CITY OF BAINBRIDGE ISLAND

KITSAP COUNTY **WASHINGTON**

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WEST EAGLE HARBOR BEACH SEWER MAIN PREDESIGN REPORT

G&O #17504
FEBRUARY 2018

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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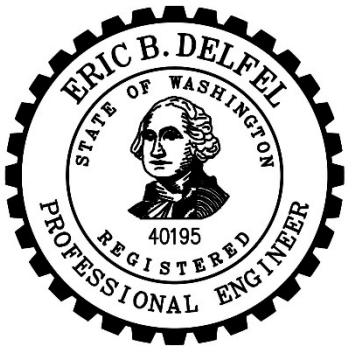

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EXECUTIVE SUMMARY

PURPOSE

The City of Bainbridge Island has contracted with Gray & Osborne to evaluate alternatives to facilitate replacing the West Eagle Harbor Beach Sewer Main. The City of Bainbridge Island currently operates and maintains approximately 2,500 linear feet of 10-inch ductile iron sanitary sewer main that is located along the West Eagle Harbor shoreline and is only accessible for maintenance via a series of cleanouts during low-tide conditions. The City has inspected the main and has noted numerous problems with the main, including sags, bellies, and joint separations due to lack of support from the surrounding soils. Deficient slopes along the main have resulted in several areas of solidified grease, which, along with age and exposure to the elements of the Puget Sound environment, have led to a significant increase in maintenance efforts and cost in recent years. Since the main is only accessible during extremely low tide, the City can only perform infrequent maintenance at increasing costs. This report evaluates approaches to replace the existing sewer main in place or reconfigure the upland sewer system to allow for the abandonment of the West Eagle Harbor Beach Sewer Main.

REPLACING/REHABILITATING THE WEST EAGLE HARBOR BEACH SEWER MAIN

For the evaluation of replacement and rehabilitation of the existing West Eagle Harbor Beach sewer main in the beach, several trenchless construction techniques were examined in the report; however, they were all seen as impractical alternatives for the following reasons:

- Most trenchless construction techniques can only be used on straight alignments and are impractical for the curved alignment of the West Eagle Harbor Beach Sewer Main.

- Any work on the beach to replace or rehabilitate the existing sewer main would require an extensive permitting effort.

- Several of the trenchless construction techniques would still require open trenching in the beach to construct insertion and receiving pits and reconnecting the existing side sewers, which would necessitate the installation of coffer dams and an extensive dewatering effort.

- The main can only be accessed via cleanouts, and the majority of the main is below the OHWM water level. This restricted access complicates all of the rehabilitating options.

- Locating, reinstating, and bypass pumping for side sewers currently connected to the main will be both challenging and costly.

- Most of the trenchless construction techniques would not correct the main's current problems with flat and negative grades and grease buildup would still continue to be an issue.

- Replacement of the existing main by open trench construction in the beach would be very expensive due to limited constructions hours for low tide, extensive dewatering, and like the trenchless construction techniques considered would also have significant permitting requirements.

- All of the construction techniques for replacing the sewer main in place, whether trenchless or open trench methods, would still result in a sewer main in the beach and would not eliminate the accessibility issues the City is currently experiencing.

- Unless an expensive structural support system is included in the project, any alternative to rehabilitate or replace the sewer main in the beach could continue to sink and have grade issues.

- Maintenance access would continue to be an issue, and would likely continue to be costly even if the rehabilitation is successful.

Consequently, the best option is to eliminate the beach main and to reconfigure the sewer system of the contributing upland area.

RECONFIGURING THE UPLAND SEWER SYSTEM

The other avenue available to the City to address the West Eagle Harbor Beach Sewer Main is to reconfigure the contributing upland sewer system to allow for the abandonment of the West Eagle Harbor Beach Sewer Main. For the purposes of analysis, design, and project phasing, the existing tributary Lower Lovell Basin has been divided into the following smaller subbasins.

- South Sunday Cove Subbasin: This subbasin is a small area west of Lovell Avenue SW and South of Winslow Way that currently flows into the northernmost end of the West Eagle Harbor Beach Sewer Main.

- Lovell Avenue Subbasin: This subbasin is defined as the area currently served by the gravity main that flows south on Lovell Avenue SW from approximately Sheppard Way NW to Lower Lovell Lift Station. The subbasin also serves one block on Parfitt Way SW to Wood Avenue SW.

- Wood Avenue Subbasin: This subbasin is comprised of the remaining existing tributary Lower Lovell Basin that is currently served by the West Eagle Harbor Beach Sewer Main segment south of the Lower Lovell Lift Station.

RECOMMENDATIONS

Discussions on all evaluated alternatives and detailed evaluation of results are included in the report. The following summarizes the recommended alternatives for future service.

SOUTH SUNDAY COVE SUBBASIN

The preferred alternative to address the flows in the South Sunday Cove Subbasin is Alternative S1 – Gravity Service to Sunday Cove Lift Station. This alternative would convey flow from the basin's nine parcels by gravity north to the existing Manhole 5-46 where it could then be conveyed to the Sunday Cove Lift Station. This alternative would require installing approximately 310 linear feet of gravity sewer main and installing side sewers to the two shoreline properties.

A significant drawback to this alternative is that currently, a portion of the properties existing sewer main runs under the foundations of two shoreline properties and the side sewers from these properties appear to drop directly into the existing main. Serving these properties by gravity would require entering the home and cutting through their foundation slabs at the point where the side sewers enter the existing main to facilitate rerouting the sewers to the proposed gravity main.

LOVELL AVENUE SUBBASIN

The preferred alternative to address the flows in the Lovell Avenue Subbasin is Alternative L1 – Rehabilitate the Existing Lower Lovell Lift Station and continue operating the subbasin as it currently operates. This is the preferred alternative primarily due to the lower cost. The City may want to consider including Alternative L5 – Directional Drilling Gravity Main in their long-term planning. This alternative would allow for the elimination of the Lower Lovell Lift Station, reducing the City's long-term O&M burden. In order for Alternative L5 to be feasible in the future, design of any lift station in the Wood Avenue Subbasin would need to include a wet well deep enough to accommodate this future pipeline.

WOOD AVENUE SUBBASIN

The preferred alternative to address the flows in the Wood Avenue Subbasin is Alternative W2 – Wood Lift Station and Existing Beach Main (Figure 15). This alternative would continue to collect flows from the east end of the basin through the existing beach main and direct these flows to the proposed Wood Lift Station. In addition, along with the existing beach main flows, the Wood Lift Station would collect

flows from the west portion of the basin and would direct these flows to the manhole at the intersection of Wood Avenue SW and Parfitt SW.

LOVELL AVENUE GRINDER PUMPS

No matter which alternatives are selected in order to abandon the north section of the West Eagle Harbor Beach Sewer Main, there are approximately six homes along the shoreline west of Lovell Avenue SW that cannot be practically served by any other alternative than to install each home with an individual grinders pump.

TABLE E-1

Recommended Alternatives Cost Summary

Alternative	Description	Cost	ERU	Cost per ERU
S1	Gravity Service to Sunday Cover Lift Station	$514,000	9	$57,111
L1	Rehabilitate the Existing Lower Lovell Lift Station	$557,000	40	$13,925
W2	Wood Lift Station and Existing Beach Main	$2,863,000	56	$51,125
	Lovell Avenue Grinder Pumps	$352,000	6	$58,667
Total Project Cost		**$4,286,000**	**111**	**$38,613**

PREDESIGN REPORT

PURPOSE

The City of Bainbridge Island has contracted with Gray & Osborne to develop a plan to address issues with the West Eagle Harbor Beach Sewer Main that serves the Lower Lovell Tributary Basin. This report describes the existing tributary sanitary sewer system, identifies potential design alternatives to address the concerns with the main, provides preliminary cost estimates for these alternatives, evaluates these alternatives based on cost and non-cost factors, and provides recommendations and potential phasing of capital improvements.

BACKGROUND

The City of Bainbridge Island is located on the east side of Kitsap County in Western Washington, approximately 10 miles west of the City of Seattle. The City currently provides sanitary sewer service to approximately 6,500 residents. The West Eagle Harbor Beach Sewer Main and the Lower Lovell Lift Station are located within the City's Lower Lovell Tributary Sanitary Sewer Basin (Lower Lovell Tributary Basin). Figure 1 shows the existing Lower Lovell Tributary Basin and the adjacent Tributary Basins, as well as the Lower Lovell, Sunday Cove, and Old Treatment Plant Lift Stations.

GEOTECHNICAL REPORT

On October 26, 2017 PanGEO Engineers completed a subsurface exploration to support the predesign effort. The results of the geotechnical investigation are contained in the Geotechnical Data Report included in Appendix C. In summary, the site reconnaissance included two test borings, one at the intersection of Parfitt Way SW and Wood Avenue SW and the second at the intersection of Wood Avenue SW and Stetson Place SW. The Preliminary Geologic Map of Bainbridge Island indicated that the soils anticipated in the project area would be Vashon glacial till. Glacial till is a very dense heterogeneous mixture of silt, sand and gravel laid down at the base of an advancing glacial ice sheet and is typically exhibits low compressibility and high-strength characteristics. The results from the investigation generally confirmed the mapped geology.

Groundwater was first encountered at 34 feet below grade at the Parfitt Way SW and Wood Avenue SW boring and 24 feet below grade at the Wood Avenue SW and Stetson Place SW boring. Because the site soils are very dense and have relatively high fines content, the groundwater is seasonal and perched. The groundwater transmission value is anticipated to be relatively low and maybe adequately addressed with sumps and pumps at the bottom of excavations.

During the development of this report we evaluated the feasibility of using pilot tube microtunneling (PTMT) to install a portion of the sewer line. Typically, this trenchless

method is used in soft soils with a Standard Penetration Test (SPT) result of 50 blows per foot (bpf) and less than 15 feet of hydrostatic head. The SPT values within the proposed pipe zone exceeded 50 bpf. As a result, PTMP was determined not to be an appropriate alternative for this project as the soils are too dense for this method and was not included in the report as a viable alternative.

The preferred trenchless method of pipe installation noted in the Predesign Report is directional drilling (HDD). The determination of the Geotechnical Data Report is that HDD techniques represent a feasible method of installing the proposed sewer main.

The report also examined the proposed site of the Wood Lift Station. It was determined that a fully-cased drilled shaft or sinking-caisson would likely be feasible to facilitate the installation of the station. Alternatively, a soldier pile wall with steel plate lagging or interlocking secant/tangent wall is also considered a feasible shoring option. However, given the very dense glacial till anticipated to be encountered during excavation it is unlikely sheet piles could be driven deep enough to provide adequate embedment to facilitate sheet piles being a feasible shoring system.

The report noted that it is anticipated that very dense glacial till will be encountered at the bottom of the excavation of the Wood Lift Station. The glacial till soils are anticipated to provide adequate support for the lift station at this location. However, the foundation soils are also anticipated to be highly moisture sensitive and care will need to be taken during construction to ensure the foundation soils remain dry and undisturbed during construction activities. To provide a firm working and bearing surface for the lift station, a leveling course of 6 to 12 inches of crushed surfacing base course is recommended.

LOWER LOVELL TRIBUTARY BASIN

The Lower Lovell Tributary Basin is approximately 38 acres and currently serves approximately 76 residential and commercial connections. Flow from the basin is collected at the Lower Lovell Lift Station, which is located at the southern end of Lovell Avenue SW. According to the City's General Sewer Plan (July 2015), the Lower Lovell Lift Station consists of two 7.5 hp pumps, each with 100 gpm capacity. The Lower Lovell Lift Station pumps flow via a 4-inch force main to the intersection of Parfitt Way SW and Wood Avenue SW within the Old Treatment Plant Lift Station sewer basin. The existing sanitary sewer system that serves the Lower Lovell Lift Station and Lower Lovell Tributary Basin is shown in Figure 2. The Lower Lovell Lift Station is currently located very close to the high tide level and the City has expressed some desire to move the station upland or, if possible, abandon it through construction of a gravity bypass.

West Eagle Harbor Beach Sewer Main

The West Eagle Harbor Beach Sewer Main is located along the shoreline and collects flow from the Lower Lovell Basin. It conveys these flows to the Lower Lovell Lift Station. The main is divided into two sections, herein referred to as the north (north of

the Lower Lovell Lift Station) and south (south of the Lower Lovell Lift Station) sections as shown on Figure 2. The north section consists of approximately 1,000 linear feet of 10-inch ductile iron gravity sewer main and the south section consists of approximately 1,500 linear feet of 10-inch ductile iron gravity sewer main. Based on a review of the record drawings, the design slope of the main is approximately 0.3 percent, and there are approximately 12 side sewers serving approximately 16 homes and several businesses that are directly connected to the main.

The City maintains West Eagle Harbor Beach Sewer Main through a series of cleanouts which can only be accessed during low tide conditions. Based on TV inspection records of the main and City staff, there are numerous sags, bellies, and joint separations caused by inadequate pipe support from the surrounding soils. The sags, bellies, and joint separations have resulted in several areas of solidified grease, resulting in a decrease in capacity and a significant increase in required maintenance. Further, tide-limited access makes maintenance difficult and costly. Significant evidence of corrosion of the main has also been observed. The City is concerned not only with the increase in maintenance required on the main, but also the future integrity of the pipe wall itself and possible leakage into the Puget Sound.

ADJACENT BASINS

Sunday Cove Tributary Basin

North of the Lower Lovell Tributary Basin is the Sunday Cove Tributary Basin, which is served by the Sunday Cove Lift Station. The Sunday Cove Lift Station is located at the south end of the basin at the west end of Winslow Way West, as shown on Figure 1. The lift station is a wet pit/dry pit configuration with two 25 hp pumps and a capacity of 490 gpm each. The Sunday Cove Lift Station pumps to the Highway 305 Tributary Basin.

Old Treatment Plant Tributary Basin

East of the Lower Lovell Tributary Basin is the Old Treatment Plant Tributary Basin which serves approximately 80 parcels. The Old Treatment Plant Lift Station is located northeast of the corner of Parfitt Way SW and Madison Avenue North as shown on Figure 1. The lift station is a wet pit/dry pit configuration which has a capacity of 250 gpm and receives flows from the Old Treatment Plant Tributary Basin as well as pumped flows from the Lower Lovell Tributary Basin via Lower Lovell Lift Station.

DESIGN AND PLANNING CRITERIA

According to the City's General Sewer Plan, the Lower Lovell Basin has an existing maximum flow of 0.03 mgd (21 gpm), increasing to an estimated 0.07 mgd (49 gpm) in 2035. A single 8-inch gravity main at the Department of Ecology minimum slope of 0.4 percent can convey over 300 gpm; well above the flows required to serve the study

area. For this reason, hydraulic modeling of any proposed gravity sewer system will not be performed as part of this report.

ALTERNATIVE ANALYSIS

We have identified the following alternatives for evaluation:

- Rehabilitation of the West Eagle Harbor Beach Sewer Main.
- Replacement of the West Eagle Harbor Beach Sewer Main in the same location.
- Abandonment of the West Eagle Harbor Beach Sewer Main through installation of new lift stations, installation of gravity mains, either through open trench or trenchless construction, or service of the area through individual grinder pump stations.

REHABILITATE THE WEST EAGLE HARBOR BEACH SEWER MAIN

One approach to addressing the City's concerns with the West Eagle Harbor Beach Sewer Main would be to rehabilitate the existing main in place using trenchless construction techniques. In certain applications, these techniques can be attractive alternatives to traditional open-cut pipe replacement methods. In order to focus the discussions in the report on the constructability of trenchless methods as they pertain to the West Eagle Harbor Beach Sewer Main and the Lower Lovell Basin, we have provided a more detailed discussion of possible trenchless construction techniques and their potential application in Appendix A.

Rehabilitation techniques that could be considered feasible for the West Eagle Harbor Sewer Main include cure-in-place pipe (CIPP), sliplining, and pipe bursting. All three of these methods have significant constructability and environmental challenges for this particular application.

All three trenchless techniques require access to the main through manholes or access pits in order to perform the work. Most of the West Eagle Harbor Sewer Main is constructed in areas that are often underwater, and only have cleanouts providing access to the sewer main. Cleanouts are not suitable access points for any of the evaluated trenchless methods. Therefore, to facilitate rehabilitating the main using trenchless technologies, either manholes would need to be installed or access pits constructed; otherwise these methods of rehabilitation would not be feasible. Also, a significant issue with sliplining and pipe bursting, and to a lesser extent for CIPP, is that construction must occur in straight lines. Documented bends in the existing main, as great as 45 degrees, would require access pits at the end of each straight section for both sliplining and pipe bursting construction techniques.

Another significant issue with constructability is that a significant portion of the West Eagle Harbor Beach Sewer Main is constructed below the Ordinary High-Water Mark (OHWM). Installation of access manholes or pits to facilitate the use of pipe bursting, installation of CIPP, or sliplining would all require significant periods of construction time in areas that are routinely underwater. This would necessitate construction of coffer dams and other expensive dewatering techniques.

In addition, any disturbance below the OHWM requires permits from the United States Army Corps of Engineers with concurrence from the National Marine Fisheries Service and the US Fish & Wildlife Service; the Washington State Departments of Ecology, Natural Resources and Fish & Wildlife; and local agencies for Shorelines Management Act compliance and local critical areas. Obtaining these permits generally takes a year or longer. Typically, mitigation is required for temporary and permanent impacts from the construction project.

Another challenge with the rehabilitation options is reconnecting the numerous side sewers after the main has been rehabilitated and maintaining service through bypass pumping during construction. Both these issues further complicate these trenchless construction options.

Finally, while these rehabilitation options may halt the deterioration of the beach main, they do not solve the other existing issues the City has with the beach main. These trenchless techniques follow the existing host pipe's alignment, which means any existing bellies in the main will continue to exist along with the associated maintenance problems, such as grease and solids deposits. The main would also still be located at or below the OHWM and all the problems the City has experienced with settling and access for maintenance would continue.

In summary, rehabilitation of the existing West Eagle Harbor Beach Sewer Main has the following issues:

- Most trenchless construction techniques can only be used on straight alignments and are impractical for the curved alignment of the West Eagle Harbor Beach Sewer Main.

- Any work on the beach to replace or rehabilitate the existing sewer main would require an extensive permitting effort.

- Several of the trenchless construction techniques would still require open trenching in the beach to construct insertion and receiving pits and reconnecting the existing side sewers, which would necessitate the installation of coffer dams and an extensive dewatering effort.

- The main can only be accessed via cleanouts, and the majority of the main is below the OHWM water level. This restricted access complicates all of the rehabilitating options.

- Locating, reinstating, and bypass pumping for side sewers currently connected to the main will be both challenging and costly.

- Most of the trenchless construction techniques would not correct the main's current problems with flat and negative grades and grease buildup would still continue to be an issue.

- Replacement of the existing main by open-trench construction in the beach would be very expensive due to limited constructions hours for low tide, extensive dewatering, and like the trenchless construction techniques considered would also have significant permitting requirements.

- All of the construction techniques for replacing the sewer main in place, whether trenchless or open trench methods, would still result in a sewer main in the beach and would not eliminate the accessibility issues the City is currently experiencing.

- Unless an expensive structural support system is included in the project, any alternative to rehabilitate or replace the sewer main in the beach could continue to sink and have grade issues.

- Maintenance access would continue to be an issue, and would likely continue to be costly even if the rehabilitation is successful.

For these reasons, rehabilitation of the existing sewer main has been determined to be an infeasible alternative and therefore is not further addressed in the report.

There is, however, one segment of the existing south main that could be continued to be used. The section of approximately 450 linear feet is located between Manhole 6-21F and Manhole 6-17 and is located under the boardwalk above the beach. The pipe is currently in good condition and, unlike the rest of the main, is accessible by manholes instead of cleanouts. And should the City need to repair this section of pipe at some future date CIPP rehabilitation may be a cost effective viable alternative since the main is located above the OHWM and accessible by manholes. For this reason the section of main has been included in Alternative W2 and W5 as a possible solution to provide for the abandonment of the south section.

REPLACE THE WEST EAGLE HARBOR BEACH SEWER MAIN IN THE SAME LOCATION

Replacement of the existing West Eagle Harbor Beach Sewer Main in the same location through standard open cut methods is another potential alternative. All of the issues that exist for rehabilitation of the existing main, which include constructability, permitting requirements, environmental concerns, and long-term maintenance, also apply to the replacement option. This approach may afford the opportunity to eliminate the bellies and sags from the main; however, unless an expensive piling system was installed to support the main, the main would eventually settle again as it has in the past. For this reason and for the similar reasons noted in the rehabilitation section, we consider replacement of the Sewer Main in the same location to be too costly and time consuming to be considered a viable option.

ABANDON THE WEST EAGLE HARBOR BEACH SEWER MAIN

Since neither replacement in place nor rehabilitation of the West Eagle Harbor Beach Sewer Main is a feasible solution, maintaining long term sewer service in this area will require decommissioning the main and reconfiguring the contributing upland sanitary sewer system. To develop a new sanitary sewer system to serve the Lower Lovell Tributary Basin, the basin must be divided into smaller subbasins based on topography and current gravity service. Dividing the basin into subbasins allows for allows for better development of possible alternatives and for manageable phasing of construction project. This analysis will identify alternatives that provide service to three smaller subbasins: the South Sunday Cove Subbasin, the Lovell Avenue Subbasin, and the Wood Avenue Subbasin, as shown in Figure 3.

Each of these smaller subbasins has alternatives for service that are presented and evaluated in the following sections. Addressing individual subbasins also presents opportunity for phasing of the project to allow the City more flexibility in funding and construction. Each alternative will be identified by its subbasin for clarity.

The criteria used to evaluate alternatives include the following:

- Cost
- Constructability and Risk
- Environmental and Permitting Factors
- Long-Term Operation and Maintenance Issues
- Public Impacts
- Easement Acquisition

Each of these factors will be evaluated and used to present the recommended alternative. Discussion and analysis of each of the alternatives are presented in the following sections.

Detailed cost estimates for each alternative are presented in Appendix B. These estimates are planning level cost estimates and include a 30 percent construction contingency, 30 percent cost for engineering, construction management and administration, and a 3 percent allowance for permitting when appropriate. Easements costs were estimated based on 10 percent of required land value, estimated at $1,000,000 per acre. In most cases, it was assumed that direct payment for easements would not be required if impacts to a property were required to provide service to the property (such as for a side sewer or grinder pump). However, for properties where lift stations or gravity sewer mains would be installed, it was assumed that payment for easements would be required.

South Sunday Cove Subbasin

The South Sunday Cove Subbasin is a small area west of Lovell Avenue SW and South of Winslow Way that currently flows into the northern-most end of the West Eagle Harbor Beach Sewer Main. It consists of only nine parcels on a private road. The existing sewer main runs underneath two of the existing shoreline homes before it flows down into the north end of the sewer main, which significantly impacts the alternatives for service.

The following are alternatives that have been considered to serve the South Sunday Cove Subbasin:

- Alternative S1 – Gravity Service to Sunday Cove Lift Station.
- Alternative S2 – Individual Grinder Pumps.
- Alternative S3 – South Sunday Cove Lift Station.

Figures 4 through 6 illustrate the evaluated alternatives.

<u>Alternative S1 – Gravity Service to Sunday Cove Lift Station</u>

Alternative S1 is shown on Figure 4. This alternative directs flow from the nine parcels by gravity north to existing Manhole 5-46, which conveys flows to the existing Sunday Cove Lift Station. The nine upland properties in this area can be served by gravity by installing a new manhole (Manhole 1) to intercept the existing main and convey this flow by gravity to existing Manhole 5-46. This would require an easement through private property and installation of approximately 350 linear feet of gravity sewer. There is an existing block retaining wall, approximately 7 feet in height that would need to be removed and restored during the construction of the gravity main.

Providing service to the two shoreline homes in the subbasin has construction challenges. Currently, the existing sewer main that serves the property runs under the two shoreline homes and the side sewers from these properties appear to drop directly into the existing main. Serving these properties by gravity would require entering the homes and cutting through their foundation slabs at the point where the side sewers enter the existing main to facilitate rerouting the sewers to the proposed gravity main. While physically possible,

there are significant legal and political hurdles and constructability issues with performing this work on private property, particularly within private residences, the City believes, however, this to be a viable alternative.

In summary, the key elements to the alternative include:

- Construction of approximately 350 linear feet of 8-inch gravity sewer, including easement acquisition and construction through an existing retaining wall.
- Installation side sewer to serve the two shoreline homes will require cutting through their foundation slabs at the point where the side sewers enter the existing main and rerouting the sewers to the proposed gravity main.
- Obtaining an easement from the adjacent property.

Estimated Project Cost: $514,000

Cost per ERU: $57,111 (9 ERU)

Constructability and Risk: Moderate risk. Additional survey and geotechnical information will be needed for a complete evaluation of the possibility of constructing a new gravity sewer to serve the area, but the alternative seems within normal risk parameters. Construction near the shoreline, near and under private residences and through the existing gravity retaining wall will have some construction concerns that will need to be evaluated during design. In addition, obtaining permission from the two shoreline properties to cut through their foundation to permit connecting their side sewers to the proposed sewer main and obtaining an easement from the adjacent property to facilitate the installation of the sewer main could be challenging.

Environmental and Permitting Factors: A shoreline permit and SEPA will be required.

Long-Term Operation and Maintenance Issues: Access to the gravity main for maintenance may also be challenging as it is located on private property.

Public Impacts: There will be localized impacts during construction and periodically providing maintenance of the gravity sewers including noise and disruption of access to homes for residents and emergency vehicles. Installing side sewers to the shoreline homes will have a significant impact to these individuals.

Easement Acquisition: Obtaining permission from the two shoreline properties to cut through their foundation to permit connecting their side sewers to the proposed sewer

main and obtaining an easement from the adjacent property to facilitate the installation of the sewer main could be challenging.

Alternative S2 – Individual Grinder Pumps

Alternative S2 is shown on Figure 5. The second alternative examined to serve this area is to install grinder pumps to serve each individual property and pump the flow up to the existing gravity main on Lovell Avenue SW. This approach has the same issue as Alternative S1 with regard to the connecting the two side sewers underneath the shoreline homes, but unlike Alternative S1, acquisition of an easement from the adjacent property would not be required.

