Feasibility Study Report: North Creek Culvert Replacement Project, Harborview Drive

Prepared for

GIG HARBOR
"THE MARITIME CITY"

January 2023

Prepared by
Parametrix

Feasibility Study Report: North Creek Culvert Replacement Project, Harborview Drive

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ACRONYMS AND ABBREVIATIONS

AASHTO	American Society of State Highway and Transportation Officials
AOP	Aquatic Organisms Program
ASCE	American Society of Engineers
BDM	Bridge Design Manual
BFW	Bank full width
cfs	Cubic feet per second
City	City of Gig Harbor
COVID-19	Coronavirus disease
dbh	Diameter at breast height
DEM	Digital Elevation Model
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIS	Flood Insurance Study
Ft	Feet
FUR	Floodplain utilization ratio
gpm	Gallons per minute
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center – River Analysis System
ID	Identification
LRFD	Load & Resistance Factor Design
LWM	Large woody material
MHHW	Mean higher high water
MHW	Mean high water
MLLW	Mean lower low water
MLW	Mean low water
mm	millimeter
MSL	Mean sea level
MTL	mean tide level
NAVD 88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NGVD 29	National Geodetic Vertical Datum of 1929

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RSI	Remote site incubator
SPT	Standard penetration test
STA	Station
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WCDG	WDFW's Water Crossing Design Guidelines
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington Department of Transportation
WWHM	Western Washington Hydrology Manual
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

This report describes the work completed to review the feasibility of replacing the North Creek culvert at Harborview Drive with a structure that will eliminate the fish barrier. Figure 1-1 presents the project area and vicinity. The culvert was constructed in before 1970 and over the operational life, the structure became a significant barrier to migrating salmon. The Washington Department of Fish and Wildlife (WDFW) maintains an inventory of fish barriers throughout the state. This crossing is cataloged as WDFW Site ID 105 K053021a and in 2013 was reported to be a 67% barrier due to a water surface drop (WDFW. 2013). It should be noted that North Creek is anecdotally referred to as Donkey Creek, and the site is adjacent to Donkey Creek Park. In 2013, the City of Gig Harbor (City) completed the first barrier removal project on North Creek, replacing the culvert in North Harborview Drive with a bridge. This project reconnected the tidal estuary and allowed free access for anadromous fish to the downstream point of the Harborview Drive crossing that is discussed herein.

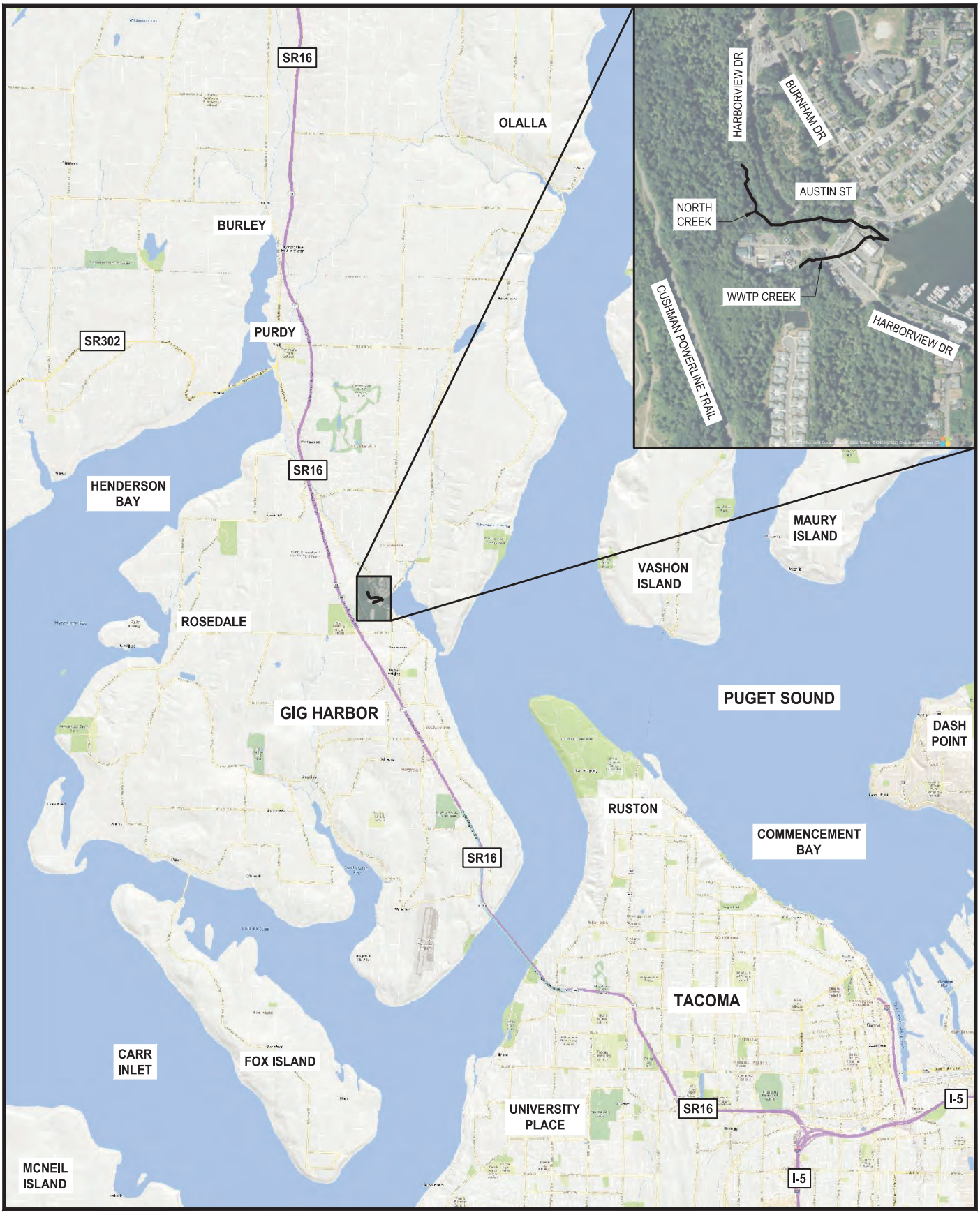

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Figure 1-1.
Area and Vicinity Map
North Creek Culvert Feasibility Study

The Harborview Drive culvert is a concrete box culvert measuring 6-ft wide by 6-ft tall by 146-ft long with a slope of 1.62%. The outlet of the existing culvert is modified with a flow control valve and removable flashboards to allow for operation of a water delivery flume that serves a remote site incubator (RSI) located approximately 220 feet downstream of the culvert outlet.

Photo 1. North Creek culvert at Harborview Drive, culvert outlet and water diversion for RSI

The culvert is located along the apparent natural flow path of North Creek. Above the culvert and supporting Harborview Drive is a soil prism of road fill. Trapezoidal in shape the road fill is approximately 40 feet wide across the top, 150 feet wide at the bottom, and extends approximately 400 feet along the road alignment to connect the natural grades of the valley with the road surface. The road fill slopes are covered in understory vegetation and mature trees that range in size from 6-in to 40-in diameter at breast height (dbh). The road fill covers the culvert with approximately 22 feet of soil at the centerline of the culvert.

To improve fish passage at this location, a new crossing is proposed to safely convey the 100-year flood and provide suitable velocity and depth over a range of flows to allow use and passage by juvenile and adult salmonids. In doing so, the crossing will provide additional benefit as a wildlife corridor and can be designed to include a pedestrian undercrossing to connect Donkey Creek Park as was done at the North Harborview Drive bridge.

This project location is the second of three known City owned fish barriers along the mainstem of North Creek. Downstream to upstream; The first was the culvert at North Harborview Drive that was replaced with a bridge and corrected the passage barrier in 2013; the second being the culvert at Harborview Drive and the focus of this project; the third is a culvert at 96th Street which is currently in the design and permitting phase. The three projects together will reconnect the historic salmonid spawning and rearing range in main channel of North Creek.

As part of the project, the intersection to the north at Harborview Drive and Austin Street will be reviewed for future inclusion of a roundabout to replace the 3-way stop intersection that is a known traffic congestion area. Traffic considerations as well as utility coordination that includes sewer, electrical, water supply, and communication will be addressed under separate design analysis, and are not discussed in detail herein.

1.1 Project Area History

The City of Gig Harbor is built upon the homelands and villages of Indigenous Peoples of the region better known as a band of the Puyallup Tribe of Indians called sx̌^{w}əbabš (translated: “swift water people”). The land surrounding the estuary of North Creek was the location of a long house of the sx̌ ^{w}əbabš band and the area was of vital importance to the sx̌^{w}əbabš band for salmon fishing, clam and oyster cultivation, and canoe carving. On February 22, 2021, the City resolved that the 7+ acre area surrounding the estuary of North Creek will be designated as the tx^{w}aalqəł Estuary (City. 2021). Appendix A includes the resolution. The area called Donkey Creek Park is included within the tx^{w}aalqəł estuary, and most recently was converted from a lumber yard to the open space that is the park.

As part of this feasibility study, a desktop cultural resource review was completed by others to determine the potential to disturb or unearth sensitive cultural resources during the construction process required to replace the culvert. The project area is located adjacent to the tx^{w}aalqəł Estuary and is likely to contain resources that need to be avoided or protected. A detailed cultural resource investigation will be completed as the design progresses, under the guidance of the consultation process, and as the more detailed construction requirements and excavation limits are known.

The primary activity for any culvert replacement will involve the handling and removal of fill material that was placed at the time of the original culvert and road construction. While it is expected to be previously disturbed fill material, the location from where it was borrowed and its contents are not known.

The Puyallup Tribe of Indians (Tribe) is actively engaged in the preservation and restoration of the area and has purchased 11.5 acres in partnership with the City. The Tribe will remain directly involved in the design and permit review.

1.2 Remote Site Incubator (RSI)

The Gig Harbor Commercial Fisherman Civic Club (Club) operates and maintains the RSI located in North Creek. It is partially visible from an observation platform in Donkey Creek Park. The RSI was constructed in 1971 and has operated annually between the months November and April, coinciding with the migration patterns of chum salmon in Gig Harbor. There have been brief interruptions in operations when egg supplies provided by the WDFW Minter Creek hatchery were limited, and most recently by COVID-19 public health safety precautions. In a typical operating cycle, the downstream end of the culvert is fitted with flashboards, and water flows by gravity through a wooden flume, from the culvert to a sediment settling pond located in the river left floodplain of North Creek. After a settling period, clarified water flows from the sediment settling pond outlet to 13 plastic barrels (Photo 2) that hold the

eggs, maintaining a constant flow of cold clean water in each barrel. Flow rate is approximately 10 gallons per minute (gpm) per barrel, a total flow rate of 112 gpm (0.25 cubic feet per second (cfs)).

Photo 2. RSI Barrels in operation, January 16, 2023.

The flow control valve, flashboard, flume, sediment settling pond, and RSI barrels are operated and maintained by the Club who hold an active surface water right certificate number S2-00667 C, Water Resource Doc ID 2209482. This certificate dated November 29, 1971, allows for 0.25 cfs of North Creek flows to be diverted for the purposes of fish propagation (Ecology, 2022). The water rights documentation is included in Appendix B.

The flow control valve was originally installed as a mechanism to promote maintenance sediment flushing for sands and gravels that become trapped behind the flashboards. It is currently non-operable and contributing to the height of the water surface drop at the culvert outlet. Removal of this flow control valve would likely improve current fish passage of the culvert.

2. STAKEHOLDER ENGAGEMENT

At the outset of the process to develop the feasibility study, Parametrix and the City completed outreach to the organizations and individuals listed in Table 2-1.

Table 2-1. Stakeholder Engagement Participants

Organization	Contact
City of Gig Harbor, floodplain administrator	Paul Rice
City of Gig Harbor, planning	Carl de Simas
City of Gig Harbor, public works	Jeff Olsen
City of Gig Harbor, public works	Jeff Langhelm
Gig Harbor Commercial Fisherman Civic Club	Tom Lovrovich
Harbor Wildwatch	Rachel Easton
Nisqually Tribe	Brad Beach
Peninsula Light Company	Michael Prentice
Puyallup Tribe	Jennifer Keating
Puyallup Tribe	SEPA Review team
Puyallup Tribe	Russ Ladley
Puyallup Tribe	Corey Corrick
Puyallup Tribe	Char Naylor
Puyallup Tribe	Angela Dillon
Puyallup Tribe	Andrew Strobel
Puyallup Tribe	Brandon Reynon
WDFW	Chris Waldbillig
WDFW	Darrin Masters
WDFW	Miles Penk
Wildfish Conservancy	Jamie Glasgow

Early outreach was completed via phone, on-site, and through virtual meetings. These discussions focused on the potential to replace the culvert with a new crossing, and feedback was collected for use in the development of alternatives that were informed by stakeholder input.

On November 8, 2022, Parametrix and the City hosted and in-person and virtual workshop to review two alternatives and their associated elements. Appendix C includes the list of meeting attendees. The purpose of the meeting was to again collect feedback from the collective group on the potential for alternatives and their elements. The major alternatives presented were the replacement of the culvert with either a 3-sided concrete structure or a bridge. Both options create the potential to restore a natural bottom that can accommodate the required width for stream design of fish barrier removal projects.

Other major topics of discussion were the potential to connect the unnamed tributary near the wastewater treatment plant (WWTP) “WWTP Creek” directly to North Creek, the future option for the remote site incubator (RSI), incorporation of salvage trees for large woody material (LWM) in the

restored stream, the future connections to the pedestrian trail, and potential use of the Donkey Creek Park open space area as a removed road fill material re-use area.

The feedback collected to guide further development and review of alternatives were the following:

1. All participants expressed their desire and commitment to remain involved in the design review process.
2. Respect the cultural significance of the project area, the potential to disturb resources, and the potential to preserve, bury, and protect potential resources in Donkey Creek Park and the tx^{w}aalqəɬ Estuary.
3. The ongoing operation of the RSI remained a split discussion amongst the stakeholders, with the following opinions expressed:
    a. Maintain the RSI in a new location as an educational opportunity, identifying a long-term project partner to continue the water right and seasonal O&M requirement (November – April).
    b. Discontinue the RSI and defer incubation of salmon eggs at the WDFW Minter Hatchery
4. Review the potential to connect "WWTP Creek" to the project area, needing additional information about potential channel geometry and utility conflicts.

The November 8 meeting adjourned, updating the participating stakeholders that the next steps included:

- Parametrix incorporating feedback into the current alternative development for use and review in a City Council Study Session on November 17, 2022.
- Final development of a recommended alternative to inform a Federal Highway Administration (FHWA) Aquatic Organism Program (AOP) culvert removal grant application due February 6, 2023.
- Concept through final project design and permitting in 2023-24.
- Target construction in 2024-26.
- Stakeholder participation will continue through the design and permit process.

3. STREAM DESIGN

The stream design is the basis for understanding the requirements for a new structure capable of creating a crossing that can accommodate the hydrology of the stream and the geomorphic response of the channel and floodplain in the new condition. Since the purpose of this design is to replace the culvert with a structure that will not act as a fish barrier to anadromous salmonids and resident fish, the new crossing must be able to adapt to expected changes in the watershed over the life of the structure, and ideally in perpetuity. This section will provide the work completed to understand the hydrology at the crossing, the natural geomorphology of the area, and the estimated hydraulic performance of a reconstructed stream channel through a new crossing.

3.1 Hydrology

The Project is located within the North Creek Drainage Basin in the City of Gig Harbor. The Drainage Basin is delineated to be approximately 1,162 acres per the United States Geological Survey (USGS) StreamStats basin delineation tool. In general, this Drainage Basin flows from North to South. The upper reaches of the Drainage Basin have been heavily altered by commercial and residential development, and the undeveloped areas are primarily forest. The reported mean slope of the basin is 6.16% using a 30-meter Digital Elevation Model (DEM). The Creek outfalls into the Harbor at Gig Harbor at North Harborview Drive adjacent to the Harbor History Museum.

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Figure 3-1.
Watershed Map
North Creek Culvert Feasibility Study

Using the Western Washington Hydrology Model (WWHM) 2012, the peak 100-year flow rate is 226 cubic feet per second (cfs). This method was selected for use in the review and preliminary design of crossing alternatives. WWHM is the local standard and when compared to other published hydrology sources for the area the estimate is reasonable for purposes of this feasibility study. Table 3-1 shows three hydrology estimates, adding two other previously published studies for the area. It should be noted that the FEMA Flood Insurance Study (FIS)(FEMA. 2017)and HEC-HMS (Pierce County. 2005) data vary slightly in the contributing basin area that is attributed to how those studies considered point of concentration and the downstream most point in the watershed. However, the variability in hydrology methods and the differences in the contributing area are complimentary, estimating a unit runoff range of 0.11 to 0.19 cfs/acre.

Table 3-1. Review of Hydrologic Estimates

Hydrology Method	Point Of Concentration	Area (sq mi)	Area (acre)	100-year flow (cfs)	Projected 2080 100-year flow[c] (cfs)
WWHM 2012	Harborview Drive	1.82	1,162	226	335
FEMA FIS 2017[a]	Harborview Drive	1.6	1,024	116	172
HEC – HMS 2005[b]	DK-03, Harborview Drive	2.16	1,382	221	328

[a] Flood Insurance Study (FEMA. 2017)

[b] Gig Harbor Basin Plan Volume 2 (Pierce County. 2005)

[c] See Section 3.2 Climate Change

Appendix D includes the detailed hydrology review.

3.2 Climate Change

As standard practice when designing fish barrier removals, the potential for change in the hydrology and stream characters at the crossing is reviewed. To complete this review, WDFW provides a web based geographic tool that maps the estimated climate-based changes to stream hydrology within the project watershed. Climate change estimates are reported for changes expected to occur by year 2040 and year 2080. Given the expected lifespan for newly constructed culverts and bridges, the 2080 estimates are utilized. The basis for the climate change estimate tool was developed from work completed by WDFW in cooperation with the Climate Impacts Group at University of Washington (WDFW. 2017). The climate change estimate tool is a web-based application (WDFW. 2022) and the results for North Creek are presented in Table 3-2.

Table 3-2. Future Projections for Climate-Adapted Crossing Design – North Creek, City of Gig Harbor

	2040	2080	Range[a]
Projected mean percent change in bank full flow	14.6%	20.4%	Not reported
Projected mean percent change in bank full width	7.0%	9.7%	0% - 23%
Projected mean percent change in 100-year flood	41.8%	48.3%	2% - 99%

[a] Range generated from application of data from 10 separate climate models.

Standard design practices in the region recommend the inclusion of the 2080 mean percent change of the 100-year flood flow in the hydraulic review. Applying the expected increase in the 100-year flood, the 2080 100-year flow is 335 cfs. Appendix D includes the WDFW climate change report for the project site.

3.3 Tides

The downstream area of the project is influenced by tides. To make direct comparison to the project topography and tidal elevations the vertical datum must be reviewed to confirm all reported elevations are based on the same zero elevation reference. The design drawings from previous projects and the proposed culvert replacement are presented on the National Geodetic Vertical Datum of 1929 (NGVD 29). Tidal information and tidal bathymetry (e.g. underwater topography) are reported in heights measured from Mean Lower Low Water (MLLW). The vertical datum used for shoreward projects before North American Vertical Datum of 1988 (NAVD 88) was the National Geodetic Vertical Datum of 1929 (NGVD 29) and it persists in the local elevation benchmark system. Going forward it is important to verify the vertical datum in the tidal area, and as benchmark data transitions from NGVD 29 toward NAVD 88. Generally, published tide charts for boating and fishing are reported using the MLLW datum, and this conversion is handy when talking with members of the public. Table 3-3 presents the direct comparison of all 3 vertical datums and their reference information. NGVD 29 is highlighted with shading to indicate the current design datum for the project.

Table 3-3. Comparison of applicable vertical datums

Datum	NGVD 29	NAVD 88	MLLW[a]	Notes
Highest Observed	8.6	12.08	14.57	1/3/2003
MHHW	5.86	9.34	11.83	
MHW	4.97	8.45	10.94	
MTL	0.93	4.41	6.9	
MSL	0.9	4.38	6.87	
NGVD29	0	3.48	5.97	NGVD 29 Datum
MLW	-3.12	0.36	2.85	
NAVD88	-3.48	0	2.49	NAVD 88 Datum
MLLW	-5.97[b]	-2.49	0	MLLW Datum
Lowest Observed	-10.66	-7.18	-4.69	11/26/2007

[a] Tidal Benchmark: Station ID 9446484 Tacoma, Commencement Bay, Tidal Epoch 1982 – 2001, Published August 10, 2013.

[b] Previous topographic survey data reports NGVD 29 to MLLW = + 5.94 ft, a slight variation attributed to the distance between Gig Harbor and Tacoma.

For design purposes, details and topography refer to NGVD 29 datum and rely on the mean higher high water (MHHW) tide elevation of 5.86 feet to set the expected high tide that will influence the project area. Measured on this datum, typical mean high tides will range from 0.9 feet to 5.9 feet, occurring twice a day. King tide cycles generate tides at higher elevations seasonally and are influenced by the lunar cycle. Extreme tide events caused by stream flooding and storm surge in Puget Sound have been historically measured near 9.0 feet (NGVD 29) near the project area. Future extreme tides would be expected to rise based on sea level rise, changing climate patterns, and the potential to coincide with North Creek flood events.

3.4 Geomorphology

On July 22, 2022, Parametrix completed a stream assessment of the project area. The assessment targeted the observations and measurement of the stream geometry, floodplain, and stream substrate. The vegetation cover and presence of large woody material were also documented. Appendix E includes the site visit photos of the bank full width (BFW) and Wolman pebble count areas.

3.4.1 Harborview Drive to Gig Harbor (downstream)

Downstream of Harborview Drive, North Creek flows in a defined channel and floodplain adjacent to Donkey Creek Park. This reach of North Creek is a transitional zone that is influenced by the tidal action of Gig Harbor. The floodplain is modified by the presence of the RSI and the associated water supply flume, sedimentation pond, and the incubation barrels. Understory riparian vegetation dominates the stream banks and reaches entirely across the main channel in several locations, providing cover and shade. The riparian vegetation transitions to salt tolerant species in the downstream direction toward the North Harborview Drive bridge. Here, cover and shading are reduced. From Harborview Drive to the North Harborview Drive bridge, a distance of 400 feet, one piece of large woody material (LWM) was observed.

3.4.2 Harborview Drive to 96th Street (upstream)

Upstream of Harborview Drive and extending to 96th Street, approximately 3,500 feet, the area is largely undeveloped. The main channel and floodplain are heavily vegetated. The site investigation on July 22, extended from Harborview Driver to approximately 700 feet upstream. In this reach, the channel is comprised of pool-riffle sequences and occasionally includes forced pool riffle or steps created by LWM that is channel spanning or creating multi-log jams. In this reach, four BFW measurements were collected along with two Wolman pebble counts. Thirty-nine LWM pieces were observed at various spacing throughout this reach, usually creating log jam features versus a more even distribution. This area was selected to serve as a reference reach for estimating the proposed restoration of the stream through a new Harborview Drive crossing.

