS	$100,000	$100,000		Based on similar 2015 Project	
	20-foot Diameter Secant Pile Wall, 35 foot Depth	1.00	LS	$125,000	$120,000		Based on similar 2015 Project	
	Tremie Slab Bottom	1.00	LS	$75,000	$60,000		Based on similar 2015 Project	
	Site Prep and Layout	1.00	LS	$75,000	$60,000		Based on similar 2015 Project	
	Site Restoration	1.00	LS	$10,000	$10,000			
	Traffic Control	1.00	LS	$10,000	$10,000			
				Total	$1,239,441	$1,240,000	Slipline Access Excavation Shaft	
	Precast 12' Diameter, Manhole Top, 30 Inch Deep	1.00	EA	$ 40,000.00	$ 40,000.00		Costs from similar Project.	
	Precast, 12' Diameter Manhole Sections, 96 Inch Deep	6.00	EA	$ 30,000.00	$ 180,000.00		Excavation costs included in shaft LS.	
	Structure Foundation	1.00	EA	$ 50,000.00	$ 50,000.00			
	Vortex Drop Insert	1.00	EA	$ 240,000.00	$ 240,000.00			
	Vortex Drop Insert Structural Supports	1.00	LS	$ 100,000.00	$ 100,000.00			
	Manhole Access Cover	1.00	EA	$ 2,500.00	$ 2,500.00			
	Piping Tie-Ins	1.00	LS	$ 20,000.00	$ 20,000.00			
40_05_36.01 / 15269	48" Reinforced Polymer Mortar Pipe, Sn 46 Psi	30.00	LF	$224.62	$ 6,738.45			
	Excavation for Overflow Pipe	1.00	LS	$50,000.00	$ 50,000.00			
				Total	$ 689,238.45	$690,000	Drop Structure & Overflow Pipe	