Like Alternative S1 serving the two shoreline homes with individual grinder pumps would require entering the homes and cutting through their foundation slabs at the points where the side sewers enter the existing main to facilitate rerouting the sewers to the individual grinder pumps. An alternative to this approach could be to intercept the existing sewer main at the north shoreline home prior to it entering the West Eagle Harbor Beach Sewer Main and install a grinder pump to serve both properties.

In summary, the key elements to the alternative include:

- Construction of approximately 500 linear feet of 3-inch low-pressure force main in the private road.
- Installation of nine individual grinder pumps and force mains to serve the subbasin.

Estimated Project Cost: $529,000

Cost per ERU: $58,778 (9 ERU)

Constructability and Risk: Moderate risk. Locating individual grinder pumps near private residence may have constructability and restoration issues that will need to be evaluated during design. Providing individual grinder pumps to the two shoreline properties could have a significant risk.

Environmental and Permitting Factors: A shoreline permit and SEPA will be required. In addition, individual easements will need to be obtained from each property owner to facilitate the installation of the grinder pumps.

Long-Term Operation and Maintenance Issues: City-maintained grinder pumps will require maintenance and can be a cost burden over the long-term. Service during extended power outages is also a concern with this option.

Public Impacts: There will be localized impacts during construction of the low pressure force main including noise and disruption of access to homes for residents and emergency vehicles. I n addition, there will be impacts to property owners due to the City periodically providing maintenance to the grinder pumps.

Easement Acquisition: Obtaining permission from the two shoreline properties to cut through their foundation to permit connecting their side sewers to the proposed individual grinder pumps could be challenging. Individual easements will also be required for the installation and service of the grinder pumps and force mains from the other residences.

Alternative S3 – South Sunday Cove Lift Station

Alternative S3 is shown on Figure 6. The third alternative examined to serve this area is to intercept the existing sewer main at the north shoreline home prior to it entering the West Eagle Harbor Beach Sewer Main. From this point the flow could be conveyed north to the existing Manhole 5-46. Based on LiDAR topographical elevation information it appears unlikely that the flow can be conveyed to Manhole 5-46 by gravity. Therefore, a small duplex grinder lift station would be required to convey flow north to existing Manhole 5-46. We would recommend the installation of a new Manhole 5 to intercept the flow from the area before it enters into the north section of the West Eagle Harbor Beachline Sewer. The flow from Manhole 5 would then be conveyed to a new South Sunday Cove Lift Station located north of the last shoreline home on the existing main. This location would provide the City with access to the new lift station. From here the flow would then be pumped north to the existing Manhole 5-46, where it can flow by gravity to the existing Sunday Cove Lift Station. Should the City elect to maintain the discharge flow from this area within the Lower Lovell Basin, the flow from the new South Sunday Cove Lift Station could be conveyed up to the gravity main on Lovell Avenue SW. However, it is a shorter distance to Manhole 5-46 and therefore would provide a less expensive solution. If the home owner is not receptive to the installation of a manhole in their backyard, the existing main could be intercepted and a cleanout installed at that location.

In summary, the key elements to the alternative include:

- Construction of a manhole and approximately 50 linear feet of 8-inch gravity sewer.
- Construction of a duplex grinder station with a generator and fuel tank.
- Construction of approximately 120 linear feet of force main in an easement to the Sunday Cove Tributary Basin.
- Construction of vehicle access to serve the new grinder station.

Estimated Project Cost: $486,000

Cost per ERU: $54,000 (9 ERU)

Constructability and Risk: Moderate risk. Additional survey and geotechnical information will be needed for a complete evaluation for construction of the new small duplex grinder lift station and interceptor manhole, but the alternative seems within normal risk parameters. Construction near the shoreline and near private structures will have some construction concerns that will need to be evaluated during design. In addition, there may also be some access issues to provide maintenance to the lift station and generator and too periodically exercise and refueling that will also need to be evaluated during design.

Environmental and Permitting Factors: A shoreline permit and SEPA will be required.

Long-Term Operation and Maintenance Issues: City maintained small duplex grinder lift station and generator is a maintenance and cost burden over the long term. In addition, the City will have to access the facility periodically for maintenance and to exercise and refuel the generator

Public Impacts: There will be localized impacts during construction of the grinder lift station and force main including noise and disruption of access to homes for residents and emergency vehicles. In addition, there will be impacts to property owners due to the City periodically providing maintenance to the facilities and to exercise and refuel the generator.

Easement Acquisition: Easements will be required for installation and maintenance of the force main and for the new lift station and generator.

South Sunday Cove Alternatives Evaluation

An alternatives evaluation matrix has been prepared in Table 1. For each of the evaluation criteria previously described, we have rated each of the three South Sunday Cove alternatives from 1 to 10, with 10 being the most positive. The scores for each criterion are summed for each alternative.

TABLE 1

South Sunday Cove Subbasin Alternatives Evaluation

Alternative	**Gravity Service S1**	**Individual Grinder Pumps S2**	**Lift Station S3**
Estimated Project Cost	7	6	8
Constructability and Risk	6	5	8
Environmental and Permitting Factors	9	8	6
Long-Term Operation and Maintenance Issues	10	5	6
Public Impacts	7	4	6
Easement Acquisition	6	7	5
Total	**45**	**35**	**39**

Based on the evaluation criteria presented in Table 1, Alternative S-1, gravity service to Sunday Cove Lift Station is the highest scoring alternative for service to the South Sunday Cove Subbasin.

Constructing the South Sunday Cove Subbasin project and the Lovell Avenue Grinder Pumps (noted in the Lovell Avenue Subbasin discussion) allow the north segment of the West Eagle Harbor Beach Sewer Main to be decommissioned. For the purposes of the report, these two projects are considered separate phases of the project.

Lovell Avenue Subbasin

The Lovell Avenue Subbasin is defined as the area currently served by the gravity main that flows south on Lovell Avenue SW from approximately Sheppard Way NW to the Lower Lovell Lift Station. This subbasin also serves one block on Parfitt Way SW to Wood Avenue SW. The alternatives for this subbasin evaluated continuing to pump the flow over to the Old Treatment Plant Tributary Basin or conveying the flow by gravity to the Old Treatment Plant Tributary Basin or to the proposed lift stations discussed in the Wood Avenue alternatives.

The following five alternatives have been considered to service the Lovell Avenue Subbasin:

- Alternative L1 – Rehabilitate the Existing Lower Lovell Lift Station.
- Alternative L2 – Relocate the Existing Lower Lovell Lift Station.
- Alternative L3 – Microtunnel Gravity Main and Decommission the Lower Lovell Lift Station.

- Alternative L4 – Auger Bore Gravity Main and Decommission the Lower Lovell Lift Station

- Alternative L5 – Directional Drill Gravity Main and Decommission the Lower Lovell Lift Station

Alternative L1 – Rehabilitate the Existing Lower Lovell Lift Station

Alternative L1 is shown on Figure 7. Rehabilitation of the Lower Lovell Lift Station at its existing location would allow the City to continue to serve the basin as it presently operates. At some point, the useful life of the mechanical and electrical equipment will necessitate the replacement of the lift station. The existing wet pit/dry pit station pumps could be replaced if they are showing signs of wear, or it may only require replacement of the impellers and motors. The existing wet well would require repair and recoating to prevent infiltration and inflow and saltwater intrusion, and to protect and rehabilitate the structure from hydrogen sulfide corrosion. The existing motor starters and generator would also eventually require replacement due to age and lack of spare parts. The motor starters may also need to be moved above grade to meet current electrical code requirements. It is important to note that rehabilitation of the Lower Lovell Lift Station is a project that would need to occur even if the West Eagle Harbor Beach Sewer Main was still serviceable.

One advantage for this option is that it can be phased for construction at any time, independent of the other work needed to decommission the West Eagle Harbor Beach Sewer Main. A disadvantage to this alternative is that the station's proximity to the shoreline could be a concern in the future.

In summary, the key elements to the alternative include:

- Replacement of the existing impellers, motors, generator and motor starters.

- Rehabilitation of the existing wet well.

Estimated Project Cost: $557,000

Cost per ERU: $13,925 (40 ERU)

Constructability and Risk: Low risk. All work could be completed within the existing lift station.

Environmental and Permitting Factors: No permits would be required as all the work is normal maintenance. The City has some concerns for this station due to its proximity to the shoreline and the environmental damage an overflow at the station would cause.

Long-Term Operation and Maintenance Issues: Maintenance of a lift station is more expensive than maintenance of a gravity main as presented in other alternatives. The operation and maintenance costs would be similar to the costs required for the existing station.

Public Impacts: There will be localized impacts due to construction noise and minor impacts to local traffic.

Easement Acquisition: None.

Alternative L2 – Relocate the Existing Lower Lovell Lift Station

Alternative L2 is shown on Figure 8. Due to the existing Lower Lovell Lift Station close proximity to the shoreline there is some concern that the Station could need be relocated upland closer to the intersection of Parfitt and Lovell. The facilities and cost of the station would be similar to the rehabilitation option, with the exception of construction of a new wet well instead of the rehabilitation of the existing wet well and the installation of a new electrical service. Some additional private grinder pumps may also be required to serve two to three homes that are currently served by gravity. It is anticipated that the existing force main could be connected to the new lift station and continue to be used to pump to Manhole 3-5.

In summary, the key elements to the alternative include:

- Construction of a new submersible lift station.
- Decommissioning of the existing lift station.
- Acquisition of an easement for the new lift station.
- Installation of approximately three individual grinder pumps.

Estimated Project Cost: $1,555,000

Cost per ERU: $38,875 (40 ERU)

Constructability and Risk: Moderate risk. Additional survey and geotechnical information will be needed for a complete evaluation for construction of the new lift station, but the alternative seems within normal risk parameters.

Environmental and Permitting Factors: A shoreline permit and SEPA will be required. In addition, a right-of-way permit, a conditional use permit and grading permit may be required.

Long-Term Operation and Maintenance Issues: Maintenance of a lift station is more expensive than maintenance of a gravity main as presented in other alternatives. The operation and maintenance costs would be similar to the costs required for the existing station.

Public Impacts: There will be localized impacts during construction of the lift station including noise and disruption of access to homes for residents and emergency vehicles. In addition, there will be impacts to property owners due to the City periodically providing maintenance of the lift station. Impacts would be greater than rehabilitation at the lift station and less than gravity sewer alternatives.

Easement Acquisition: Property may need to be purchased or an easement obtained from the property owner should the lift station be constructed on private property.

Alternative L3 – Microtunnel Gravity Main and Decommission the Lower Lovell Lift Station

Alternative L3 is shown on Figure 9. The survey performed in connection with this report indicates that it is possible to convey flow by gravity from the intersection of Lovell Avenue SW and Parfitt Way SW, to approximately 130 feet west of the intersection of Madison Avenue South and Parfitt Way SW at a slope of approximately 1 percent. This distance is approximately 1,200 linear feet, and would require the sewer main to range in depth from 5 feet deep at its terminus, to approximately 37 feet deep at the intersection of Wood Avenue SW. Due to the depth, utility conflicts, and the narrow right-of-way in portions of Parfitt Way SW, open trench construction of the gravity main has substantial risk and is considered infeasible.

One potentially feasible alternative is microtunneling. See Appendix A for a description of the microtunneling construction method. The microtunneling method would require installation of a 42-inch casing to ensure that large underground obstructions could be removed and to allow for grade adjustment of the carrier pipe after construction and also to provide for a microtunneling machine capable of installing pipe for this distance based on soil conditions. Some additional private grinder pumps may also be required to serve two to three of the homes that are currently served by gravity.

The primary advantage of this option is that the microtunneling machine could be inserted at a relatively shallow depth, bore through the deep areas, and keep most of Parfitt Way SW open to traffic. This option would also allow the City to decommission the Lower Lovell Lift Station permanently and convey the flows by gravity to the Old Treatment Plant Tributary Basin.

The disadvantages of this option include a very high capital cost, insufficient access points such as manholes to allow for cleaning of the sewer main, and a risky construction method due to such concerns as underground obstructions that could result in expensive claims and deep rescue pit excavations.

A variation for microtunneling, pilot tube microtunneling was also considered in this evaluation; however, this technique can only be used in soils with standard penetration test (SPT) results of less than 50 and the soils in the project area have SPTs well above 50. For this reason, pilot tube microtunneling was not evaluated as a feasible alternative in this report.

In summary, the key elements to the alternative include:

- Installation of approximately 1,200 linear feet of gravity sewer in a 42-inch steel casing via microtunneling construction.
- Decommissioning of the existing lift station.
- Approximately three individual grinder pump installations.

Estimated Project Cost: $5,199,000

Cost per ERU: $129,975 (40 ERU)

Constructability and Risk: High risk. Subsurface unknowns and the depth of construction make this a high-risk construction method. Additional geotechnical effort is recommended to reduce these risks.

Environmental and Permitting Factors: A shoreline permit, right-of-way permit and SEPA will be required.

Long-Term Operation and Maintenance Issues: Vactor trucks typically cannot reach further than 200 linear feet, which means portions of the main would not be able to be cleaned.

Public Impacts: There will be localized impacts during construction at the bore and receiving pits including noise and disruption of access to homes for residents and emergency vehicles. Impacts would be greater than rehabilitation or relocation of the lift station. Road closures may also be required.

Easement Acquisition: No permanent easements are likely to be required for this alternative; however, it is possible a temporary construction easement may be necessary for set up and staging of the microtunneling effort.

<u>Alternative L4 – Auger Bore Gravity Main and Decommission the Lower Lovell Lift Station</u>

Alternative L4 is shown on Figure 10. The auger bore alternative is similar to Alternative L3 in that it would use trenchless construction to install a gravity sewer main

that would allow for the decommissioning of the Lower Lovell Lift Station. Auger boring is a different type of trenchless construction that cannot bore the distances that microtunneling machines can, so bores would be limited to 400 linear feet in length. This would allow for the installation of manholes at drilling and receiving pits. See Appendix A for additional discussion of the auger-bore construction method.

The advantages of this option over microtunneling include that it is generally less expensive and manholes would be installed, allowing for better maintenance access. While the construction would require closing off the road to traffic to construct drilling and receiving pits, this would be limited to 40-foot by 20-foot bore pit excavations that would also serve as manhole locations. Some of these excavations would need to be 25 to 30 feet deep.

This option does still have a relatively high capital cost, and there is some risk of unknown underground obstructions resulting in expensive change orders.

In summary, the key elements to the alternative include:

- Installation of approximately 1,200 linear feet of gravity sewer in a 30-inch steel casing via auger-bore construction.
- Installation of two deep manhole structures at bore and receiving pits.
- Decommissioning of the existing lift station.
- Installation of approximately three individual grinder pumps.

Estimated Project Cost: $3,826,000

Cost per ERU: $91,095 (40 ERU)

Constructability and Risk: High risk. Subsurface unknowns and the depth of construction make this a higher risk construction method. Additional geotechnical effort is recommended to reduce these risks. However, the trenchless technique has less risk than microtunneling.

Environmental and Permitting Factors: A shoreline permit, right-of-way permit and SEPA will be required.

Long-Term Operation and Maintenance Issues: Deep manholes may be difficult to maintain, but overall this option has minimal long-term operations and maintenance impacts.

Public Impacts: There will be localized impacts during construction of the bore and receiving pits including noise and disruption of access to homes for residents and

emergency vehicles. Impacts would be greater than rehabilitation or relocation of the lift station and greater than the microtunneling alternative due to the installation of manholes. Road closures may also be required.

Easement Acquisition: No permanent easements are likely to be required for this alternative. It is possible a temporary construction easement may be necessary for set up and staging of the auger-bore effort and installation of the manholes.

Alternative L5 – Directional Drill Gravity Main and Decommission Lower Lovell Lift Station

Alternative L5 is shown on Figures 11 and 12. This alternative is similar to Alternatives L3 and L4 in that it would use trenchless construction to install a gravity sewer main that would convey flow from the intersection of Lovell Avenue SW and Parfitt Way SW, allowing for the decommissioning of the Lower Lovell Lift Station. Alternative L5 would incorporate the use of directional drilling to install the gravity sewer main, and unlike Alternatives L3 and L4, Alternative L5 would not discharge to a manhole on Parfitt Way SW, but instead would discharge into the wet well of the Wood Lift Station outlined herein in the Wood Avenue Subbasin Alternative W2 or the wet well of the Boardwalk Lift Station outlined in the Wood Avenue Subbasin Alternative W5, described later in this report. Discharging to one of the these lift station alternatives is required because unlike the microtunneling or auger boring, directional drilling requires a minimum slope of 2 percent, and at this greater slope it is not possible to install a sewer main at the required elevation needed to connect to a manhole within the Old Treatment Plant Tributary Basin.

The advantage of this alternative is that unlike Alternatives L3 and L4, a 10-inch HDPE (8-inch ID) sewer main could be installed without having to install a casing, resulting in significantly lower costs. This alternative would however require that the Wood or the Boardwalk Lift Station be constructed, and at greater depths than would otherwise be required if horizontal directional drilling is not selected.

This option would provide the least expensive alternative to decommission Lower Lovell Lift Station.

In summary, the key elements to this alternative include:

- Require construction of Wood or Boardwalk Lift Station at deeper wet well depths.
- Installation of approximately 1,400 linear feet of 10-inch HDPE by directional drilling.
- Installation of three manholes.

- Does not require construction of bore pit.
- Decommissioning of the existing lift station.
- Installation of approximately three individual grinder pumps.

Estimated Project Cost: $942,000

Cost Per ERU: $22,429 (40 ERU)

Constructability and Risk: Moderate risk. Subsurface unknowns and the depth of construction make this a moderately risk construction method. Additional geotechnical effort is recommended to reduce these risks. Directional drilling techniques generally present less risk than microtunneling of auger boring.

Environmental and Permitting Factors: A shoreline permit, right-of-way permit and SEPA will be required.

Long-Term Operation and Maintenance Issues: Deep manholes may be difficult to maintain, but overall this option has the smallest long-term operational and maintenance impacts.

Public Issues: There will be localized impacts during construction of the manholes including noise and disruption of access to homes for residents and emergency vehicles. Impacts would be greater than rehabilitation or relocation of the lift station but less then microtunneling of auger boring as the construction of a boring pit would not be required.

Easement Acquisition: No permanent easements are likely to be required for this alternative. A right-of-way permit would be required and it is possible temporary construction easements may be necessary for construction of manholes.

Lovell Avenue Subbasin Alternatives Evaluation

An alternatives evaluation matrix has been prepared in Table 2. For each of the evaluation criteria previously described, we have rated each of the five Lovell Avenue alternatives from 1 to 10, with 10 being the most positive. The scores for each criterion are summed for each alternative.

TABLE 2

Lovell Avenue Subbasin Alternatives Evaluation

Alternative	**Rehabilitate Lower Lovell LS L1**	**Relocate Lower Lovell LS L2**	**Microtunneling Gravity Main L3**	**Auger Bore Gravity Main L4**	**Directional Drill Gravity Main L5**
Estimated Project Cost	10	6	1	3	8
Constructability and Risk	10	8	3	5	6
Environmental and Permitting Factors	9	5	8	8	8
Long-Term Operation and Maintenance Issues	4	6	7	8	7
Public Impacts	9	7	5	4	4
Easement Acquisition	10	5	8	8	7
Total	**52**	**37**	**32**	**36**	**40**

Based on the evaluation criteria presented in Table 2, Alternative L1, rehabilitate the existing Lower Lovell Lift Station is the highest scoring alternative for service to the Lovell Avenue Subbasin.

Lovell Avenue Grinder Pumps

There are approximately seven homes along the west side of Lovell Avenue SW south of the South Sunday Cove Subbasin on the waterfront that have side sewers that discharge directly to the north segment of the West Eagle Harbor Beach Sewer Main. There is no option to provide sewer service for these homes except to install individual grinder pumps that will pump to the existing gravity sewer main on Lovell Avenue SW (Figure 13).

No matter what alternative is chosen for the Lovell Avenue Subbasin grinder pumps will be required to serve these seven homes.

Estimated Project Cost: $352,000

Cost per ERU: $58,667 (6 ERU)

Wood Avenue Subbasin

The Wood Avenue Subbasin is the area currently served by the south segment of the West Eagle Cover Beach Sewer Main. The area is characterized as being located south of Parfitt Way SW, serving both side of Wood Avenue SW, including Stetson Place SW.

The following five alternatives have been considered to serve the Wood Avenue Subbasin:

- Alternative W1 – Public House Lift Station
- Alternative W2 – Wood Lift Station and Existing Beach Main
- Alternative W3 – Wood Lift Station and Public House Lift Station
- Alternative W4 – Individual Grinder Pumps
- Alternative W5 – Boardwalk Lift Station and Existing Beach Main

Alternative W1 – Public House Lift Station

Alternative W1 is shown on Figure 14. The first alternative we examined to address the easterly part of the basin is to install a new lift station in the vicinity of the Harbour Public House restaurant, located approximately one block east of Wood Avenue SW. The new lift station would be located in the parking area of the restaurant and would pump to the existing gravity system on Parfitt Way SW. This alternative includes construction of approximately 400 linear feet of gravity sewer main through the Harbourside Retirement Community to connect the Public House Lift Station to the existing sewers on Wood Avenue SW. The project would also include construction of approximately 70 linear feet of gravity sewer main to intercept flows at Manhole 6-21F that serve properties to the east of the station and convey them to the new lift station. Finally, a number of individual grinder pumps will be required to serve the residences on Stetson Place and possibly the shoreline properties to the south of the station.

In summary, the key elements to the alternative include:

- Installation of approximately 400 linear feet of 8-inch gravity sewer and manholes from Wood Avenue SW through the Harbourside Retirement Community to the new lift station.
- Installation of approximately 70 linear feet of 8-inch gravity sewer from Manhole 6-21F to the new lift station.
- Construction of a submersible lift station in the parking lot of the Harbour Public House.
- Construction of approximately 350 linear feet of 4-inch force main.
- Installation of approximately seven to eleven individual grinder pumps on Stetson Place and along the water front to serve properties that are

currently directly served by the north segment of the West Eagle Harbor Beach Sewer Main.

Estimated Project Cost: $3,111,000

Cost Per ERU: $55,554 (56 ERU)

Constructability and Risk: Moderate risk. Additional survey and geotechnical work is recommended to site the proposed lift station. There is some risk in excavating gravity mains through the private property due to narrow utility corridors and excavating for the lift station.

Environmental and Permitting Factors: A shoreline permit and SEPA will be required. A conditional use permit and grading permit may also be required.

Long-Term Operation and Maintenance Issues: This alternative adds a lift station to the City sewer system in an area that is currently served by gravity and the Lower Lovell Lift Station.

Public Impacts: There will be dramatic localized impacts during construction to the restaurant and local residences including noise and disruption of access to customers, residents and emergency vehicles and there could also be impacted by routine maintenance of the lift station and gravity sewer mains. Construction process could significantly impact the Harbourside Retirement Community and the Harbour Public House restaurant.

Easement Acquisition: This option will require the acquisition of an easement through the Harbourside Retirement Community for the gravity sewer, and an easement from the Harbor Public House for the lift station and force main. Individual grinder pump installations on Stetson Place and perhaps to the shoreline properties will also require easements from each property owner.

Alternative W2 – Wood Lift Station and Existing Beach Main

Alternative W2 is shown on Figure 15. The second alternative is to install a new lift station at the intersection of Wood Avenue SW and Stetson Place, called the Wood Lift Station for this analysis. The Wood Lift Station would pump north to the existing gravity system on Parfitt Way SW.

This alternative also includes continual use of approximately 350 linear feet of the West Eagle Harbor Beach Sewer Main from Manhole 6-17 to Manhole 6-21F. As mentioned in earlier sections of the report, this segment of the West Eagle Harbor Beach Sewer Main is above the OHWM and is accessible through existing manholes should rehabilitation of this main be required at some future date could be accomplished using

CIPP techniques. A short auger bore would also be required to connect the new wet well for the Wood Lift Station to the existing Manhole 6-17.

Finally, properties on Stetson Place would have to be served by gravity or with individual grinder pumps. The new wet well could be constructed deep enough to serve Stetson Place by gravity. However, this may be more expensive from a capital perspective, and less practical than installing individual grinder pumps.

In summary, the key elements to the alternative include:

- Installation of approximately 80 linear feet of 8-inch gravity sewer from Manhole 6-17 to the new lift station. This construction will likely need to be via auger bore with a 30-inch steel casing.
- Construction of a submersible lift station at the intersection of Wood Avenue SW and Stetson Place.
- Construction of approximately 600 linear feet of 4-inch force main.
- Installation of approximately seven individual grinder pump installations in Stetson Place.
- Continual use of approximately 350 linear feet of the West Eagle Harbor Beach Sewer Main from Manhole 6-17 to Manhole 6-21F.

Estimated Project Cost: $2,863,000

Cost Per ERU: $51,125 (56 ERU)

Constructability and Risk: Moderate Risk. Additional survey is recommended to determine the depth and constructability the proposed lift station and for the auger bore from the lift station to the existing shoreline main. Access for the existing homes on Stetson Place during construction will be of concern.

Environmental and Permitting Factors: A shoreline permit is required. A conditional use permit and grading permit may also be required. Dewatering could be a concern due to deep construction and the auger bore close to the shoreline.

Long-Term Operation and Maintenance Issues: This alternative adds a lift station to the City sewer system in an area that is currently served by gravity and the Lower Lovell Lift Station. However, it could also facilitate the decommissioning of the Lower Lovell Lift Station at some future date if the City construct Alternatives L3, L4 or L5, resulting in a no net change to the City's number of lift stations.

Public Impact: There will be localized impacts during construction of the lift station and sewers including noise and disruption of residential and emergency vehicles access for the homes on Stetson Place.

Easement Acquisition: Individual grinder pump installations on Stetson Place will also require easements from each homeowner. Temporary construction easements may also be required from adjacent property owners to facilitate the construction of the lift station.

Alternative W3 – Wood Lift Station and Public House Lift Station

Alternative W3 is shown on Figure 16. This alternative combines Alternatives 1 and 2 and constructs two lift stations. In this scenario, the gravity sewer from Wood Avenue to the Public House Lift Station identified in Alternative W1 would not be constructed.