Floodplain terraces varied in elevation 1 to 3-feet above the apparent BFW height, and high-water mark debris indicators were observed indicating the floodplain is connected. Several small tributary drainages were observed, and actively flowing.

3.4.3 Reference Reach

Based on the initial site review and the available stream profile data, it was determined that the project should rely on a reference reach on the upstream side of the crossing. Selecting a reference reach in this area will allow the design to focus on the riverine section of the project and focus on a stream design to provide a smooth transition from the upstream to downstream, where the slope flattens and is tidally influenced. To develop a recommendation for the size requirements for a replacement crossing, the BFW of the channel, the floodplain utilization ratio (FUR), the distribution of streambed material gradation, and the size and frequency of large woody material was observed and documented.

3.4.3.1 Bank Full Width (BFW)

The bank full width is a measurement of the expected water surface when the channel is flowing at a discharge just before it would flow over the banks and into the floodplain. This is considered a suitable representation of the flow discharge that has the power to alter the channel, called a channel forming

flow. Several locations are measured to determine an average and reduce some of the variability that is inherent in subjective interpretation since it is rare that the stream is flowing at bank full width during site visits and measurements. A total of four locations were measured and presented in Table 3-4.

Table 3-4. Measured Bank full Width Locations and Measurements

Cross Section ID	Station	Cross Section Location to Crossing	Measured BFW (feet)
BFW #1	14+20	620 feet upstream	13.0
BFW #2	13+35	535 feet upstream	15.0
BFW #3	12+25	425 feet upstream	17.0
BFW #4	10+70	270 feet upstream	14.0
		Average BFW =	14.75

To estimate a starting width that is capable to achieve the design objective, the following equation is applied:

$$W = 1.2\ W_{ch} + 2 \qquad \text{(feet)}$$

Where:

W = minimum design width of crossing location

W_{ch} = width of bank full channel, average measured BFW

Based on the field measurements, the recommended minimum width of the channel design is 20 feet. The calculation result is rounded to the nearest foot. This represents a starting width to inform the design. In general, incorporation of floodplain widths, wildlife passage, and streambed scour may drive the need for the crossing width to increase.

3.4.3.2 Floodplain Utilization Ratio (FUR)

The floodplain near Harborview Drive is approximately 40 feet in width and is variable but generally narrowing in the upstream direction of the stream corridor. The ratio of the floodplain width divided by the BFW is called the floodplain utilization ratio (FUR). In this case the FUR is calculated as follows:

FUR = BFW/Floodplain Width

14.75 ft/40 ft = 2.7

FUR less than 3 indicates that channel is not prone to significant lateral movement and restored stream and floodplain cross sections targeting a similar total width will perform better in the long term. Field observations confirmed the channel corridor in the reference reach was established and did not exhibit a tendency for lateral migration in the crossing reach. This allows the design to consider crossing widths that are less than the width of the adjacent floodplain. When the crossing width is less than the floodplain, the hydraulic characteristics through the crossing will be effected, but can be designed to maintain a stable streambed and channel alignment.

3.4.3.3 Streambed Material Gradation

General observations in the upstream reach noted several areas where steeper valley slopes were eroding or had mass wasted along the outside edge of a stream bend. Distribution of sediment and

range of grain sizes was apparent throughout the reach investigated. Where gravel bars have formed, material is unconsolidated and apparently mobile, providing quality substrate conditions for salmonids. In some locations, LWM was holding accumulated sediment and creating steps or forced step-pools. In other locations, LWM was visible in the streambed mix having been apparently buried overtime.

Wolman pebble counts were collection in two locations. This method collects 100 or more samples and bins each sample into a grain size category based on the median axis of the sampled particle. Sample #1 was collected in the same location as BFW #1, at 620 feet upstream of Harborview Drive (STA 14+20). Sample Site #2 was collected in the same location as BFW #3, at 425 feet upstream of Harborview Drive (STA 12+25). The data in Table 3-5 show the grain sizes upstream are coarser than those sampled downstream. This aligns with the visual observations of bar complexes and floodplain depositional areas more apparent in the vicinity of the culvert, likely influenced by the culvert altering the natural flow characteristics of a free-flowing stream.

Table 3-5. Sediment Distribution, Median Grain Sizes

Diameter $_{\%Passing}$	Sample Site #1 (mm)	Sample Site #2 (mm)
D_{15}	1.41	0.35
D_{25}	2.83	1.41
D_{50}	22.63	5.66
D_{75}	45.26	11.31
D_{84}	45.26	22.63
D_{90}	90.51	22.63

These values presented in the table are the binned sizes of particles for the median grain sizes. The maximum particle size sampled was 304.8mm at Sample Site #1 and 200.0mm at Sample Site #2. The final stream sediment design that accompanies the new crossing should consider incorporation of materials that represent maximum size observed and may consider sizing for class thresholds to help provide added stability to a newly reconstructed channel segment.

3.4.3.4 Large Woody Material (LWM)

The observed large woody material frequency in the reference reach serves as a guide for placement of logs to be incorporated in the stream design. In the reference reach, thirty-nine (39) larger logs, presumably key pieces, were counted over the 620-foot length of the reach. They were typically grouped together in two to four logs occurrences. These pieces of LWM were generally near locations in the stream where they had rotated out of the bank and into the stream. Other mobile pieces (smaller in diameter and length) where also present, increasing the overall stream complexity. There are healthy stands of riparian species all along the reach, and future recruitment of key pieces and smaller mobile pieces is expected.

At the crossing, the road fill slopes are supporting several large trees (30+, depending on limits of excavation) that can be salvaged for the LWM component of the stream design, since the earthwork to the replace the crossing will not allow the protection of those trees in place. Salvaged trees will provide the necessary quantity to create stream complexity through the new crossing, mimicking the function and frequency of LWM observed in the reference reach. Future design should consider use of individual logs with and without root boles, more complex integrated log features (e.g. engineered log jams), and embedment of logs in the stream substrate as observed in the upstream channel. The incorporation of

LWM should consider wood sizing and log stability requirements to protect the downstream bridge at North Harborview Drive and potential post flood maintenance requirements in the harbor.

3.4.4 Stream Design Recommendations

3.4.4.1 Proposed Stream Geometry

The alignment of North Creek is slightly skewed north to south and it flows west to east under Harborview Drive, the skew is about 26 degrees to the south when measured from the perpendicular to the road alignment. This skew appears to be the natural topographic alignment of the creek and no stream realignment is necessary, as the creek is already in its historic path. The slope of the culvert is slightly less than 2 percent, and this appears to have been the historic slope of the stream in this reach. Based on detailed survey data collected by Parametrix in 2022, the culvert is causing a disruption of sediment transport, and there is a slope discontinuity at the outlet. Sediment is collecting in the upstream reach. Local scour has occurred at the culvert outfall. This does not present a significant concern for design as the discontinuity is local to the culvert. On the downstream side, the tidal influence has controlled stream degradation, and on the upstream side the sediment deposition is along a short segment of the channel and visible in portions of the floodplain nearer to the last 100 feet approaching the culvert inlet. The stream slope and floodplain slope in the vicinity of the crossing can effectively be regraded during construction, and natural sediment and LWM transport processes are expected to re-initiate and reach equilibrium in a single winter flow season.

Using the calculated minimum width of a 20-ft wide opening and adding floodplain width to mimic the function of the immediate upstream section, a HEC-RAS hydraulic model (HEC-RAS. 2022) was constructed to test channel and floodplain hydraulic performance for a variety of opening widths and channel slopes compared to a range of flood flows and tidal conditions. It was determined that hydraulically, a 25-ft wide opening can accommodate a stream size that performs as required for the passage of salmonids. This incorporates the recommended streambed width of 20 feet, with an additional 5 feet for floodplain benches. Wider openings did not appreciably improve hydraulic performance, but they do offer the width for more floodplain habitat, future increased flood capacity, and the ability to accommodate a pedestrian path to connect with the path that currently terminates within Donkey Creek Park.

3.4.4.2 HEC-RAS Review and Results

HEC-RAS models are comprised of combinations of geometric data that describe the topographic surface, the hydraulic characteristics of the stream, and the hydrologic inputs for a range of storm runoff flow rates. The following geometries and tide conditions were compared:

1. Existing conditions at low tide
2. Existing conditions at high tide
3. Proposed Bridge conditions at low tide
4. Proposed Bridge conditions at high tide
5. Proposed 3-sided structure conditions at low tide
6. Proposed 3-sided structure conditions at high tide

Each of the above combinations was reviewed over a range of stream discharges from the 2-year flood (78 cfs) to the 100_{2080} -yr flood (335 cfs).

Direct comparison of data requires some interpretation of the existing condition, recognizing that the existing culvert does influence the flow, and creates a backwater upstream of the culvert inlet. This effectively causes slower deeper water to pond until the flows can push through the culvert. In the Proposed conditions, the restriction of the culvert is removed, and water velocities are generally increased throughout the reach which is likely representative of historic hydraulic conditions.

3-Sided structures are bottomless and allow the streambed to move more freely, than a box structure. Though they have shorter maximum span length than other bridges due to restrictions in available span lengths and load capacities for the design type and materials. For this review, the 3-sided structure was tested as a 25-ft span to allow for the required channel width to fit throughout the length of the structure. Given the need to maintain the road fill to support the road, this structure will visually be similar to a culvert. The other proposed structure was modeled as a bridge with associated abutments. To maintain the road geometry, this structure required an 85-ft span, and would remove most of the current road fill. The span of the bridge considered a balance of constructability and abutment construction to support the valley slopes. It was considered a better solution to span further and avoid the need for slope reinforcement and walls to maintain portions of the road fill that would be needed for a shorter span. Table 3-6 shows the comparison between the existing conditions and proposed alternatives at both low and high tide conditions.

Table 3-6. Hydraulic Modeling Results Comparison, Bounding Sections of the Road Crossing

Upstream of Crossing (STA 7+99)

	Velocity (feet/sec)			Water Surface Elevation (feet, NAVD88)			Water Depth (feet)		
	2-yr	100-yr	100_{2080} - yr	2-yr	100-yr	100_{2080} - yr	2-yr	100-yr	100_{2080} - yr
Low Tide									
Existing	1.8	1.4	1.3	19.3	22.5	24.3	7.4	10.6	12.4
Bridge	3.6	5.1	5.9	12.5	13.3	13.8	1.3	2.1	2.5
3-sided	2.1	3.2	3.6	13.1	14.2	14.9	1.9	3.0	3.6
High Tide									
Existing	1.8	1.4	1.3	19.3	22.5	24.3	7.4	10.6	12.4
Bridge	3.6	5.1	5.9	12.6	13.4	13.8	1.4	2.2	2.5
3-Sided	2.1	3.2	3.6	13.1	14.2	14.9	1.9	3.0	3.6

Downstream of Crossing (STA 6+70)

	Velocity (feet/sec)			Water Surface Elevation (feet, NAVD88)			Water Depth (feet)		
	2-yr	100-yr	100_{2080} - yr	2-yr	100-yr	100_{2080} - yr	2-yr	100-yr	100_{2080} - yr
Low Tide									
Existing	8.4	10.4	9.1	12.2	14.5	16.2	4.4	6.7	8.4
Bridge	3.0	4.6	5.2	9.6	10.3	10.7	1.1	1.8	2.2
3-sided	3.0	4.6	5.2	9.6	10.3	10.7	1.1	1.7	2.2
High Tide									
Existing	8.4	10.4	9.1	12.2	14.5	16.2	4.4	6.7	8.4
Bridge	3.0	4.6	5.2	9.6	10.3	10.7	1.1	1.8	2.2
3-Sided	3.0	4.6	5.2	9.6	10.3	10.7	1.1	1.8	2.2

It is worth noting that the 3-sided structure hydraulic modeling results reflect a slight influence from the upstream face of the structure. While low flow conditions would not be influenced by the structure, the 2-yr and higher flows do start to inundate the structure walls, and it causes a minor change in the water surface elevation and the associated flow velocities. The hydraulic results for the bridge do not engage any part of the bridge structure and reflect the channel only influences on the hydraulic results. The current review of the hydraulic modeling does include roughness adjustments to represent the placement of LWD through this reach. The final design and associated hydraulic modeling will be refined, building from these initial results.

The hydraulic results in the table show there is no effect on the water surface elevation caused by the tidal elevation downstream. The initial analysis also indicates that the 3-sided structure and the standard bridge maintain similar hydraulic results given they have the same hydraulic capacity through the crossing at the range of design flows. Further modeling refinement may be necessary in future design efforts to determine if structure foundation depths would require an increase in the span to reduce stability risk and potential streambed scour concerns.

3.4.4.3 STREAMBED MATERIAL GRADATION

Given the stream is located along its historic corridor, the likelihood of encountering suitable gravel and boulder material that is characteristic for the stream in this reach is high. However, substrate below the culvert is unknown. Therefore, planning for over-excavation and replacement with suitable streambed material is recommended.

Based on the collected Wolman pebble count samples, a suitable streambed material for the re-construction and initial restoration of the stream channel, if necessary, are shown in Table 3-7. This is a material mix based on the standard WSDOT specification and would be typical for meeting the design review expectations that have evolved during the many regional culvert replacement projects permitted and constructed as part of the on-going State effort to remove fish barriers throughout Puget Sound.

Table 3-7. Streambed Material and Gradation

Material Name	Percent	WSDOT Standard Specification
Streambed Sediment	55	9-03.11 (1)
Streambed Cobbles 4-inch	25	9-03.11 (2)
Streambed Cobbles 12-inch	10	9-03.11 (2)
Streambed Boulders, One Man	5	9-03.11 (3)
Habitat Boulders, Two Man	5	9-03.11(4)

The Streambed and Habitat boulders will be required. They are necessary for hydraulic roughness and stream complexity elements as boulder clusters or key anchor points. They are typical for use in establishment of constructed meander bars or other similar geomorphic functioning stream features.

3.5 Preliminary Geotechnical Considerations

HWA Geosciences completed site reconnaissance of the culvert alignment on June 30, 2022 (HWA. 2022). Site observations of the stream and culvert upstream and downstream of the headwalls, and the slopes of the roadway fill. Deciduous trees on the east slope of the fill exhibited slightly curved trunks, indicating some slow creep of the surficial soils. Subsurface review of the site relies on explorations previously completed for the Donkey Creek Restoration and Roadway Improvements Project (North Harborview Drive), and an exploration designated EB-8, completed by Associated Earth Sciences, Inc. (AESI. 2011). The boring completed at EB-8 is within 30 feet of the culvert. Additional information regarding soil and groundwater conditions were obtained from boring and test pit explorations performed by HWA for the Gig Harbor Wastewater Treatment Plant Improvements (HWA. 2008) and a boring designated BH-6, completed for Phase 1 of the Burnham Drive and Harborview Drive Improvements Project in 2020 (HWA. 2020).

The interpretation of the existing conditions for this alignment were developed based on limited existing geotechnical data. From this information, we conclude that the upper subsurface materials at the culvert site consist primarily of fill with varying thicknesses and composition. At the culvert, the fill slope for the roadway, represented by boring EP-8, indicates that medium dense, slightly gravelly sand underlies the roadway to a depth of about 20 feet. The material grades to dense at a depth of about 20 feet, where soils appear to transition to an advance outwash material. The boring was terminated in this material at about 21.5 feet below the top of the embankment. The material observed in EP-8 is similar in

composition to the material that was observed in the explorations performed for the Gig Harbor Wastewater Treatment Plant site, including BH-3, BH-4, TP-9 and TP-10, which was also characterized as outwash deposits. None of the explorations extended below the base of the culvert. Future explorations will be needed to provide information for the soils present below the culvert structure.

Groundwater levels near the culvert are expected to generally coincide with the elevation of the stream. Groundwater levels are expected to vary depending on the weather and time of year. Future explorations should include at least one boring that would be completed as a monitoring well to provide water data from use in the design and crossing of the structure.

3.5.1 Geotechnical Recommendations

A detailed explanation of the geotechnical recommendations is included as the preliminary geotechnical report (HWA. 2022) provided in Appendix F. Three potential foundation solutions are suitable for the geotechnical conditions at the site. They include spread footings, driven steel pipe piles, and drilled shafts. Spread footing will require significant excavation to reach the depth necessary to set the footings on suitable soils below the restored streambed and potential hydraulic scour depth. Excavations to these depths will likely encounter saturated soils and groundwater, requiring shoring and control of water to maintain the work site in a dry condition. Installation of deep foundations either driven or drilled options introduces risk associated with the protection of the water and sewer mainline utilities that underly Harborview Drive.

3.5.1.1 Spread Footings

The use of spread footings could be considered if a 3-sided structure were selected as the new crossing structure. This option would require excavation of the about 20 feet of fill materials to expose the advance outwash on which the spread footings could be constructed. The bearing capacities of the spread footings will depend on the final selected footing elevations as well as the depth of embedment below the anticipated scour depth for the culvert. This embedment depth will likely encounter groundwater and further complicate construction methods.

Excavations needed for installation of the foundations would require sloping the existing fill at about 1.5H:1V, which will result in a significant section of the existing roadway embankment that would have to be removed. The extents of the excavation could be reduced by using temporary shoring; however, interference with existing utilities and nearby structures would need to be considered. This option is most economical if a full road closure is permitted. Otherwise, shoring requirements to maintain traffic could increase costs so that the disadvantages of this option outweigh the cost savings.

One significant consideration regarding the feasibility of using a spread footing foundation is the utilities that cross the alignment. Plans indicate that both water and sewer pipes underlie the site and likely will cross the culvert above the foundation levels. In these cases, the pipelines will likely require a bypass during construction and need to be reconnected above or through the box culvert structure following construction. If the pipelines run beneath the foundations, these utilities will require evaluation of methods that avoid loading the pipelines where they are located below the base of the proposed footings. Additional information regarding utility elevations will be needed to assess the impact the spread footings and crossing structures will have on the utilities present at the site.

3.5.1.2 Driven Steel Pipe Piles

Driven steel pipe piles, either closed-ended and open-ended piles are feasible at this site. Closed-end pipe piles typically provide ultimate capacities approaching the structural capacity of the section. Based on experience from driving piles at the North Harborview Drive Bridge structure, 18-inch diameter, closed-ended pipe piles will likely develop the required nominal axial capacity within the upper approximately 5 to 10 feet of the dense glacial outwash. However, to ensure lateral fixity for the piles, pile may need to be overdriven, beyond the depth at which they meet the required nominal axial capacity. Alternatively, open-ended piles could be used, though they typically require deeper embedment to achieve similar axial capacities to that of a closed-ended pile. They can, however, allow the piles to be driven more easily to a depth that will provide fixity for the lateral loading condition, and thus could be the preferred pile alternative for this site.

Driven piles are advantageous in that they typically require less time to install and can be less costly when compared with the alternative of using drilled shafts. When possible, we would recommend using driven piles. However, a disadvantage of using driven piles is that their installation method generates vibrations, which could damage the existing utilities that are present at the site. Additionally, these methods could heave or densify the adjacent soils around the piles such that if driven piles are too close to existing utility pipes, in particular the sanitary sewer pipe, they may put additional lateral pressure on the pipes that could damage them. Utilities that will get replaced as part of this project are not likely to be affected; however, if the underlying sewer line is to remain functional during and/or following construction, installation of driven piles may not be favorable. For these reasons, the open-ended pile option is recommended if piles are selected for design.

3.5.1.3 Drilled Shafts

Drilled shafts may be preferred to reduce concerns regarding the impact of vibrations to the utilities at the site. Drilled shafts are deep foundation elements in which soil is excavated out of the ground and replaced with concrete and steel reinforcing, such as a rebar cage, or steel beam. Drilling methods typically use flighted augers or clamshells to extract the soil. Depending on the soil and ground water conditions, some casing and/or drilling fluid may be required to stabilize the sides and bottom of the excavation as the steel reinforcing and concrete are placed in the open hole. For the construction of drilled shafts that this site, we would recommend utilizing drilled shaft installation methods that do not include the use of vibratory methods for hole excavation or casing advancement.

If drilled shafts are selected, the appropriate diameter of the shafts will need to be determined by the designer. Based on site conditions the suitable diameters will range between 18-inch and 36-inch shafts. Additional explorations will be needed for design of the shafts as bottom of the one available boring does not extend deep enough.

At expected depths of embedment, the advance outwash bearing support layer will be likely will be saturated and will require casing and/or drilling fluid to stabilize the sides and bottoms of the holes. This will increase the time and cost of installing drilled shafts. Use of drilled shafts as a foundation alternative will likely be based on the need to limit the impact of the deep foundations to the underlying sewer line rather than construction cost.

3.5.1.4 Seismic Design Considerations

Earthquake loading for the project alignment was developed in accordance with the General Procedure provided in Section 3.4 of the American Association of State Highway and Transportation Officials (AASHTO) Guide Specifications for Load & Resistance Factor Design (LRFD) Seismic Bridge Design

(AASHTO. 2011) and the Washington State Department of Transportation (WSDOT) amendments to the AASHTO Guide Specifications provided in the Bridge Design Manual (BDM) (WSDOT, 2022). For seismic analysis, the Site Class is required to be established and is determined based on the average soil properties in the upper 100 feet below the ground surface. The Site Class can be correlated to the average standard penetration resistance (SPT) in the upper 100 feet of the soil profile. Based on our characterization of the subsurface conditions, the subject site classifies as Site Class C for "Very dense soil". The design parameters for the design level event of 7 percent probability of exceedance in 75 years (approximately equal to a return period of 975 years) were obtained using BridgeLink (BridgeLink. 2021) which uses the probabilistic seismic hazard parameters developed from the 2014 Updates to the National Hazard Maps (Peterson, et al., 2014). Site coefficients were developed following the WSDOT BDM that adopts the site coefficients provided in American Society of Civil Engineers (ASCE. 2017) 7-16. The recommended seismic coefficients for the design event are provided in Table 2-1. The spectral acceleration coefficient at 1-second period (SD1) is greater than 0.3 but less than 0.5 g; therefore, Seismic Design Category C, as given by AASHTO Table 3.5-1 (AASHTO, 2011), should be used (Table 3-8).

Table 3-8. AASTHO Table 3.5-1

Site Class	Peak Horizontal Bedrock Acceleration PBA (g)	Spectral Bedrock Acceleration at 0.2 sec S_s (g)	Spectral Bedrock Acceleration at 1.0 sec S_1 (g)	Site Coefficients			Peak Horizontal Acceleration PGA (A_s) (g)
				F_{pga}	F_a	F_v	
C	0.456	1.038	0.306	1.200	1.200	1.500	0.547

Notes: Values based on 7% probability of exceedance in 75 years for Latitude 47.33753° and Longitude 122.59482°

3.5.1.5 Liquefaction Considerations

Liquefaction is a temporary loss of soil shear strength due to earthquake shaking. Loose, saturated cohesionless soils are the most susceptible to earthquake-induced liquefaction; however, research has shown that certain silts and low-plasticity clays are also susceptible. Primary factors controlling the development of liquefaction include the intensity and duration of strong ground motions, the characteristics of subsurface soils, in-situ stress conditions and the depth to ground water.

Based on the data available from boring EB-8 drilled within the fill placed to form the roadway embankment, the fill soils could be susceptible to liquefaction if they were encountered below the ground water table. The available data does not indicate that ground water was present; however, no ground water monitoring well was installed, and it is possible that the ground water table associated with North Creek could extend up into the fill soils near the culvert, particularly during the wet season.

Based on the current information, the thickness of the potentially liquefiable soils that could be saturated is expected to be 5 feet or less. This material could experience liquefaction that may result in small amounts of liquefaction settlement of the existing fill embankment. The medium dense nature of the fill soils could provide adequate frictional resistance following liquefaction and, as a result, slope instability would be limited, and large lateral displacement of the roadway embankment is unlikely. This will need to be confirmed by performing explorations near the proposed crossing structure foundations once selected and design is advanced.

4. ALTERNATIVES

The purpose of this project is to determine a feasible crossing design to replace the culvert and eliminate the migratory fish barrier. The culvert is also nearing the end of the expected design life for a concrete box structure. Development of alternatives was informed by the stakeholder engagement process and the feedback collected to date. The potential project elements that can be assembled to create feasible alternatives for review, were also considered by City Council during a study session.

Two alternatives are described below. These represent the refinements based on the initial review of engineering and construction feasibility, input from stakeholders, and initial input from City Council. Some design elements that were part of the alternative development include:

WWTP Creek

The unnamed tributary that flows along the south edge of the WWTP and into the City's stormwater system was considered as a potential addition to the project. The potential to re-route WWTP Creek to North Creek. The alignment appears in the alternative figures, but it was determined to be prohibitive based on the extensive underground utilities in the WWTP driveway and the limited width and profile in which to daylight the channel along a potential alignment to the north.

Remote Site Incubator (RSI)

The RSI is currently located in the floodplain of North Creek. It will be at risk for flood damage and additional maintenance after the culvert is replaced and the natural stream processes re-engages the full width of the floodplain. The potential exists to relocate the RSI to higher ground in the park and operate seasonally, potentially as a publicly accessible educational opportunity. Long term agreements for the altered water right, delivery of salmon eggs, and operation and maintenance are necessary to incorporate the relocated RSI in the design. A mobile option is feasible and will require a new system of water delivery, incubation trays, and a dedicated operational platform in Donkey Creek Park.

Roundabout

The potential exists to construct a roundabout intersection to replace the 3-way stop intersection at Harborview Drive and Austin Street, to the north of the new crossing. Further investigation and planning decisions are necessary to move forward with this design element. Based on review of the alternatives, the new crossing is forward compatible with a roundabout, and it can be added to the design or design and constructed under a separate project.

These elements discussed above are not currently included in the alternatives that follow. All remain forward compatible with the alternatives if they were to be developed in detail in the future.

4.1.1 Alternative 1 – 85-ft span Steel Girder Bridge

Alternative 1 would replace the culvert with an 85-ft span, bulb tee girder steel bridge. The supported road width would be 45 feet, carrying two lanes of vehicular traffic and pedestrian sidewalks. The road width requires 7 girders. Construction of the bridge may require minor shoring and would be staged to allow continuous flow of controlled traffic, reduced to a single lane. Deep foundations would support the abutments and the size and height of walls for the abutments will be refined based on the final geotechnical report. Generally, the bridge span and the abutments require sufficient width for the designed stream channel design and offers additional width that can accommodate an expanded

floodplain restoration and a pedestrian path undercrossing. The path located under the North Harborview Drive Bridge is a nearby example. The bridge also provides adequate height clearance to maintain the sewer and water utilities that are currently buried in Harborview Drive. These utilities can be carried by hangers, same as the design of the North Harborview Drive Bridge. This alternative offers flexibility in the design as the design is developed further and more is understood about the site and the permitting process is initiated.

This alternative offers key advantages to the project. The first is the ability to accommodate the pedestrian path under the new structure, connecting the park to the future expansion of the public trail system. The second is the ability to construct a significant amount of the project at grade, allowing the bridge to be completed and open to traffic while the stream design is completed as a separate item, reducing the duration that the creek would be disturbed. The third is the reduced width and increased height of the bridge. It would cover much less of the stream, effectively daylighting approximately 100 feet of the creek, and being tall enough to let the angle of the sun penetrate under the bridge depending on the season.

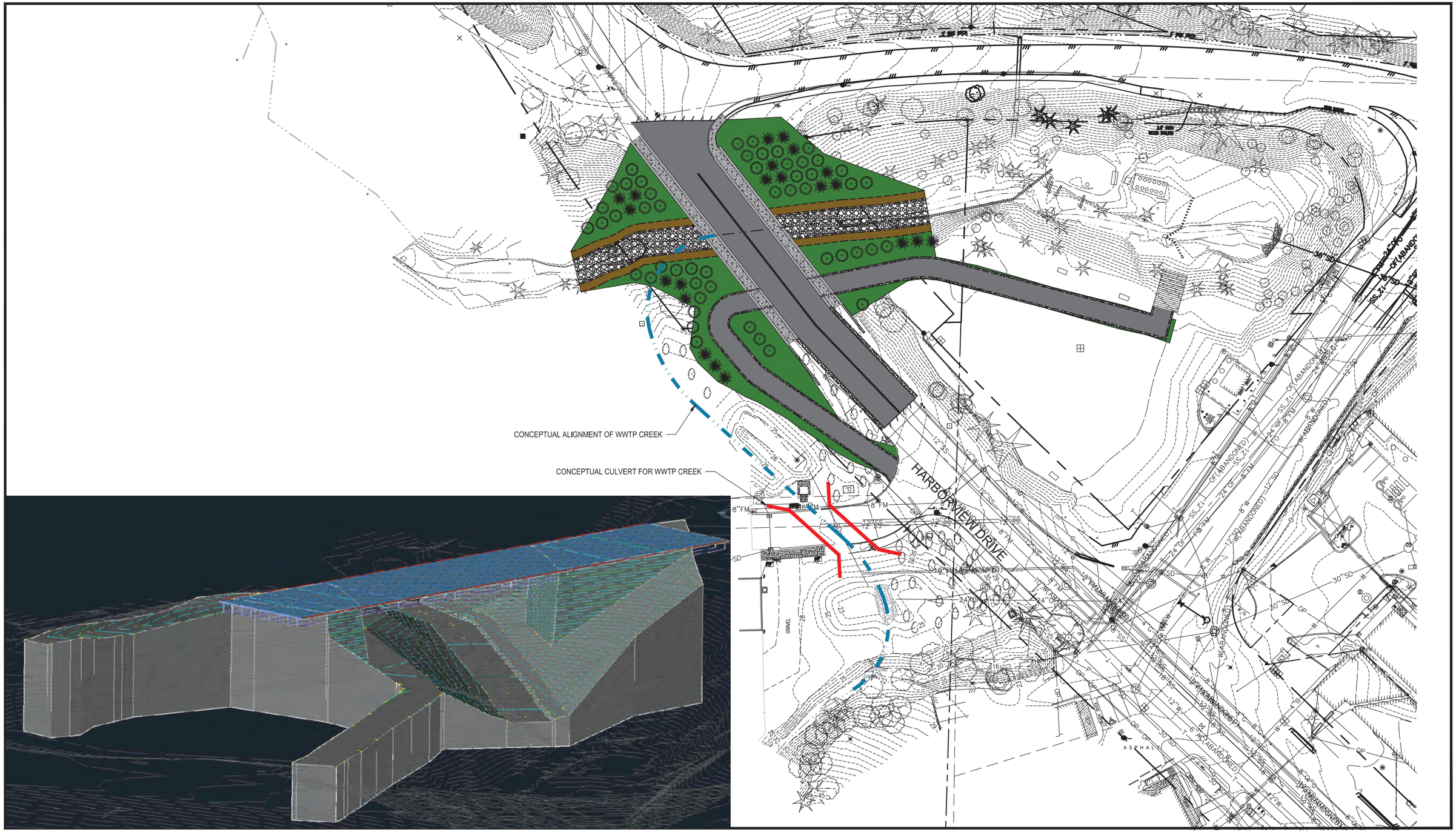

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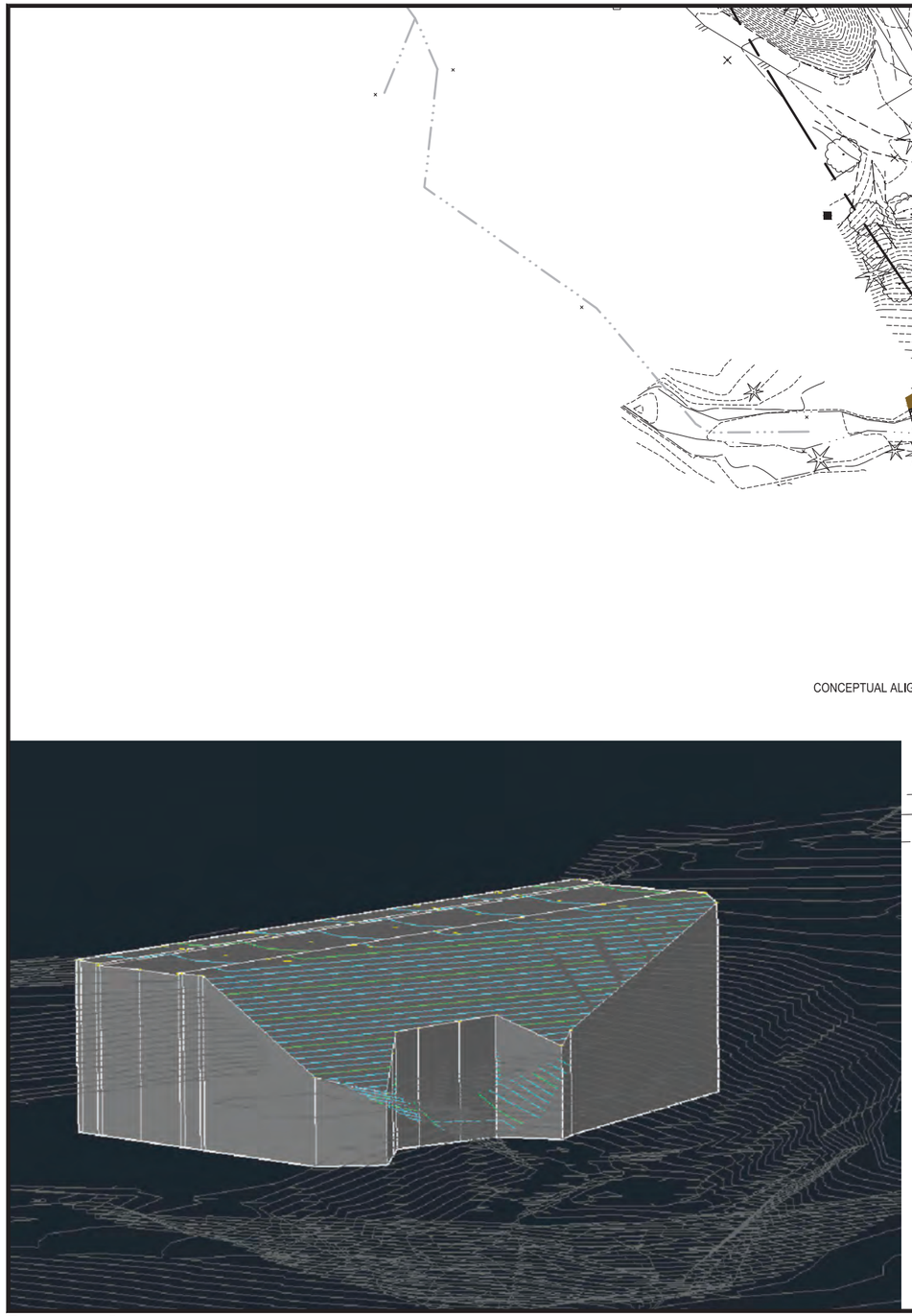
Figure 4-1.
Alternative 1 -
Bulb Tee Girder Bridge

North Creek Culvert FS
City of Gig Harbor, WA

4.1.2 Alternative 2 – 25-ft span 3-Sided Concrete Structure

Alternative 2 would replace the culvert with a 25-ft span, 3-sided concrete structure. These structures are open bottom and can be placed on spread footings or deep foundations. They are efficient to install because they are precast and are assembled quickly after excavation and foundation elements are prepared. However, given the depth of the crossing, the excavation is challenging is the quantity of material to be removed, the need to maintain traffic, and the likelihood that groundwater will be present above the depths required to set the foundations. Construction is possible with adequate pumping to control water and shoring maintain valley slopes and during excavation.

This alternative can provide a crossing that removes the fish barrier. However, this alternative requires a complicated and lengthy period of construction within the creek. It also requires that the road fill material be removed and stored nearby, so it can be replaced after the structure is installed. Given the depth of the road fill, maintaining traffic will be a significant challenge. The width of the structure for a typical sized structure does not accommodate the pedestrian path. It is also at the limit for the width requirements of the stream. Should additional design challenges arise, there is no additional width to accommodate adjustments. The 3-sided structure would also be approximately the same length of the current culvert. The length of the structure along the stream is approaching a ratio of 10:1 ($L:W_{BFW}$) and is less desirable, leaving the stream in a non-daylighted condition. Additionally, the ratio of width to height of the 3-side structure becomes a challenge, requiring a structure that is elongated in the vertical, having tall sides that extend below estimated streambed scour depths and above the 100-year flood freeboard requirement.



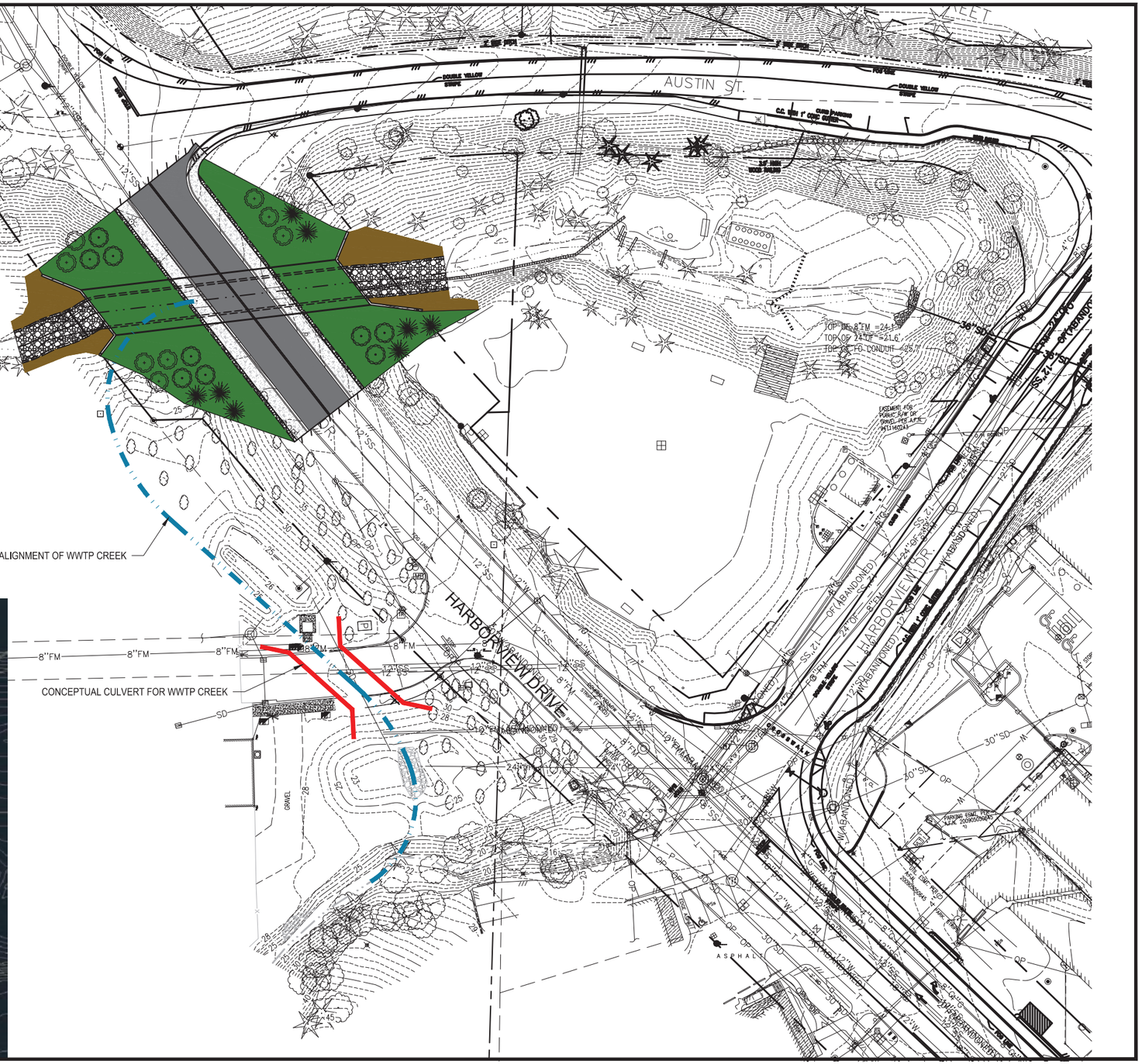


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Figure 4-2.
Alternative 2 -
3-Sided Box Culvert
North Creek Culvert FS
City of Gig Harbor, WA

4.2 Design, Permitting, and Construction Cost

Table 4-1 compares the preliminary cost for the design, permitting, and construction of the two alternatives. Alternative 1 is shown as an 85-ft span steel girder bridge, and Alternative 2 is a 25-ft span 3-sided precast concrete structure. The detailed preliminary cost estimates are provided in Appendix G. The preliminary cost estimates include a 30% contingency to help address the change in future construction costs and unknowns to be resolved in the final design and permitting process.

Table 4-1. Preliminary Cost Estimate

Alternatives	$ (2022 dollars)
1 85-ft span steel bridge with deep foundations	$7,540,257
2 25-ft span, 3- sided precast concrete structure	$6,219,150

The bridge alternative is estimated to be $1.3 million more expensive. However, it has a natural advantage providing a larger span of the creek, providing flexibility for design refinements, and permitting. The 3-sided structure represents the expected minimum and may need to be enlarged to accommodate future design and potential permit review challenges that could arise. Additional considerations in the direct comparison of these costs are the potential construction schedule disruption and necessary staging area to remove and replace the road fill volume under Alternative 2. Alternative 2 also lacks the ability to accommodate the pedestrian trail.

4.3 Recommended Alternative

This feasibility study was initiated to review options for replacement of the existing culvert on North Creek that supports the Harborview Drive crossing. Working through feasible design alternatives to create a new crossing that meets water crossing design guidelines to maintain fish passage and collecting input from participating stakeholders and the City Council study session, Alternative 1 is the recommended alternative.

The 85-ft span steel girder bridge creates the most flexibility to move forward with the stream design. Future design phases that advance this alternative through 30% level of detail, into permitting and review will go deeper into the final project requirements. This will include the addition of stream complexity, large woody material, and reconnection to the floodplain. There will also be a clear understanding of calculated streambed scour potential based on the more developed designs. These elements tend to require some adjustment to the crossing. In some instances, adjustments are most easily addressed with a wider stream design. The bridge crossing has the capacity to accommodate a wider stream and reduce or completely mitigate design and permitting risk. The bridge is the only alternative that can include a pedestrian undercrossing of Harborview Drive, connecting the existing pedestrian trail system in the park to the west side of the street. The bridge also offers a construction phasing advantage. It can be constructed at grade with limited initial excavation. This will help to better facilitate traffic control and reduce the temporal disturbance on the stream itself. The entire stream reconstruction and culvert removal can occur under the bridge, after the bridge is completed and open to normal traffic. Table 4-2 presents the main design features of the recommended alternative.

Table 4-2. Recommended Alternative Design Elements

Structure Type	Steel Girder
Span	85 feet
Width	45 feet, with sidewalks and railing
Proposed channel	Pool-riffle
Slope	1.9%
Low flow width	10 feet
Bank full width	15 feet
100-yr width through crossing	25 feet
100 -yr water surface elevation (NAVD 88)	11.5 feet
Low chord of utilities elevation (NAVD 88)	28.5 feet
100-yr freeboard to low chord of utilities	17.0 feet
Pedestrian Trail elevation (NAVD 88)	21.0 feet
Pedestrian Trail to low chord of utilities	7.5 feet
Streambed material	Native preferred, imported WSDOT specification acceptable

Appendix H includes preliminary design drawings with plan, profile, and detail information developed during the review of the bridge alternative.

4.4 Other Considerations

- The utilities that are carried in or along the Harborview Drive corridor need additional review and coordination to determine the design details necessary for inclusion in a new bridge crossing solution.
- The local floodplain mapping as part of the FEMA NFIP at the crossing and along Donkey Creek Park will require review and updating as part of the culvert replacement.
- The preliminary cost estimates are based in previous projects that are similar in scope and scale and presented in 2022 dollars. Design, permitting, and construction schedules, may require an adjustment in the final cost estimate to reflect cost of materials and inflation. This is currently addressed with the applied 30% contingency.

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Appendix A

txʷaalqəɬ Estuary resolution

RESOLUTION NO. 1199

A RESOLUTION OF THE CITY OF GIG HARBOR, WASHINGTON, RENAMING AUSTIN ESTUARY PARK AND DESIGNATING THE txʷaalqəɬ ESTUARY AREA IN HONOR OF THE sx̌ʷəbabš BAND OF THE PUYALLUP TRIBE.

WHEREAS, the City recognizes and honors the fact that Gig Harbor is built upon the homelands and villages of Indigenous Peoples of this region better known as a band of the Puyallup Tribe called sx̌ʷəbabš (translated: "swift water people"); and

WHEREAS, the land surrounding the estuary of North Creek was the location of a long house of the sx̌ʷəbabš band and the area was of vital importance to the sx̌ʷəbabš band for salmon fishing, clam and oyster cultivation, and canoe carving; and

WHEREAS, the City and Puyallup Tribe are committed to work in cooperation to build the relationship between the two governments; and

WHEREAS, these actions are a demonstration of the City's ongoing commitment to strengthening the relationship between the Puyallup Tribe and the City; and

WHEREAS, the City wishes to continue to honor the contributions of the Austin family to the development of Gig Harbor; and

WHEREAS, the Mayor formed an ad hoc committee of councilmembers, tribal representatives, and others from the community to explore options for renaming a City park to honor the sx̌ʷəbabš band; and

WHEREAS, after a series of meetings, the ad hoc committee forwarded its recommendations to the Gig Harbor Parks Commission; and

WHEREAS, on February 3, 2021, the Parks Commission held a public hearing on renaming the park based on the recommendations of the ad hoc committee and subsequently recommended to the City Council that the name of "Austin Estuary Park" be changed to "Austin Park"; and

WHEREAS, the Parks Commission further recommended, based on the recommendation of the ad hoc committee, that the area surrounding the North Creek (aka Donkey Creek) estuary be referred to as the "txʷaalqəɬ Estuary." In the Lutshootseed language of the Puyallup Tribe, txʷaalqəɬ means "place where game exists;" and

WHEREAS, the Gig Harbor Peninsula Historical Society (aka Harbor History Museum) expressed support for the name change to "Austin Park"; and

WHEREAS, the protocol included in Resolution 717 has been adhered to by staff and the Parks Commission;

NOW THEREFORE, THE CITY COUNCIL OF THE CITY OF GIG HARBOR, WASHINGTON, HEREBY RESOLVES AS FOLLOWS:

Section 1. The existing City park named "Austin Estuary Park" shall now be named "Austin Park."