In summary, the key elements to the alternative include:

- Construction of a submersible lift station at the intersection of Wood Avenue SW and Stetson Place.
- Construction of a submersible lift station in the parking lot of the Harbor Public House.
- Construction of approximately 450 linear feet of 4-inch force main to serve the Wood Lift Station and approximately 350 linear feet of 4-inch force main to serve the Public House Lift Station.
- Approximately seven to eleven individual grinder pump installations on Stetson Place and along the water front that are currently directly served by the north segment of the West Eagle Harbor Beach Sewer Main.

Estimated Project Cost: $4,529,000

Cost Per ERU: $80,875 (56 ERU)

Constructability and Risk: Moderate Risk. This alternative is directly comparable to the two other alternatives in that it includes the constructions of the lift station noted in each alternative. In comparison to W1 this alternative will require the construction of the Wood Lift Station; however, it will not require the installation of the gravity sewer main through the Harbourside Retirement Community eliminating a risky component of W1. When compared to W2 this alternative this alternative will not require connecting to the existing shoreline sewer main; however, it will require the installation of the Public House Lift Station.

Environmental and Permitting Factors: A shoreline permit may be required. A conditional use permit may also be required for each lift station.

Long-Term Operation and Maintenance Issues: This alternative adds two lift stations resulting in additional long-term maintenance costs.

Public Impacts: There will be localized impacts during construction of the lift station and sewer force main including noise and disruption of residential and emergency vehicles access for the homes on Stetson Place, surrounding business at the Public House area. Local residence could also be impacted by routine maintenance on the lift stations.

Easement Acquisition: This option will require the acquisition of an easement from the Harbor Public House for the lift station and force main. Individual grinder pump installations on Stetson Place will also require easements from each homeowner. Temporary construction easements may also be required from adjacent property owners to facilitate the construction of the lifts stations.

Alternative W4 – Individual Grinder Pumps

Alternative W4 is shown on Figure 17. With this alternative, the City could elect to serve the entire Wood Basin area with individual grinder pumps. This would require approximately 25 individual grinder pumps and force mains, including easements. This option would require approximately 3,000 linear feet of individual 1-1/4-inch force main and approximately 1,750 linear feet of 3-inch low-pressure force main.

In summary, the key elements to the alternative include:

- Installation of approximately 25 individual grinder pumps.
- Construction of approximately 3,000 linear feet of individual 1-1/4-inch force main and approximately 1,750 linear feet of 3-inch low-pressure force main.

Estimated Project Cost: $1,576,000

Cost Per ERU: $28,143 (56 ERU)

Constructability and Risk: Low Risk. Siting individual grinder pump stations may have some issues, particularly if the existing side sewers are difficult to locate. However this option is generally a low risk from a construction perspective.

Environmental and Permitting Factors: A shoreline permit may be required.

Long-Term Operation and Maintenance Issues: This adds dozens of grinder stations and will put a significant operation and maintenance burden on City staff.

Public Impacts: There will be significant public interaction to site the grinder pumps, acquire easements, and maintain grinder pumps for each property. There will be construction noise and access impacts for each property.

Easement Acquisition: Easements will need to be established for every property owner if the pumps are located on private property. Approximately 25 separate easements will be required.

Alternative W5 – Boardwalk Lift Station and Existing Beach Main

Alternative W5 is shown on Figure 18. This alternative provides for the installation a new lift station in the boardwalk close to the existing Manhole 6-21. The Boardwalk Lift Station would pump north to the existing Manhole 3-5 in the intersection of Parfitt Way SW and Wood Avenue SW.

This alternative is very similar to Alternative W2 except that the lift station is located closer to the beach, in the boardwalk. As with Alternative W2 the generator and associated fuel tank would still be located above at the intersection of Wood Avenue SW and Stetson Place. This location will require a shallower wet well, thus a cheaper alternative. As with Alternative W2 this alternative also includes continual use of approximately 350 linear feet of the West Eagle Harbor Beach Sewer Main from Manhole 6-17 to Manhole 6-21F. One significant drawback of this alternative is that access to the lift station at this location for periodically maintenance will be difficult.

Like W2 properties on Stetson Place have the option of being served by gravity or with individual grinder pumps. The new wet well could be constructed deep enough to serve Stetson Place by gravity. However, this may be more expensive from a capital perspective, and more impractical than installing individual grinder pumps.

In summary, the key elements to the alternative include:

- Construction of a submersible lift station in the boardwalk, west of existing Manhole 6-17.
- Construction of approximately 650 linear feet of 4-inch force main.
- Installation of approximately seven individual grinder pump installations in Stetson Place.
- Continual use of approximately 350 linear feet of the West Eagle Harbor Beach Sewer Main from Manhole 6-17 to Manhole 6-21F.

Estimated Project Cost: $1,874,000

Cost Per ERU: $33,464 (56 ERU)

Constructability and Risk: Moderate Risk. Additional survey is recommended to determine the depth and constructability the proposed lift station. Like Alternative W2 access for the existing homes on Stetson Place during construction will be of concern. In addition construction this close to the shoreline and seawall could have some significant constructability issues.

Environmental and Permitting Factors: A shoreline permit is required. A conditional use permit and grading permit may also be required. Dewatering could be a concern due to deep construction close to the shoreline.

Long-Term Operation and Maintenance Issues: This alternative adds a lift station to the City sewer system in an area that is currently served by gravity and the Lower Lovell Lift Station. However, it could also facilitate the decommissioning of the Lower Lovell Lift Station at some future date resulting in a no net change to the City's number of lift stations.

Public Impact: There will be localized impacts during construction of the lift station and sewers including noise and disruption of residential and emergency vehicles access for the homes on Stetson Place.

Easement Acquisition: Individual grinder pump installations on Stetson Place will also require easements from each homeowner. Temporary construction easements may also be required from adjacent property owners to facilitate the construction of the lift station.

Wood Avenue Subbasin Alternatives Evaluation

An alternatives evaluation matrix has been prepared in Table 3. For each of the evaluation criteria previously described, we have rated each of the four Wood Avenue alternatives from 1 to 10, with 10 being the most positive. The rating for each criterion is multiplied by the weighting factor to develop the score for each criterion. The scores for each criterion are summed for each alternative.

TABLE 3

Wood Subbasin Alternatives Evaluation

Alternative	Public House LS W1	Wood LS and Existing Beach Main W2	Wood LS and Public House LS W3	Individual Grinder Pumps W4	Boardwalk LS and Existing Beach Main W5
Estimated Project Cost	4	5	2	8	7
Constructability and Risk	2	5	6	8	3
Environmental and Permitting Factors	7	6	5	8	4
Long-Term Operation and Maintenance Issues	7	7	4	2	6
Public Impacts	2	6	4	3	5
Easement Acquisition	4	8	6	2	8
Total	**26**	**37**	**33**	**31**	**33**

Based on the evaluation criteria presented in Table 3, Alternative W2, Wood Lift Station and Rehabilitate the Existing Beach Main is the highest scoring alternative for service to the Wood Avenue Subbasin.

PREFERRED ALTERNATIVES

Based on the preliminary evaluation of alternatives using the evaluation criteria shown, the preferred alternatives to decommission the West Eagle Harbor Beach Sewer Main and provide service to the Lower Lovell Tributary Basin are as follows:

SOUTH SUNDAY COVE SUBBASIN

The preferred alternative to address the flows in the South Sunday Cove Subbasin is Alternative S1 – Gravity Service to Sunday Cove Lift Station. This alternative would convey flow from the basin's nine parcels by gravity north to the existing Manhole 5-46 where it could then be conveyed to the Sunday Cove Lift Station (Figure 4). The alternative would require the installation of approximately 350 linear feet gravity sewer main and would also require sawcutting through the slabs of the two shoreline homes to facilitate connecting their side sewers to the proposed sewer main.

LOVELL AVENUE SUBBASIN

The preferred alternative to address the flows in the Lovell Avenue Subbasin is Alternative L1 – Rehabilitate the Existing Lower Lovell Lift Station (Figure 7). This is the preferred alternative due primarily to the lower cost; however, it is recommended that the City's long-term planning include Alternative L5 – Directional Drilling Gravity Main and Decommission the Lower Lovell Lift Station. This alternative would convey flow to the Wood Avenue Lift Station proposed in Alternative W2 – Wood Lift Station and

Existing Beach Main or Alternative W5 – Boardwalk Lift Station and Existing Beach Main and allow for the elimination of the Lower Lovell Lift Station.

WOOD AVENUE SUBBASIN

The preferred alternative to address the flows in the Wood Avenue Subbasin is Alternative W2 – Wood Lift Station and Existing Beach Main (Figure 15). This alternative would continue to collect flows from the east end of the basin through the existing beach main and direct these flows to the proposed Wood Lift Station. In addition, to the existing beach main flows, the Wood Lift Station would also collect flows from the west portion of the basin and would direct these flows to the manhole at the intersection of Wood Avenue SW and Parfitt SW.

TABLE 4

Recommended Alternatives Cost Summary

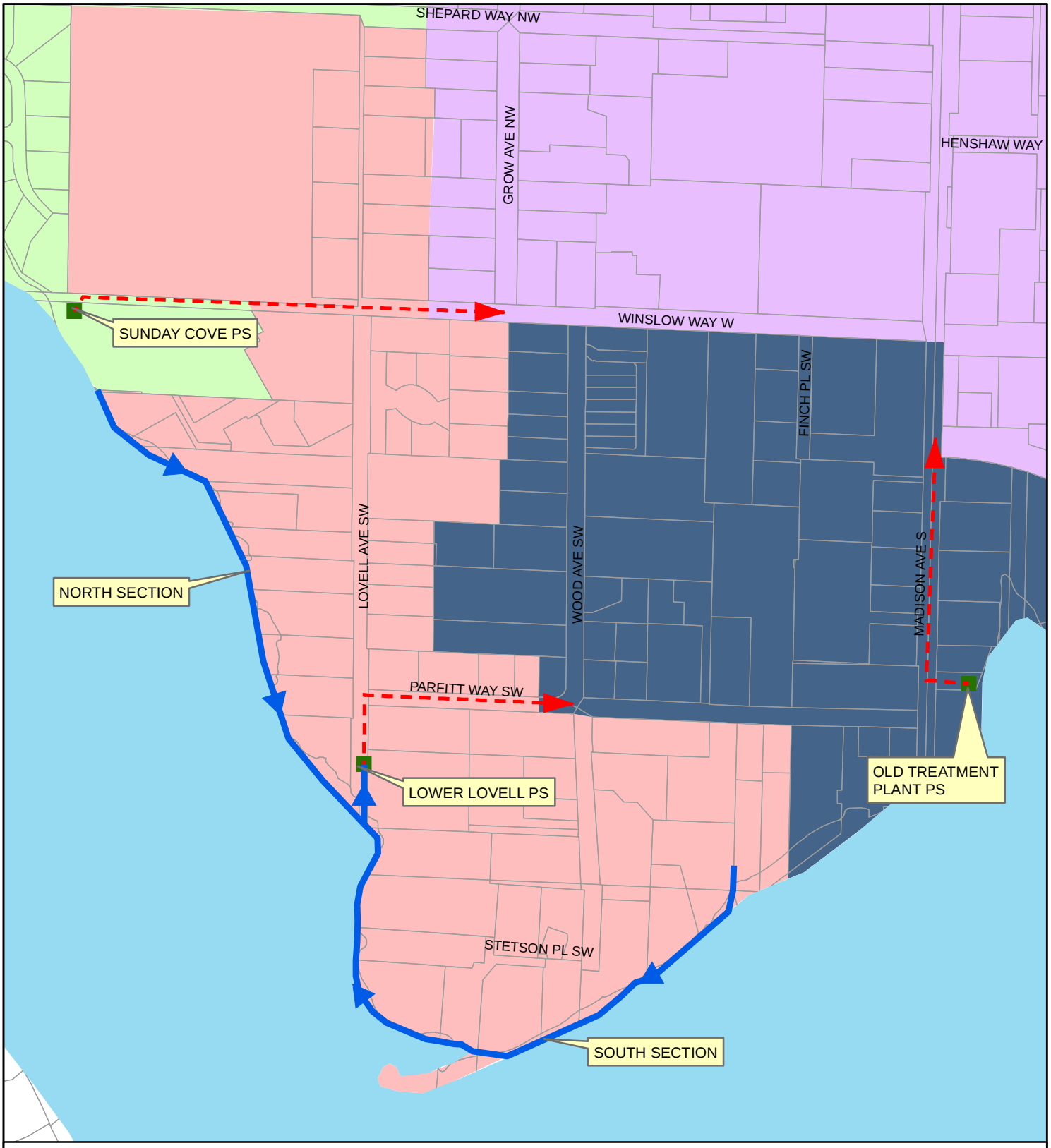
Alternative	Description	Cost	ERU	Cost per ERU
S1	Gravity Service to Sunday Cover Lift Station	$514,000	9	$57,111
L1	Rehabilitate the Existing Lower Lovell Lift Station	$557,000	40	$13,925
W2	Wood Lift Station and Existing Beach Main	$2,863,000	56	$51,125
	Lovell Avenue Grinder Pumps	$352,000	6	$58,667
Total Project Cost		**$4,286,000**	**111**	**$38,613**

PROJECT PHASING

Due to budgetary concerns, the City may wish to phase the construction of the project. The recommended alternatives for the South Sunday Cove, Lovell Avenue and Wood Avenue Subbasin are independent of each other and could be installed in any order. The City has expressed that the area where they have the greatest concern and the area they would first like to address is the Wood Avenue Subbasin. This subbasin is believed to contribute the most grease into the main due to the commercial properties within the subbasin. Therefore, the City may wish to implement Alternative W2 – Wood Lift Station and Existing Beach Main as the first phase of the project. The improvement to the two other subbasins could occur at any time depending on the City's needs. The advantage of Alternative S1 – Gravity Service to Sunday Cove is that once it is constructed, along with the installation of individual grinder pumps to serve the shoreline properties to the west of Lovell Avenue, the north section of the West Eagle Harbor Beach Sewer Main could be decommissioned. The timing for implementation of Alternative L1 – Rehabilitate the Existing Lower Lovell Lift Station would depend on the condition of the existing mechanical and electrical systems at the Lower Lovell Lift Station. Consequently, we would recommend the following sequence for the projects:

- Alternative W5 – Wood Lift Station and Existing Beach Main
- Alternative S1 – Gravity Service to Sunday Cove
- Alternative L1 – Rehabilitate the Existing Lower Lovell Lift Station

FIGURES



LEGEND:

- PUMP STATION
- WEST EAGLE HARBOR BEACH SEWER MAIN
- FORCE MAIN

EXISTING TRIBUTARY BASIN:

- LOWER LOVELL TRIBUTARY BASIN
- SUNDAY COVE TRIBUTARY BASIN
- HIGHWAY 305 TRIBUTARY BASIN
- OLD TREATMENT PLANT TRIBUTARY BASIN

N

0 200 400 Feet

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN PREDESIGN REPORT FIGURE 1 EXISTING TRIBUTARY BASINS

Gray & Osborne, Inc.
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100' 50' 0 100' 200'

SCALE: 1"=100'

LEGEND:

- SEWER MANHOLE
- SEWER CLEANOUT
- SEWER MAIN
- WEST EAGLE HARBOR BEACH SEWER MAIN SOUTH SECTION
- WEST EAGLE HARBOR BEACH SEWER MAIN NORTH SECTION
- LOWER LOVELL FORCEMAIN

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 2

EXISTING SEWER SYSTEM

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CONSULTING ENGINEERS

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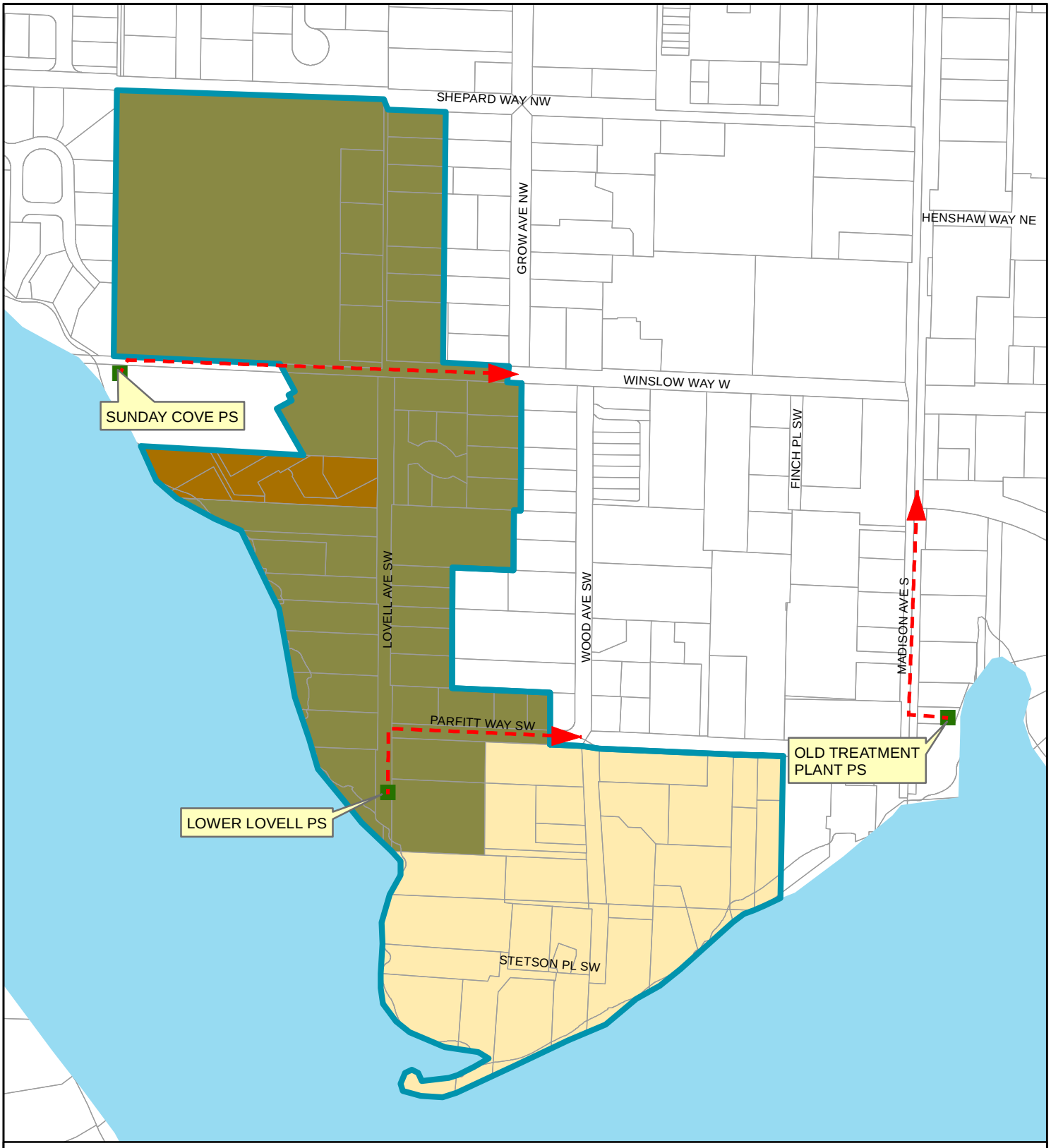

LEGEND:

- EXISTING LIFT STATION
- EXISTING LOWER LOVELL TRIBUTARY BASIN
- FORCE MAIN

PROPOSED TRIBUTARY BASIN:

- PROPOSED LOVELL AVENUE SUBBASIN
- PROPOSED WOOD SUBBASIN
- PROPOSED SOUTH SUNDAY COVE SUBBASIN

N

0 200 400 Feet

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN PREDESIGN REPORT FIGURE 3 PROPOSED SUBBASINS

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH MAIN

PREDESIGN REPORT

FIGURE 4

SOUTH SUNDAY COVE SUBBASIN - ALTERNATIVE S1

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S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

N

50' 25' 0 50' 100'

SCALE: 1"=50'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 5

SOUTH SUNDAY COVE SUBBASIN - ALTERNATIVE S2

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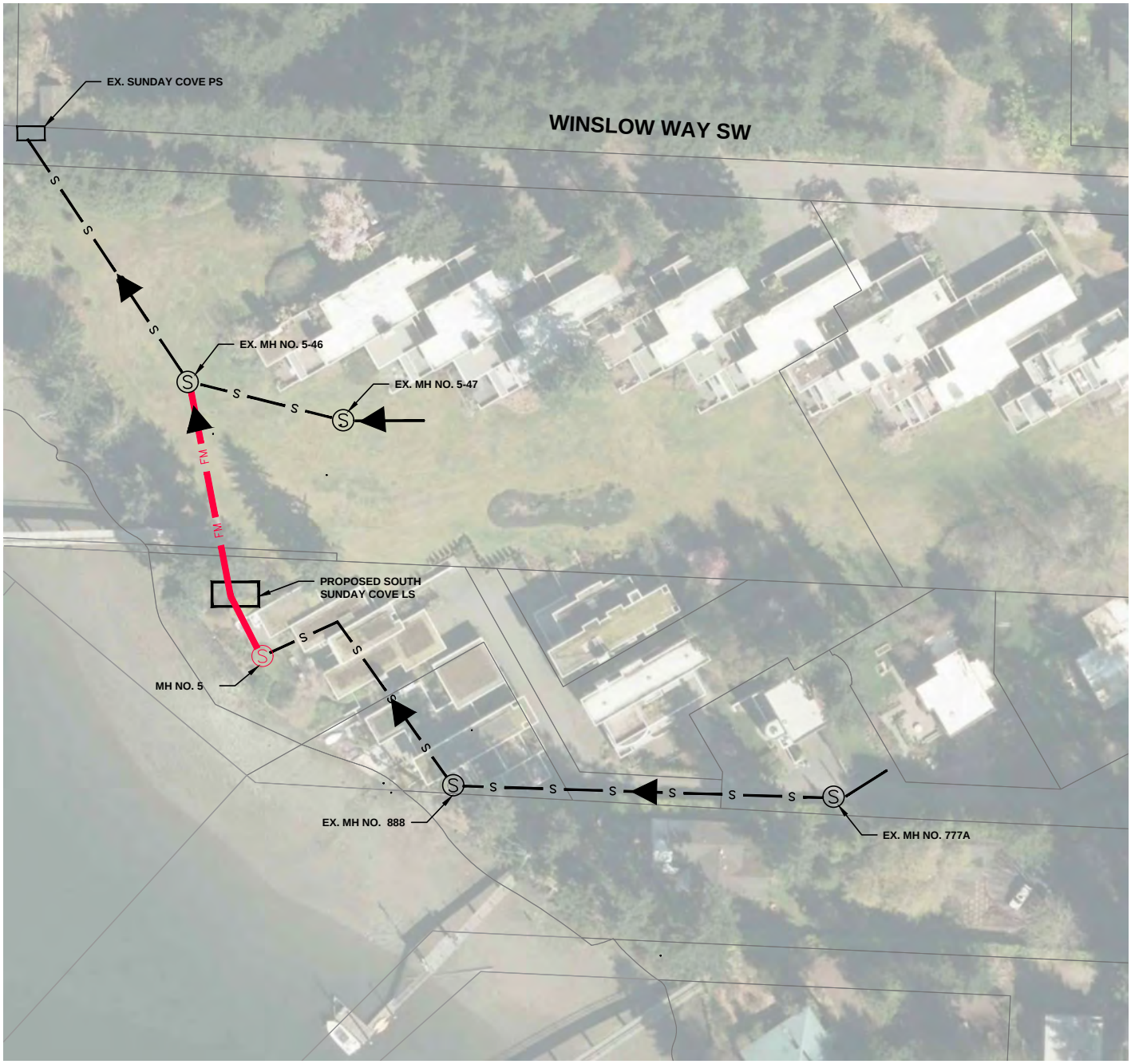

S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

N

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 6

SOUTH SUNDAY COVE SUBBASIN - ALTERNATIVE S3

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S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

N

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 7

LOVELL AVE SUBBASIN - ALTERNATIVE L1

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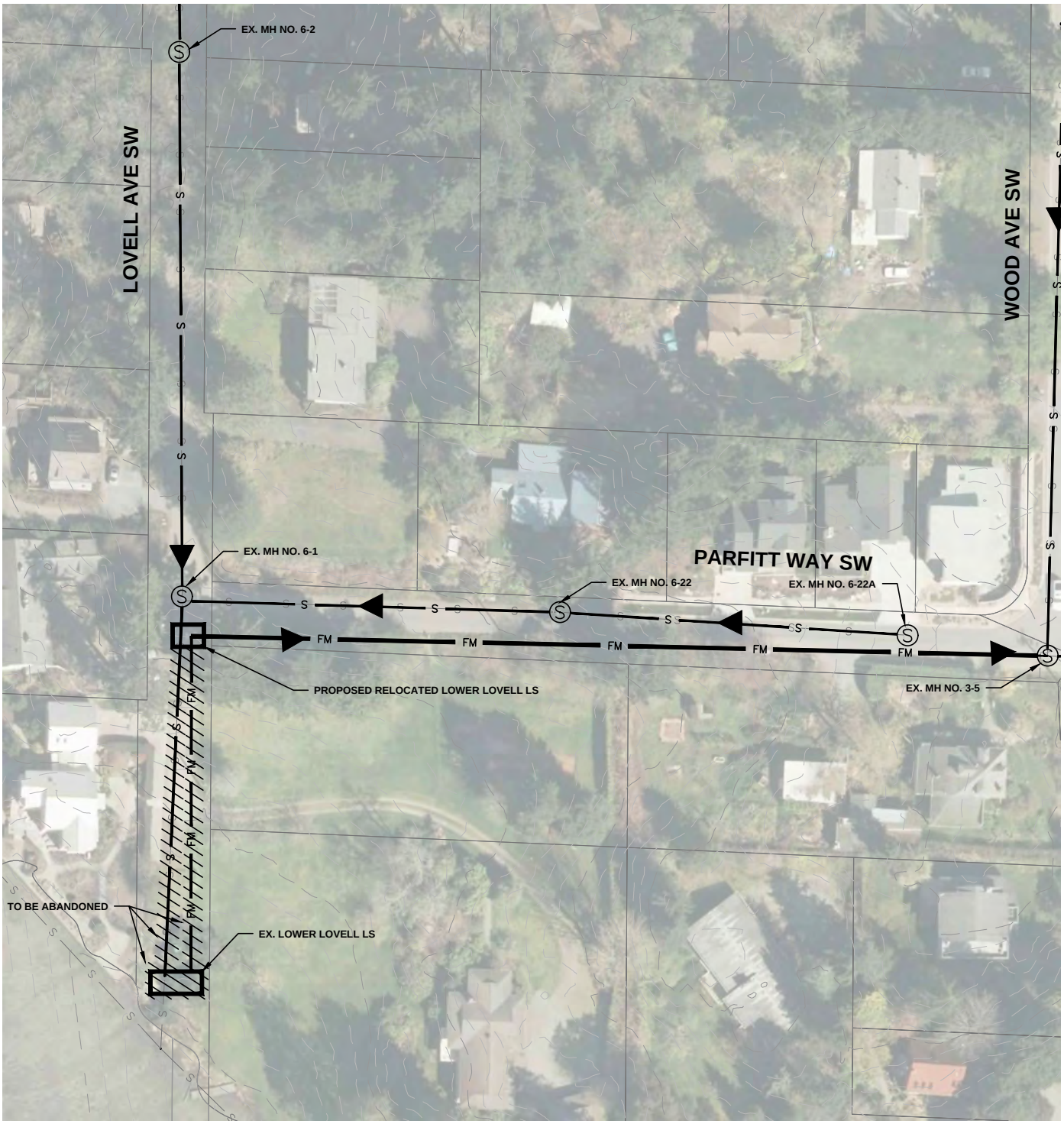