Section 2. The 7+ acre area surrounding the estuary of North Creek which includes the Harbor History Museum site, other lands in and around Donkey Creek Park and Austin Park, and is located within the North Creek watershed (as shown on Exhibit A) is designated as the "txʷaalqəɬ Estuary." The Mayor is authorized, in consultation with the Puyallup Tribe and other entities that support the tribe, to develop and install interpretive signage on City-owned property within the txʷaalqəɬ Estuary area and to provide educational information on the City's website and other avenues.

Section 3. Recognition of Ancestral Homelands of sx̌ʷəbabš Peoples. The Mayor is directed to add to future staff work plans the establishment of an honorary historic area along the Gig Harbor waterfront to recognize the ancestral homelands of the sx̌ʷəbabš band for educational and awareness purposes. Establishment of the historic area should be done in consultation with the Puyallup Tribe, the Design Review Board Historic Preservation designees, and other entities that support the tribe, as appropriate. City staff will work with the Puyallup Tribe to establish the area to be called the "Ancestral Homelands of the sx̌ʷəbabš." This would be an honorary designation for educational and awareness purposes only and would carry with it no regulatory impact.

APPROVED by the City Council this 22nd day of February, 2021.

APPROVED:

Kit Kuhn
Mayor Kuhn

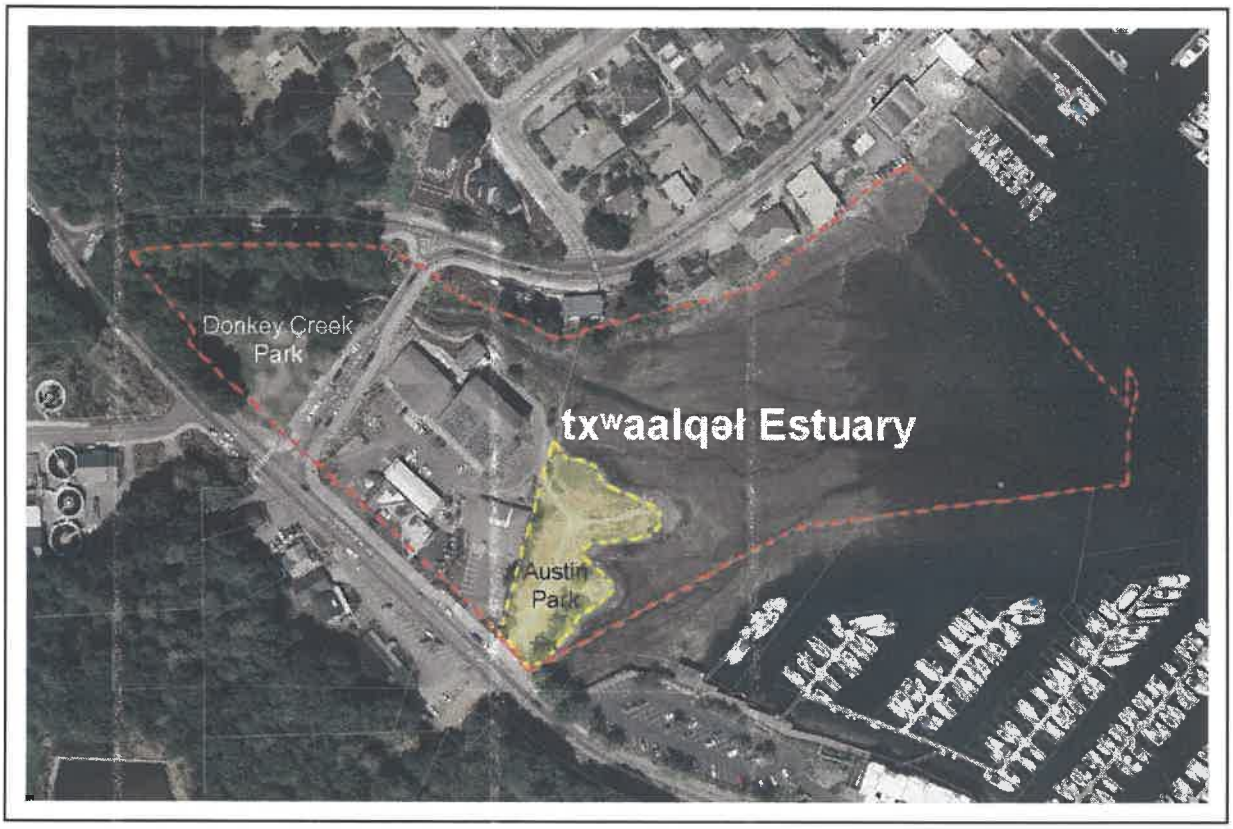
ATTEST/AUTHENTICATED:

Molly Towslee
City Clerk

FILED WITH THE CITY CLERK: 2/9/2021
PASSED BY THE CITY COUNCIL: 2/22/21
RESOLUTION NO: 1199

EXHIBIT A

Map of txʷaalqəɬ Estuary



Appendix B

Water Rights Records

Record/Document Number S2-00667CWRIS

Back to Search

At A Glance

Record/Document Number	S2-00667CWRIS	Phase	Certificate	Priority Date	11/29/1971	View Documents
Application Number	23560	Stage	NA	WRIA	15	
Permit Number		Status	Active	County	Pierce	View on Map
Certificate Number	S2-00667 C	WR Class	Surface Water	Region	SWRO	
Consrv Bd Number						Submit Record Correction
WR Doc ID	2209482					

Persons or Organizations

Click to Show Contacts

Last or Organization Name	First Name	MI	Role	Address	Zip	Phone	Email
BORGEN GEORGE W			Primary				

Phase Quantities

Phase	Qi	Units	Qa	Irr Acres
Certificate	0.25	CFS		

Assignment Groups

No assignment groups found.

Provisions

Provision
No Dam

Water Banks

No water banks found.

Purposes of Use

Basic Information | Additional Information

Purpose	From	To	Qi	Units	Use Type	Qa	Use Type	Irr Acres	Use Type
Fish Propagation	11/01	04/30	0.25	CFS	Primary				

Sources

Basic Information | Additional Information | Latitude/Longitude Information

Device Type	Source Name	Common Name	Tributary To	WRIA	County	Twp	Rge	Sec	QtrQtr	Qtr
Headworks (Gravity Flow)	NORTH CREEK		GIG HARBOR	15	Pierce	21N	2E	6		

Places of Use

No places of use found.

Associated Document Numbers

Doc # Type	Doc #
SAID	2960731990147726
Cert #	S2-00667 C
App #	23560

Progress Sheet—Surface Water

NAME Gig Harbor Fishermen's Civic Club
for George W. Borgen
Rt. 2 Box 2080
Gig Harbor, Wa. 98335

Assigned to

Date

APPLI. NO. 23560 PERMIT NO. 200667 CERT. NO. S200667C

AMENDED CANCELLED

Application received 11-29-71 Initial $10.00 fee received 12-16-71
Statement of additional examination fee $ Sent Received

Returned for completion or correction Received

Temporary permit approved by Issued

PUBLICATION:
O.K.'d by Rew Date 2/10/72 Notice sent 2-14-72
Protests
Filed

Affidavit received and checked OK Rew 3/6/72 Time expires 3-1-72

Report of game: Approved 4-25-72 Proviso NO DAM SCREEN Protest
Report of fish: Approved 4-25-72 Proviso REDUCE Q Protest Held Fish 3/20/72

EXAMINATION made 3-2-72 by OK

O.K.'d for permit 6-11-73 by WB

Statement of permit fee sent 6-11-73 Amount $ 2.00 Received 6-11-73

PERMIT NO. 200667 ISSUED 6-25-73

BEGINNING OF CONSTRUCTION: Notice sent Started Filed
Extension fee $ Extended to
To

COMPLETION OF CONSTRUCTION: Notice sent Completed Filed
Extension fee $2.00, extended to
To

PROOF OF APPROPRIATION: Notice sent 6-25-73 Filed
Extension fee $2.00, extended to
To

Statement of certificate fee sent Received 12-23-74
O.K.'d for certificate 12-23-74 by WB

CERTIFICATE OF WATER RIGHT NO. S200667C Issued 1-20-75

STATE PRINTING PLANT OLYMPIA WASHINGTON

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

CERTIFICATE OF WATER RIGHT

☒ *Surface Water* Issued in accordance with the provisions of Chapter 117, Laws of Washington for 1917 and amendments thereto, and the rules and regulations of the Department of Ecology

☐ *Ground Water* Issued in accordance with the provisions of Chapter 263, Laws of Washington for 1945, and amendments thereto, and the rules and regulations of the Department of Ecology

CERTIFICATE NUMBER	PERMIT NUMBER	APPLICATION NUMBER	PRIORITY DATE
52-00667C	52-00667P	23560	November 20, 1972

NAME
GEORGE W. BORGEN

ADDRESS (STREET) | CITY | STATE | ZIP CODE
9712 N Harbor View Drive | Gig Harbor | Washington | 98335

This is to certify that the herein named applicant has made proof to the satisfaction of the Department of Ecology of a right to the use of the public waters of the State of Washington as herein defined, and under and specifically subject to the provisions contained in the Permit issued by the Department of Ecology, and that said right to the use of said waters has been perfected in accordance with the laws of the State of Washington, and is hereby confirmed by the Department of Ecology and entered of record as shown

PUBLIC WATER TO BE APPROPRIATED

SOURCE
North Creek

TRIBUTARY OF (IF S. REACH WATERS)
Gig Harbor

MAXIMUM CUBIC FEET PER SECOND	MAXIMUM GALLONS PER MINUTE	MAXIMUM ACRE-FEET PER YEAR
0.25		non-consumptive

QUANTITY TYPE OF USE PERIOD OF USE		
non-consumptive	fish propagation	November 1 to April 30 each year

LOCATION OF DIVERSION/WITHDRAWAL

APPROXIMATE LOCATION OF DIVERSION/WITHDRAWAL
1400 feet east and 50 feet south of the center of Sec. 6

LOCATED WITHIN SMALLEST LEGAL SUBDIVISION	SECTION	TOWNSHIP N	RANGE E OR W	W.M.	W.R.I.A.	COUNTY
Government Lot 2	6	21	2 E		15	Pierce

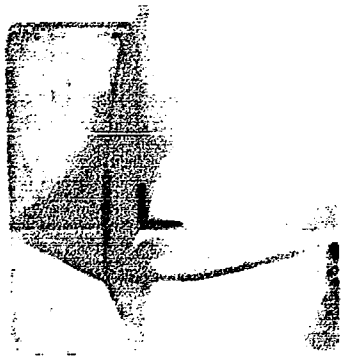
RECORDED PLATTED PROPERTY

LOT	BLOCK	OFFICIAL NAME OF PLAT OR ADDITION

LEGAL DESCRIPTION OF PROPERTY WATER TO BE USED ON

ALL that portion of Government Lot 2, Sec. 6, T. 21 N., R. 2 E.W.M., lying northeasterly of the northeasterly line of State Highway No. 14 and northwesterly of the northwesterly line of Burnham-Hunt County Road.

EXCEPT that part thereof conveyed to the Town of Gig Harbor for road by deed recorded under Auditor's Fee No. 1520256.



CERTIFICATE

PROVISIONS

Nothing in this certificate shall be construed as excusing the certificate holder from compliance with any applicable federal, state, or local statutes, ordinances, or regulations including those administered by local agencies under the Shoreline Management Act of 1971.

Diversion intake shall be tightly screened at all times with wire mesh having openings with dimensions not greater than .125 (1/8) inch. Water approach velocity to the screen shall be less than 1 foot per second and approaching 0.5 foot per second, as measured one foot in front of the screen.

No dam shall be constructed in connection with this diversion.

The right to the use of the water aforesaid hereby confirmed is restricted to the lands or place of use herein described, except as provided in RCW 90.03.380, 90.03.390, and 90.44.020.

This certificate of water right is specifically subject to relinquishment for nonuse of water as provided in RCW 90.14.180.

Given under my hand and the seal of this office at Olympia, Washington, this 24th *day of* January, *19*75.

JOHN A. BIGGS, *Director*
Department of Ecology

ENGINEERING DATA
OK.

by R. Jerry Bollen, Assistant Director

FOR COUNTY USE ONLY

Form 10 S F No 370— Rev 6-70

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

Permit to Appropriate Public Surface Waters of the State of Washington

Book No. — of Permits, on Page 82-00667P Under Application No. 23960

GIG HARBOR FISHERMEN'S CIVIC CLUB for GEORGE W. BORGEN

of Gig Harbor, Washington 200667

is, pursuant to the Report of Examination which has been accepted by the applicant, hereby granted a permit to appropriate the following described public surface waters of the State of Washington, subject to existing rights and to the limitations and provisions set out herein.

Priority date of this permit is November 29, 1972

Source of the proposed appropriation is North Creek

tributary of Gig Harbor

The quantity of water appropriated shall be limited to the amount which can be beneficially applied and not to exceed 0.25 cubic feet per second, non-consumptive acre-feet per year, or its equivalent in case of rotation, to be used for the following purposes: fish propagation as more definitely set out below.

The approximate point of diversion is 1400 feet east and 30 feet south of the center of Sec. 6

being within Government Lot 2

of Sec. 6 , Twp. 21 N Rge 2 E. W.M., Pierce County.

The use, or uses, to which water is to be applied:

Domestic/municipal supply cubic feet per second. acre-feet per year, during entire year.

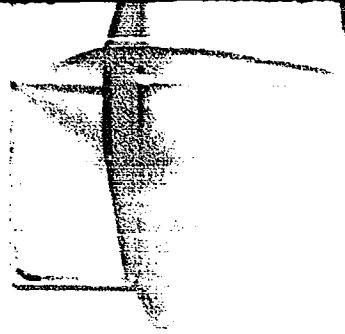
Irrigation. cubic feet per second. acre-feet per year from to each year, for irrigation of acres.

Other use(s): ~~fish propagation~~ 0.25 cubic feet per second. non-consumptive acre-feet per year, from ~~November 30~~ to April 30 each year.

LEGAL DESCRIPTION OF LANDS UPON WHICH THIS WATER IS TO BE USED:

ALL that portion of Government Lot 2, Sec. 6, T. 21 N., R. 2 E.W.M., lying northeasterly of the northeasterly line of State Highway No. 14 and northwesterly of the northwesterly line of Burnham-Hunt County Road.

EXCEPT that part thereof conveyed to the Town of Gig Harbor for road by deed recorded under Auditor's Fee No. 1520256.



FOR POWER. cubic feet per second continuously each year. Total power to be developed theoretical horse power. Total fall to be utilized feet.

Works to be located in Sec , Twp. N., Rge. W.M.

Water to be returned to

Point of return Sec Twp N., Rge W.M.

Use to which power is to be applied

ADDITIONAL LIMITATIONS AND PROVISIONS. Permittee shall construct and maintain at his own expense a weir, or other suitable device, for measurement of water related to this appropriation, as required by the Department of Ecology.

Diversion intake shall be tightly screened at all times with wire mesh having openings with dimensionsmot greater than .125 (1/8) inch. Water approach velocity to the screen shall be less than 1 foot per second and approaching 0.5 foot per second, as measured one foot in front of the screen.

Notdam shall be constructed in connection with this diversion.

Nothing in this permit shall be construed as excusing the permittee from compliance with any applicable federal, state, or local statutes, ordinances, or regulations including those administered by local agencies under the Shoreline Management Act of 1971.

DESCRIPTION OF PROPOSED WORKS **small drop board dam in culvert under roadway; gravity 4 inch pipeline to settling box; gravity pipeline to rearing troughs.**

DEVELOPMENT SCHEDULE

Construction work shall begin on or before **Started**

and shall thereafter be prosecuted with reasonable diligence and completed on or before **Completed**

and complete application of water to proposed uses shall be made on or before **July 1, 1974**

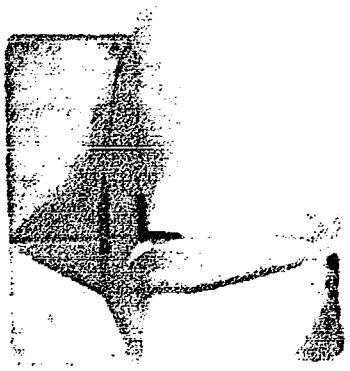
This permit shall be subject to cancellation should the permittee fail to comply with the above development schedule and or fail to give notice to the Department of Ecology on forms provided by that Department documenting such compliance

Given under my hand and the seal of this office at Olympia, Washington, this **29th** day of **June** 19 **73**

JOHN A. BIGGS, Director
Department of Ecology

ENGINEERING DATA

By **R. Jerry Bollen, Assistant Director**



FOR POWER. cubic feet per second continuously each year. Total power to be developed theoretical horse power. Total fall to be utilized feet.

Works to be located in Sec. Twp. N., Rge. W.M.

Water to be returned to

Point of return Sec. Twp N., Rge W.M.

Use to which power is to be applied

ADDITIONAL LIMITATIONS AND PROVISIONS: Permittee shall construct and maintain at his own expense a weir, or other suitable device, for measurement of water related to this appropriation, as required by the Department of Ecology.

Diversion intake shall be tightly screened at all times with wire mesh having openings with dimensions not greater than .125 (1/8) inch. Water approach velocity to the screen shall be less than 1 foot per second and approaching 0.5 foot per second, as measured one foot in front of the screen.

No dam shall be constructed in connection with this diversion.

Nothing in this permit shall be construed as excusing the permittee from compliance with any applicable federal, state, or local statutes, ordinances, or regulations including those administered by local agencies under the Shoreline Management Act of 1971.

DESCRIPTION OF PROPOSED WORKS **small drop board dam in culvert under roadway; gravity 4 inch pipeline to settling box; gravity pipeline to rearing troughs.**

DEVELOPMENT SCHEDULE

Construction work shall begin on or before **Started**

and shall thereafter be prosecuted with reasonable diligence and completed on or before **Completed**

and complete application of water to proposed uses shall be made on or before **July 1, 1974**

This permit shall be subject to cancellation should the permittee fail to comply with the above development schedule and or fail to give notice to the Department of Ecology on forms provided by that Department documenting such compliance

Given under my hand and the seal of this office at Olympia, Washington, this **25th** day of **June** 19**73**

JOHN A BIGGS *Director*
Department of Ecology

ENGINEERING DATA

BK

by
R. Jerry Beller
Assistant Director

Form 10 8 F No 170—(Rev 6-70)

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

Permit to Appropriate Public Surface Waters of the State of Washington

Book No. --- of Permits, on Page S2-00667P Under Application No. 23560

GIG HARBOR FISHERMEN'S CIVIC CLUB for GEORGE W. BORGEN

of Gig Harbor, Washington

is, pursuant to the Report of Examination which has been accepted by the applicant, hereby granted a permit to appropriate the following described public surface waters of the State of Washington, subject to existing rights and to the limitations and provisions set out herein.

Priority date of this permit is November 29, 1971

Source of the proposed appropriation is North Creek

tributary of Gig Harbor

The quantity of water appropriated shall be limited to the amount which can be beneficially applied and not to exceed 0.25 cubic feet per second, non-consumptive acre-feet per year, or its equivalent in case of rotation, to be used for the following purposes: fish propagation as more definitely set out below.

The approximate point(s) of diversion is/are 1400 feet east and 50 feet south of the center of Sec. 6

being within Government Lot 2

of Sec. 6 Twp. 21 N., Rge. 2 E. W.M., Pierce County.

The use or uses to which water is to be applied:

Domestic/municipal supply: cubic feet per second acre-feet per year, during entire year.

Irrigation: cubic feet per second. acre-feet per year from to each year, for irrigation of acres.

Other use(s): fish propagation 0.25 cubic feet per second, non-consumptive acre-feet per year, from continuously to each year.

LEGAL DESCRIPTION OF LANDS UPON WHICH THIS WATER IS TO BE USED:

ALL that portion of Government Lot 2, Sec. 6, T. 21 N., R. 2 E.W.M., lying northeasterly of the northeasterly line of State Highway No. 14 and northwesterly of the northwesterly line of Burnham-Hunt County Road.
EXCEPT that part thereof conveyed to the Town of Gig Harbor for road by deed recorded under Auditor's Fee No. 1520256.

REPORT OF EXAMINATION

Date of application November 27, 1972 Date of examination August 2, 1973 Application No. 53562

Name Gig Harbor Fishermen's Civic Club Address P.O. Box 1300, Gig Harbor, WA 98335

Quantity applied for 0.25 c.f.s. Use Fish propagation

Source of appropriation Spring Creek Tributary of Gig Harbor

Legal sub Govt. Lot 2 Sec. 6 Twp. 21 N. Rge 2 E. County Pierce

Measured or estimated quantity 17.0 c.f.s. Probable low flow 3.0 c.f.s.

Quantity previously appropriated W.T. for records CWT. ET.

Other use made of water All prior rights are upstream from this application

Diversion works contemplated or observed Small dam board dam in culvert under roadway, gravity 4" pipeline to settling box, gravity pipeline to rearing troughs.

Other equipment

Irrigable acreage: Planned Present Feasible

Other water rights appurtenant to this land None

Progress of project Complete

Protests None

Quantity recommended (total) 0.25 c.f.s. (nonconsumptive) Irrig. Dom. Fish propagation - 0.25 c.f.s. (consumptive)

Power Municipal Other uses

Department of Fisheries and Game report See below

Special remarks and provisions:

In accordance with the recommendations of the Departments of Fisheries and Game, the permit shall be issued subject to the following provisions that:

1) Diversion intake shall be tightly screened at all times with wire mesh having openings with dimensions not greater than .125 (1/8) inch. Water approach velocity to the screen shall be less than 1 foot per second and approaching 0.5 foot per second, as measured one foot in front of the screen.

2) No dam shall be constructed in connection with this diversion.

The existing small dam would not appear to impede migratory fish. However, this is a matter between the applicant and the State Departments of Fisheries and Game.

This application can be approved for 0.25 cubic foot per second for fish propagation to incubate Salmon eggs from November 1 to April 30 of each year and is a nonconsumptive use.

Additionally, the permit when issued shall carry the following provision. "Nothing in this permit shall be construed as excusing the permittee from compliance with any applicable federal, state, or local statutes, ordinances or regulations including those administered by local agencies under the Shoreline Management Act of 1971."