S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 8

LOVELL AVE SUBBASIN - ALTERNATIVE L2

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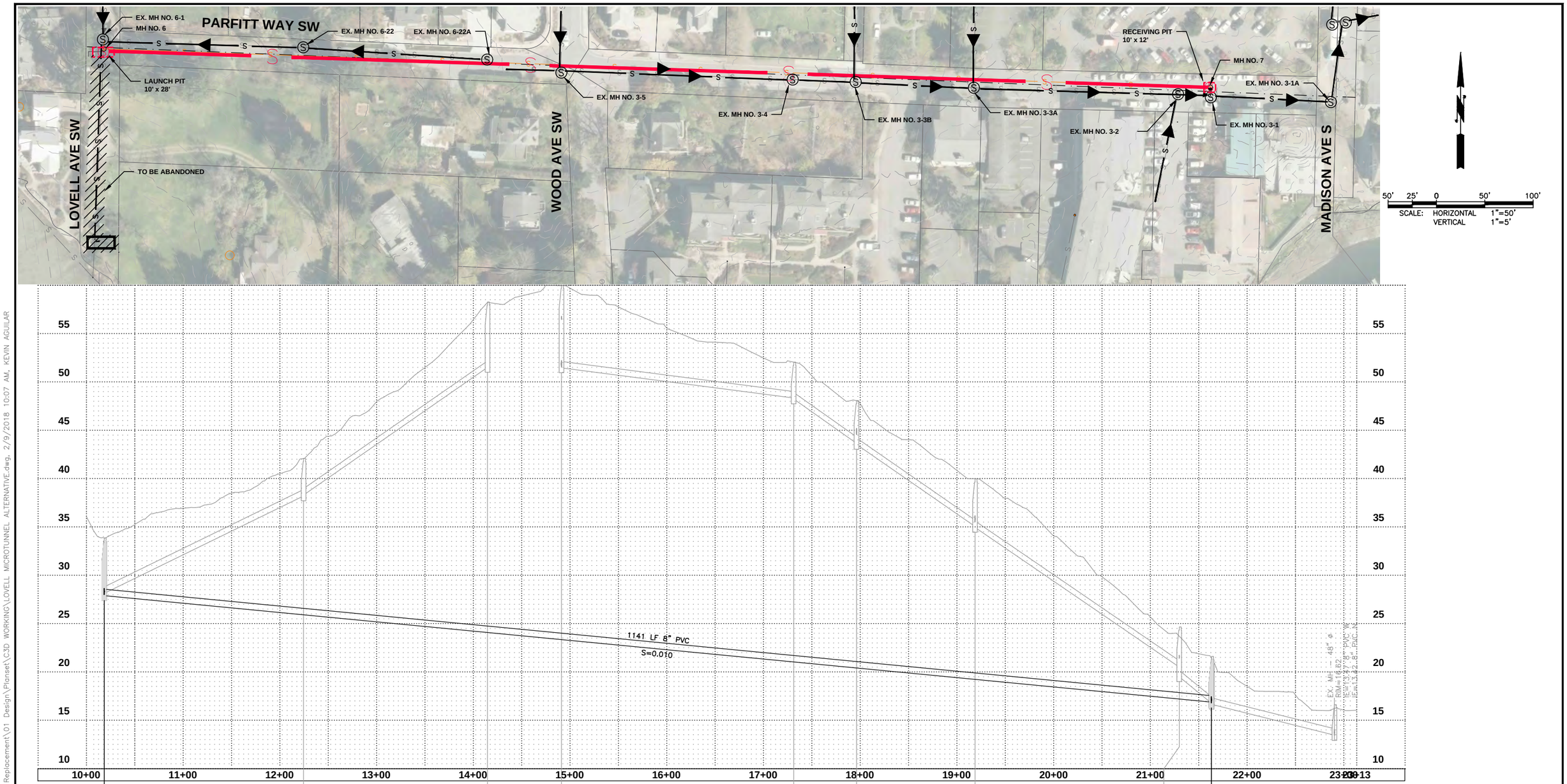

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WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 9

LOVELL AVE SUBBASIN - ALTERNATIVE L3

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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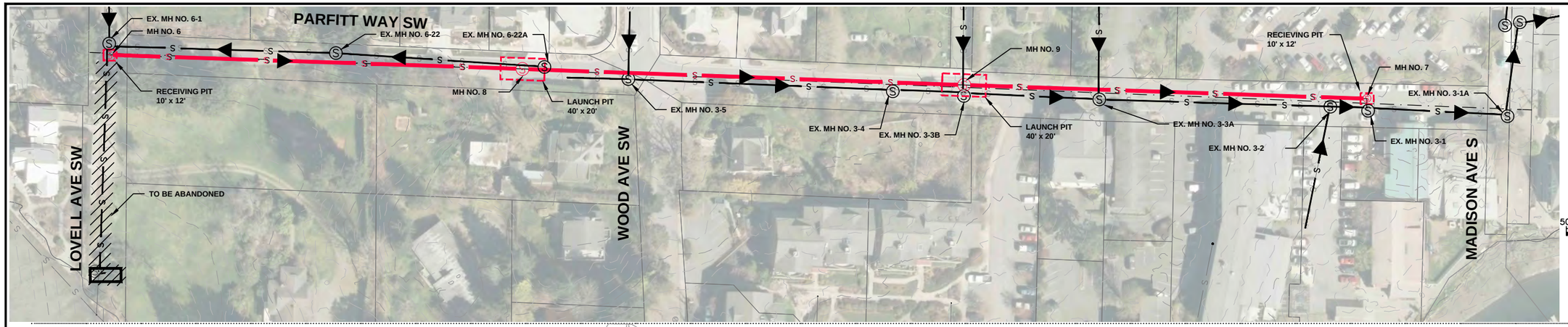

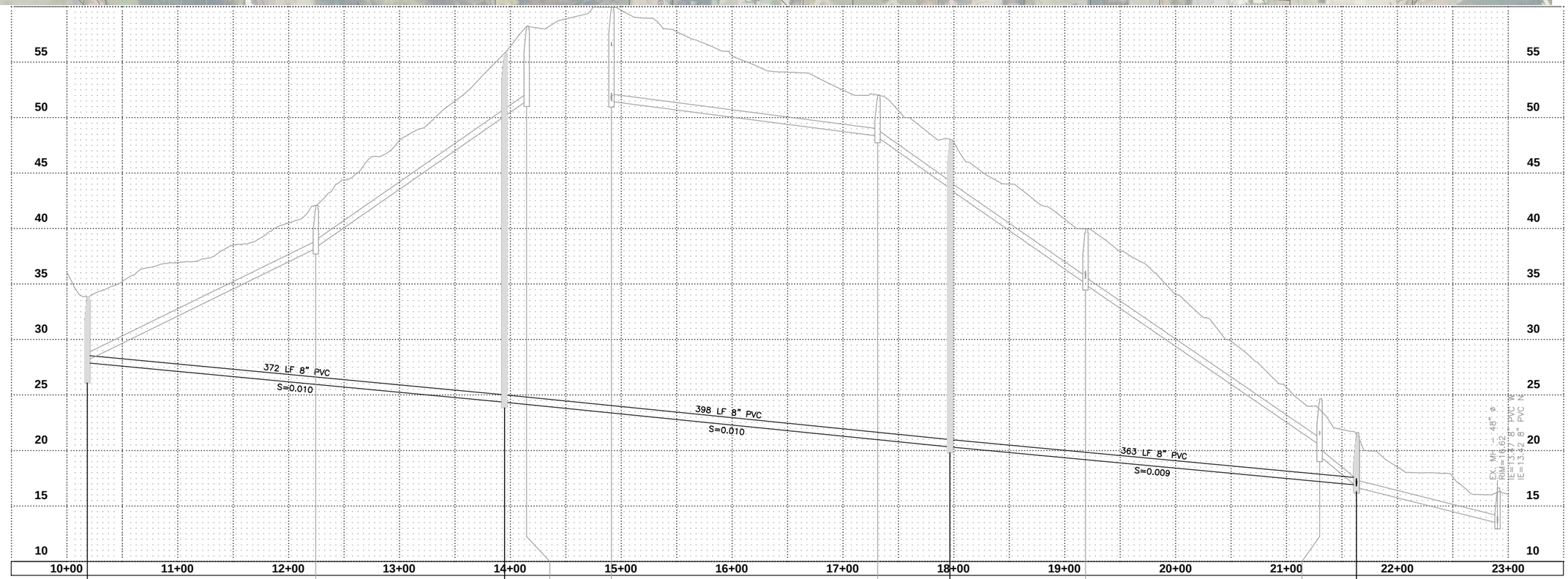

S — EXISTING SEWER MAIN

S — PROPOSED SEWER MAIN

FM — EXISTING FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

PROPOSED MANHOLE

EXISTING MANHOLE

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 10

LOVELL AVE SUBBASIN- ALTERNATIVE L4

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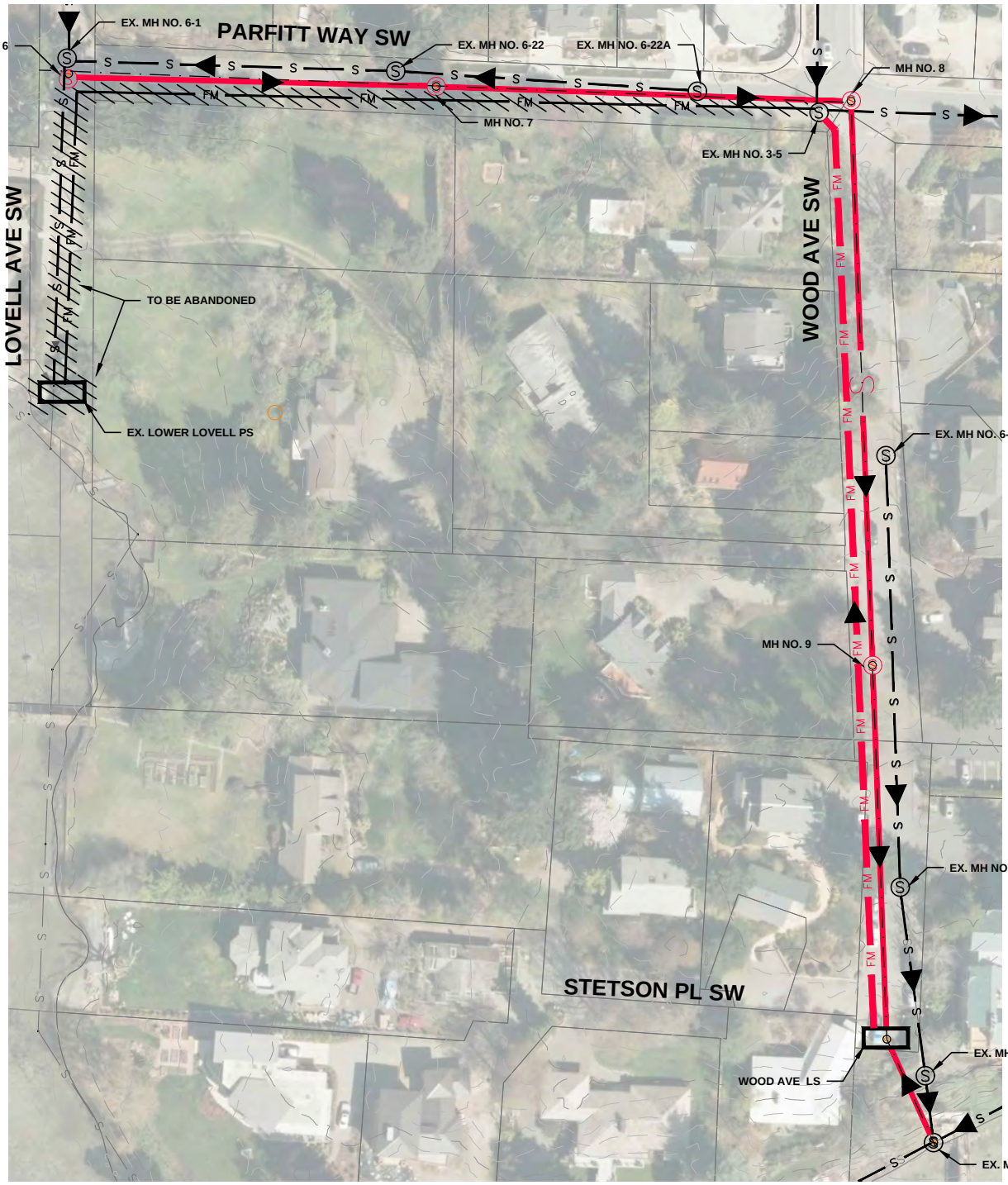

S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 11

LOVELL AVE SUBBASIN - ALTERNATIVE L5

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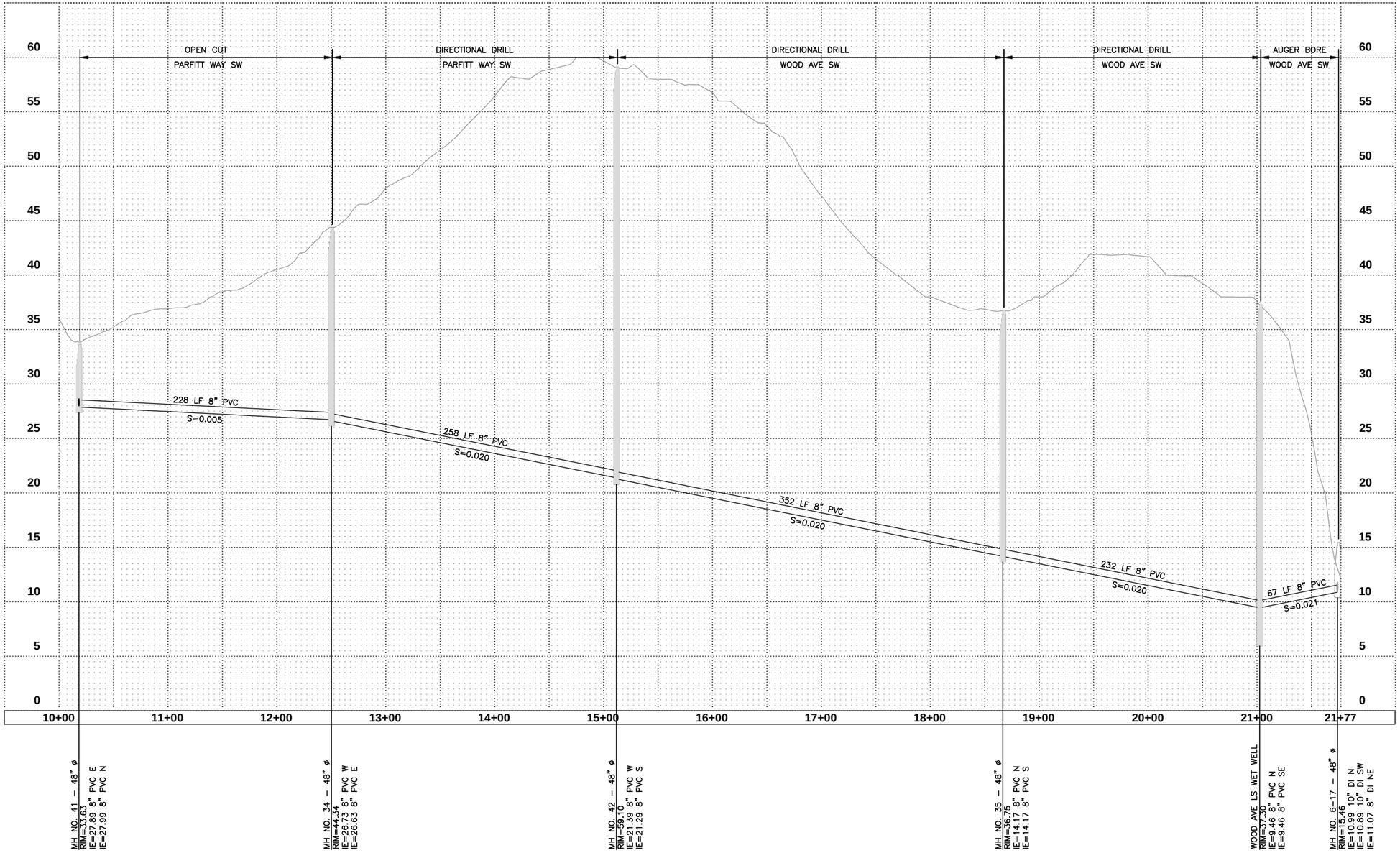

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 12

LOVELL AVE SUBBASIN - ALTERNATIVE L5

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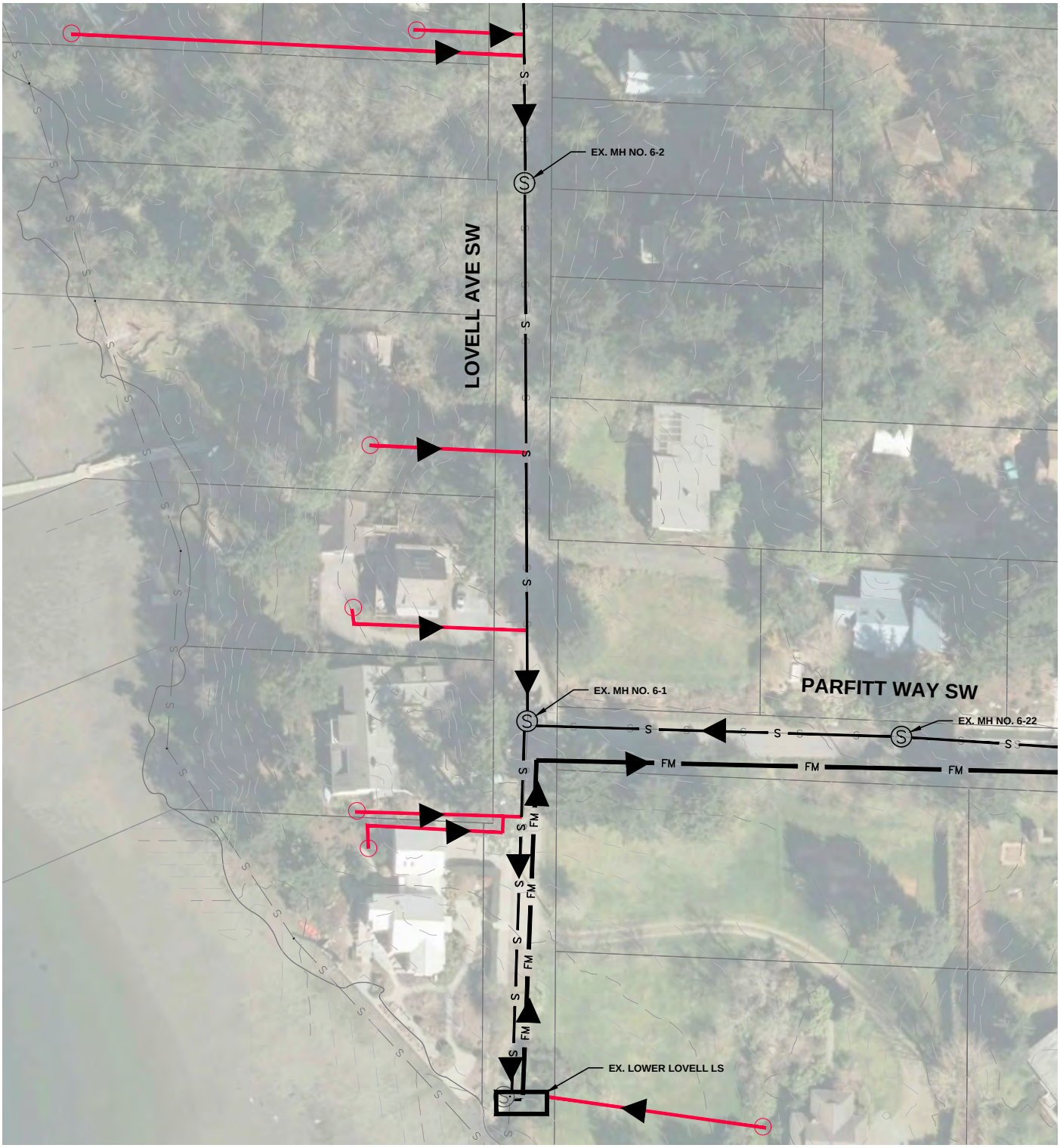

S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

N

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 13

LOVELL AVE GRINDER PUMPS

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S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 14

WOOD SUBBASIN - ALTERNATIVE W1

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S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

N

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 15

WOOD SUBBASIN - ALTERNATIVE W2

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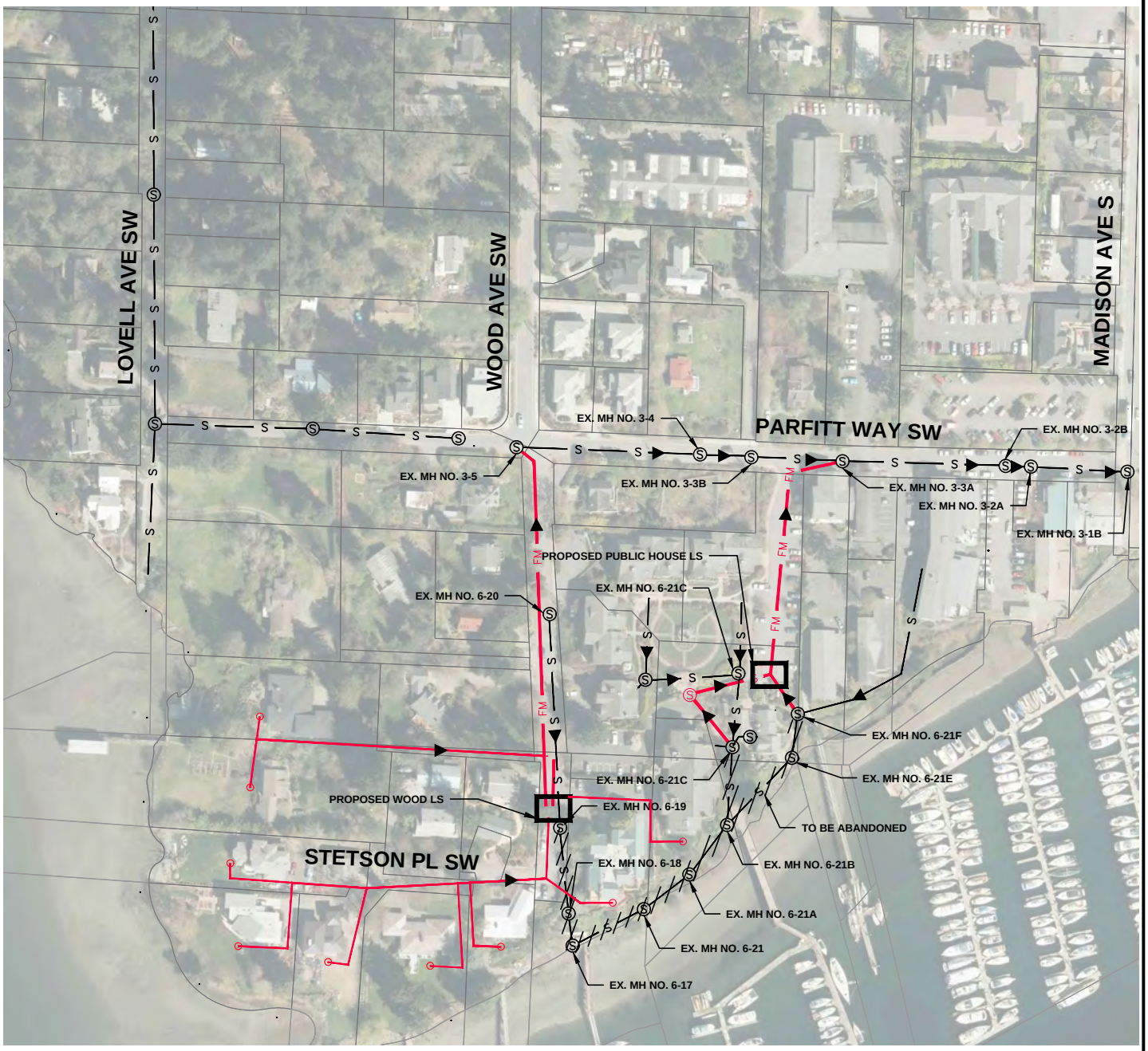

S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 16

WOOD SUBBASIN - ALTERNATIVE W3

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

N

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 17

WOOD SUBBASIN - ALTERNATIVE W4

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CONSULTING ENGINEERS

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S EXISTING SEWER MAIN

S PROPOSED SEWER MAIN

FM PROPOSED LIFT STATION FORCE MAIN

PROPOSED GRINDER PUMP FORCE MAIN

GRINDER PUMP

EXISTING MANHOLE

PROPOSED MANHOLE

N

40' 20' 0 40' 80'

SCALE: 1"=40'

CITY OF BAINBRIDGE ISLAND

WEST EAGLE HARBOR BEACH SEWER MAIN

PREDESIGN REPORT

FIGURE 18

WOOD SUBBASIN - ALTERNATIVE W5

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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APPENDIX A

TRENCHLESS TECHNOLOGY MEMORANDUM

APPENDIX A

TRENCHLESS TECHNOLOGY MEMORANDUM

Various trenchless construction techniques are noted throughout the report that could be used to rehabilitate or provide for the replacement of the City of Bainbridge Island West Eagle Harbor Beachline Sewer Main. This appendix has been included to offer a more in-depth discussion of these trenchless techniques than included in the report.