In accordance with Section [illegible] RCW, it is the finding that there is water available for appropriation from the source in question and that the diversion as recommended above will not impair existing rights or be detrimental to the public welfare. Therefore, permit should issue, subject to existing rights and the following provisions.

Issued at Olympia, Washington, this 29 day of May, 1973.

[illegible] Resources Management
Department of Ecology

REPORT OF EXAMINATION

Date of application 11-29-71 Date of examination _____ Application No. 23560

Name Gig Harbor Fishermen's Civic Club for George W. Borgen Address Rt. 2, Box 2080, Gig Harbor, Wa. 98335

Quantity applied for 0.25 c.f.s. Use Fish progagation

Source of appropriation North Creek Tributary of Gig Harbor

Legal sub. Govt lot 2 Sec. 6 Twp. 21 Rge. 2 E. County Pierce

Measured or estimated quantity 10.0 cfs Probable low flow 3.0 cfs

Quantity previously appropriated: W.T See rec. CWT. E.T.

Other use made of water All prior rights are upstream from this app.

Diversion works contemplated or observed 4"

Other equipment

Irrigable acreage: Planned Present Feasible

Other water rights appurtenant to this land none

Progress of project Complete

Protests none

Quantity recommended (total) 0.25 cfs (non-con) Irrig. Dom.

Power Municipal Fish prop Other uses 0.25 cfs (n-c)

Department of Fisheries and Game report 1) Screen 2) no dam

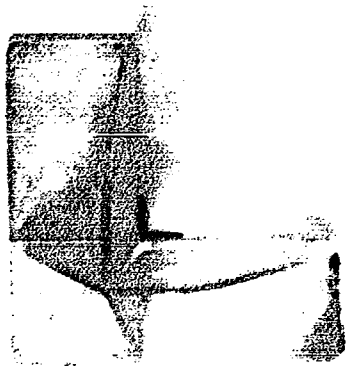
Special remarks and provisions:

$20.00

The existing small dam would not appear to impede migratory fish. However, this is a question between the applicant & the State Dept's of fisheries & Game

This appl. can be approved for 0.25 cfs for fish prop ~~[illegible]~~ to incubate Salmon Eggs from Nov. 1 to April 30 of each year. It is a non-consumptive use

Sec 2



Form 10
S F No 370-A—OS (Rev 4-70

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

OLYMPIA, WASHINGTON

Please send $10.00 minimum statutory examination fee with application

PRIORITY	
Date	NOV. 29 1971
Time	1000 hrs
Accepted	

Application No. 23560

APPLICATION FOR A PERMIT
To Appropriate Public Surface Waters of the State of Washington

(Note: Gray boxes are for office use only)
(Read instruction sheet before filling out this form.)

I, Gig Harbor Fishermen's Civic Club FOR GEORGIE W. BOEGEN
Name of applicant

If the applicant is a corporation, give date and place of incorporation

of Rt. 3, Box 2[illegible], Gig Harbor, Wn. [illegible]
(Complete postoffice address)

do hereby make application for a permit to appropriate the following described public waters of the State of Washington subject to existing rights

1. *The source of the proposed appropriation is* [redacted] North Creek
(Name of source stream, lake, river, spring, etc. If unnamed so state)
tributary of Gig Harbor Bay (Puget Sd.)

NORTH CREEK TRIBUTARY OF GIG HARBOR

2. *The amount of water which the applicant intends to apply to beneficial use is* ¼ CFS max. *cubic feet per second.* [redacted] *acre-feet per year.* 0.25

3. *The use to which the water is to be applied is* Incubate Salmon Eggs
Irrigation, power, mining, manufacturing, domestic supply, etc.)

FISH PROPAGATION

4. *Time during which water will be required each year* Nov. 1 - April 30

5. *The approximate point of diversion is located* [illegible] feet S. E. of the center of Sec. 6
Give measured distance and bearing of north-south and east-west distances from nearest section or subsection corner

TO BE EXACT [redacted] 1400' E & 50' S of the center of Sec. 6

being within the [redacted] *Sec.* 6 *Tp.* 21 N. *R.* 2 E. *or W., W.M.*
(Give aliquot legal subdivision)

in the county of Pierce
(Accurately mark and identify each point of diversion on the maps or plats submitted with this application.)

[redacted] of Sec. 6, T. 21 N., R. 2 E. W.M.
Govt Lot 2

6. **WORK SCHEDULE:**

(a) *Construction work will begin on or before* [illegible]

(b) *Construction work will be completed on or before* December 15, 1971 Complete

(c) *Water will be put to complete beneficial use on or before* December 15, 1971 In use

7. *Is the source from which you wish to appropriate water on the tract of land on which the water is to be used?* Yes

8. **DESCRIPTION OF WORKS:**

(a) *Nature of works:* (*Reservoir, dam, ditch, flume, pumping plant, etc.*)

Pipe running from 11" dam.

(b) *Dimensions of works:*

Dam: Height 11" ~~feet~~ *length at bottom* 6 *feet; length at top* 6 *feet; thickness at bottom* 2" ~~feet~~ *thickness at top* " ~~feet~~ *slope at front water face* 90° *, slope at back face* none *: material used in construction* 1 plank

Reservoir: Capacity when filled 66 Cu. ~~acre~~ *feet. Surface area at highwater mark* *acres.*

If 10 acre-feet or more of water is to be stored and or if the water depth will be 10 feet or more at the deepest point, a storage permit must be filed in addition to the above. These forms can be secured, together with instructions, by addressing the Department of Ecology, Olympia, Washington.

(c) *Description of Ditch or Pipeline System* one ¾" pipe 24' in length

9. **IRRIGATION:** *Number of acres to be irrigated* NA

If you are an S.C.S. cooperator, please include a tracing of your farm plan map with this application.

10. **MUNICIPAL WATER SUPPLY:**

To supply the city of NA *, having a present population of* *and an estimated population of* *in 19* ....

(a *Estimated present requirement*

11. **MULTIPLE DOMESTIC WATER SUPPLY** (*Unincorporated Areas*)

Maximum number and type of family units to be supplied from this requested appropriation

NA

12. **LEGAL DESCRIPTION OF PROPERTY** *on which water is to be used, for all purposes*

(*Copy legal description from deed; or attach copy of deed. Tax statement descriptions are not acceptable. Also outline this property on the maps or plats submitted with this application.*)

All that portion of Government Lot 2 in Section 6, Township 21 North, Range 2 East of the Willamette Meridian lying Northeasterly of the Northeasterly line of State Highway No. 14 and Northwesterly of the of the Northwesterly line of Burnham-Hunt County Road. EXCEPT that part thereof conveyed to the Town of Gig Harbor for road by deed recorded under Auditor's Fee No. 1[illegible]

(a) What interest do you have in the property described under Item No 12? Use of property donated by owner to the Gig Harbor Fishermans Civic Club for this project
(Owner, lessee, contract purchaser)

(b) Are there any existing water rights appurtenant to the above described property?

If so, from what source and under what authority

13. POWER GENERATION:

(a) Total amount of power to be developed NA H.P.
(The actual horsepower)

(b) Total fall to be utilized feet
(Head)

(c) The nature of the works by means of which the power is to be developed

(d) Such works to be located in (Legal subdivision) Sec. , Tp N., Rge. (E. or W.) W.M.

(e) To what stream is the water to be returned? Same Stream

(f) Locate point of return Sec. , Tp. 21 N., Rge. 2 E (E. or W.) W.M.

(g) The use to which power is to be applied is

14. SIGNATURES:

(SIGN HERE) Mike Halligan (Applicant) Address P. O. Box 1250, Gig Harbor, Wa.

(SIGN HERE) (Owner of Land in Item 12) Address P. O. Box 2, Gig Harbor, Wa.

Remarks: The water is to be taken out of a County land culvert which is now in existence on the street.

STATE OF WASHINGTON, } ss.

COUNTY OF THURSTON.

This is to certify that I have examined the foregoing application together with the accompanying maps and data, and return the same for correction or completion, as follows: (1) Furnish a full size, facsimile copy of the Auditors Plat of E½ of Sec. 2, T. 21N, R. 2 W.W.M., to include the 2 tracts referred to under Item 12. Outline, outline the land upon which this water is to be used and more fully identify the point of diversion on North Creek. (2) Recommend you show applicant to be "[illegible] Harbor Fishermans Club for George W. Bergen [sp.]", since water right may be issued only in the name of the land owner.

In order to retain its priority, this application must be returned to the Department of Ecology, with corrections, on or before 3 JANUARY, 1972

WITNESS my hand this 30th day of November, 1971

Benjamin [illegible]
Department of Ecology

Appendix C

Stakeholder Meeting Attendees, November 8, 2022

GIG HARBOR
"THE MARITIME CITY"

NORTH CREEK CULVERT REPLACEMENT FEASIBILITY STAKEHOLDER MEETING
NOVEMBER 8, 2022 ~ 1:00 p.m. to 2:00 p.m.

ATTENDEES

NAME	EMAIL ADDRESS
Bradley Beach	beach.brad@navy.mil
Jessica Cunningham	jessicac@penlight.org
JEFF OLSEN	JOLSEN@GIGHARBORWA.GOV
JEFF LANGHELM	jlanghelm@gigharborwa.gov
Jennifer Haro	jharo@gigharborwa.gov
DAVID DINKUHN	ddinkuhn@parametrix.com
STEVE SEVILLE	SSEVILLE@PARAMETRIX.COM
Katrina Knutson	KKnutson@gigharborWA.gov
Jennifer Keating, PTOI	REMOTELY
Margaret Berger, CRC	
Robin Bolster-Grant	
Miles Penk, WDFW	
Angela Dillon, PTOI	
Brandon Reynon, PTOI	
Rachel, Harbor Wildwatch	

Appendix D

Hydrology and WDFW Climate Change Report

North Creek Preliminary Hydrologic Analysis

Prepared for

City of Gig Harbor

Prepared by

Parametrix
60 Washington Avenue, Suite 390
Bremerton, WA 98337
T. 360.377.0014 F. 1.855.542.6353
www.parametrix.com

August 2022 | 233-2750-042

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Figure 2A: NRCS Soils Map

Figure 2B: NRCS Soils Map Legend

Figure 2C: NRCS Soils Map Descriptions

APPENDICES

A SWMMWW Reference

B WWHM 2012 Report

ACRONYMS AND ABBREVIATIONS

Basin	North Creek Basin
cfs	cubic feet per second
City	City of Gig Harbor
Creek	North Creek
DNR	Washington State Department of Natural Resources
Drainage Basin	North Creek Drainage Basin
Ecology	Washington State Department of Ecology
gpm	gallons per minute
GULD	General Use Level Designation
LID	Low Impact Development
Manual	Pierce County Stormwater Manual 2021
NPGHS	non-pollution-generating hard surfaces
PGHS	pollution-generating hard surfaces
pH	potential of hydrogen
Project	North Creek Fish Passage Barrier Removal Project
Project Basin	North Creek Basin
PS&E	plans, specifications, and estimate
sf	square feet
SPCC	Spill Prevention Countermeasures and Control
SSP	Stormwater Site Plan
SWPPP	Stormwater Pollution Prevention Plan
SWMMWW	2019 Stormwater Management Manual for Western Washington
TAPE	Technology Assessment Protocol – Ecology
TDA	Threshold Discharge Area
TP	total phosphorus
WSDOT	Washington State Department of Transportation

1. INTRODUCTION

Harborview Drive is a two-lane bi-directional, minor arterial roadway that blocks fish passage on North Creek, previously known as Donkey Creek. Removing this fish passage barrier would open about one mile of stream for Chum, Coho, Steelhead, Sea Run Cutthroat, and resident trout. The existing rectangular box culvert is not adequately sized to allow fish passage and appropriately handle the 100 – year flows produced by the North Creek Drainage Basin (Drainage Basin).

This write up attempts to bracket the 100-year flow rate of North Creek and specifies a design flow that shall be used to design the chosen fish passage alternative. Flows were calculated in WWHM 2012 and gathered from previous reports.

2. BASIN DESCRIPTION

The Project is located within the North Creek Drainage Basin Near the city of Gig Harbor. The Drainage Basin was delineated to be approximately 1,162 acres per the StreamStats basin delineation tool. In general, this Drainage Basin flows from North to South. The upper reaches of the Drainage Basin have been heavily impacted by commercial and residential development, and the undeveloped areas are primarily forest. The mean slope of the basin was determined to be 6.16% per the StreamStats mean slope tool using a 30-meter Digital Elevation Model (DEM). The Creek outfalls into the Harbor at Gig Harbor at North Harborview Drive adjacent to the Harbor History Museum.

2.1 Land Use

The Project Basin encompasses 1,162 acres of commercial, residential, and forested properties. Land use for the Basin is quantified in Table 1. A visual representation of land use is in Figure 1 (figures are located at the end of this document).

Table 1. North Creek Basin Land Use Types

Land Use Designation	Area (acres)
Residential DU/GA = 1	11
Residential DU/GA = 2	24
Residential DU/GA = 3.5	231
Residential DU/GA = 6	108
Residential DU/GA = 8	134
Impervious	199
Lawn	51
Pond	13
Forest	391
Total	1,162

Note: DU/GA = Dwelling Unit per Gross Acre. Higher DU/GA corresponds with a higher density of homes.

2.2 Soils

Soils within the Drainage Basin are categorized as predominantly Harstine Gravelly Ashy Sandy Loam with a smaller area classified as Indianola Loamy Sand, per the Natural Resources Conservation Service (NRCS) Soils map (Figures 2A, 2B, and 2C). Harstine Gravelly Ashy Sandy Loam is classified as soil type C (Moderately well drained) and Indianola Loamy Sand is classified as soil type A (Somewhat excessively drained). These soil types were specified in the WWHM 2012 analysis appropriately.

2.3 Analysis

Gig Harbor uses the 2021 Pierce County Stormwater and Site Development Manual which requires storm water conveyance designs to be sized for the peak of the 100-year 24-hour storm runoff. For this analysis the 100-year 24-hour storm runoff flow rate was calculated using WWHM 2012. WWHM 2012 is an approved continuous runoff model.

WWHM 2012 requires inputs of location data, slope, land use, and soil type to run the model. The 38in CENTRAL location was specified on the WWHM 2012 software's provided map. A moderate slope (5% to 15%) was used for all land use types since the StreamStats mean slope result was 6.16%. Soil types were appropriately specified based on the soils map that was discussed in the Soils section of this report. Final model inputs used in the WWHM 2012 are presented in Table 4. Land use types were specified as follows:

Land Use Type: Residential DU/GA = "X"

Residential areas were broken down into impervious, lawn, and forest, so they could be modeled in WWHM 2012. All residential numbers were preliminarily determined by Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas (continued) located in Volume III – Chapter 2 – Page 459 of the 2019 Stormwater Management Manual for Western Washington (SWMMWW). This table is located in Appendix A. The breakdown of DU/GA was associated with the areas corresponding to the hatches in Figure 1 of this report. It was then assumed that 50% of each of these residential areas had flow control present so that 50% of the total area could be modeled as Forest with Soil Type C. This assumption removes some of the conservatism that is built into the WWHM 2012 Model.

Example: DU/GA = 6 (108 AC)

Table 2. DU/GA = 6 (108 Acres) Example Preliminary Breakdown

Land Type	Percentage	Area (acres)
Impervious	52%	56.16
Lawn	48%	51.84
Total		108

Note: Percentage column comes from Table III-2.5 cited in the above paragraph.

After assuming 50% flow control this break down would change to:

Table 3. DU/GA = 6 (108 Acres) Example Final Breakdown with Flow Control Included

Land Type	Percentage	Area (acres)
Impervious	26%	28.08
Lawn	24%	25.92
Forest**	50%	54
Total		108

** Designates flow-controlled area which will be modeled as forest soil type C in the WWHM 2012 model.

Land Use Type: Impervious

Similar to the Residential areas, all impervious designated areas in Figure 1 were multiplied by a factor to assume the effects of flow control measures that are likely in place. It was assumed that 80% of the designated impervious areas would have flow control present, and that 80 percent of the 199 acres present in the basin could be modeled as Forest with Soil Type C in the WWHM 2012 model.

Land Use Type: Lawn

Lawn area was determined by summing the lawn area from the residential area final breakdown and the designated lawn area in Figure 1 (Yellow hatch).

Land Use Type: Forest

Forest area was determined by summing the forest area and "Flow Control" area from the residential area final breakdown, the "Flow Control" area from the impervious area, and the designated forest area in Figure 1 (Peach hatch). Forest was further broken down by Soil type according to the soils map figure in Figure 2A. 40% of the designated forest area (Peach hatch) was modeled with Soil Type A and 60% was modeled with Soil Type C.

Land Use Type: Pond

Approximately 13 acres of ponds are present in the basin.

Table 4. North Creek Basin WWHM 2012 Model Inputs

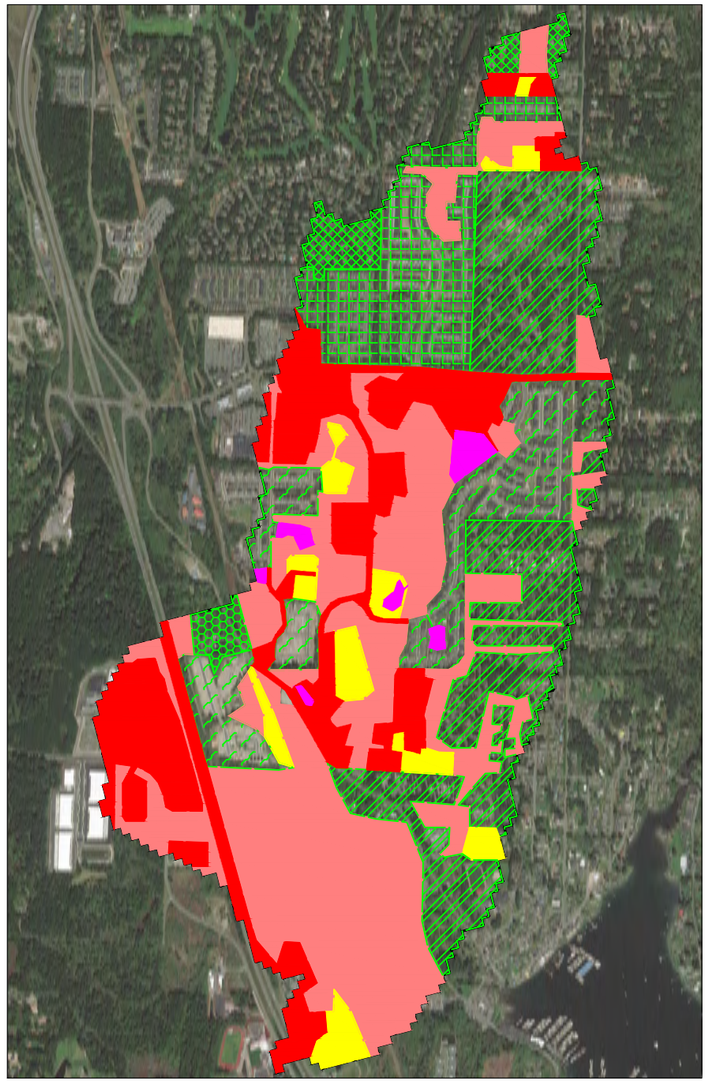
Land Use Designation	Area (acres)
Forest Moderate Slope (5% - 15%) Soil Type A/B	156.4
Forest Moderate Slope (5% - 15%) Soil Type C	689.32
Lawn Moderate Slope (5% - 15%) Soil Type C	147.31
Pond	13
Impervious Moderate Slope (5% - 15%)	155.97
Total	1,162

Modeling results of the hydrologic analysis are presented in Table 5 below. Other flows presented in Table 5 are flow rates gathered from older reports using different methods. The full WWHM 2012 report is included in Appendix B.

Table 5. Peak Runoff Rates (100-year Storm)

Analysis Method	Location	Area (sq mi)	Area (acre)	100 – year (cfs)	Projected 100 – year Flow in 2080 (48.3% Increase) (cfs)
WWHM 2012	Harborview Drive	1.82	1162	226	335
FEMA FIS 2017	Harborview Drive	1.6	1024	116	172
HEC-HMS Modeling Results - Gig Harbor Basin Plan Volume 2 (2005)	DK-04 (Harborview Drive)	2.16	1382.4	221	328

In conclusion, the 100-year design flowrate should fall between the 116 CFS and 226 cfs. This range is due to the use of varying analysis methods and the dates at which these analyses were completed. Due to the basin having an expected 48.3% increase in flow by 2080 per the WDFW Climate Change App, the more conservative 100-year design flow rate of 226 cfs should be used and the projected 100-year flowrate of 335 cfs should be considered when designing the culvert and associated structures.