Trenchless construction techniques offer the means of installing and renewing underground utility pipes without the surface disruption or social costs while often costing less than traditional open-cut methods. Trenchless technology methods are divided into two main categories, trenchless construction methods (TCM) and trenchless renewal methods (TRM). TCM includes trenchless techniques to install new pipeline utilities. TRM encompasses all trenchless techniques that renew and rehabilitate existing host pipes.

TRENCHLESS CONSTRUCTION METHODS

HORIZONTAL AUGER BORING

Horizontal Auger Boring (HAB) provides a cost-effective method of installing a steel casing pipe and is generally used where there is a need to install a utility under a road section or railroad. HAB can be used to install casing ranging from 8 to 60 inches in lengths up to 600 feet. HAB can be used in a wide range of soil conditions, ranging from sand to solid rock; however, firm sandy clay is the most compatible soil condition for the method. This method can install casing in soil with boulders or cobbles as large as one-third of the casing diameter, however boring in soils with large boulders is not the best application for HAB.

HAB requires the construction of a driving and receiving pit. HAB equipment includes an auger boring machine, augers, and cutting head, all of which are located in the driving pit. The cutting head is attached to an auger and inserted into the casing which is then connected to the boring machine. The auger boring machine generates torque that is transmitted through the auger to the rotating cutting head. The spoils from the cutting head are removed back through the casing to the driving pit by the movement of the helically-wound augers where the spoils can be lifted to the surface for removal. Simultaneously as the spoils are removed at the cutting face, the boring machine drives the casing forward into the void created by the cutting face using hydraulic jacking force. As the boring continues, additional augers are installed end to end to move the cutting head forward and additional pipe is inserted as needed. Usually, after the casing has been installed, a carrier pipe is installed through the casing with spacers to hold the pipe in place. HAB operation has limited line and grade control and the initial setup of the boring equipment is critical to the accuracy of the boring operation. An illustration of a

typical horizontal auger boring process and a summary of its advantages and disadvantages are shown below.

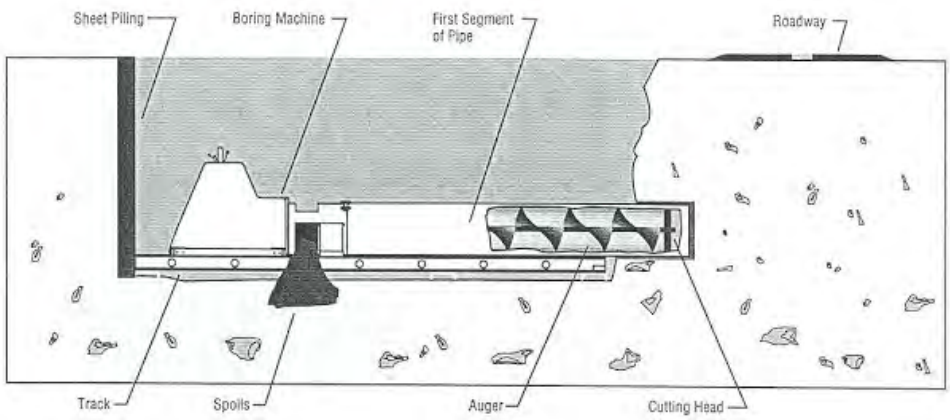

FIGURE 1

Horizontal Auger Boring Illustration

TABLE 1

Horizontal Auger Boring Advantages and Disadvantages

Advantages	• Relatively inexpensive. • Can be used in a wide range of soils.
Disadvantages	• Limited control of line and grade, initial setup critical. • Can only be installed in straight alignment applications. • Not appropriate in running and unstable soils. • Generally, requires installation of casing to accommodate a carrier pipe. • Requires construction of driving and receiving pits.

HORIZONTAL DIRECTIONAL DRILLING

Horizontal directional drilling (HDD) involves a steerable system for the installation of both small and large diameter pipelines. A HDD machine is set on the surface slightly behind, but in alignment with, the entry point and is anchored into the ground. The drilling rod is composed of hollow, threaded steels rod with a drilling head attached to the end. The machine is tilted to facilitate the drilling head entry into the ground. The HDD machine turns the rod and in turn the drilling head and drives the head into the ground. Additional rods are attached to the drilling shaft and the HDD machine continues to drive

the drilling head forward. The process consists of three-stages. The first stage includes drilling a small-diameter pilot hole along the centerline of the proposed utility line. The second stage includes enlarging the boring by connecting reamers to the drilling rod and repeatedly pulling them through the boring, while gradually increasing them in size with each pass, until a boring hole approximately 1.5 times the diameter of the pipe is obtained. The third stage is to attach the pipe to the drilling rod and physically pulling it through the boring hole. The pipe type generally used in in directional drilling projects is HDPE, however fusible PVC and restrained PVC and DI Pipe can be used

High-pressure jetting is used in conjunction with the boring process. This method utilizes high-pressure, low-volume drilling fluid, usually bentonite. The bentonite is injected into the boring through the drilling head and assists the boring on several levels. The jetting action assists in breaking up the soils at the drilling head, acts as a lubricant to the drilling rods, conveys the spoils the entry hole, and supports the surrounding soils to stop them from collapsing into the boring. For small projects the drilling fluid is simple disposed of, for large projects the contractor may elect to filter the spoils from the drilling fluid and recycle the fluid.

The tracking system most widely used by directional drilling systems is a walkover system. With this system a transmitter is housed behind the drilling head. The transmitter transmits a signal to the ground surface. An operator on the surface with a hand-held receiver picks up the signal, analyses the data and makes corrections as required to stay on alignment.

Major advantages of this method are that it does not require the construction of drilling and receiving pits and it is steerable. While the drilling head can be steered it is typically recommended that alignment radiuses be kept greater than 200 feet. Steering is accomplished by manipulating the drilling head. The drilling head configuration and operation can vary depending on the type of soil conditions In sandy soils a simple drilling head that resembles a curved shovel head can be used. Here steering is accomplished by pushing the slanted drilling head without rotation, and a straight path is achieved by applying thrust and torque to the drilling head at the same time. In more complex soils the drilling head may be equipped with carbide-tipped blades that are driven by the hydraulic pressure of the drilling fluid to cut through material. With this arrangement, the drilling head is slightly bend to one side. Like the shovel shaped drilling head, a straight path is achieved by applying thrust and torque to the drilling head as well as turning the blades in the drilling head. In this case however to steer the alignment the drilling head is rotated so the bend is in the direction the operator wishes to go and only the blades in the drilling head are rotated.

An illustration of a typical horizontal directional drilling process and a summary of its advantages and disadvantages are shown below.

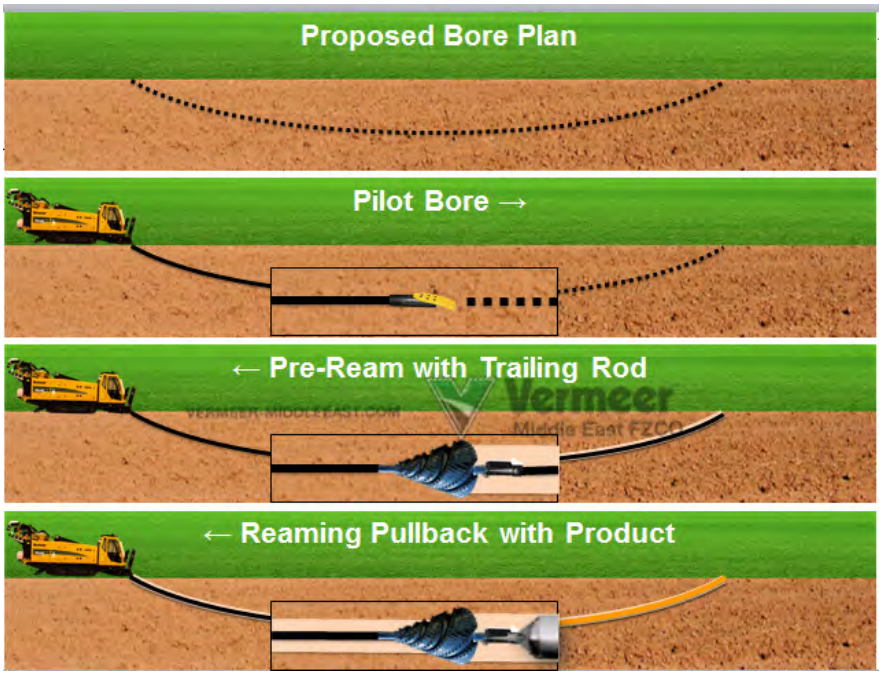

FIGURE 2

Horizontal Direction Drilling Illustration

TABLE 2

Horizontal Direction Drilling Advantages and Disadvantages

Advantages	• Relatively inexpensive. • Does not require the construction of driving and receiving pits. • Steerable system. • Can be used in a wide range of soils. • Can be launched from surface. • Short setup time.
Disadvantages	• Requires the disposal of the slurry mixture. • The possibility of slurry migration/contamination in native soil, especially if initial site investigation is flawed or inadequate. • Not accurate for pipe grades of less than 2 percent. • Can require large layout area for pipe.

MICROTUNNELING

Microtunneling (MT) is a trenchless method of installing pipes in a wide range of soil conditions while maintaining close tolerances in line and grade. MT requires the construction of a driving and receiving pit at each end of the pipe alignment. A remotely-controlled, steerable, microtunnel boring machine (MTBM) is lowered into the driving pit. Pipe is attached to the MTBM and the MTBM is forced into the soil by a hydraulic jacking machine. Slurry of bentonite and water is pumped hydraulically to the cutting face of the MTBM where it is mixed with the excavated material during the cutting process. The slurry and excavated material is then pumped away from the cutting face into a soil separation unit above ground where the slurry is separated and recycled back to the cutting face for reuse and the excavated material is hauled away. After each drive stroke an additional section of pipe is inserted into the jacking machine and the process is repeated until the MTBM reaches the receiving pit. Pipe diameters commonly range between 24 and 48 inches and can be installed in lengths up to 1,500 feet.

Microtunneling methods commonly use laser guidance systems. The laser is installed in the drive shaft and provides a fixed reference point on a target grid on the cutting face to control line and grade. A closed circuit television is installed in the MTBM to view the target grid and this information is transmitted to the operator's control panel. The operator can make steering corrections based on this information feedback. MT is a precise and accurate system and results in minimal settlement and heave during, as well as after, installation. The method can also be used in most soil types, though soils with significant rocks and boulders larger than 20 to 30 percent of the machine's diameter can be particularly problematic. The most favorable soil condition is wet sand. An illustration of a typical mircotunneling process and a summary of its advantages and disadvantages are shown below.

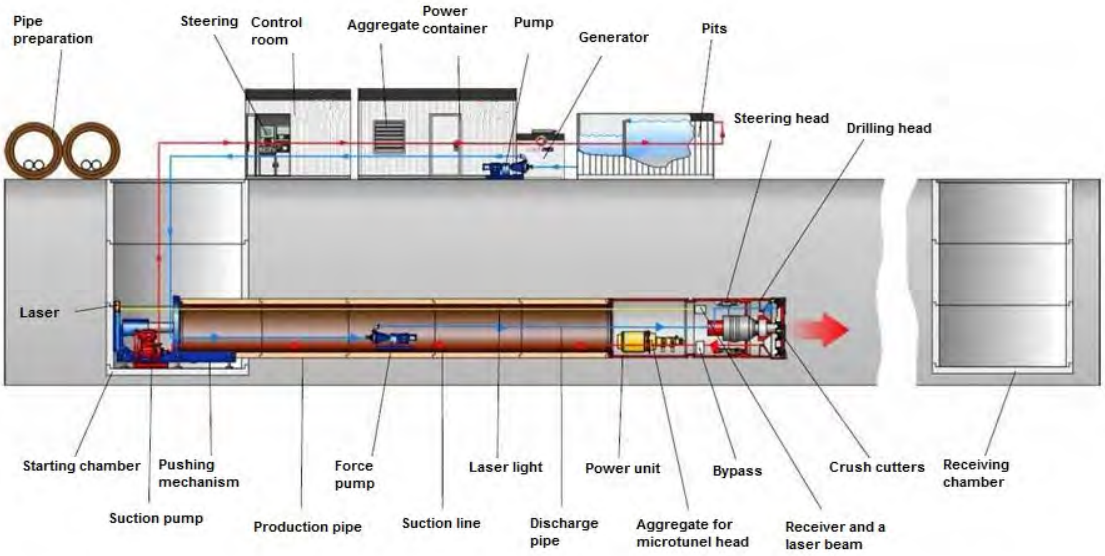

FIGURE 3

Microtunneling Illustration

TABLE 3

Microtunneling Advantages and Disadvantages

Advantages	• Minimizes surface settlement and heave. • Can be used above and below water table. • Can be used in a wide range of soils. • Very accurate. • Performs well in difficult soil conditions without the need for dewatering.
Disadvantages	• High capital cost. • Difficulty with boulders 20 to 30 percent of the machine's diameter. • Problematic with obstructions, large boulders, roots, manmade structures etc.

TRENCHLESS RENEWAL METHODS

PIPE BURSTING REHABILITATION

Pipe bursting is a trenchless replacement method capable of replacing existing pipelines along the same alignment without physically removing the existing pipe. Pipe bursting can be used to install pipes with the same or larger diameter as the existing pipe. Generally, the new pipe size is limited to an increase of one or two pipe sizes larger than

the host pipe. Rehabilitation of an existing host pipe is accomplished by pulling new pipe through the existing host pipe, which is the same diameter as or larger than the existing pipe, behind a "bursting/cutting head." The pipe bursting/cutting head is inserted into a pit and pulled through the breakable host pipe by a winch. The head is pulled, cutting and breaking the existing pipe ahead of the new pipe and forcing the ground outward to accommodate pieces of the old pipe and the new pipe, which is attached to the rear of the head.

Pipe bursting can only be used in the replacement of straight sections of pipe and should only be used when dealing with breakable host pipe such as PVC, concrete, clay, asbestos cement. The pipe bursting head can be equipped with an expander that can further displace the host pipe fragments. The replacement pipe is usually standard diameter HDPE. Generally, the pipe is fused together prior to installation, which can require a large staging area to string the pipe out.

Prior to any bursting activity, the existing line must be removed from service and bypass pumping provided. Sewer segments that are candidates for this method are in areas that benefit by minimal surface disturbance, have silty-clay soil conditions, have an easily breakable host pipe and have a straight alignment. While this method does replace the existing pipe, it is important to note that it will not eliminate any existing sags or high points in the existing main line. Any existing connections to the existing pipe will need to be reinstated by open cut after the new pipe is in place.

Difficult pipe bursting conditions are encountered in non-expansive soils that do not move well to accommodate the new pipe. When obstructions are encountered, the pipe generally deflects away from them. In severe cases, obstructions can prevent the bursting head from moving forward. When this occurs, it may be necessary to excavate the area and expose and remove the obstruction before the pipe bursting process can continue. An illustration of a typical pipe bursting process and a summary of its advantages and disadvantages are shown below.

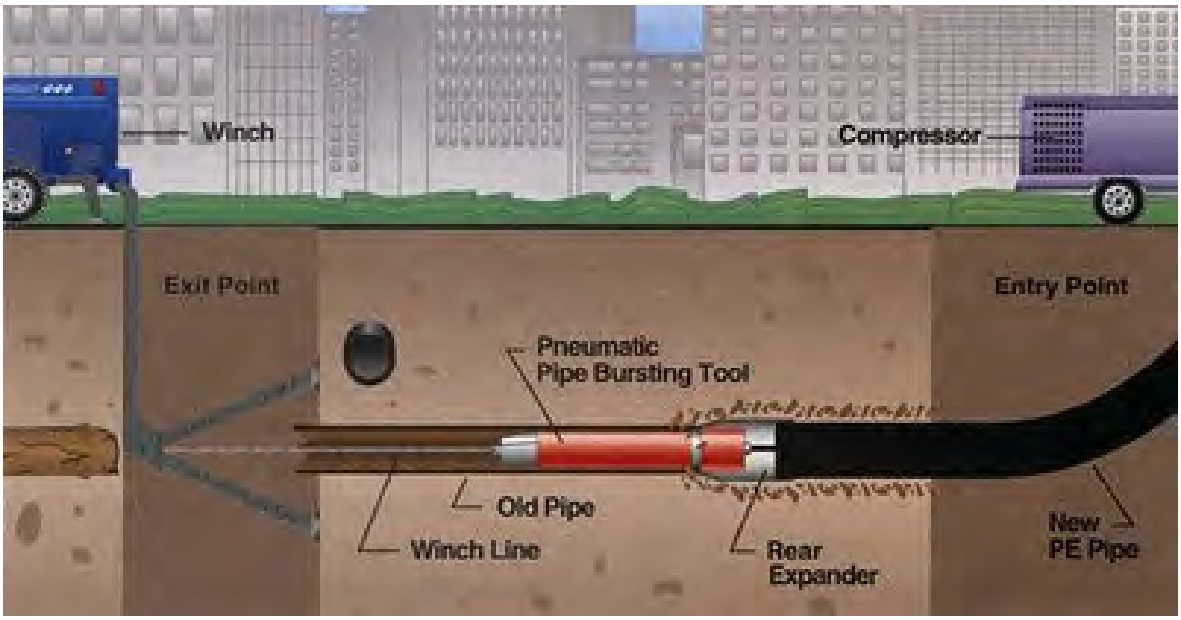

FIGURE 4

Pipe Bursting Illustration

TABLE 4

Pipe Bursting Rehabilitation Advantages and Disadvantages

Advantages	• Relatively inexpensive. • Process can allow for upsizing of the pipe. • New HDPE or PVC pipe has no joints. • Host pipe does not need to be cleaned.
Disadvantages	• Potential risk of surface heaving. • Technique cannot accommodate bends and can only be used in straight sections of pipe. • Does not repair existing sags or bellies. • Requires construction of entrance and receiving pits. • Maximum pull length of 500 feet. • Connections to new main must be made by open cut techniques. • Can require large layout area for pipe.

SLIPLINING REHABILITATION

Sliplining is one of the oldest, cheapest, and least invasive trenchless methods for restoring existing utilities. The process involves the insertion of a new pipe into an existing host pipe. The outside diameter of the new pipe must be smaller than the inside dimension of the existing host pipe, generally by at least 2 inches. Several types of thermoplastic pipes have been used for sliplining. HDPE is the most common, however, fusible PVC pipe is becoming more common.

During the installation process, an entrance pit is excavated at the connection to the existing pipeline where the carrier pipe is winched through the host pipe either to an exit pit or to an existing structure. As with pipe bursting, sliplining cannot be performed through pipe bends or curves. HDPE carrier pipe is typically butt-fused to its design length in order to provide a continuous installation. For long rehabilitation sections, the carrier pipe can typically be pulled 500 feet in between the insertion and exit pits. Depending on the pulling equipment, longer pull lengths are possible. The pits are sized to accommodate the bending radius of the pipe chosen. Here again any existing connections to the existing pipe will need to be reinstated by open cut after the new pipe is in place. An illustration of a typical sliplining process and a summary of its advantages and disadvantages are shown below.

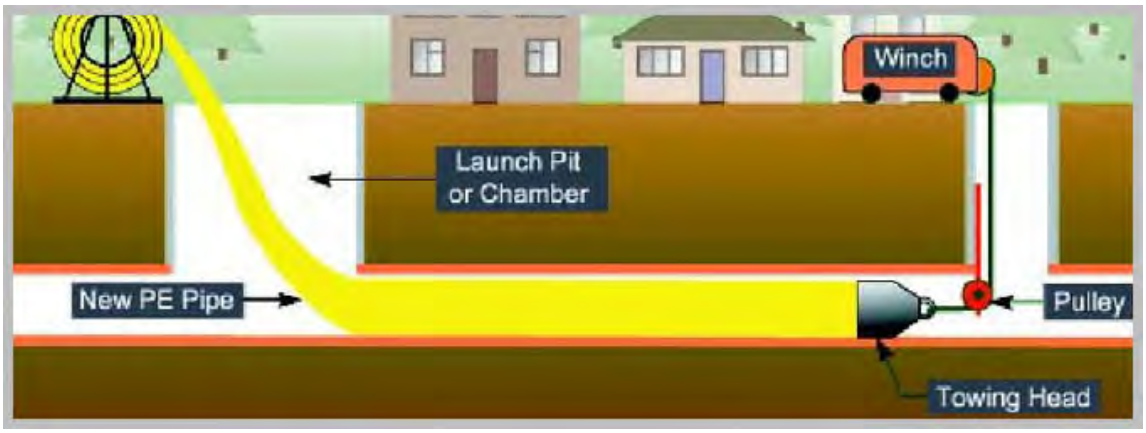

FIGURE 5

Sliplining Illustration

TABLE 5

Sliplining Rehabilitation Advantages and Disadvantages

Advantages	• Relatively inexpensive. • New HDPE or PVC pipe has no joints. • Host pipe does not need to be cleaned.
Disadvantages	• Technique cannot accommodate bends and can only be used in straight sections of pipe. • Loss of internal diameter resulting in reduction in carrying capacity. • Maximum pull length of 500 feet. • Does not repair existing sags or bellies. • Requires construction of entrance and receiving pits. • Connections to new main must generally be made by open cut. • Can require large layout area for pipe.

CURED-IN-PLACE PIPE REHABILITATION

Cured-in-place pipe (CIPP) is a method of rehabilitation where a new pipe is inserted and formed within an existing host pipe. An inverted resin-impregnated liner is inserted into the pipe segment from one end and extended to the other end. The liner is expanded into the host pipe using either a hydrostatic head of water or steam to press the liner firmly into and against the existing host pipe, and is generally heated to activate the resin to cure against the host pipe.

Typically, a CIPP installer will clean, CCTV video-inspect the host sewer segment, and take exact inside pipe diameter dimensions prior to mobilizing. The rehabilitated pipeline is also video inspected after completion of the work. The thickness of the liner and physical properties of the resins can be specified to suit the specific application. When the resin cures, the inside diameter is smaller than the host pipe, but generally the hydraulic capacity of the line typically remains close to the original capacity due to reduced friction.

The maximum length between access points for CIPP applications is approximately 1,000 to 1,200 feet. The liner can be installed through bends up to 45 degrees, however, multiple bends in the pipe alignment may present unfavorable conditions as failure of the lining may occur on the outside of a bend with a tight radius. The liner can be installed through a manhole if the alignment is relativity straight. Connections can be made by open cut or by inserting a remotely controlled cutting machine into the pipeline and cutting a hole in the liner at the connection. An illustration of a typical horizontal CIPP installation section and a summary of its advantages and disadvantages are shown below.

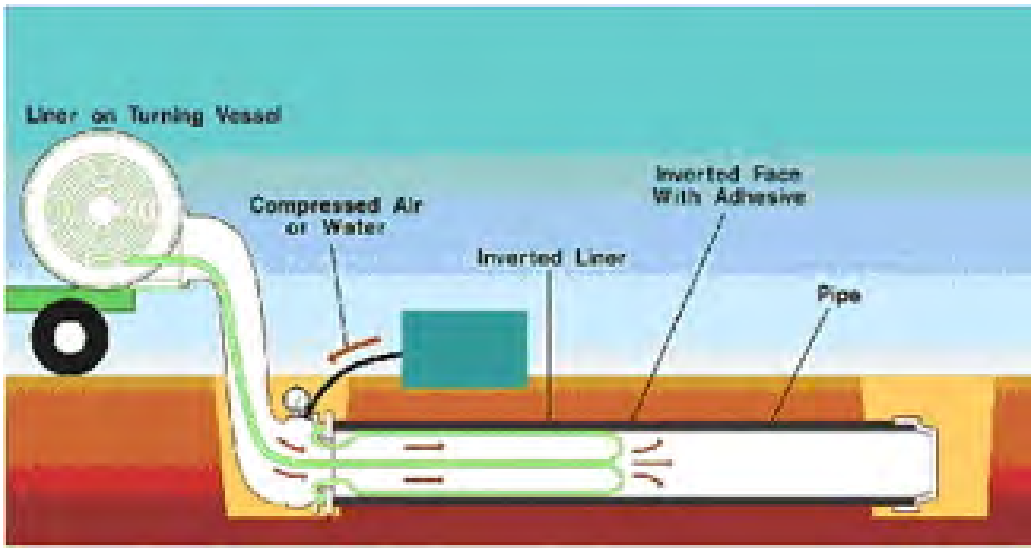

FIGURE 6

CIPP Illustration

TABLE 6

CIPP Rehabilitation

Advantages	• Pipe can be pulled through a limited number of bends. • Pipe is pressed against host pipe for minimal reduction in capacity. • Technique can be used between manholes with no excavation required. • Liner can be blown through manhole. • Maximum rehab length of 1000 to 1,200 feet. • Sources can be reconnected using trenchless methods
Disadvantages	• Bumps or wrinkles in the pipe are possible. • Host pipe must be cleaned before installation. • Follows existing sewer alignment and cannot remove sags or structural deficiencies. • Large staging area required.