DU/GA = 1
AREA = 466,962 SF (11 AC)

DU/GA = 2
AREA = 1,023,064 SF (24 AC)

DU/GA = 3.5
AREA = 10,055,913 SF (231 AC)

DU/GA = 6
AREA = 4,685,697 SF (108 AC)

DU/GA = 8
AREA = 5,807,618 SF (134 AC)

IMPERVIOUS (FACTOR: 20% IMPERVIOUS / 80% FOREST SOIL TYPE C)
AREA = 8,665,615 SF (199 AC)

LAWN (SOIL TYPE C)
AREA = 2,227,168 SF (51 AC)

POND
AREA = 540,345 SF (13 AC)

FOREST (FACTOR: 40% SOIL TYPE A / 60% SOIL TYPE C)
AREA = 17,030,262 SF (391 AC)

NORTH CREEK BASIN BOUNDARY
AREA = 50,502,643 (1,162 AC)

GENERAL NOTES:
1. DU/GA = DWELLING UNIT PER GROSS ACRE
2. ALL LAND TYPES WERE MODELED WITH MODERATE SLOPES (5%–15%)
3. AVERAGE SLOPE ACROSS BASIN = 6.16% (PER STREAMSTATS 30m DEM)

N

SCALE IN FEET
0 500 1000

PRELIMINARY

	REVISIONS	DATE	BY

DESIGNED
DRAWN
CHECKED
APPROVED

ONE INCH AT FULL SCALE. IF NOT, SCALE ACCORDINGLY

FILE NAME: NorthCreek_Aerial
JOB No.: 233-2750-042
DATE: 10/01

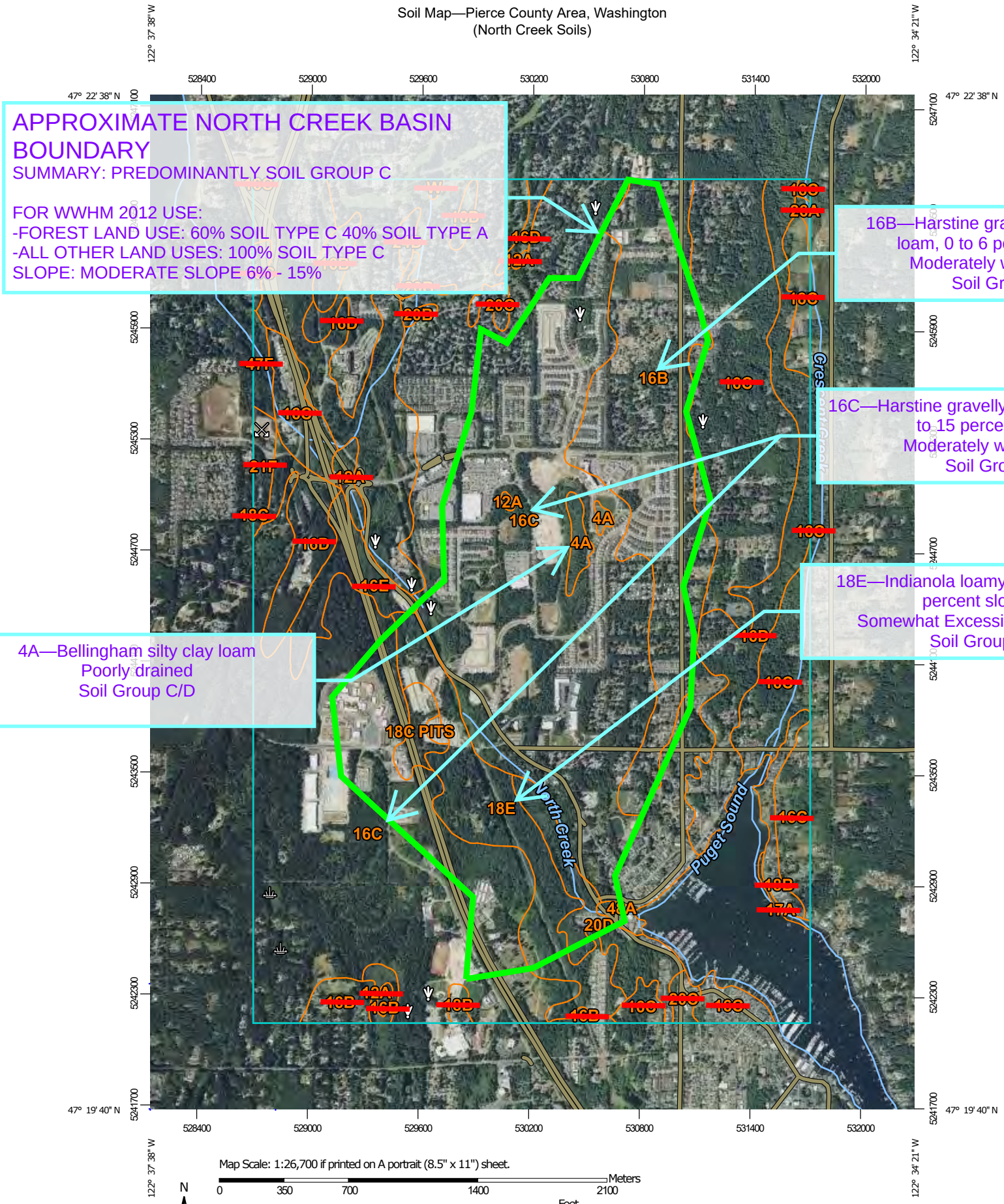
Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

NORTH CREEK CULVERT FEASIBILITY STUDY

PRELIMINARY HYDROLOGIC ANALYSIS

FIGURE 1
LAND USE TYPES

LAYOUT: 22X34 PATH: \\parametrix.com\pmx\PSO\Projects\Clients\2750-CityOfGigHarbor\233-2750-042 North Creek Culvert FS\995vcs\CADD\DWG\Hydrologic Analysis PLOTTED BY: OdegaCoo DATE: Thursday, September 1, 2022 12:11:00 PM



Map Scale: 1:26,700 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 350 700 1400 2100

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

FIGURE 2A

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Pierce County Area, Washington
Survey Area Data: Version 17, Aug 31, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 21, 2021—Nov 29, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

FIGURE 2B

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
4A	Bellingham silty clay loam	13.6	0.4%
12A	Dupont muck	22.0	0.6%
16B	Harstine gravelly ashy sandy loam, 0 to 6 percent slopes	363.2	10.6%
16C	Harstine gravelly ashy sandy loam, 6 to 15 percent slopes	2,075.7	60.7%
16D	Harstine gravelly ashy sandy loam, 15 to 30 percent slopes	393.6	11.5%
16E	Harstine gravelly ashy sandy loam, 30 to 45 percent slopes	46.3	1.4%
17A	Hydraquents, level	3.3	0.1%
18B	Indianola loamy sand, 0 to 5 percent slopes	27.0	0.8%
18C	Indianola loamy sand, 5 to 15 percent slopes	42.1	1.2%
18E	Indianola loamy sand, 15 to 30 percent slopes	143.9	4.2%
20B	Kitsap silt loam, 2 to 8 percent slopes	9.1	0.3%
20C	Kitsap silt loam, 8 to 15 percent slopes	17.0	0.5%
20D	Kitsap silt loam, 15 to 30 percent slopes	61.3	1.8%
21F	Kitsap-Indianola complex, 45 to 70 percent slopes	15.7	0.5%
24D	Neilton gravelly loamy sand, 8 to 25 percent slopes	5.9	0.2%
28A	Norma fine sandy loam	2.8	0.1%
47F	Xerochrepts, 45 to 70 percent slopes	12.0	0.4%
48A	Urban Land, 0 to 5 percent slopes	6.5	0.2%
PITS	Pits	2.9	0.1%
W	Water	1.4	0.0%
Totals for Area of Interest		**3,417.2**	**100.0%**

FIGURE 2C

Appendix A

SWMMWW Reference

Table III-2.5: Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas (continued)

	CNs for Hydrologic Soil Group			
Cover type and hydrologic condition	**A**	**B**	**C**	**D**
(use impervious area CNs)				
Single Family Residential[3]:				
Should only be used for subdivisions > 50 acres				
Dwelling Unit/Gross Acre	Average Percent impervious area[3,4]			
1.0 DU/GA	15	Separate curve number shall be selected for pervious & impervious portions of the site or basin		
1.5 DU/GA	20			
2.0DU/GA	25			
2.5 DU/GA	30			
3.0 DU/GA	34			
3.5 DU/GA	38			
4.0 DU/GA	42			
4.5 DU/GA	46			
5.0 DU/GA	48			
5.5 DU/GA	50			
6.0 DU/GA	52			
6.5 DU/GA	54			
7.0 DU/GA	56			
7.5 DU/GA	58			
PUD's condos, apartments, commercial businesses, industrial areas & subdivisions < 50 acres:				
% impervious must be computed	Separate curve numbers shall be selected for pervious and impervious portions of the site			

Notes:

1. Composite CN's may be computed for other combinations of open space cover type.

2. Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in BMP T5.10A: Downspout Full Infiltration, BMP T5.10B: Downspout Dispersion Systems, or BMP T5.30: Full Dispersion, the average percent impervious area may be adjusted in accordance with the procedures described in BMP T5.10A: Downspout Full Infiltration, BMP T5.10B: Downspout Dispersion Systems, or BMP T5.30: Full Dispersion.

3. Assumes roof and driveway runoff is directed into street/storm system.

4. All the remaining pervious area (lawn) are considered to be in good condition for these curve numbers.

Appendix B

WWHM 2012 Report

APPENDIX B

WWHM2012
PROJECT REPORT

Project Name: NorthCreek
Site Name:
Site Address:
City :
Report Date: 9/1/2022
Gage : 38 IN CENTRAL
Data Start : 10/01/1901
Data End : 09/30/2059
Precip Scale: 1.00
Version Date: 2019/09/13
Version : 4.2.17

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : Assumed Flow Control
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Mod	156.4
C, Forest, Mod	689.32
C, Lawn, Mod	147.31
Pervious Total	993.03

Impervious Land Use	acre
ROADS MOD	155.97
POND	13
Impervious Total	168.97
Basin Total	1162

Element Flows To:
Surface **Interflow** **Groundwater**

MITIGATED LAND USE

Name : Moderate Slope

Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Mod	156.4
C, Forest, Mod	689.32
C, Lawn, Mod	147.31
Pervious Total	993.03

Impervious Land Use	acre
ROADS MOD	155.97
POND	13
Impervious Total	168.97
Basin Total	1162

Element Flows To:
Surface **Interflow** **Groundwater**

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:993.03
Total Impervious Area:168.97

Mitigated Landuse Totals for POC #1
Total Pervious Area:993.03
Total Impervious Area:168.97

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	78.231286
5 year	110.152898
10 year	134.224802
25 year	168.162746
50 year	196.12297
100 year	226.482834

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)

2 year	78.231286
5 year	110.152898
10 year	134.224802
25 year	168.162746
50 year	196.12297
100 year	226.482834

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1902	76.254	76.254
1903	83.293	83.293
1904	140.320	140.320
1905	48.339	48.339
1906	51.995	51.995
1907	92.639	92.639
1908	62.864	62.864
1909	67.390	67.390
1910	96.953	96.953
1911	80.070	80.070
1912	227.938	227.938
1913	62.768	62.768
1914	260.239	260.239
1915	49.749	49.749
1916	83.838	83.838
1917	35.921	35.921
1918	63.504	63.504
1919	51.011	51.011
1920	76.083	76.083
1921	65.748	65.748
1922	104.045	104.045
1923	64.417	64.417
1924	90.144	90.144
1925	42.960	42.960
1926	72.036	72.036
1927	64.879	64.879
1928	58.129	58.129
1929	102.489	102.489
1930	98.635	98.635
1931	56.803	56.803
1932	64.958	64.958
1933	65.605	65.605
1934	118.782	118.782
1935	50.022	50.022
1936	67.225	67.225
1937	105.889	105.889
1938	57.835	57.835
1939	52.864	52.864
1940	106.633	106.633
1941	106.003	106.003
1942	95.444	95.444
1943	74.499	74.499
1944	135.732	135.732
1945	76.991	76.991
1946	84.731	84.731
1947	47.107	47.107

1948	88.419	88.419
1949	96.020	96.020
1950	62.266	62.266
1951	109.708	109.708
1952	172.492	172.492
1953	146.868	146.868
1954	64.531	64.531
1955	63.138	63.138
1956	54.575	54.575
1957	55.385	55.385
1958	110.963	110.963
1959	111.807	111.807
1960	57.266	57.266
1961	180.544	180.544
1962	66.913	66.913
1963	45.343	45.343
1964	201.458	201.458
1965	92.438	92.438
1966	56.156	56.156
1967	96.156	96.156
1968	69.993	69.993
1969	64.177	64.177
1970	87.223	87.223
1971	87.544	87.544
1972	242.049	242.049
1973	114.648	114.648
1974	91.296	91.296
1975	140.932	140.932
1976	124.820	124.820
1977	44.148	44.148
1978	105.453	105.453
1979	75.714	75.714
1980	98.491	98.491
1981	76.603	76.603
1982	57.611	57.611
1983	86.269	86.269
1984	83.276	83.276
1985	119.697	119.697
1986	58.947	58.947
1987	110.888	110.888
1988	55.592	55.592
1989	55.341	55.341
1990	73.303	73.303
1991	112.693	112.693
1992	96.427	96.427
1993	79.689	79.689
1994	82.442	82.442
1995	50.504	50.504
1996	98.712	98.712
1997	65.905	65.905
1998	88.136	88.136
1999	81.363	81.363
2000	65.169	65.169
2001	60.620	60.620
2002	139.658	139.658
2003	75.240	75.240
2004	81.766	81.766

2005	195.929	195.929
2006	70.255	70.255
2007	87.862	87.862
2008	70.609	70.609
2009	53.653	53.653
2010	67.387	67.387
2011	66.974	66.974
2012	65.060	65.060
2013	73.553	73.553
2014	62.185	62.185
2015	129.532	129.532
2016	68.960	68.960
2017	94.111	94.111
2018	119.708	119.708
2019	154.206	154.206
2020	89.584	89.584
2021	74.645	74.645
2022	101.740	101.740
2023	125.174	125.174
2024	228.735	228.735
2025	69.375	69.375
2026	107.751	107.751
2027	79.189	79.189
2028	30.237	30.237
2029	64.666	64.666
2030	100.697	100.697
2031	35.911	35.911
2032	57.565	57.565
2033	66.272	66.272
2034	51.848	51.848
2035	106.372	106.372
2036	67.797	67.797
2037	84.916	84.916
2038	96.849	96.849
2039	143.732	143.732
2040	60.804	60.804
2041	70.464	70.464
2042	104.711	104.711
2043	83.509	83.509
2044	69.778	69.778
2045	55.127	55.127
2046	62.489	62.489
2047	60.196	60.196
2048	51.330	51.330
2049	76.884	76.884
2050	70.960	70.960
2051	109.087	109.087
2052	72.334	72.334
2053	54.447	54.447
2054	147.804	147.804
2055	66.021	66.021
2056	90.575	90.575
2057	43.680	43.680
2058	95.617	95.617
2059	125.354	125.354

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	260.2390	260.2390
2	242.0490	242.0490
3	228.7350	228.7350
4	227.9380	227.9380
5	201.4580	201.4580
6	195.9290	195.9290
7	180.5440	180.5440
8	172.4920	172.4920
9	154.2060	154.2060
10	147.8040	147.8040
11	146.8680	146.8680
12	143.7320	143.7320
13	140.9320	140.9320
14	140.3200	140.3200
15	139.6580	139.6580
16	135.7320	135.7320
17	129.5320	129.5320
18	125.3540	125.3540
19	125.1740	125.1740
20	124.8200	124.8200
21	119.7080	119.7080
22	119.6970	119.6970
23	118.7820	118.7820
24	114.6480	114.6480
25	112.6930	112.6930
26	111.8070	111.8070
27	110.9630	110.9630
28	110.8880	110.8880
29	109.7080	109.7080
30	109.0870	109.0870
31	107.7510	107.7510
32	106.6330	106.6330
33	106.3720	106.3720
34	106.0030	106.0030
35	105.8890	105.8890
36	105.4530	105.4530
37	104.7110	104.7110
38	104.0450	104.0450
39	102.4890	102.4890
40	101.7400	101.7400
41	100.6970	100.6970
42	98.7121	98.7121
43	98.6347	98.6347
44	98.4912	98.4912
45	96.9525	96.9525
46	96.8487	96.8487
47	96.4273	96.4273
48	96.1555	96.1555
49	96.0197	96.0197
50	95.6168	95.6168
51	95.4435	95.4435
52	94.1106	94.1106
53	92.6392	92.6392
54	92.4383	92.4383

55	91.2961	91.2961
56	90.5748	90.5748
57	90.1443	90.1443
58	89.5843	89.5843
59	88.4186	88.4186
60	88.1357	88.1357
61	87.8620	87.8620
62	87.5440	87.5440
63	87.2233	87.2233
64	86.2685	86.2685
65	84.9157	84.9157
66	84.7306	84.7306
67	83.8384	83.8384
68	83.5087	83.5087
69	83.2931	83.2931
70	83.2755	83.2755
71	82.4420	82.4420
72	81.7655	81.7655
73	81.3632	81.3632
74	80.0701	80.0701
75	79.6889	79.6889
76	79.1885	79.1885
77	76.9911	76.9911
78	76.8841	76.8841
79	76.6033	76.6033
80	76.2542	76.2542
81	76.0829	76.0829
82	75.7136	75.7136
83	75.2398	75.2398
84	74.6451	74.6451
85	74.4987	74.4987
86	73.5529	73.5529
87	73.3033	73.3033
88	72.3342	72.3342
89	72.0363	72.0363
90	70.9604	70.9604
91	70.6085	70.6085
92	70.4641	70.4641
93	70.2551	70.2551
94	69.9931	69.9931
95	69.7779	69.7779
96	69.3745	69.3745
97	68.9600	68.9600
98	67.7971	67.7971
99	67.3895	67.3895
100	67.3867	67.3867
101	67.2253	67.2253
102	66.9740	66.9740
103	66.9133	66.9133
104	66.2716	66.2716
105	66.0208	66.0208
106	65.9046	65.9046
107	65.7484	65.7484
108	65.6054	65.6054
109	65.1687	65.1687
110	65.0599	65.0599
111	64.9579	64.9579

112	64.8785	64.8785
113	64.6660	64.6660
114	64.5307	64.5307
115	64.4172	64.4172
116	64.1771	64.1771
117	63.5035	63.5035
118	63.1379	63.1379
119	62.8637	62.8637
120	62.7682	62.7682
121	62.4885	62.4885
122	62.2658	62.2658
123	62.1848	62.1848
124	60.8039	60.8039
125	60.6200	60.6200
126	60.1960	60.1960
127	58.9471	58.9471
128	58.1289	58.1289
129	57.8348	57.8348
130	57.6113	57.6113
131	57.5650	57.5650
132	57.2661	57.2661
133	56.8025	56.8025
134	56.1559	56.1559
135	55.5918	55.5918
136	55.3852	55.3852
137	55.3410	55.3410
138	55.1272	55.1272
139	54.5750	54.5750
140	54.4474	54.4474
141	53.6531	53.6531
142	52.8639	52.8639
143	51.9953	51.9953
144	51.8480	51.8480
145	51.3302	51.3302
146	51.0109	51.0109
147	50.5041	50.5041
148	50.0221	50.0221
149	49.7492	49.7492
150	48.3388	48.3388
151	47.1069	47.1069
152	45.3432	45.3432
153	44.1478	44.1478
154	43.6795	43.6795
155	42.9595	42.9595
156	35.9213	35.9213
157	35.9112	35.9112
158	30.2374	30.2374

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
39.1156	6371	6371	100	Pass

40.7016	5518	5518	100	Pass
42.2875	4792	4792	100	Pass
43.8734	4140	4140	100	Pass
45.4594	3580	3580	100	Pass
47.0453	3159	3159	100	Pass
48.6312	2780	2780	100	Pass
50.2172	2456	2456	100	Pass
51.8031	2188	2188	100	Pass
53.3890	1944	1944	100	Pass
54.9750	1729	1729	100	Pass
56.5609	1548	1548	100	Pass
58.1468	1405	1405	100	Pass
59.7328	1267	1267	100	Pass
61.3187	1151	1151	100	Pass
62.9046	1031	1031	100	Pass
64.4906	922	922	100	Pass
66.0765	817	817	100	Pass
67.6624	727	727	100	Pass
69.2484	646	646	100	Pass
70.8343	578	578	100	Pass
72.4202	515	515	100	Pass
74.0062	464	464	100	Pass
75.5921	423	423	100	Pass
77.1780	385	385	100	Pass
78.7640	361	361	100	Pass
80.3499	339	339	100	Pass
81.9358	307	307	100	Pass
83.5218	282	282	100	Pass
85.1077	266	266	100	Pass
86.6936	242	242	100	Pass
88.2796	223	223	100	Pass
89.8655	202	202	100	Pass
91.4514	188	188	100	Pass
93.0374	176	176	100	Pass
94.6233	169	169	100	Pass
96.2092	155	155	100	Pass
97.7951	147	147	100	Pass
99.3811	137	137	100	Pass
100.9670	131	131	100	Pass
102.5529	123	123	100	Pass
104.1389	117	117	100	Pass
105.7248	109	109	100	Pass
107.3107	99	99	100	Pass
108.8967	91	91	100	Pass
110.4826	85	85	100	Pass
112.0685	78	78	100	Pass
113.6545	76	76	100	Pass
115.2404	69	69	100	Pass
116.8263	66	66	100	Pass
118.4123	59	59	100	Pass
119.9982	54	54	100	Pass
121.5841	52	52	100	Pass
123.1701	50	50	100	Pass
124.7560	49	49	100	Pass
126.3419	45	45	100	Pass
127.9279	44	44	100	Pass
129.5138	42	42	100	Pass

131.0997	37	37	100	Pass
132.6857	36	36	100	Pass
134.2716	35	35	100	Pass
135.8575	32	32	100	Pass
137.4435	32	32	100	Pass
139.0294	32	32	100	Pass
140.6153	29	29	100	Pass
142.2013	28	28	100	Pass
143.7872	27	27	100	Pass
145.3731	25	25	100	Pass
146.9591	24	24	100	Pass
148.5450	22	22	100	Pass
150.1309	22	22	100	Pass
151.7169	21	21	100	Pass
153.3028	21	21	100	Pass
154.8887	20	20	100	Pass
156.4747	20	20	100	Pass
158.0606	20	20	100	Pass
159.6465	20	20	100	Pass
161.2325	20	20	100	Pass
162.8184	18	18	100	Pass
164.4043	18	18	100	Pass
165.9903	18	18	100	Pass
167.5762	18	18	100	Pass
169.1621	18	18	100	Pass
170.7480	17	17	100	Pass
172.3340	17	17	100	Pass
173.9199	15	15	100	Pass
175.5058	15	15	100	Pass
177.0918	15	15	100	Pass
178.6777	15	15	100	Pass
180.2636	15	15	100	Pass
181.8496	13	13	100	Pass
183.4355	12	12	100	Pass
185.0214	12	12	100	Pass
186.6074	12	12	100	Pass
188.1933	12	12	100	Pass
189.7792	12	12	100	Pass
191.3652	12	12	100	Pass
192.9511	12	12	100	Pass
194.5370	12	12	100	Pass
196.1230	10	10	100	Pass

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0 **acre-feet**
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**

LID Report

LID Technique	Used for	Total Volume	Volume	Infiltration	Cumulative Percent	Water Quality	Percent	Comment

	Treatment?	Needs Treatment (ac-ft)	Through Facility (ac-ft)	Volume (ac-ft.)	Volume Infiltration Credit	Volume Infiltrated	Water Quality Treated
Total Volume Infiltrated		0.00	0.00	0.00	0.00	0.00	0%

No Treat. Credit
Compliance with LID Standard 8
Duration Analysis Result = Passed

Perlnd and Implnd Changes

No changes have been made.

Future Projections for Climate-Adapted Culvert Design

Project Name:	City of Gig Harbor Feasibility Stud
Stream Name:	North Creek
Drainage Area:	1,264 ac

Projected mean percent change in bankfull flow:

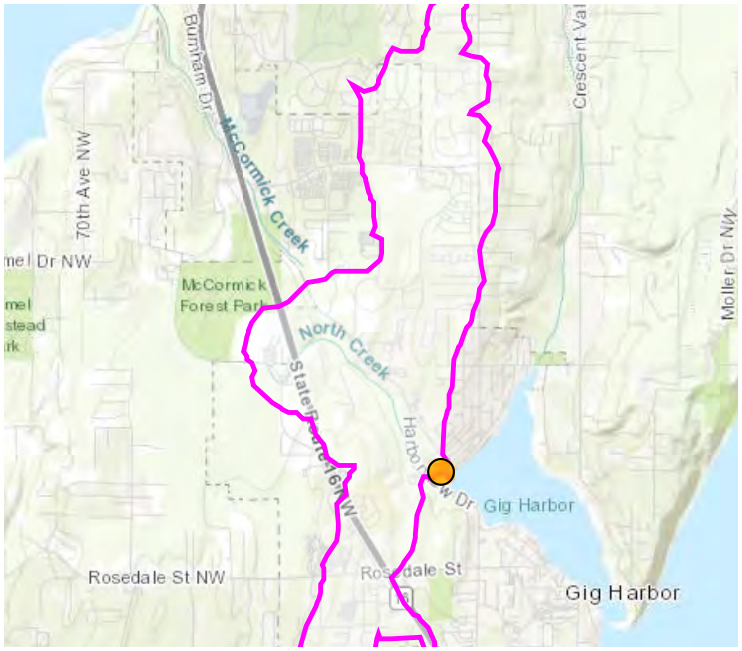
2040s:	14.6%
2080s:	20.4%

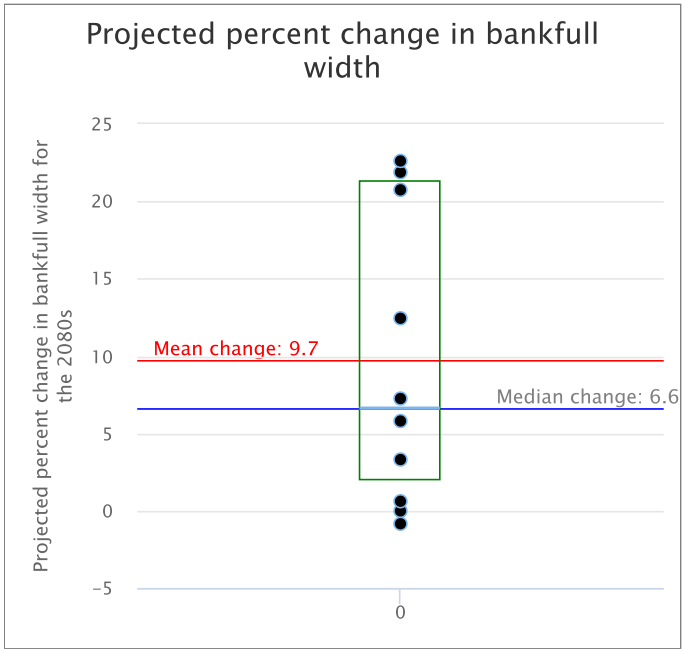
Projected mean percent change in bankfull width:

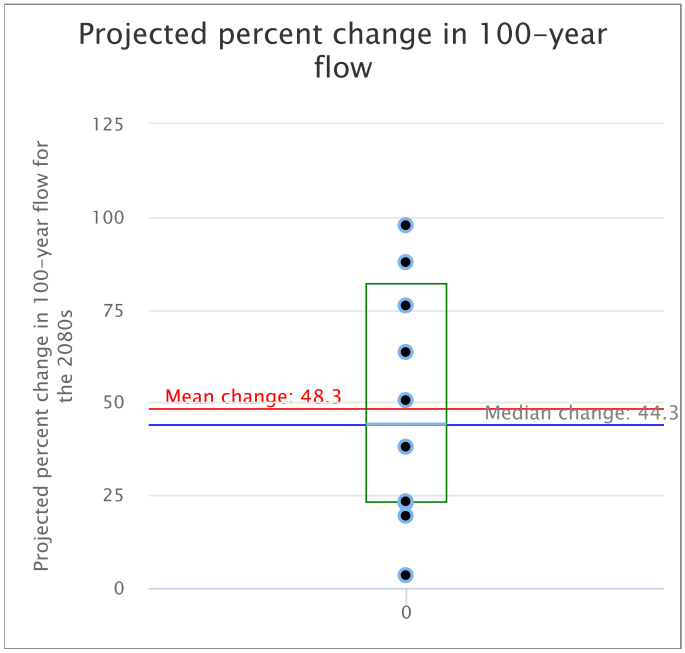
2040s:	7%
2080s:	9.7%

Projected mean percent change in 100-year flood:

2040s:	41.8%
2080s:	48.3%



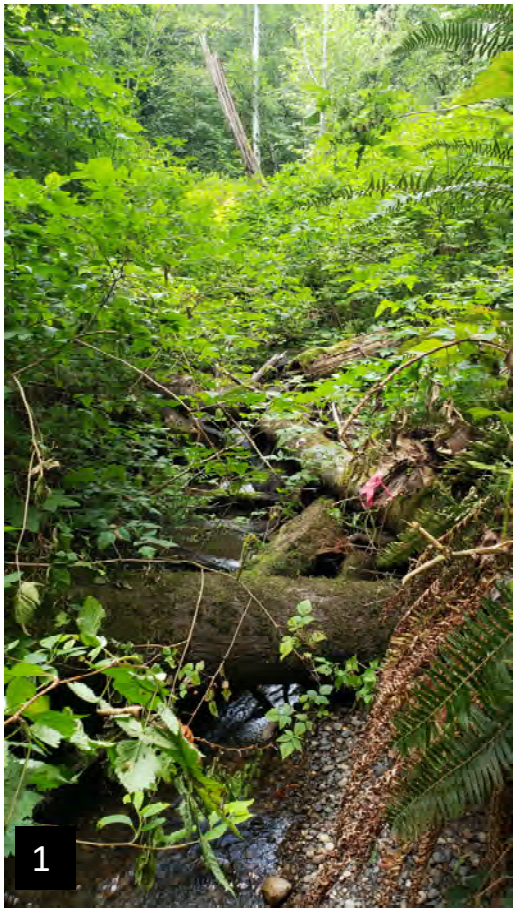


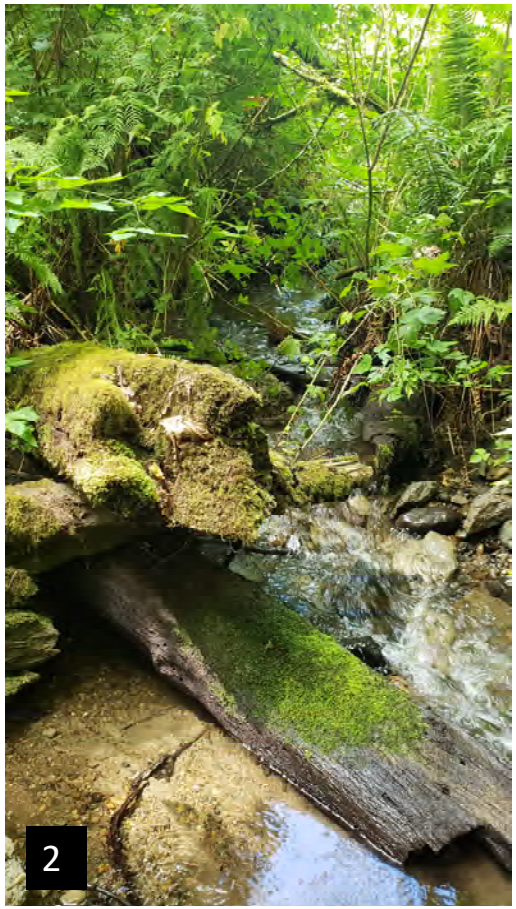


Black dots are projections from 10 separate models

Appendix E

Stream Assessment Site Visit Photos



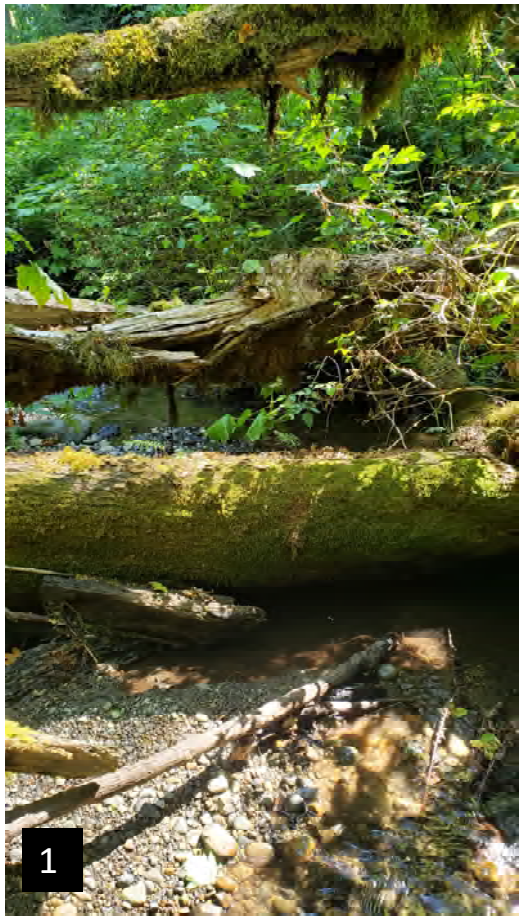


~680 feet upstream of culvert

1. Looking upstream from upstream extent
2. Looking upstream, typical sediment and log complexity
3. Left bank slope, mass failure, sediment supply

~620 ft upstream of culvert
BFW measurement #1 = 13 ft
Wolman pebble count #1

1. BFW measurement d/s of spanning log
2. Gravelometer for scale in pebble count area
3. Gravelometer for scale in pebble count area
4. Gravelometer for scale in pebble count area



~530 feet upstream of culvert

1. Sediment supply typical of u/s of logs
2. Clayey vertical bank, supporting log overhang and spanning

~515ft upstream of culvert
BFW measurement #2 = 15 ft
No Wolman pebble count

1. Looking d/s and BFW measurement #2
2. Gravelometer for scale in pebble count area

~400 ft upstream of culvert
BFW measurement #3 = 17 ft
Wolman pebble count #2

1. BFW measurement looking d/s
2. Gravelometer for scale in pebble count area
3. Gravelometer for scale in pebble count area

~340 ft upstream of culvert

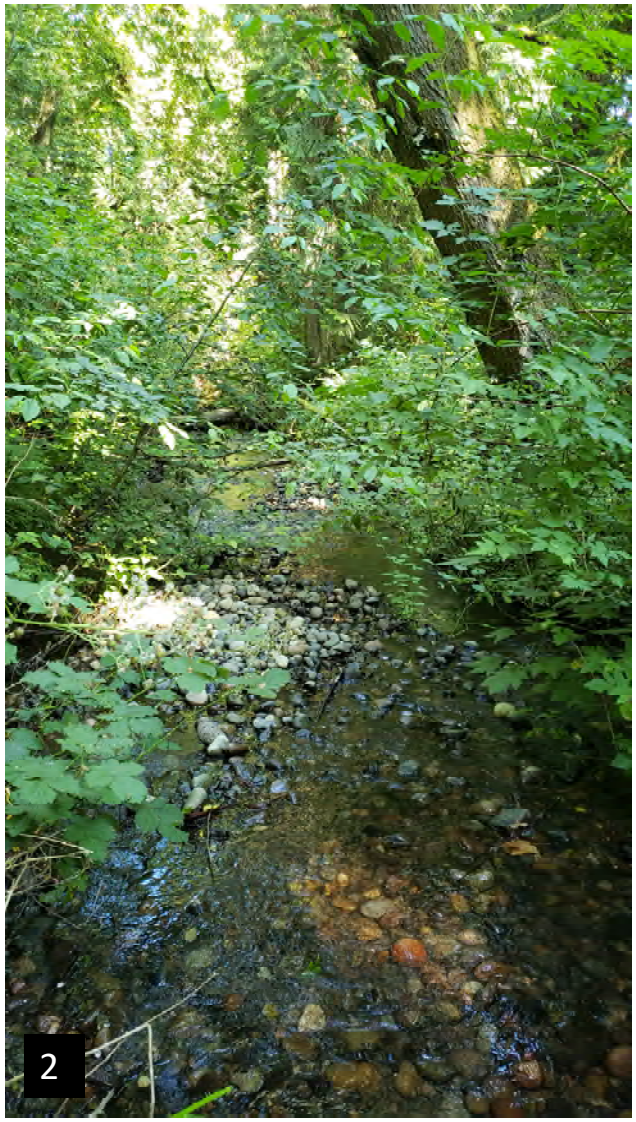
1. Log and gravel jam
2. Vertical clayey bank
3. Gravel bar looking d/s

~250 ft upstream of culvert
BFW measurement #4 = 14 ft

1. BFW measurement looking d/s

~90 ft upstream of culvert
No pebble count, more cobble appears in influence zone of culvert

1. Gravelometer for scale
2. Looking d/s
3. Looking d/s
4. Gravelometer for scale

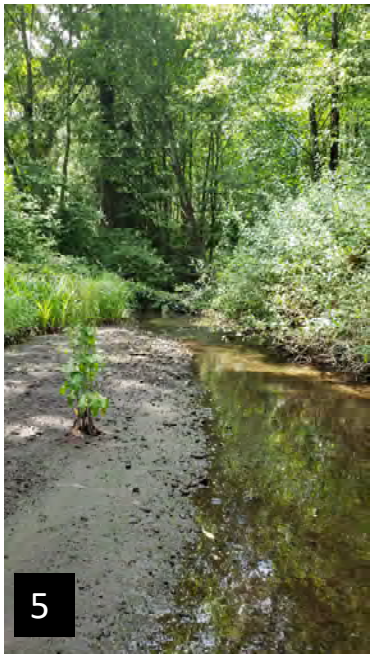


~50 ft upstream of culvert
Can see blue vehicle on roadway

1. Looking d/s

Photos at Culvert location

1. U/S face looking u/s
2. U/S face looking d/s
3. D/S face looking u/s



Photos downstream of culvert

1. Culvert outlet, flume and gravelometer for scale
2. Looking downstream near outlet
3. D/S face looking u/s
4. Looking u/s from tidal zone
5. Looking u/s from further d/s in tidal zone
6. Gravelometer for scale d/s of culvert outlet scour pool, beyond the sand deposit

Photos d/s of culvert at RSI location

1. Looking d/s RSI flume crossing creek
2. RSI flume entering settling pond in floodplain
3. RSI settling pond
4. RSI settling pond berm, creek side, tires and other bank stabilization techniques

Appendix F

Preliminary Geotechnical Report

DRAFT PRELIMINARY GEOTECHNICAL REPORT
North Creek Culvert Feasibility Study
Gig Harbor, Washington

HWA Project No. 2022-105-21

Prepared for
Parametrix, Inc.

August 18, 2022

HWA | GeoSciences Inc.
DBE/MWBE

Geotechnical Engineering
Pavement Engineering
Geoenvironmental
Hydrogeology
Inspection & Testing

HWA GeoSciences Inc.
DBE/MWBE

August 18, 2022
HWA Project No. 2022-105-21

Parametrix, Inc.
60 Washington Avenue, Suite 390
Bremerton, Washington 98337

Attention: David Dinkuhn, Project Manager

Subject: **PRELIMINARY GEOTECHNICAL REPORT**
North Creek Culvert Feasibility Study
Gig Harbor, Washington

Dear Mr. Dinkuhn:

HWA GeoSciences Inc. (HWA) is providing geotechnical support services to Parametrix and the City of Gig Harbor related to the feasibility of replacing the existing culvert structure of where North Creek crosses below Harborview Drive. The attached preliminary geotechnical report summarizes the results of our evaluation of the available information studies and presents our preliminary geotechnical assessment of foundation alternatives for the proposed culvert crossing structure.

We appreciate the opportunity to provide geotechnical engineering services on this project. If you have questions or require additional information, please contact the undersigned at your convenience.

Sincerely,

HWA GEOSCIENCES INC.

JoLyn Gillie, P.E.
Geotechnical Engineer, Principal

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Figure 1. Vicinity Map
Figure 2. Site and Exploration Plan

APPENDIX A: PREVIOUS EXPLORATIONS

PRELIMINARY GEOTECHNICAL REPORT
NORTH CREEK CULVERT FEASIBILITY STUDY
GIG HARBOR, WASHINGTON

1. INTRODUCTION

1.1 GENERAL

This report presents the results of a geotechnical study performed by HWA GeoSciences Inc. (HWA) in support of a feasibility study for the replacement of the existing North Creek culvert that crosses Harborview Drive in Gig Harbor, Washington. The project location is shown on the Vicinity Map presented on Figure 1, and a Site and Exploration Plan is presented on Figure 2. The purpose of this study is to evaluate anticipated soil and ground water conditions based on available geotechnical explorations in the vicinity of the crossing and provide preliminary recommendations for foundation and wall design alternatives associated with construction of a new crossing structure. Additional explorations will be needed to provide detailed geotechnical recommendations for design and construction the crossing structure once the feasibility study is completed.

Our work scope included a site visit to perform a site reconnaissance and review of available geologic and subsurface information from previous studies performed near the proposed culvert crossing. In this report we have presented a summary of our evaluation of site geotechnical conditions, and preliminary considerations for foundation types that could be used with the crossing structure and possible retaining walls, and open stream channel excavations.

1.2 PROJECT DESCRIPTION

North Creek flows below Harborview Drive within a 5-foot by 5-foot box culvert that is considered by Washington Department of Fish and Wildlife (WDFW) as a partial fish barrier. The project would replace the culvert with a fish passable structure that would augment the fish friendly open channel created by a previous stream restoration project downstream of the existing culvert in 2014.

Key geotechnical aspects of this project include assessing feasibility of removing the culvert and installing a new crossing structure. The crossing structure is likely to consist of a single span bridge. The structure will need to accommodate the existing underground utilities withing Harborview Drive. Wing walls and/or slopes protected against erosion and scour will also likely be required.

We understand the feasibility study includes consideration for connecting Wastewater Treatment Plan Creek to North Creek along the frontage between the Wastewater Treatment Plant and

Harborview Drive; however, since the feasibility of that option from a hydrogeologic aspect is not known, no geotechnical assessment for those improvements has been made at this time.

2. SITE ASSESSMENT

2.1 SITE RECONNAISSANCE

HWA completed a site reconnaissance of the existing culvert alignment on June 30, 2022. This included observing the stream and culvert at the upstream and downstream headwalls. The soils observed within the stream bed on the upstream end of the culvert consisted primarily of sand, while the soils within the stream bed at the downstream end consisted of clean, subrounded gravel. The headwalls and wingwalls of the culvert support the fill that has placed to form the embankment of Harborview Drive. The embankment slopes appear to be steepest around the culvert headwalls and flatten out somewhat to the north and south of the culvert. The sides of the fill slopes are vegetated with ferns and ivy undergrowth. On the east slope, deciduous trees are growing and have slightly curved trunks, indicating some slow creep of the surficial soils.

2.2 EXISTING SUBSURFACE INFORMATION

Existing information for the site comes from explorations performed for the Donkey Creek Restoration and Roadway Improvements Project. The exploration, designated EB-8, that is closest to the alignment was performed by Associated Earth Sciences, Inc. (AESI) in a preliminary design phase of the Donkey Creek Project (AESI, 2011). This boring is within about 30 feet of the existing culvert. Other information regarding local soil and ground water conditions was obtained from boring and test pit explorations performed by HWA for the Gig Harbor Wastewater Treatment Plant Improvements (HWA, 2008) and a boring, designated BH-6, completed for Phase 1 of the for the Burnham Drive and Harborview Drive Improvements Project in 2020 (HWA, 2020).

3. SITE CONDITIONS

3.1 SURFACE CONDITIONS

The project site is on Harborview Drive between its intersections with Austin Street to the north and Harborview Drive North to the south. The Gig Harbor Wastewater Treatment Plant (WWTP) is situated upslope from the culvert to the southwest and Donkey Creek Park downslope to the southeast. The road in this area was constructed as a fill embankment to support the roadway through the ravine through which North Creek flows. The culvert was installed to allow the creek to flow toward Gig Harbor which is downslope to the southeast.

Based on available contour data, the fill embankment in this area has slopes as steep as 1.4H:1V with a maximum slope height of about 25 feet.

3.2 GENERAL GEOLOGIC CONDITIONS

The Puget Lowland has repeatedly been occupied by a portion of the continental glaciers that developed during the ice ages of the Quaternary period. During at least four periods, portions of the ice sheet advanced south from British Columbia into the lowlands of western Washington. The southern extent of these glacial advances was near Olympia, Washington. Each major advance included numerous local advances and retreats, and each advance and retreat resulted in its own sequence of erosion and deposition of glacial lacustrine, outwash, till, and drift deposits. Between and following these glacial advances, sediments from the Olympic and Cascade Mountains accumulated in the Puget Lowland. As the most recent glacier retreated, it uncovered a sculpted landscape of elongated, north-south trending hills and valleys between the Cascade and Olympic mountain ranges, composed of a complex sequence of glacial and interglacial deposits.

Surficial geological information for the site area was obtained from the published geological map; *Geologic Map of the Gig Harbor 7.5-minute quadrangle*, (Troost, et. al.). The surficial geology of the project site is mapped as alluvium which consists of poorly graded sand with varying amounts of silty and gravel. However, our site reconnaissance indicates that the subgrade soils are likely to be fill over glacial outwash, which is mapped upslope to the northwest. Glacial (advance) outwash is deposited in front of an advancing glacier or during inter-glacial periods, this fluvial deposit consists primarily of slightly silty sandy gravel to clean medium to fine sand. The primary difference between this and other glaciofluvial deposits is the relative density, which is commonly dense to very dense due to the fact it was overridden by the weight of the advancing ice sheet. It is often water bearing. Outwash can be massive or laminated, with layers of gravel, and silt layers and lenses. Typically, advance outwash soils have relatively high shear strengths and moderate to high permeability and low compressibility.

3.3 SUBSURFACE CONDITIONS

The interpretation of the existing conditions for this alignment were developed based on limited existing geotechnical data. From this information, we conclude that the upper subsurface materials at the culvert the site consist primarily of fill with varying thicknesses and composition. At the culvert, the fill slope for the roadway, represented by boring EP-8, indicates that medium dense, slightly gravelly sand underlies the roadway to a depth of about 20 feet. The material grades to dense at a depth of about 20 feet, where soils appear to transition to an advance outwash material. The boring was terminated in this material at about 21½ feet below the top of the embankment. The material observed in EP-8 is similar in composition to the material that was observed in the explorations performed for the Gig Harbor Wastewater

Treatment Plant site, including BH-3, BH-4, TP-9 and TP-10, which was also characterized as outwash deposits. None of the explorations extended below the base of the culvert. Future explorations will be needed to provide information for the soils present below the culvert structure.

3.4 GROUND WATER

Ground water was observed at depth in the borings drilled at the WWTP site, but in the test pits advanced at the base of the slope. No ground water was observed in the boring EB-8; however, a ground water monitoring well was not installed and the lack of oxidation staining in the sample at 20 feet bgs may indicate the presence of a static water level that was not noted during drilling.

We anticipate that ground water levels near the culvert will generally coincide with the elevation of the stream. Ground water levels are expected to vary depending on the weather and time of year. Future explorations should include at least one boring that would be completed as a monitoring well to provide ground water data for use in design and construction of the crossing structure.

4. GEOTECHNICAL RECOMMENDATIONS

4.1 GENERAL

At the culvert location, existing information indicates that about 20 feet of medium dense fill comprises the fill embankment of Harborview Drive at the culvert crossing. Below the fill is dense, advance outwash that is anticipated to provide adequate bearing capacity for the proposed crossing structure. Three foundation alternatives are presented including spread footings, driven piles and drilled shafts.