APPENDIX B

COST ESTIMATES

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
SUNDAY COVE SUBBASIN ALTERNATIVE S1 - GRAVITY SERVICE TO SUNDAY COVE LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$10,000.00	$10,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$30,000.00	$30,000.00
3.	Survey	1	LS	$2,000.00	$2,000.00
4.	Project Temporary Traffic Control	1	LS	$8,000.00	$8,000.00
5.	Erosion/Water Pollution Control	1	LS	$5,000.00	$5,000.00
6.	Locate Existing Utilities	1	LS	$5,000.00	$5,000.00
7.	Trench Excavation Safety Systems	1	LS	$10,000.00	$10,000.00
8.	Dewatering	1	LS	$5,000.00	$5,000.00
9.	Temporary Bypass Pumping	1	LS	$10,000.00	$10,000.00
10.	Crushed Surfacing	150	TN	$28.00	$4,200.00
11.	Bank Run Gravel for Trench Backfill	250	TN	$25.00	$6,250.00
12.	PVC Sanitary Sewer Pipe 8 In. Diam.	350	LF	$160.00	$56,000.00
13.	Manhole 48 In. Diam	3	EA	$6,000.00	$18,000.00
14.	HMA Cl. 1/2" PG 64-22	40	TN	$150.00	$6,000.00
15.	Plug Existing Pipe	1	EA	$500.00	$500.00
16.	Connect to Existing System	3	EA	$2,000.00	$6,000.00
17.	PVC Sanitary Side Sewer Pipe 6 In. Diam.	250	LF	$120.00	$30,000.00
18.	Rebuild Wall	1	LS	$15,000.00	$15,000.00
19.	Site Restoration	1	LS	$8,000.00	$8,000.00
20.	Plumbing Work Within Private Home	1	LS	$30,000.00	$30,000.00
	Subtotal				$264,950.00
	Contingency 30%				$79,485.00
	Subtotal				$344,435.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$30,999.15
	Total Construction Cost:				**$375,434.15**
	Permitting/Easements (3% + Easement Cost)				$25,266.70
	Engineering, Construction Management and Administration (30%)				$112,630.25
	Total Project Cost:				**$514,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
SUNDAY COVE SUBBASIN ALTERNATIVE S2 - INDIVIDUAL GRINDER PUMPS
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$12,000.00	$12,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$30,000.00	$30,000.00
3.	Survey	1	LS	$2,500.00	$2,500.00
4.	Project Temporary Traffic Control	1	LS	$10,000.00	$10,000.00
5.	Erosion/Water Pollution Control	1	LS	$7,000.00	$7,000.00
6.	Locate Existing Utilities	1	LS	$5,000.00	$5,000.00
7.	Trench Excavation Safety Systems	1	LS	$5,000.00	$5,000.00
8.	Dewatering	1	LS	$3,000.00	$3,000.00
9.	Temporary Bypass Pumping	1	LS	$5,000.00	$5,000.00
10.	Crushed Surfacing	100	TN	$28.00	$2,800.00
11.	Bank Run Gravel for Trench Backfill	250	TN	$25.00	$6,250.00
12.	Low Pressure Force Main 3 In. Diam. HDPE	500	LF	$60.00	$30,000.00
13.	Manhole 48 In. Diam	1	EA	$6,000.00	$6,000.00
14.	HMA Cl. 1/2" PG 64-22	60	TN	$150.00	$9,000.00
15.	Plug Existing Pipe	1	EA	$500.00	$500.00
16.	Connect to Existing System	2	EA	$2,000.00	$4,000.00
17.	Grinder Pump Installation	9	EA	$10,000.00	$90,000.00
18.	1-1/4 In. Diam. Low Pressure Force Main	200	LF	$50.00	$10,000.00
19.	Property Restoration	1	EA	$10,000.00	$10,000.00
20.	Plumbing Work Within Private Home	1	LS	$30,000.00	$30,000.00
	Subtotal				$278,050.00
	Contingency 30%				$83,415.00
	Subtotal				$361,465.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$32,531.85
	Total Construction Cost:				**$393,996.85**
	Permitting/Easements (3% + Easement Cost)				$16,411.27
	Engineering, Construction Management and Administration (30%)				$118,199.06
	Total Project Cost:				**$529,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
SUNDAY COVE SUBBASIN ALTERNATIVE S3 - SOUTH SUNDAY COVE LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$10,000.00	$10,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$25,000.00	$25,000.00
3.	Survey	1	LS	$2,000.00	$2,000.00
4.	Project Temporary Traffic Control	1	LS	$5,000.00	$5,000.00
5.	Erosion/Water Pollution Control	1	LS	$5,000.00	$5,000.00
6.	Locate Existing Utilities	1	LS	$3,000.00	$3,000.00
7.	Trench Excavation Safety Systems	1	LS	$8,000.00	$8,000.00
8.	Dewatering	1	LS	$5,000.00	$5,000.00
9.	Temporary Bypass Pumping	1	LS	$7,000.00	$7,000.00
10.	Crushed Surfacing	40	TN	$28.00	$1,120.00
11.	Bank Run Gravel for Trench Backfill	60	TN	$25.00	$1,500.00
12.	Low Pressure Force Main 3 In. Diam. HDPE	120	LF	$60.00	$7,200.00
13.	PVC Sanitary Sewer Pipe 8 In. Diam.	50	LF	$160.00	$8,000.00
14.	Manhole 48 In. Diam	1	EA	$6,000.00	$6,000.00
15.	Plug Existing Pipe	1	EA	$500.00	$500.00
16.	Connect to Existing System	2	EA	$2,000.00	$4,000.00
17.	Lift Station	1	LS	$50,000.00	$50,000.00
18.	Electrical and Telemetry	1	LS	$60,000.00	$60,000.00
19.	New Generator	1	LS	$40,000.00	$40,000.00
20.	Site Restoration	1	LS	$5,000.00	$5,000.00
	Subtotal				$253,320.00
	Contingency 30%				$75,996.00
	Subtotal				$329,316.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$29,638.44
	Total Construction Cost:				**$358,954.44**
	Permitting/Easements (3% + Easement Cost)				$19,033.10
	Engineering, Construction Management and Administration (30%)				$107,686.33
	Total Project Cost:				**$486,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
LOVELL AVENUE SUBBASIN ALTERNATIVE L1 - REHAB EXISTING LOWER LOVELL LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$15,000.00	$15,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$30,000.00	$30,000.00
3.	Project Temporary Traffic Control	1	LS	$15,000.00	$15,000.00
4.	Erosion/Water Pollution Control	1	LS	$10,000.00	$10,000.00
5.	Temporary Bypass Pumping	1	LS	$25,000.00	$25,000.00
6.	New Pumps and Motors	1	LS	$50,000.00	$50,000.00
7.	Electrical and Telemetry	1	LS	$75,000.00	$75,000.00
8.	New Generator	1	LS	$60,000.00	$60,000.00
9.	Rehabilitation Wet Well	1	LS	$20,000.00	$20,000.00
10.	Site Restoration	1	LS	$2,000.00	$2,000.00
	Subtotal				$302,000.00
	Contingency 30%				$90,600.00
	Subtotal				$392,600.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$35,334.00
	Total Construction Cost:				**$427,934.00**
	Permitting/Easement				$0.00
	Engineering, Construction Management and Administration (30%)				$128,380.20
	Total Project Cost:				**$557,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN REPLACEMENT
LOVELL AVENUE SUBBASIIN ALTERNATIVE L2 - RELOCATE EXISTING LOWER LOVELL LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$40,000.00	$40,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$85,000.00	$85,000.00
3.	Survey	1	LS	$5,000.00	$5,000.00
4.	Project Temporary Traffic Control	1	LS	$35,000.00	$35,000.00
5.	Erosion/Water Pollution Control	1	LS	$15,000.00	$15,000.00
6.	Locate Existing Utilities	1	LS	$5,000.00	$5,000.00
7.	Trench Excavation Safety Systems	1	LS	$20,000.00	$20,000.00
8.	Dewatering	1	LS	$5,000.00	$5,000.00
9.	Temporary Bypass Pumping	1	LS	$15,000.00	$15,000.00
10.	Crushed Surfacing	110	TN	$28.00	$3,080.00
11.	Bank Run Gravel for Trench Backfill	150	TN	$25.00	$3,750.00
12.	4 In. Diam. HDPE Force Main	475	LF	$80.00	$38,000.00
13.	Abandon Existing Manhole	1	EA	$2,000.00	$2,000.00
14.	HMA Cl. 1/2" PG 64-22	55	TN	$150.00	$8,250.00
15.	Temporary HMA Cl. 1/2" PG 64-22	10	TN	$150.00	$1,500.00
16.	Plug Existing Pipe	1	EA	$500.00	$500.00
17.	Connect to Existing System	2	EA	$2,000.00	$4,000.00
18.	Lift Station	1	LS	$400,000.00	$400,000.00
19.	Demolition of Existing Lower Lovell Lift Station	1	LS	$20,000.00	$20,000.00
20.	Electrical and Telemetry	1	LS	$50,000.00	$50,000.00
21.	New Generator	1	LS	$60,000.00	$60,000.00
22.	Site Restoration	1	LS	$5,000.00	$5,000.00
	Subtotal				$821,080.00
	Contingency 30%				$246,324.00
	Subtotal				$1,067,404.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$96,066.36
	Total Construction Cost				**$1,163,470.36**
	Permitting/Easements (3% + Easement Cost)				$41,791.16
	Engineering, Construction Management and Administration (30%)				$349,041.11
	Total Project Cost:				**$1,555,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
LOVELL AVENUE SUBBASIN ALTERNATIVE L3 - MICRO-TUNNELING GRAVITY MAIN AND DECOMMISSION LOWER LOVELL LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$50,000.00	$50,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$280,000.00	$280,000.00
3.	Survey	1	LS	$20,000.00	$20,000.00
4.	Project Temporary Traffic Control	1	LS	$125,000.00	$125,000.00
5.	Erosion/Water Pollution Control	1	LS	$25,000.00	$25,000.00
6.	Locate Existing Utilities	1	LS	$10,000.00	$10,000.00
7.	Removal and Wastehaul of Unsuitable Excavation	10	TN	$50.00	$500.00
8.	Dewatering	1	LS	$20,000.00	$20,000.00
9.	Temporary Bypass Pumping	1	LS	$10,000.00	$10,000.00
10.	Crushed Surfacing	50	TN	$28.00	$1,400.00
11.	Bank Run Gravel for Trench Backfill	100	TN	$25.00	$2,500.00
12.	HMA Cl. 1/2" PG 64-22	25	TN	$150.00	$3,750.00
13.	Temporary HMA Cl. 1/2" PG 64-22	5	TN	$150.00	$750.00
14.	Plug Existing Pipe	1	EA	$500.00	$500.00
15.	Control Density Fill	50	CY	$200.00	$10,000.00
16.	Connect to Existing System	2	EA	$5,000.00	$10,000.00
17.	Micro-tunneling Bore (incl. Shafts, 8" Carrier Pipe & 42" Casing)	1,133	LF	$1,750.00	$1,982,750.00
18.	Launch Pit (40'x20')	2	EA	$100,000.00	$200,000.00
19.	Receiving Pit (10'x12')	2	EA	$20,000.00	$40,000.00
18.	Demolition of Lower Lovell Pump Station	1	LS	$20,000.00	$20,000.00
19.	Site Restoration	1	LS	$10,000.00	$10,000.00
	Subtotal				$2,822,150.00
	Contingency 30%				$846,645.00
	Subtotal				$3,668,795.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$330,191.55
	Total Construction Cost:				**$3,998,986.55**
	Engineering, Construction Management and Administration (30%)				$1,199,695.97
	Total Project Cost:				**$5,199,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
LOVELL AVENUE SUBBASIN ALTERNATIVE L4 - AUGER BORE GRAVITY MAIN AND DECOMMISSION LOWER LOVELL LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$50,000.00	$100,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$210,000.00	$210,000.00
3.	Survey	1	LS	$10,000.00	$10,000.00
4.	Project Temporary Traffic Control	1	LS	$80,000.00	$80,000.00
5.	Erosion/Water Pollution Control	1	LS	$20,000.00	$20,000.00
6.	Locate Existing Utilities	1	LS	$10,000.00	$10,000.00
7.	Dewatering	1	LS	$10,000.00	$10,000.00
8.	Temporary Bypass Pumping	1	LS	$5,000.00	$5,000.00
9.	Crushed Surfacing	50	TN	$28.00	$1,400.00
10.	Bank Run Gravel for Trench Backfill	100	TN	$25.00	$2,500.00
11.	HMA Cl. 1/2" PG 64-22	25	TN	$150.00	$3,750.00
12.	Temporary HMA Cl. 1/2" PG 64-22	5	TN	$150.00	$750.00
13.	Plug Existing Pipe	1	EA	$500.00	$500.00
14.	Control Density Fill	50	CY	$200.00	$10,000.00
15.	Connect to Existing System	2	EA	$5,000.00	$10,000.00
16.	Auger Bore (Casing & pipes included)	1,133	LF	$1,000.00	$1,133,000.00
17.	Launch Pit (10'x28')	2	EA	$200,000.00	$400,000.00
18.	Receiving Pit (10'x12')	2	EA	$20,000.00	$40,000.00
19.	Demolition of Lower Lovell Pump Station	1	LS	$20,000.00	$20,000.00
20.	Site Restoration	1	LS	$10,000.00	$10,000.00
	Subtotal				$2,076,900.00
	Contingency 30%				$623,070.00
	Subtotal				$2,699,970.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$242,997.30
	Total Construction Cost:				**$2,942,967.30**
	Engineering, Construction Management and Administration (30%)				$882,890.19
	Total Project Cost:				**$3,826,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
LOVELL AVENUE SUBBASIN ALTERNATIVE L5 - DIRECTIONAL DRILL GRAVITY MAIN AND DECOMMISSION LOWER LOVELL LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$20,000.00	$25,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$50,000.00	$50,000.00
3.	Survey	1	LS	$5,000.00	$5,000.00
4.	Project Temporary Traffic Control	1	LS	$20,000.00	$20,000.00
5.	Erosion/Water Pollution Control	1	LS	$10,000.00	$10,000.00
6.	Locate Existing Utilities	1	LS	$10,000.00	$10,000.00
7.	Dewatering	1	LS	$8,000.00	$8,000.00
8.	Temporary Bypass Pumping	1	LS	$5,000.00	$5,000.00
9.	Crushed Surfacing	90	TN	$28.00	$2,520.00
10.	Bank Run Gravel for Trench Backfill	250	TN	$25.00	$6,250.00
11.	PVC Sanitary Sewer Pipe 8 In. Diam.	235	LF	$160.00	$37,600.00
12.	Manhole 48 In. Diam	3	EA	$6,000.00	$18,000.00
13.	Manhole 60 In. Diam	1	EA	$30,000.00	$30,000.00
14.	HMA Cl. 1/2" PG 64-22	50	TN	$150.00	$7,500.00
15.	Temporary HMA Cl. 1/2" PG 64-22	10	TN	$150.00	$1,500.00
16.	Control Density Fill	50	CY	$200.00	$10,000.00
17.	Connect to Existing System	2	EA	$5,000.00	$10,000.00
18.	Directional Drill 10" O.D. HDPE	900	LF	$250.00	$225,000.00
19.	Demolition of Lower Lovell Pump Station	1	LS	$20,000.00	$20,000.00
20.	Site Restoration	1	LS	$10,000.00	$10,000.00
	Subtotal				$511,370.00
	Contingency 30%				$153,411.00
	Subtotal				$664,781.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$59,830.29
	Total Construction Cost:				**$724,611.29**
	Engineering, Construction Management and Administration (30%)				$217,383.39
	Total Project Cost:				**$942,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
WOOD AVENUE SUBBASIN ALTERNATIVE W1 - PUBLIC HOUSE LIFT STATION
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$70,000.00	$70,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$165,000.00	$165,000.00
3.	Survey	1	LS	$20,000.00	$20,000.00
4.	Project Temporary Traffic Control	1	LS	$50,000.00	$50,000.00
5.	Erosion/Water Pollution Control	1	LS	$40,000.00	$40,000.00
6.	Locate Existing Utilities	1	LS	$20,000.00	$20,000.00
7.	Trench Excavation Safety Systems	1	LS	$30,000.00	$30,000.00
8.	Dewatering	1	LS	$15,000.00	$15,000.00
9.	Temporary Bypass Pumping	1	LS	$30,000.00	$30,000.00
10.	Crushed Surfacing	450	TN	$28.00	$12,600.00
11.	Bank Run Gravel for Trench Backfill	1,200	TN	$25.00	$30,000.00
12.	Low Pressure Force Main 3 In. Diam. HDPE	900	LF	$60.00	$54,000.00
13.	HDPE Force Main 4-In. Diam.	350	LF	$75.00	$26,250.00
14.	PVC Sanitary Sewer Pipe 8 In. Diam.	500	LF	$160.00	$80,000.00
15.	Abandon Existing Manhole	7	EA	$2,000.00	$14,000.00
16.	Manhole 48 In. Diam	5	EA	$6,000.00	$30,000.00
17.	HMA Cl. 1/2" PG 64-22	250	TN	$150.00	$37,500.00
18.	Temporary HMA Cl. 1/2" PG 64-22	50	TN	$150.00	$7,500.00
19.	Plug Existing Pipe	1	EA	$500.00	$500.00
20.	Connect to Existing System	4	EA	$2,000.00	$8,000.00
21.	Grinder Pump Installation	10	EA	$10,000.00	$100,000.00
22.	1-1/4 In. Diam. HDPE Force Main	1,000	LF	$50.00	$50,000.00
23.	Lift Station	1	LS	$600,000.00	$600,000.00
24.	Electrical and Telemetry	1	LS	$50,000.00	$50,000.00
25.	New Generator	1	LS	$60,000.00	$60,000.00
26.	Site Restoration	1	LS	$50,000.00	$50,000.00
	Subtotal				$1,650,350.00
	Contingency 30%				$495,105.00
	Subtotal				$2,145,455.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$193,100.00
	Total Construction Cost:				**$2,338,555.00**
	Permitting/Easement (3%)				$70,156.65
	Engineering, Construction Management and Administration (30%)				$701,566.50
	Total Project Cost:				**$3,111,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
WOOD AVENUE SUBBASIN ALTERNATIVE W2 - WOOD LIFT STATION AND EXISTING BEACH MAIN
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$50,000.00	$50,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$155,000.00	$155,000.00
3.	Survey	1	LS	$10,000.00	$10,000.00
4.	Project Temporary Traffic Control	1	LS	$30,000.00	$30,000.00
5.	Erosion/Water Pollution Control	1	LS	$30,000.00	$30,000.00
6.	Locate Existing Utilities	1	LS	$10,000.00	$10,000.00
7.	Trench Excavation Safety Systems	1	LS	$10,000.00	$10,000.00
8.	Dewatering	1	LS	$10,000.00	$10,000.00
9.	Temporary Bypass Pumping	1	LS	$20,000.00	$20,000.00
10.	Crushed Surfacing	450	TN	$28.00	$12,600.00
11.	Bank Run Gravel for Trench Backfill	650	TN	$25.00	$16,250.00
12.	Low Pressure Force Main 3 In. Diam. HDPE	720	LF	$60.00	$43,200.00
13.	HDPE Force Main 4-In. Diam.	600	LF	$75.00	$45,000.00
14.	Manhole 48 In. Diam.	1	EA	$6,000.00	$6,000.00
15.	HMA Cl. 1/2" PG 64-22	250	TN	$150.00	$37,500.00
16.	Temporary HMA Cl. 1/2" PG 64-22	50	TN	$150.00	$7,500.00
17.	Plug Existing Pipe	1	EA	$500.00	$500.00
18.	Connect to Existing System	4	EA	$2,000.00	$8,000.00
19.	Grinder Pump Installation	7	EA	$10,000.00	$70,000.00
20.	1-1/4 In. Diam. HDPE Force Main	750	LF	$50.00	$37,500.00
21.	Auger Bore (Casing & pipes included)	80	LF	$1,000.00	$80,000.00
22.	Receiving Pit (10'x12')	1	EA	$20,000.00	$20,000.00
23.	Lift Station (Incl. Launch Pit)	1	LS	$650,000.00	$650,000.00
24.	Electrical and Telemetry	1	LS	$80,000.00	$80,000.00
25.	New Generator	1	LS	$50,000.00	$50,000.00
26.	Site Restoration	1	LS	$30,000.00	$30,000.00
	Subtotal				$1,519,050.00
	Contingency 30%				$455,715.00
	Subtotal				$1,974,765.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$177,730.00
	Total Construction Cost:				**$2,152,495.00**
	Permitting/Easements (3%)				$64,574.85
	Engineering, Construction Management and Administration (30%)				$645,748.50
	Total Project Cost:				**$2,863,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
WOOD AVENUE SUBBASIN ALTERNATIVE W3 - WOOD LIFT STATION AND PUBLIC HOUSE LIFT STATIONS
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$70,000.00	$70,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$240,000.00	$240,000.00
3.	Survey	1	LS	$15,000.00	$15,000.00
4.	Project Temporary Traffic Control	1	LS	$40,000.00	$40,000.00
5.	Erosion/Water Pollution Control	1	LS	$40,000.00	$40,000.00
6.	Locate Existing Utilities	1	LS	$15,000.00	$15,000.00
7.	Trench Excavation Safety Systems	1	LS	$20,000.00	$20,000.00
8.	Dewatering	1	LS	$15,000.00	$15,000.00
9.	Temporary Bypass Pumping	1	LS	$25,000.00	$25,000.00
10.	Crushed Surfacing	750	TN	$28.00	$21,000.00
11.	Bank Run Gravel for Trench Backfill	1,200	TN	$25.00	$30,000.00
12.	Low Pressure Force Main 3 In. Diam. HDPE	900	LF	$60.00	$54,000.00
12.	HDPE Force Main 4-In. Diam.	800	LF	$75.00	$60,000.00
13.	PVC Sanitary Sewer Pipe 8 In. Diam.	350	LF	$160.00	$56,000.00
14.	Abandon Existing Manhole	7	EA	$2,000.00	$14,000.00
15.	Manhole 48 In. Diam	2	EA	$6,000.00	$12,000.00
16.	HMA Cl. 1/2" PG 64-22	220	TN	$150.00	$33,000.00
17.	Temporary HMA Cl. 1/2" PG 58-22	50	TN	$150.00	$7,500.00
18.	Plug Existing Pipe	1	EA	$500.00	$500.00
19.	Connect to Existing System	5	EA	$2,000.00	$10,000.00
21.	Grinder Pump Instalation	11	EA	$10,000.00	$110,000.00
22.	1-1/4 In. Diam. HDPE Force Main	1100	LF	$50.00	$55,000.00
23.	Lift Station	2	EA	$600,000.00	$1,200,000.00
24.	Electrical and Telemetry	2	EA	$50,000.00	$100,000.00
25.	New Generator	2	EA	$60,000.00	$120,000.00
20.	Site Restoration	1	LS	$40,000.00	$40,000.00
	Subtotal				$2,403,000.00
	Contingency 30%				$720,900.00
	Subtotal				$3,123,900.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$281,160.00
	Total Construction Cost:				**$3,405,060.00**
	Permitting/Easements (3%)				$102,151.80
	Engineering, Construction Management and Administration (30%)				$1,021,518.00
	Total Project Cost:				**$4,529,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
WOOD AVENUE SUBBASIN ALTERNATIVE W4 - INDIVIDUAL GRINDER PUMPS
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$5,000.00	$30,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$85,000.00	$85,000.00
3.	Survey	1	LS	$5,000.00	$5,000.00
4.	Project Temporary Traffic Control	1	LS	$20,000.00	$20,000.00
5.	Erosion/Water Pollution Control	1	LS	$10,000.00	$10,000.00
6.	Locate Existing Utilities	1	LS	$8,000.00	$8,000.00
7.	Trench Excavation Safety Systems	1	LS	$10,000.00	$10,000.00
8.	Dewatering	1	LS	$5,000.00	$5,000.00
9.	Temporary Bypass Pumping	1	LS	$5,000.00	$5,000.00
10.	Crushed Surfacing	650	TN	$28.00	$18,200.00
11.	Bank Run Gravel for Trench Backfill	1450	TN	$25.00	$36,250.00
12.	Low Pressure Force Main 3 In. Diam. HDPE	1,750	LF	$60.00	$105,000.00
13.	HMA CL. 1/2" PG 64-22	220	TN	$150.00	$33,000.00
14.	Temporary HMA Cl. 1/2" PG 64-22	50	TN	$150.00	$7,500.00
15.	Grinder Pump Installation	27	EA	$10,000.00	$270,000.00
16.	1-1/4 In. Diam. HDPE Force Main	3,000	LF	$50.00	$150,000.00
17.	Property Restoration	19	EA	$2,000.00	$38,000.00
	Subtotal				$835,950.00
	Contingency 30%				$250,785.00
	Subtotal				$1,086,735.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$97,806.15
	Total Construction Cost:				**$1,184,541.15**
	Permitting/Easements (3%)				$35,536.23
	Engineering, Construction Management and Administration (30%)				$355,362.35
	Total Project Cost:				**$1,576,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
WOOD AVENUE SUBBASIN ALTERNATIVE W5 - BOARDWALK LIFT STATION AND EXISTING BEACH MAIN
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$50,000.00	$50,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$100,000.00	$100,000.00
3.	Survey	1	LS	$10,000.00	$10,000.00
4.	Project Temporary Traffic Control	1	LS	$30,000.00	$30,000.00
5.	Erosion/Water Pollution Control	1	LS	$30,000.00	$30,000.00
6.	Locate Existing Utilities	1	LS	$10,000.00	$10,000.00
7.	Trench Excavation Safety Systems	1	LS	$10,000.00	$10,000.00
8.	Dewatering	1	LS	$10,000.00	$10,000.00
9.	Temporary Bypass Pumping	1	LS	$20,000.00	$20,000.00
10.	Crushed Surfacing	500	TN	$28.00	$14,000.00
11.	Bank Run Gravel for Trench Backfill	750	TN	$25.00	$18,750.00
12.	Low Pressure Force Main 3 In. Diam. HDPE	720	LF	$60.00	$43,200.00
13.	HDPE Force Main 4-In. Diam.	650	LF	$75.00	$48,750.00
14.	PVC Sanitary Sewer Pipe 8 In. Diam.	100	LF	$160.00	$16,000.00
15.	Abandon Existing Manhole	1	EA	$2,000.00	$2,000.00
16.	Manhole 48 In. Diam.	1	EA	$6,000.00	$6,000.00
17.	HMA Cl. 1/2" PG 64-22	160	TN	$150.00	$24,000.00
18.	Temporary HMA Cl. 1/2" PG 64-22	50	TN	$150.00	$7,500.00
19.	Plug Existing Pipe	1	EA	$500.00	$500.00
20.	Connect to Existing System	3	EA	$2,000.00	$6,000.00
21.	Grinder Pump Installation	7	EA	$10,000.00	$70,000.00
22.	1-1/4 In. Diam. HDPE Force Main	750	LF	$50.00	$37,500.00
23.	Directional Drill 4" HDPE Force Main	80	LF	$250.00	$20,000.00
24.	Lift Station	1	LS	$250,000.00	$250,000.00
25.	Electrical and Telemetry	1	LS	$80,000.00	$80,000.00
26.	New Generator	1	LS	$50,000.00	$50,000.00
27.	Site Restoration	1	LS	$30,000.00	$30,000.00
	Subtotal				$994,200.00
	Contingency 30%				$298,260.00
	Subtotal				$1,292,460.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$116,330.00
	Total Construction Cost:				**$1,408,790.00**
	Permitting/Easements (3%)				$42,263.70
	Engineering, Construction Management and Administration (30%)				$422,637.00
	Total Project Cost:				**$1,874,000.00**

CITY OF BAINBRIDGE ISLAND
WEST EAGLE HARBOR BEACH SEWER MAIN
LOVELL AVENUE GRINDER PUMPS
ENGINEER'S PRELIMINARY COST ESTIMATE
February 7, 2018

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY		UNIT PRICE	AMOUNT
1.	Minor Changes	1	MC	$10,000.00	$10,000.00
2.	Mobilization, Cleanup, and Demobilization	1	LS	$20,000.00	$20,000.00
3.	Survey	1	LS	$2,000.00	$2,000.00
4.	Project Temporary Traffic Control	1	LS	$5,000.00	$5,000.00
5.	Erosion/Water Pollution Control	1	LS	$5,000.00	$5,000.00
6.	Locate Existing Utilities	1	LS	$3,000.00	$3,000.00
7.	Trench Excavation Safety Systems	1	LS	$5,000.00	$5,000.00
8.	Dewatering	1	LS	$3,000.00	$3,000.00
9.	Temporary Bypass Pumping	1	LS	$3,000.00	$3,000.00
10.	Crushed Surfacing	100	TN	$28.00	$2,800.00
11.	Bank Run Gravel for Trench Backfill	150	TN	$25.00	$3,750.00
12.	Grinder Pump Installation	6	EA	$10,000.00	$60,000.00
13.	1-1/4 In. Diam. Low Pressure Force Main	500	LF	$50.00	$25,000.00
14.	HMA CL. 1/2" PG 64-22	10	TN	$150.00	$1,500.00
15.	Temporary HMA Cl. 1/2" PG 64-22	5	TN	$150.00	$750.00
16.	Property Restoration	15	EA	$2,000.00	$30,000.00
	Subtotal				$179,800.00
	Contingency 30%				$53,940.00
	Subtotal				$233,740.00
	Sales Tax at 9.0% per Washington State Dept. of Revenue				$21,036.60
	Total Construction Cost:				**$254,776.60**
	Permitting/Easements (3% + Easement Cost)				$20,039.99
	Engineering, Construction Management and Administration (30%)				$76,432.98
	Total Project Cost:				**$352,000.00**

APPENDIX C

GEOTECHNICAL REPORT

PanGEO
INCORPORATED
Geotechnical & Earthquake
Engineering Consultants

November 17, 2017
Project No. 17-195

Mr. Steve Clarke, P.E.
Gray & Osborne, Inc.
701 Dexter Avenue North, Suite 200
Seattle, Washington 98109

Subject: **Geotechnical Data Report**
West Eagle Harbor Sewer Replacement Project
Predesign Subsurface Data - Wood Avenue SW Lift Station
Bainbridge Island, Washington
Gray & Osborne IPN #17504

Dear Mr. Clarke,

As requested, PanGEO completed a subsurface exploration program to assist the project team with predesign efforts for the proposed Wood Avenue Southwest sewer line alignment and lift station in Bainbridge Island, Washington. The results of our study are summarized in the attached data report. The report summarizes the results of our subsurface exploration program, anticipated subsurface conditions, and cursory-level design information. We understand it is planned to install the new 8-inch diameter sewer line using directional drilling methods. Based on the results of our subsurface exploration program, the Wood Avenue Southwest sewer line alignment and lift station are primarily expected to encounter very dense glacial till deposits. It is our opinion that directional drilling is feasible.

We appreciate the opportunity to assist you with this project. We are available to meet to discuss our findings at your convenience.

Sincerely,

Siew L. Tan, P.E.
Principal Geotechnical Engineer

3213 Eastlake Avenue East, Ste B
Seattle, WA 98102
Tel (206) 262-0370

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GEOTECHNICAL DATA REPORT
WEST EAGLE HARBOR SEWER REPLACEMENT PROJECT
PREDESIGN SUBSURFACE DATA - WOOD AVENUE SW LIFT STATION
BAINBRIDGE ISLAND, WASHINGTON

1.0 INTRODUCTION

As requested, PanGEO completed a subsurface exploration program to support the predesign efforts for the West Eagle Harbor sewer replacement project in Bainbridge Island, Washington. Our work included conducting a site reconnaissance, advancing two test borings, a laboratory testing program, and providing cursory-level design information in this report.

Please note that the design of the project is in a conceptual stage, additional geotechnical engineering recommendations may be needed during the final design phase of the project.

2.0 SITE AND PROJECT DESCRIPTION

The Wood Avenue Southwest portion of the City of Bainbridge Island's West Eagle Harbor sewer replacement project is approximately as shown on the attached Figure 1, Vicinity Map. We understand it is planned to install approximately 584 lineal feet of new 8-inch diameter PVC sewer line in Wood Avenue Southwest using trenchless construction methods such as directional drilling. The Wood Avenue Southwest lift station will include installing a new 4-foot dimeter wet well that will extend approximately 32 feet below grade. Given the proximity to the new wet well to adjacent private properties and the depth of the excavation, excavation shoring will be needed to accomplish the wet well excavation. The Wood Avenue Southwest proposed sewer alignment and lift station are indicated in Figure 2. As currently planned, we understand the sewer line invert will extend as deep as approximately 39 feet below existing grade as shown on Figure 3.

3.0 SUBSURFACE EXPLORATION

On October 26, 2017, two test borings (PG-1 and PG-2) were drilled in the Wood Avenue Southwest right-of-way approximately as shown on Figure 2. The borings were located in the field by taping from existing site features and its approximate locations are shown on Figure 2. Test boring PG-1 was advanced to approximately 42½ feet below grade and PG-2 was advanced to about 36 feet below grade.

The borings were drilled using a limited access track-mounted drill rig owned and operated by Boretec1, Inc. of Bellevue, Washington. The borings were drilled using 6-inch outside diameter augers. Soil samples were obtained from the borings at 2½- and 5-foot depth intervals in

conjunction with Standard Penetration Test (SPT) sampling methods in general accordance with ASTM test method D-1586, in which the samples are obtained using a 2-inch outside diameter (OD) split-spoon sampler. The 2-inch OD samplers were driven into the soil a distance of 18 inches using a 140-pound weight falling a distance of 30 inches. The number of blows required for each 6-inch increment of sampler penetration was recorded. The number of blows required to achieve the last 12 inches of sample penetration is defined as the SPT N-value. The N-value provides an empirical measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils.

A geologist from PanGEO was present during the field exploration to observe the drilling, to assist in sampling, and to describe and document the soil samples obtained from the boring. The soil samples were described using the system outlined on Figure A-1 in Appendix A. The summary boring logs are included in Appendix A.

Grain size distribution laboratory tests were performed on representative soil samples obtained from the test borings. The grain size distribution analyses were performed in general accordance with ASTM D-422. The test results are included in Appendix B.

4.0 SUBSURFACE CONDITIONS

4.1 SITE GEOLOGY AND SOILS

The *Preliminary Geologic Map of Bainbridge* Island (Haugerud, 2005) indicates that the surficial geologic unit in the vicinity of the project is Vashon glacial till (Map Unit Qvt). Glacial till is a very dense heterogeneous mixture of silt, sand, and gravel laid down at the base of an advancing glacial ice sheet. Glacial till typically exhibits low compressibility and high strength characteristics.

The results from our test borings generally confirmed the mapped geology. A generalized subsurface profile depicting the conditions encountered at our boring locations is attached as Figure 3.

Dense to very dense silty sand with gravel that we interpret to be glacial till was encountered directly below the topsoil at PG-1, and below the 6-inch thick surficial gravel layer at PG-2. The upper 2 to 3 feet of the glacial till was weathered to a medium dense condition. Based on the drill cuttings and soil samples, this soil unit contains cobbles. Although not encountered in our test borings, boulders may be present within this soil unit.

In general, an increase in relative density with depth was noted. This soil unit was encountered to the maximum exploration depth of about 42½ feet below grade at PG-1 and 36 feet below grade at PG-2.

4.2 GROUNDWATER

Groundwater was first encountered at 34 feet below grade at PG-1 (approx. Elevation 26 feet) and 24 feet below grade at PG-2 (approx. Elevation 13 feet) at the time of drilling. In addition, localized areas of iron oxide staining were observed within the glacial till soils. The iron oxide staining was typically noted near the transition from weathered glacial till to fresh glacial till and is likely indicative of a seasonal perched groundwater condition in which groundwater collects above the low permeability glacial till.

Groundwater elevations and seepage rates may vary depending on the season, local subsurface conditions, rainfalls, and other factors. Groundwater levels are normally highest during the winter and early spring.

5.0 GEOTECHNICAL CONSIDERATIONS

5.1 WOOD AVENUE SW LIFT STATION

5.1.1 Design Lateral Earth Pressure

The wet well should be designed to resist lateral loads imposed by the surrounding soils and applicable surcharge loads. For a circular wet well structure, the lateral earth pressure may be evaluated using an equivalent fluid pressure of 50 pcf above groundwater, and 90 pcf below groundwater. The earth pressure will be partially offset by the hydrostatic pressure exerted by the water inside the structure. The hydrostatic pressure inside the wet well should be calculated based on a unit weight for water of 62.4 pcf.

5.1.2 Buoyancy Force

The proposed wet well will extend below the groundwater table and will be subjected to hydrostatic uplift forces when the groundwater level outside the structure will be higher than the water level inside the structure. As such, the proposed wet well should be designed to resist such forces. For design purposes, based on the subsurface conditions observed at PG-2, we recommend that the groundwater level be assumed to rise within 20 feet of the existing grade. As an alternative,

pressure relief valves (PRVs) may be incorporated to prevent buildup of excessive pore water pressure.

5.1.3 Foundation Support

Assuming the excavation for the wet well will extend to about 32 feet below the existing site grade, we anticipate very dense glacial till will be encountered at the bottom of the excavation. The glacial till soils are anticipated to provide adequate support for the wet well. However, the foundation soils are anticipated to be highly moisture sensitive, and can be easily disturbed when exposed to moisture and construction activities. To provide a firm working and bearing surface, a leveling course consisting of about 6 inches to a foot of crushed surfacing base course (CSBC, WSDOT 9-03.9(3)) should be placed below the base of the structure.

For design purposes, an allowable bearing pressure of 4,000 psf may be used for sizing the foundation. A representative of Gray & Osborne or PanGEO should verify the adequacy of the subgrade prior to placing forms or reinforcing steel.

5.1.4 Temporary Shoring

Although we recommend the design of the temporary shoring system be the contractor's responsibility, it is our opinion that a fully-cased drilled shaft or sinking-caisson would likely be feasible. However, the very dense condition of the glacial till should be considered when selecting excavation methods within the caisson

Alternatively, a soldier pile wall with steel plate lagging or an interlocking secant/tangent pile wall is also considered a feasible temporary shoring option. The soldier piles would be installed in pre-drilled holes then backfilled, but the use of temporary casings may be needed to prevent caving during drilling.

Given the very dense glacial till expected to be encountered in the excavation, we do not envision that sheet piles could be driven deep enough to provide adequate embedment.

Selection of installation methods should consider the potential impacts to existing nearby structures and utilities and the presence of large cobbles and boulders.

Because the anticipated excavation will be about 32 feet, internal bracing will be needed to provide a more economical design than a cantilevered wall, and to limit excessive lateral movements near the top of the walls.

The adequacy and safety of the shoring installation should be made the sole responsibility of the contractor. A qualified geotechnical engineer/shoring designer should be retained by the contractor to design and evaluate the shoring system used. The excavation support and shoring system used must comply with all applicable safety requirements.

During construction, the ground adjacent to excavations should be monitored for cracks or dips and other indications of movements and possible sloughing of the excavation walls. Such monitoring is particularly critical in areas adjacent to existing structures and utilities.

5.1.5 Dewatering For Wet Well Excavation

Groundwater was first encountered at approximately 24 feet below grade (approx. Elevation 13 feet) in PG-2 at the time of drilling on October 26, 2017. Because the site soils are very dense and have relatively high fines content, the flow rate is anticipated to be quite low, and maybe adequately addressed with sumps and pumps at the bottom of the excavation.

The design of the dewatering system should be determined by the contractor, and may be determined during construction based on field observations at the time of construction. The need for dewatering can be reduced with the use of a drilled shaft or caisson instead of a soldier pile wall, because they provide better groundwater cutoff. In general, the groundwater level should be lowered to about 2 feet below the bottom of the excavation.

The rate of groundwater discharge will largely depend on the groundwater level at the time of excavation, the depth of excavation, the size of the excavation, the actual soil conditions (sand vs. silt), the dewatering systems installed by the contractor, and the sequencing of the excavation. The selection of equipment and methods of dewatering should be left up to the contractor provided they are in accordance with the recommendations in this report and the project specifications. The contractor should be aware that modifications to the dewatering system may be required during construction depending on the conditions encountered. The dewatering method selected should have minimal impact on the groundwater level surrounding the proposed excavation.

Grain size analyses were conducted on the water bearing glacial till soil samples. The results of the analyses are contained in Appendix B. The contractor may use the information from the boring logs and the laboratory test results to develop a dewatering program for this project.

5.1.6 Wet Well Backfill

Based on field observations and laboratory testing, the glacial till deposits have a fines content in the range of 30 to 83 percent and are considered moisture sensitive. Due to the high fines content,

we do not anticipate the excavated soils could be properly compacted as backfill in their present condition as the onsite soil will likely become difficult or impossible to adequately compact if it becomes too wet. If import material is needed for backfill, we recommend that wall backfill consist of granular soils such as Gravel Borrow (WSDOT 9.03.14(1)).

Structural fill should be moisture conditioned to within about 3 percent of optimum moisture content, placed in loose, horizontal lifts less than 8 inches in thickness, and systematically compacted to a dense and relatively unyielding condition and to at least 95 percent of the maximum dry density, as determined using test method ASTM D 1557.

5.2 Pilot Tube Microtunneling

We understand that the City is evaluating the feasibility of using pilot tube microtunneling (PTMT) to install a portion of the sewer line. PTMT is a trenchless method that generally performs well in softer soils that are considered displaceable, typically with a maximum SPT N-values of less than 50 bpf, and less than about 15 feet of hydrostatic head.

Based on the results of our test borings, as depicted on Figure 3, the SPT N-values within the pipe zone consistently exceed 50 bpf. In addition, during drilling, the soil matrix along the project alignment also contains gravelly and cobbly zones. As a result, it is our opinion that PTMT is not appropriate for this project as the soils are too dense for this method.

5.3 Directional Drilling

In our opinion, horizontal directional drilling (HDD) techniques represent a feasible method to install the proposed sewer line. Based on our test borings and understanding of the subsurface conditions along the Wood Avenue Southwest portion of the project alignment, we anticipate that very dense silty sand with gravel and cobbles (glacial till) will be the primary soil unit encountered during the sewer line installation process. Boulders, although not encountered in the test borings, may also be present. Furthermore, the new sewer line will be installed below the groundwater table. To assist the directional drilling contractor in the selection of installation equipment for this project, photos of the soil samples from the proposed sewer alignment are included in Appendix C.

A consideration for HDD is the hydrofracturing of mud slurry when excessive pressure is applied, allowing mud slurry to surface through granular soils, fractures in fine-grained soils, or through man-made conduits. During active drilling and reaming, visual inspections of surface area along the pipe crossing alignment should be made several times a day to identify signs of

hydrofracturing. Changes to drilling and flushing technique may be modified to reduce the potential of hydrofracturing.

5.4 Excavation Support and Shoring

We anticipate that excavations for the bore pits will generally be less than about 20 feet deep. We anticipate the bore pit excavations to generally encounter medium dense weathered glacial till and very dense glacial till consisting of silty sand and sandy silt with various amounts of gravel.

It is the contractor's responsibility to maintain safe working conditions, including temporary excavation stability. All excavations in excess of 4 feet in depth should be sloped in accordance with Washington Administrative Code (WAC) 296-155, or be shored. For planning purposes, it is our opinion that temporary excavations in weathered glacial till may be sloped as steep as 1H:1V and temporary excavations in very dense unweathered glacial till may be sloped as steep as ½H:1V. However, if groundwater is encountered in site excavations, flatter side slopes or temporary shoring may be necessary. The inclination of temporary slopes should be evaluated in the field during construction based on actual observed soil conditions.

Alternatively, because space will not likely be available for open cuts, excavation shoring should be used to support the bore pit excavations. Trench boxes and/or steel plates with hydraulic braces are considered feasible for the proposed bore pits. The excavation and shoring scheme must be property selected and installed to protect existing nearby utilities.

As a minimum, we recommend that all shoring systems be designed to withstand a lateral earth pressure, expressed in equivalent fluid pressure, of 35 pounds per cubic foot (pcf). An appropriate safety factor should be included by the contractor's shoring designer. Lateral loads due to construction equipment traffic or sloping ground conditions adjacent to the excavations should also be added to the recommended earth pressures for design purposes.

The adequacy and safety of the shoring installation should be made the sole responsibility of the contractor. A qualified geotechnical engineer/shoring designer should be retained by the contractor to design and evaluate the shoring system used. The excavation support and shoring system used must comply with all applicable safety requirements.

5.5 Settlement Monitoring

Surficial settlement could occur during and/or after the casing installation due to excessive removal of soil. As a result, baseline monitoring points should be established in the vicinity of the directional drilling alignment prior to any construction activities. As a general guideline, the

monitoring points should be spaced on an approximately 20 foot by 20 foot grid and the points should extend about 40 feet perpendicular to both sides of the casing alignment. The elevations of the monitoring points should be checked regularly with an optical survey during casing installation.

The volume of soil removal should be continuously monitored during installation. The actual volume of the removed soils should be estimated and compared to its theoretical volume as an indication of excessive soil removal and ground loss. If appreciable loss of soil occurs during the casing installation, the voids shall be grouted promptly.

6.0 LIMITATIONS

We have prepared this report for Gray and Osborne and the project design team. Recommendations contained in this report are based on a site reconnaissance, a subsurface exploration program, review of pertinent subsurface information, and our understanding of the project. The study was performed using a mutually agreed-upon scope of work.

Variations in soil conditions may exist between the locations of the explorations and the actual conditions underlying the site. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at the site that are different from those described in this report, we should be notified immediately to review the applicability of our recommendations. Additionally, we should also be notified to review the applicability of our recommendations if there are any changes in the project scope.

The scope of our work does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design. Additionally, the scope of our work specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances.

This report has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its

issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

It is the client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk. Any party other than the client who wishes to use this report shall notify PanGEO of such intended use and for permission to copy this report. Based on the intended use of the report, PanGEO may require that additional work be performed and that an updated report be reissued. Noncompliance with any of these requirements will release PanGEO from any liability resulting from the use this report.

We appreciate the opportunity to be of service.

Sincerely,

Steven T. Swenson, L.G.
Project Geologist

Siew L. Tan, P.E.
Principal Geotechnical Engineer

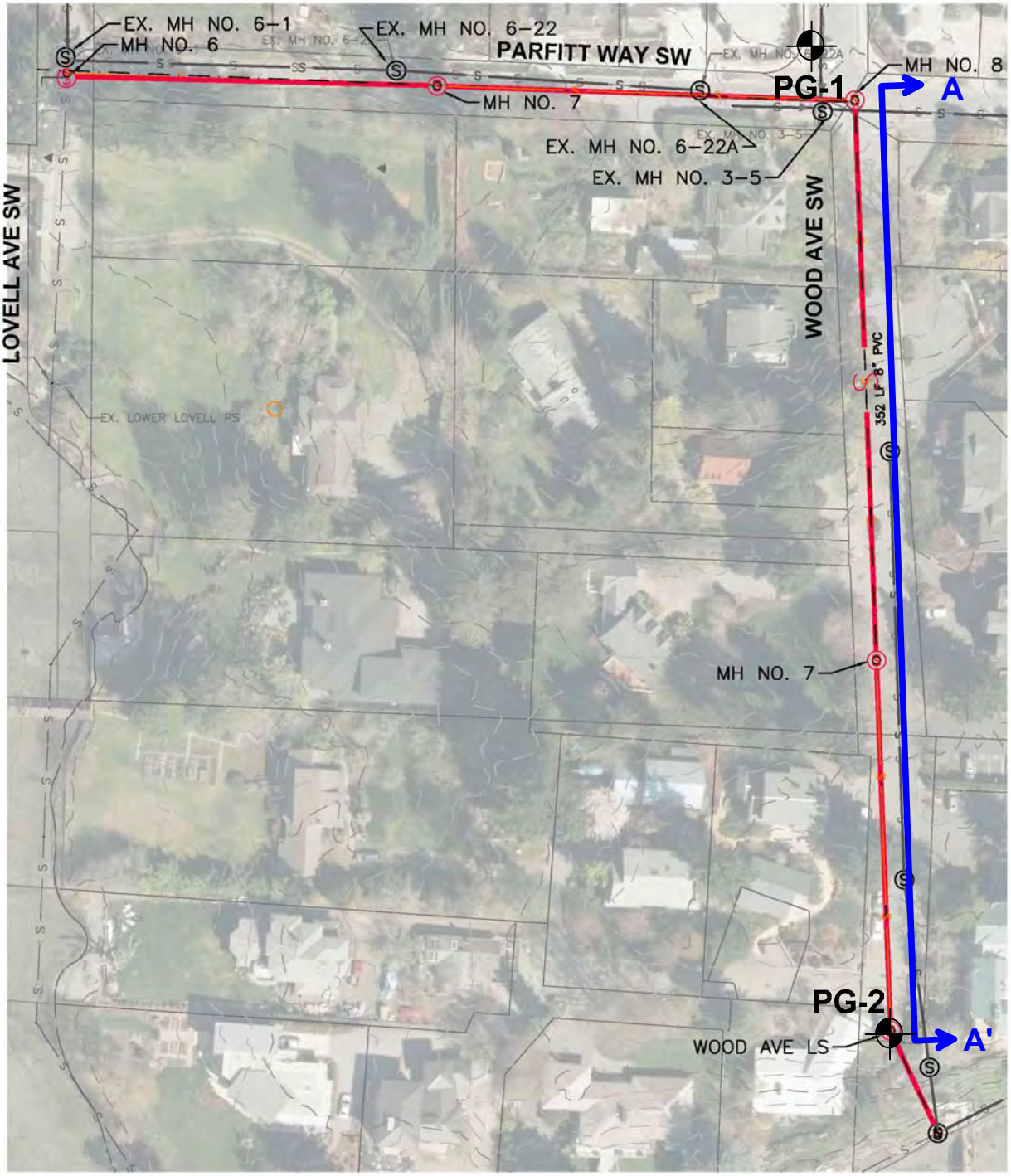
7.0 LIST OF REFERENCES

Haugerud, R. A., 2005, Preliminary geologic map of Bainbridge Island [part of Bremerton East, Duwamish Head, Shilshole Bay, Suquamish 7½′ quadrangles], Washington: U.S. Geological Survey Open-File Report 2005-1387, version 1.0, 1 sheet, scale 1:24,000.

Not to Scale

Image Source: Google Maps

PanGEO INCORPORATED	**West Eagle Harbor Sewer Replacment Project Predesign Subsurface Data Wood Ave SW Lift Station Bainbridge Island, Washington**	**VICINITY MAP**	
		Project No. **17-195**	Figure No. **1**



Approx. Scale
1" = 100'

Legend:

Approx. Borehole Location

Location of Subsurface Profile (see Figure 3)

Note: Base map modified from Figure 11 of Gray & Osborne Predesign Report.

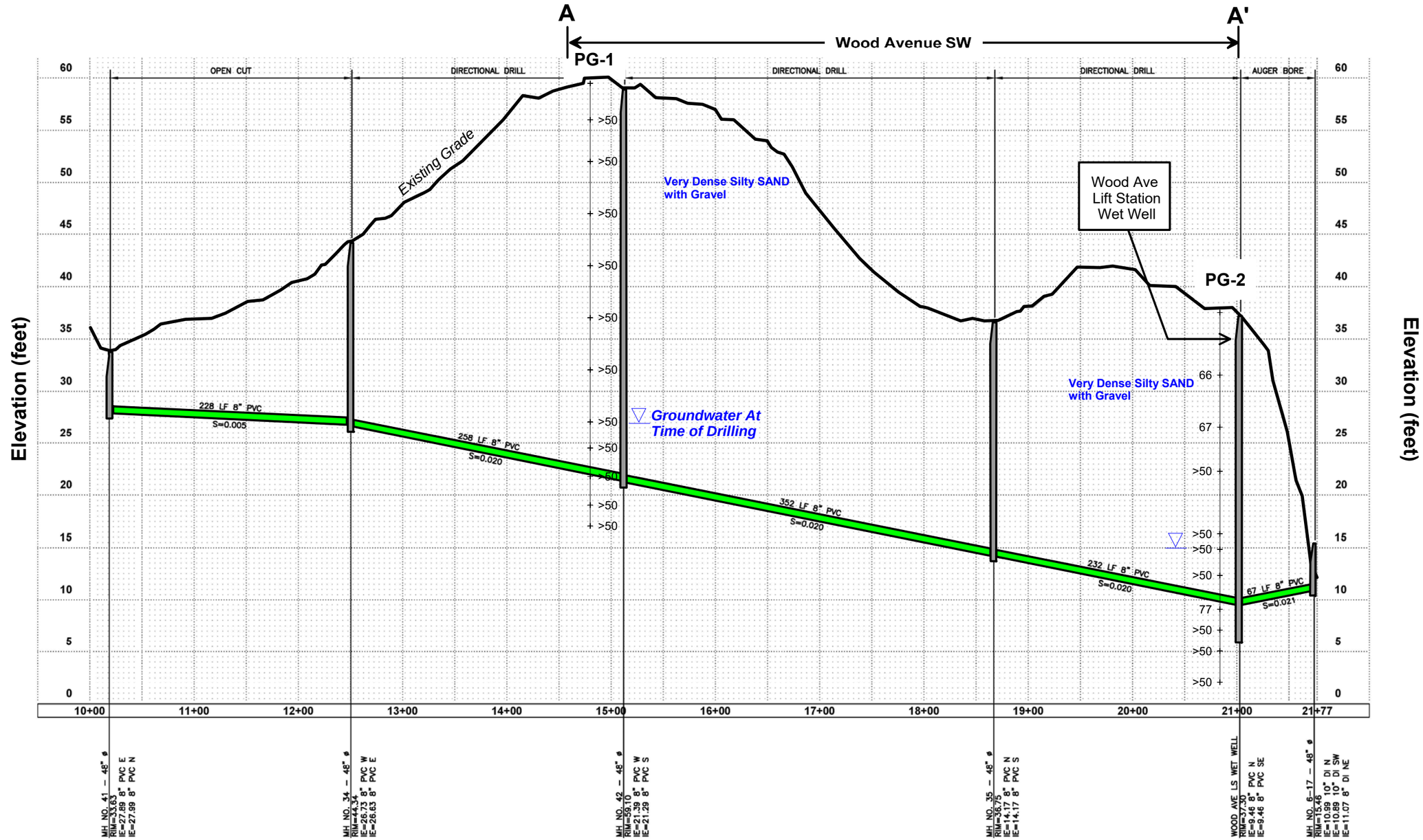
PanGEO INCORPORATED

West Eagle Harbor
Sewer Replacment Project
Predesign Subsurface Data
Wood Ave SW Lift Station
Bainbridge Island, Washington

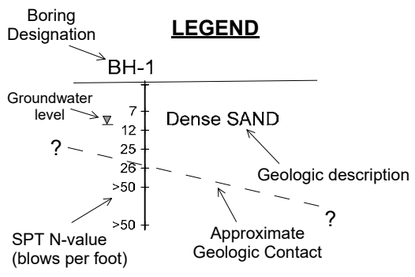
SITE AND EXPLORATION PLAN
(Wood Avenue SW)

Project No.	Figure No.
17-195	2

17-195 Fig 2 Site Plan.grf 11/8/17 (13:10) STS



LEGEND



0 25 50 75 100
Horizontal Scale (Feet)

Note: Preliminary profile provided by Gray & Osborne.

PanGEO INCORPORATED

West Eagle Harbor Sewer Replacment Project Predesign Subsurface Data Wood Ave SW Lift Station Bainbridge Island, Washington

GENERALIZED SUBSURFACE PROFILE A-A'

Project No. **17-195**

Figure No. **3**

17-195 Fig 3 Subsurface Profile.grf 11/8/17 (13:37) STS

APPENDIX A

SUMMARY BORING LOGS

APPENDIX A

RELATIVE DENSITY / CONSISTENCY

SAND / GRAVEL			SILT / CLAY		
Density	SPT N-values	Approx. Relative Density (%)	Consistency	SPT N-values	Approx. Undrained Shear Strength (psf)
Very Loose	<4	<15	Very Soft	<2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Med. Dense	10 to 30	35 - 65	Med. Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	>50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	>30	>4000

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS		GROUP DESCRIPTIONS	
Gravel 50% or more of the coarse fraction retained on the #4 sieve. Use dual symbols (eg. GP-GM) for 5% to 12% fines.	GRAVEL (<5% fines)	GW	Well-graded GRAVEL
		GP	Poorly-graded GRAVEL
	GRAVEL (>12% fines)	GM	Silty GRAVEL
		GC	Clayey GRAVEL
Sand 50% or more of the coarse fraction passing the #4 sieve. Use dual symbols (eg. SP-SM) for 5% to 12% fines.	SAND (<5% fines)	SW	Well-graded SAND
		SP	Poorly-graded SAND
	SAND (>12% fines)	SM	Silty SAND
		SC	Clayey SAND
Silt and Clay 50%or more passing #200 sieve	Liquid Limit < 50	ML	SILT
		CL	Lean CLAY
		OL	Organic SILT or CLAY
	Liquid Limit > 50	MH	Elastic SILT
		CH	Fat CLAY
		OH	Organic SILT or CLAY
Highly Organic Soils		PT	PEAT

Notes: 1. Soil exploration logs contain material descriptions based on visual observation and field tests using a system modified from the Uniform Soil Classification System (USCS). Where necessary laboratory tests have been conducted (as noted in the "Other Tests" column), unit descriptions may include a classification. Please refer to the discussions in the report text for a more complete description of the subsurface conditions.

2. The graphic symbols given above are not inclusive of all symbols that may appear on the borehole logs. Other symbols may be used where field observations indicated mixed soil constituents or dual constituent materials.

DESCRIPTIONS OF SOIL STRUCTURES

Layered:	Units of material distinguished by color and/or composition from material units above and below	Fissured:	Breaks along defined planes
Laminated:	Layers of soil typically 0.05 to 1mm thick, max. 1 cm	Slickensided:	Fracture planes that are polished or glossy
Lens:	Layer of soil that pinches out laterally	Blocky:	Angular soil lumps that resist breakdown
Interlayered:	Alternating layers of differing soil material	Disrupted:	Soil that is broken and mixed
Pocket:	Erratic, discontinuous deposit of limited extent	Scattered:	Less than one per foot
Homogeneous:	Soil with uniform color and composition throughout	Numerous:	More than one per foot
		BCN:	Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

COMPONENT	SIZE / SIEVE RANGE	COMPONENT	SIZE / SIEVE RANGE
Boulder:	> 12 inches	Sand	
Cobbles:	3 to 12 inches	Coarse Sand:	#4 to #10 sieve (4.5 to 2.0 mm)
Gravel		Medium Sand:	#10 to #40 sieve (2.0 to 0.42 mm)
Coarse Gravel:	3 to 3/4 inches	Fine Sand:	#40 to #200 sieve (0.42 to 0.074 mm)
Fine Gravel:	3/4 inches to #4 sieve	Silt	0.074 to 0.002 mm
		Clay	<0.002 mm

TEST SYMBOLS

for In Situ and Laboratory Tests listed in "Other Tests" column.

ATT	Atterberg Limit Test
Comp	Compaction Tests
Con	Consolidation
DD	Dry Density
DS	Direct Shear
%F	Fines Content
GS	Grain Size
Perm	Permeability
PP	Pocket Penetrometer
R	R-value
SG	Specific Gravity
TV	Torvane
TXC	Triaxial Compression
UCC	Unconfined Compression

SYMBOLS

Sample/In Situ test types and intervals

- 2-inch OD Split Spoon, SPT (140-lb. hammer, 30" drop)
- 3.25-inch OD Spilt Spoon (300-lb hammer, 30" drop)
- Non-standard penetration test (see boring log for details)
- Thin wall (Shelby) tube
- Grab
- Rock core
- Vane Shear

MONITORING WELL

- Groundwater Level at time of drilling (ATD)
- Static Groundwater Level
- Cement / Concrete Seal
- Bentonite grout / seal
- Silica sand backfill
- Slotted tip
- Slough
- Bottom of Boring

MOISTURE CONTENT

Dry	Dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water

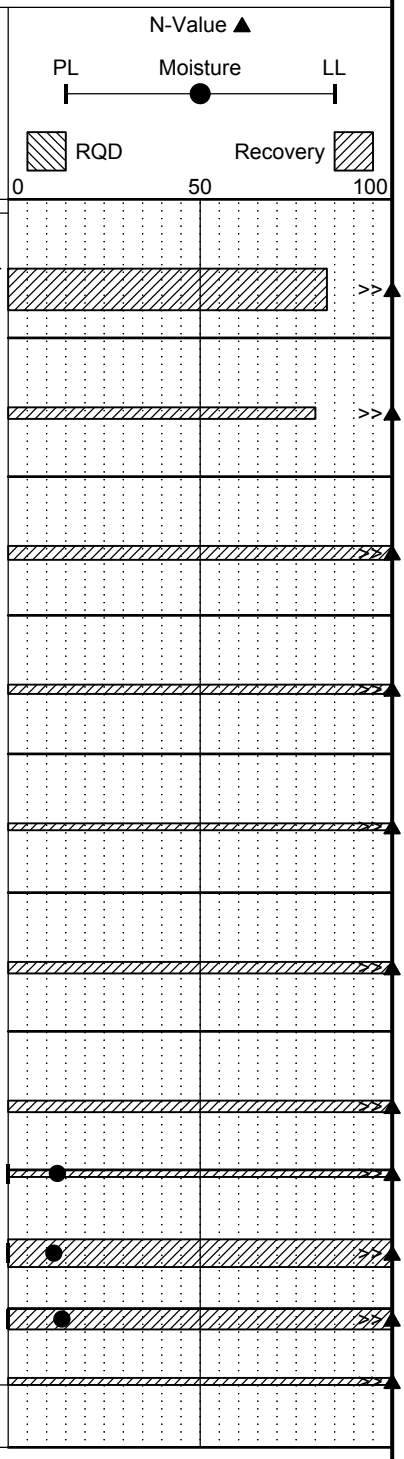
PanGEO INCORPORATED
Phone: 206.262.0370

Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	West Eagle Harbor Sewer Replacement	Surface Elevation:	60.0ft
Job Number:	17-195	Top of Casing Elev.:	N/A
Location:	Wood Ave SW, Bainbridge Island	Drilling Method:	HSA
Coordinates:	Northing: 47.62258, Easting: -122.52431	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
0	S-0				Mulch over loose, dark brown, slightly organic silty fine SAND (SM); moist; poorly graded [Topsoil].
	S-1		6 28 50/6		Medium dense, brown, silty fine to medium SAND with gravel (SM); moist; poorly graded, trace iron oxide staining [Weathered Till].
5					Very dense, olive-brown, silty fine to medium SAND with gravel (SM); moist; poorly graded, trace iron oxide staining [Qvt - Vashon Till].
	S-2		50/5		
10					
	S-3		50/6		
15					
	S-4		50/4		--angular/broken cobbles from 12.5' to 22.5'.
20					
	S-5		50/3		
25					
	S-6		50/5		--increasing moisture.
30					
	S-7		50/5		
35	S-8		50/3	GS	--becomes wet at about 34'. --moisture content = 13%.
	S-9		37 50/6	GS	--moisture content = 12%. --silt lamination.
40	S-10		29 50/3	GS	--moisture content = 14%. --sandy SILT with gravel.
	S-11		50/3		
45					Boring terminated at about 42.75 feet below grade. Groundwater was encountered at about 34 feet below grade during drilling.



Completion Depth:	42.8ft
Date Borehole Started:	10/26/17
Date Borehole Completed:	10/26/17
Logged By:	B. Weitering
Drilling Company:	Boretec

Remarks: Drilling was performed using an RCT 60 Track Drill. Standard Penetration Test (SPT) sampler driven with a 140 lb hammer using a rope and cathead dropping 30 inches per stroke.

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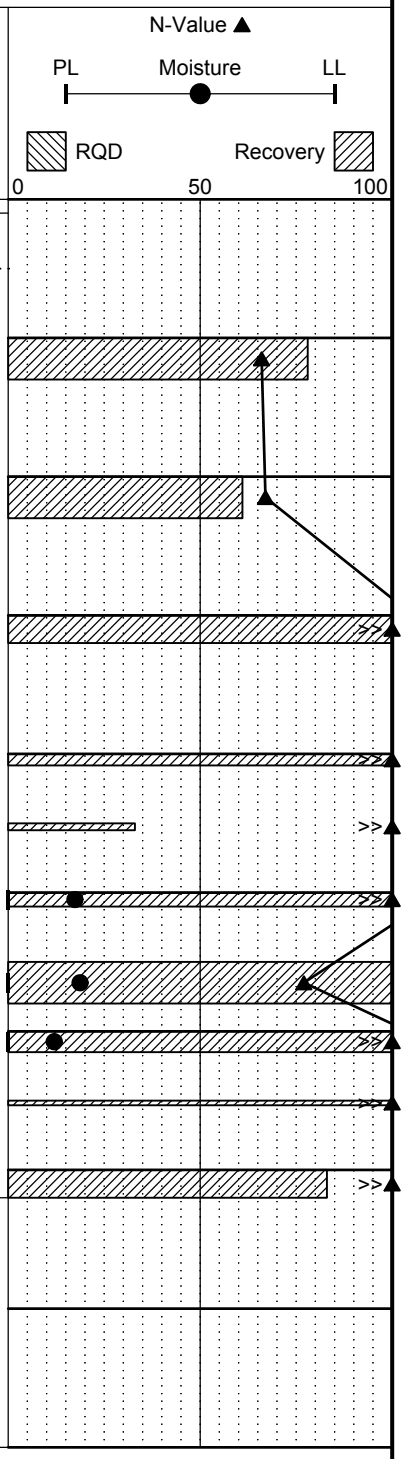
LOG OF TEST BORING PG-1

Figure A-2

The stratification lines represent approximate boundaries. The transition may be gradual.

Project:	West Eagle Harbor Sewer Replacement	Surface Elevation:	37.0ft
Job Number:	17-195	Top of Casing Elev.:	N/A
Location:	Wood Ave SW, Bainbridge Island	Drilling Method:	HSA
Coordinates:	Northing: 47.6209, Easting: -122.52407	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	MATERIAL DESCRIPTION
0					6" gravel (parking area).
					Medium dense, brown, silty fine to medium SAND with gravel (SM); moist; poorly graded, trace iron oxide staining [Weathered Till].
					Very dense, olive-brown, silty fine to medium SAND with gravel (SM); moist; poorly graded, trace iron oxide staining [Qvt - Vashon Till].
5	S-1		16 16 50		
10	S-2		25 36 31		--angular/broken cobbles.
15	S-3		28 50/6		
20	S-4		50/5		
	S-5		50/3		--poor recovery (tip only).
25	S-6		50/6	GS	--becomes wet at about 24 feet. --moisture content = 17%.
	S-7		19 35 42	GS	--sandy SILT trace gravel. --moisture content = 19%.
30	S-8		31 50/3	GS	--moisture content = 12%.
	S-9		50/2		
35	S-10		22 50/6		
					--1" silt interlayer.
					Boring terminated at about 36 feet below grade. Groundwater was encountered at about 24 feet below grade during drilling.
40					
45					



Completion Depth:	36.0ft
Date Borehole Started:	10/26/17
Date Borehole Completed:	10/26/17
Logged By:	B. Weitering
Drilling Company:	Boretec

Remarks: Drilling was performed using an RCT 60 Track Drill. Standard Penetration Test (SPT) sampler driven with a 140 lb hammer using a rope and cathead dropping 30 inches per stroke.

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LOG OF TEST BORING PG-2

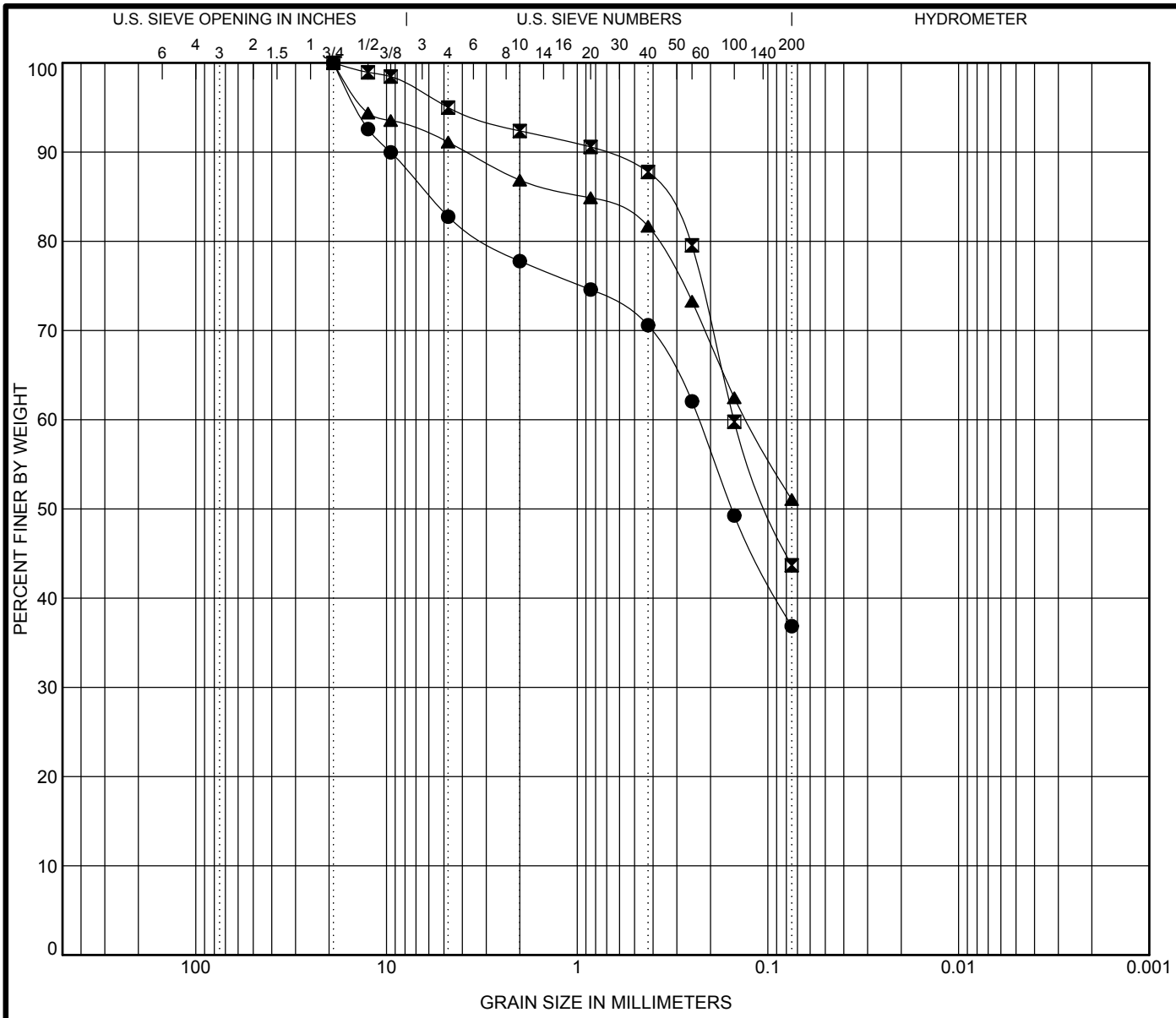
Figure A-3

The stratification lines represent approximate boundaries. The transition may be gradual.

APPENDIX B

LABORATORY TEST RESULTS

APPENDIX B



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	PG-1	@ 35.0 ft.	Olive-brown silty SAND with gravel (SM)	NP	NP	NP		
⊠	PG-1	@ 37.5 ft.	Olive-brown silty SAND (SM)	NP	NP	NP		
▲	PG-1	@ 40.0 ft.	Olive-brown, sandy SILT (ML)	NP	NP	NP		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	PG-1	35.0	19	0.23			17.2	45.9	36.9	
⊠	PG-1	37.5	19	0.151			5.0	51.3	43.7	
▲	PG-1	40.0	19	0.129			8.9	40.1	51.1	

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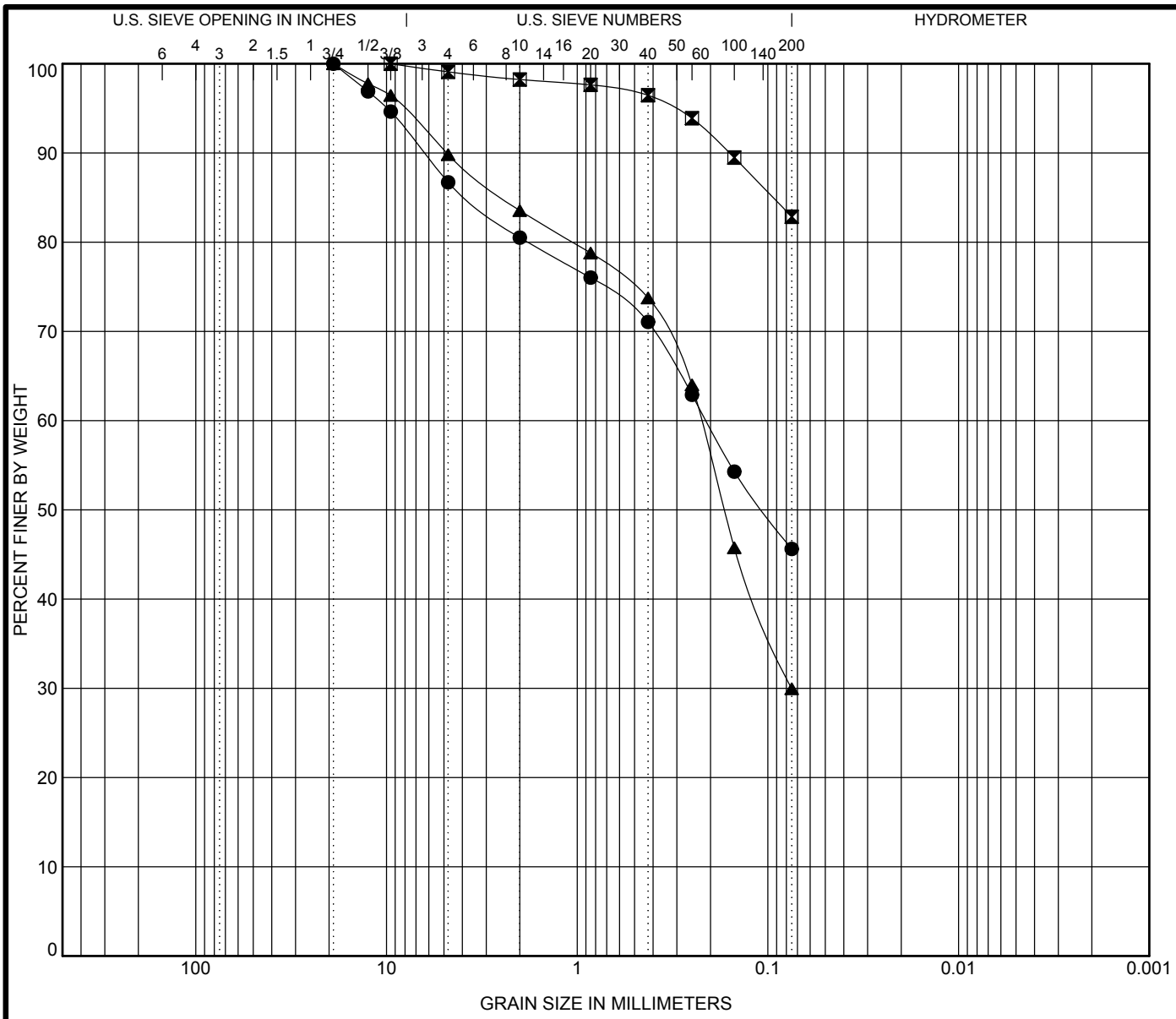
GRAIN SIZE DISTRIBUTION

Project: West Eagle Harbor Sewer Replacement
Job Number: 17-195
Location: Wood Ave SW, Bainbridge Island

Figure B-1

APPENDIX B



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	PG-2	@ 25.0 ft.	Olive-brown silty SAND	NP	NP	NP		
⊠	PG-2	@ 27.5 ft.	Olive-brown SILT with sand	NP	NP	NP		
▲	PG-2	@ 30.0 ft.	Olive-brown silty SAND	NP	NP	NP		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	PG-2	25.0	19	0.211			13.3	41.1	45.6	
⊠	PG-2	27.5	9.5				0.9	16.2	82.9	
▲	PG-2	30.0	19	0.224	0.075		10.2	59.9	29.9	

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GRAIN SIZE DISTRIBUTION

Project: West Eagle Harbor Sewer Replacement
Job Number: 17-195
Location: Wood Ave SW, Bainbridge Island

Figure B-2

APPENDIX C

PHOTOS OF SELECT SOIL SAMPLES

Photos of Select Soil Samples
West Eagle Harbor Sewer Replacement Project,
Wood Avenue SW Lift Station,
Bainbridge Island, WA

PG-1; S-6: 27.5'

PG-1; S-7: 32.5'

Figure C-1

Photos of Select Soil Samples
West Eagle Harbor Sewer Replacement Project,
Wood Avenue SW Lift Station,
Bainbridge Island, WA

PG-1; S-8: 35’

PG-1; S-9: 37.5’

Figure C-2

Photos of Select Soil Samples
West Eagle Harbor Sewer Replacement Project,
Wood Avenue SW Lift Station,
Bainbridge Island, WA

PG-1; S-10: 40'

PG-1; S-11: 42.5'

Figure C-3

Photos of Select Soil Samples
West Eagle Harbor Sewer Replacement Project,
Wood Avenue SW Lift Station,
Bainbridge Island, WA

PG-2; S-4: 20’

PG-2; S-5: 22.5’

Figure C-4

Photos of Select Soil Samples
West Eagle Harbor Sewer Replacement Project,
Wood Avenue SW Lift Station,
Bainbridge Island, WA

PG-2; S-6: 25’

PG-2; S-7: 27.5’

Figure C-5

Photos of Select Soil Samples
West Eagle Harbor Sewer Replacement Project,
Wood Avenue SW Lift Station,
Bainbridge Island, WA

PG-2; S-8: 30’

PG-2; S-9: 32.5’

Figure C-6

Photos of Select Soil Samples
West Eagle Harbor Sewer Replacement Project,
Wood Avenue SW Lift Station,
Bainbridge Island, WA

PG-2; S-10: 35’

Figure C-7