We anticipate that the excavations needed to install spread footings will be undesirable and that a deep foundation alternative is likely to be selected. The design element that is likely to most influence the selection of foundation type is the existing sanitary sewer that underlies the site. To limit potential for damage to the pipe, the use of drilled shafts may be preferred over driven piles. However, if driven pile are used the use of open-ended piles could be considered to mitigate some of the densification and vibration concerns associated with driven pile as they are likely to be more cost effective compared to drilled shafts.

Another item that will impact cost is the need to maintain traffic for the duration of culvert construction. The most cost-effective method of constructing the structure will be to allow a full closure; however, we anticipate that maintenance of two way traffic will also need to be considered. Future design will need to consider the methods for providing temporary support of roadways at the culvert location. This is likely to consist of MSE walls constructed on the

existing embankment slopes. Evaluation of the slope stability of constructing temporary embankments on the existing slope will need to be completed in future studies for this project.

4.2 SEISMIC DESIGN CONSIDERATIONS

4.2.1 Seismic Design Acceleration Coefficients

Earthquake loading for the project alignment was developed in accordance with the General Procedure provided in Section 3.4 of the AASHTO *Guide Specifications for LRFD Seismic Bridge Design*, 2nd Edition, 2011, and the Washington State Department of Transportation (WSDOT) amendments to the AASHTO *Guide Specifications provided in the Bridge Design Manual* (LRFD) (WSDOT, 2022). For seismic analysis, the Site Class is required to be established and is determined based on the average soil properties in the upper 100 feet below the ground surface. The Site Class can be correlated to the average standard penetration resistance (N_{SPT}) in the upper 100 feet of the soil profile. Based on our characterization of the subsurface conditions, the subject site classifies as Site Class C for "Very dense soil".

The design parameters for the design level event of 7 percent probability of exceedance in 75 years (approximately equal to a return period of 975 years) were obtained using BridgeLink which uses the probabilistic seismic hazard parameters developed from the *2014 Updates to the National Hazard Maps* (Peterson, et al., 2014). Site coefficients were developed following the WSDOT BDM that adopts the site coefficients provided in ASCE 7-16. The recommended seismic coefficients for the design event are provided in Table 1. The spectral acceleration coefficient at 1-second period (S_{D1}) is greater than 0.3 but less than 0.5 g; therefore, Seismic Design Category C, as given by AASHTO Table 3.5-1 (AASHTO, 2011), should be used.

Table 1. Seismic Coefficients Using AASHTO Guide Specifications and WSDOT BDM Site Coefficients

Site Class	Peak Horizontal Bedrock Acceleration PBA, (g)	Spectral Bedrock Acceleration at 0.2 sec S_s, (g)	Spectral Bedrock Acceleration at 1.0 sec S_1, (g)	Site Coefficients			Peak Horizontal Acceleration PGA (A_s), (g)
				F_{pga}	F_a	F_v	
C	0.456	1.038	0.306	1.200	1.200	1.500	0.547

Notes: *Values Based on 7% Probability of Exceedance in 75 years for Latitude 47.33753° and Longitude 122.59482°*

4.2.2 Liquefaction Considerations

Liquefaction is a temporary loss of soil shear strength due to earthquake shaking. Loose, saturated cohesionless soils are the most susceptible to earthquake-induced liquefaction; however, research has shown that certain silts and low-plasticity clays are also susceptible.

Primary factors controlling the development of liquefaction include the intensity and duration of strong ground motions, the characteristics of subsurface soils, in-situ stress conditions and the depth to ground water.

Based on the data available from boring EB-8 drilled within the fill placed to form the roadway embankment, we determined that the fill soils could be susceptible to liquefaction if they were encountered below the ground water table. The available data does not indicate that ground water was present; however, no ground water monitoring well was installed, and it is possible that the ground water table associated with North Creek could extend up into the fill soils near the culvert, particularly during the wet season. At this time, we conclude that the thickness of the potentially liquefiable soils that could be saturated is on the order of 5 feet or less. This material could experience liquefaction that may result in small amounts of liquefaction settlement of the existing fill embankment. In our preliminary assessment, we also conclude that the medium dense nature of the fill soils would likely provide adequate frictional resistance following liquefaction and, as a result, slope instability would be limited and large lateral displacement of the roadway embankment is unlikely. This will need to be confirmed by performing explorations near the proposed crossing structure foundations once the preferred alternative is selected.

4.3 STRUCTURE FOUNDATION ALTERNATIVES

The previous exploration drilled near the proposed crossing structure indicates that the roadway embankment consists of about 20 feet of medium dense sand (fill) placed over dense sand with gravel (advance outwash). We conclude that the dense sand will be suitable to provide bearing support for the structure below the fill materials. Three foundation options have been considered. These include (1) excavating to construct a spread footing on the advance outwash soils encountered below the fill, (2) founding the proposed structure on piles driven through the fill to bear within the advance outwash soils, and (3) constructing drilled shafts that penetrate through the fill materials and extend into the advance outwash. A discussion of each foundation alternative is provided in the following sections.

4.3.1 Spread Footings

The use of spread footings could be considered if a three-sided box culvert structure were selected as the new crossing structure. This option would require excavation of the about 20 feet of fill materials to expose the advance outwash on which the spread footings could be constructed. The bearing capacities of the spread footings will depend on the final selected footing elevations as well as the depth of embedment below the anticipated scour depth for the culvert.

Excavations needed for installation of the foundations would require sloping the existing fill at about 1.5H:1V, which will result in a significant section of the existing roadway embankment that would have to be removed. The extents of the excavation could be reduced by using temporary shoring; however, interference with existing utilities and nearby structures would need to be considered. This option is most economical if a full road closure is permitted. Otherwise, shoring requirements to maintain traffic could increase costs so that the disadvantages of this option outweigh the cost savings.

One significant consideration regarding the feasibility of using a spread footing foundation is the utilities that cross the alignment. Plans indicate that both water and sewer pipes underlie the site and likely will cross the culvert above the foundation levels. In these cases, the pipelines will likely require a bypass during construction and need to be reconnected above or through the box culvert structure following construction. If the pipelines run beneath the foundations, these utilities will require evaluation of methods that avoid loading the pipelines where they are located below the base of the proposed footings. Additional information regarding utility elevations will be needed to assess the impact the spread footings and crossing structures will have on the utilities present at the site.

4.3.2 Driven Steel Pipe Piles

Deep foundations could be used to mitigate for the amount of excavation needed to expose the suitable bearing soils encountered at about 20 feet. One type of deep foundation that could be considered is driven piles. Driven piles would likely consist of steel pipe piles, with consideration given to both closed-ended and open ended piles. Closed-end pipe piles typically provide ultimate capacities approaching the structural capacity of the section. Based on experience from driving piles at the existing bridge structure constructed as part of the rehabilitation of the North Creek channel to the east, 18-inch diameter, closed-ended pipe piles will likely develop the required nominal axial capacity within the upper approximately 5 to 10 feet of the dense glacial outwash. However, to ensure lateral fixity for the piles, we anticipate that piles will need to be overdriven, which means that the piles would be driven beyond the depth at which they meet the required nominal axial capacity. Alternatively, open-ended piles could be used, though they typically require deeper embedment to achieve similar axial capacities to that of a closed-ended pile. They can, however, allow the piles to be driven more easily to a depth that will provide fixity for the lateral loading condition, and thus could be the preferred pile alternative for this site.

Driven piles are advantageous in that they typically require less time to install and can be less costly when compared with the alternative of using drilled shafts. When possible, we would recommend using driven piles. However, a disadvantage of using driven piles is that their installation method generates vibrations, which could damage the existing utilities that are present at the site. Additionally, these methods could heave or densify the adjacent soils around

the piles such that if driven piles are too close to existing utility pipes, in particular the sanitary sewer pipe, they may put additional lateral pressure on the pipes that could damage them. Utilities that will get replaced as part of this project are not likely to be affected; however, if the underlying sewer line is to remain functional during and/or following construction, installation of driven piles may not be favorable. We conclude that an assessment of the feasibility of using open-ended pipe piles to reduce the densification and overall vibrations from pile installation would be warranted if steel piles are still desired.

Note that piles with diameters of 8 inches or less are not considered to provide lateral capacity. However, if smaller piles were used, some lateral resistance could be provided using battered piles. Additionally, we would recommend that the piles be installed with continuous steel sections or with sections connected with full penetration welds to provide uplift resistance (e.g steel pile sections would not be connected using couplers that only provide resistance for compression loads).

For future design phases, additional borings are needed that extend to a sufficient depth below the anticipated base of foundation elements. These explorations would be used to assess suitability of either closed- or open-ended piles for the bridge structure.

4.3.3 Drilled Shafts

Drilled shafts may be preferred where there are concerns regarding the impact of vibrations to the utilities at the site. Drilled shafts are deep foundation elements in which soil is excavated out of the ground and replaced with concrete and steel reinforcing, such as a rebar cage, or steel beam. Drilling methods typically use flighted augers or clamshells to extract the soil. Depending on the soil and ground water conditions, some casing and/or drilling fluid may be required to stabilize the sides and bottom of the excavation as the steel reinforcing and concrete are placed in the open hole. For the construction of drilled shafts that this site, we would recommend utilizing drilled shaft installation methods that do not include the use of vibratory methods for hole excavation or casing advancement.

If drilled shafts are selected, the appropriate diameter of the shafts will need to be determined by the designer. Smaller shafts could be installed with smaller drilling equipment, which may be an advantage, particularly with the narrow width of the existing road that will limit the space available for construction equipment. Based on these considerations, we anticipate that drilled shafts are likely to consist of small diameter drilled shafts between about 18-inch and 36-inch diameter. Additional explorations will be needed for design of the shafts as bottom of the one available boring does not extend deep enough.

We anticipate that the advance outwash that is anticipated to provide bearing support, will be saturated and is likely to require casing and/or drilling fluid to stabilize the sides and bottoms of the holes. This will increase the time and cost of installing drilled shafts. Use of drilled shafts as

a foundation alternative will likely be based on the need to limit the impact of the deep foundations to the underlying sewer line rather than as a cost effective option.

4.3.4 Temporary Embankment Support

Ideally, a full closure of the roadway would be performed to limit the cost of constructing a temporary roadway and the inefficiencies of constructing the culvert in phases. However, if maintenance of traffic along Harborview Drive is required during the installation of the proposed crossing structure, it is likely that a temporary embankment will need to be constructed on the existing embankment slopes to provide adequate room to construct one half of the structure at a time. To provide support for the traffic, temporary mechanically stabilized (MSE) walls could be used to widen the existing embankment. We anticipate that this is feasible; however, evaluation of the stability of the existing slopes for placement of the MSE walls on them will need to be assessed. These evaluations will be performed to determine if there are any constraints on the placement of the MSE walls that will need to be reflected on the plans.

4.3.5 Utilities

Design of the proposed structure will need to account for the presence of the pipelines within the existing embankment. We understand that a gravity sanitary sewer main flows along the Harborview Drive alignment, as well as a water main. If the utilities are above the bottom of the stream they may be able to be incorporated into or suspended below the crossing structure. If, however, deep foundation elements are selected and utilities are to remain in place, they will likely be located near the existing utility pipeline. If utilities are to remain in place and operable during or following construction, the use of drilled shafts, or open-ended pipe piles will need to be considered. Shaft/pile locations should be assessed to provide a suitable separation distance between the pipelines and the edges of the foundations. This will require determining the location of the sewer line as accurately as possible. Considerations for selecting a suitable separation distance between the pipe and the shafts include the possibility of a drill catching on a cobble or obstruction present in the embankment fill that could cause the drill to deviate from its path and impact the pipe. For a pile, an obstruction could cause the pile to deflect and drive it at an angle toward the sewer pipe. It would also be prudent to perform an assessment of the pipeline condition before construction to have a baseline by which assessment of potential damage during construction could be better identified. If piles were selected, assessment of vibration characteristics that could impact the pipe would be needed and incorporated into the project specifications. Monitoring of vibrations during construction would be recommended, as well.

4.4 RETAINING WALLS

We anticipate that some retaining walls, such as wing walls will be needed for the proposed structure and associated roadway grading to limit the extents of cuts and fills on the adjacent

properties and streams. At this time, the locations and extents of the walls is not known such that the preferred wall types cannot be determined at this time. Once an alternative is selected and the proposed grading provided, recommendations for wall types and design parameters for lateral earth pressures will be evaluated.

5. CONDITIONS AND LIMITATIONS

We have prepared this preliminary geotechnical report for Parametrix, Inc. and the City of Gig Harbor for use in design for this project. Additional geotechnical studies will be necessary for final design. Experience has shown that soil and ground water conditions can vary significantly over small distances. Inconsistent conditions can occur between exploration locations and may not be detected by a geotechnical study of this nature. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, HWA should be notified for review of the recommendations of this preliminary report, and revision of such if necessary.

Within the limitations of scope, schedule and budget, HWA attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology in the area at the time the report was prepared. No warranty, express or implied, is made.

HWA does not practice or consult in the field of safety engineering. We do not direct the contractor's operations and cannot be responsible for the safety of personnel other than our own on the site. As such, the safety of others is the responsibility of the contractor. The contractor should notify the owner if any of the recommended actions presented herein are considered unsafe.

We appreciate the opportunity to provide geotechnical services on this project. Should you have any questions or comments, or if we may be of further service, please do not hesitate to call.

Sincerely,

HWA GEOSCIENCES INC.

JoLyn Gillie, P.E.
Geotechnical Engineer, Principal

6. REFERENCE

American Association of State Highway and Transportation Officials (AASHTO), 2011, *AASHTO Guide Specifications for LRFD Seismic Bridge Design*, 2nd edition, American Association of State Highway and Transportation Officials. Washington, DC.

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Petersen, M.D., Moschetti, M.P., Powers, P.M., Mueller, C.S., Haller, K.M., Frankel, A.D., Zeng, Yuehua, Rezaeian, Sanaz, Harmsen, S.C., Boyd, O.S., Field, Ned, Chen, Rui, Rukstales, K.S., Luco, Nico, Wheeler, R.L., Williams, R.A., and Olsen, A.H., 2014, *Documentation for the 2014 update of the United States national seismic hazard maps*, U.S. Geological Survey Open-File Report 2014–1091, 243 p.

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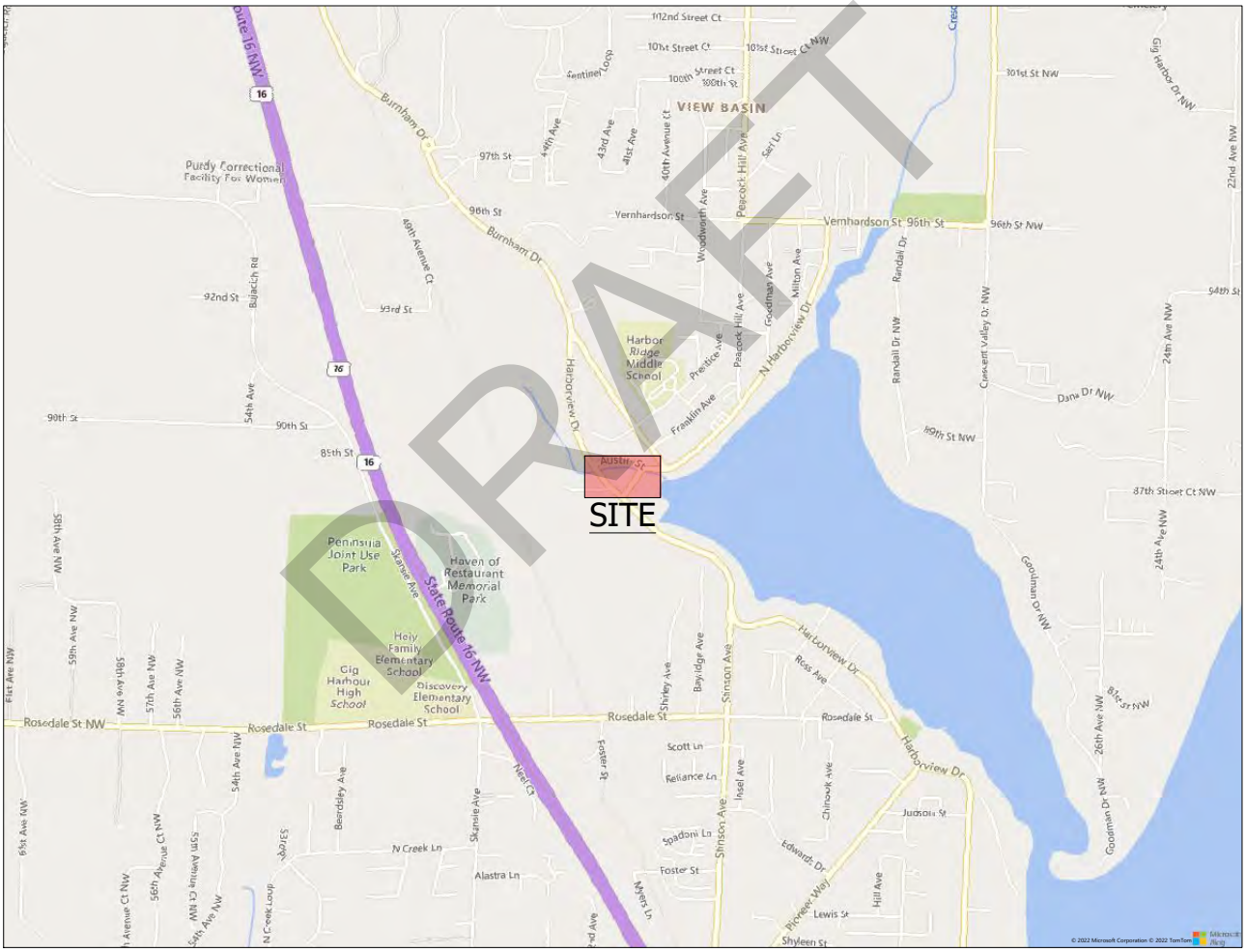
SITE MAP

0 200' 400' 600' 800'

SCALE: 1" = 400'



VICINITY MAP

0 1000' 2000' 3000' 4000'

SCALE: 1" = 2000'

GEOSCIENCES INC.
DBE/MWBE

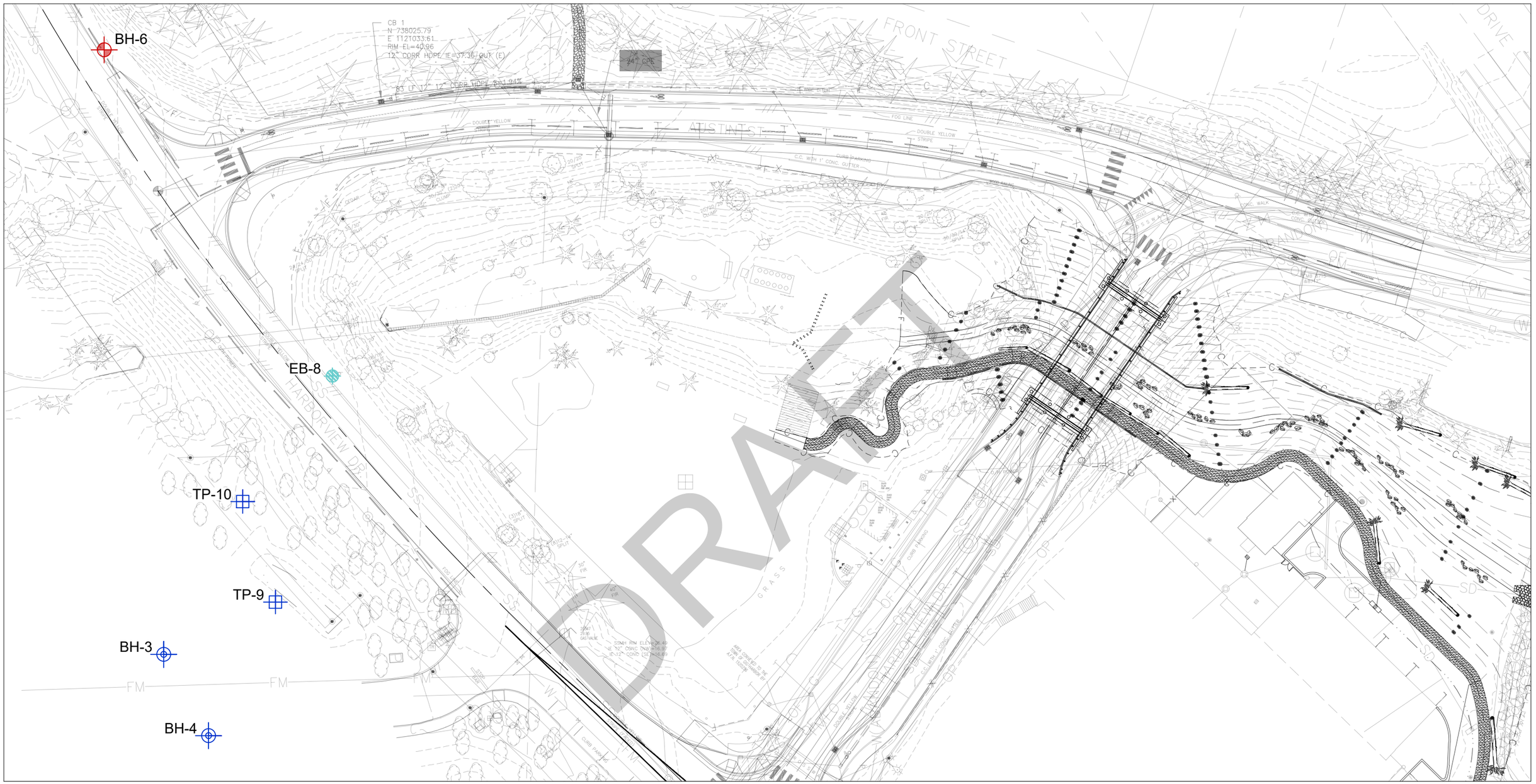
SITE AND VICINITY MAP

NORTH CREEK CULVERT
FEASIBILITY STUDY
GIG HARBOR, WASHINGTON

FIGURE NO.: 1

DRAWN BY: CF
CHECK BY: JLG

PROJECT # 2022-105-21



NORTH CREEK CULVERT
Scale: 1" = 50'-0"

EXPLORATION LEGEND

- BH-6 — BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (HWA, 2021)
- EB-8 — BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (AESI, 2011)
- BH-6 — BOREHOLE DESIGNATION AND APPROXIMATE LOCATION (HWA, 2008)
- TP-6 — TEST PIT DESIGNATION AND APPROXIMATE LOCATION (HWA, 2008)

N

0 25 50 75 100

SCALE: 1" = 50'

BASE MAP PROVIDED BY: BING AND PARAMETRIX 2011

C:\USERS\CFRY\DESKTOP\2022-105-21 NORTH CREEK\2022-105-21 NORTH CREEK CULVERT.DWG <2> Plotted: 8/18/2022 5:23 PM

HWA GEOSCIENCES INC. DBE/MWBE

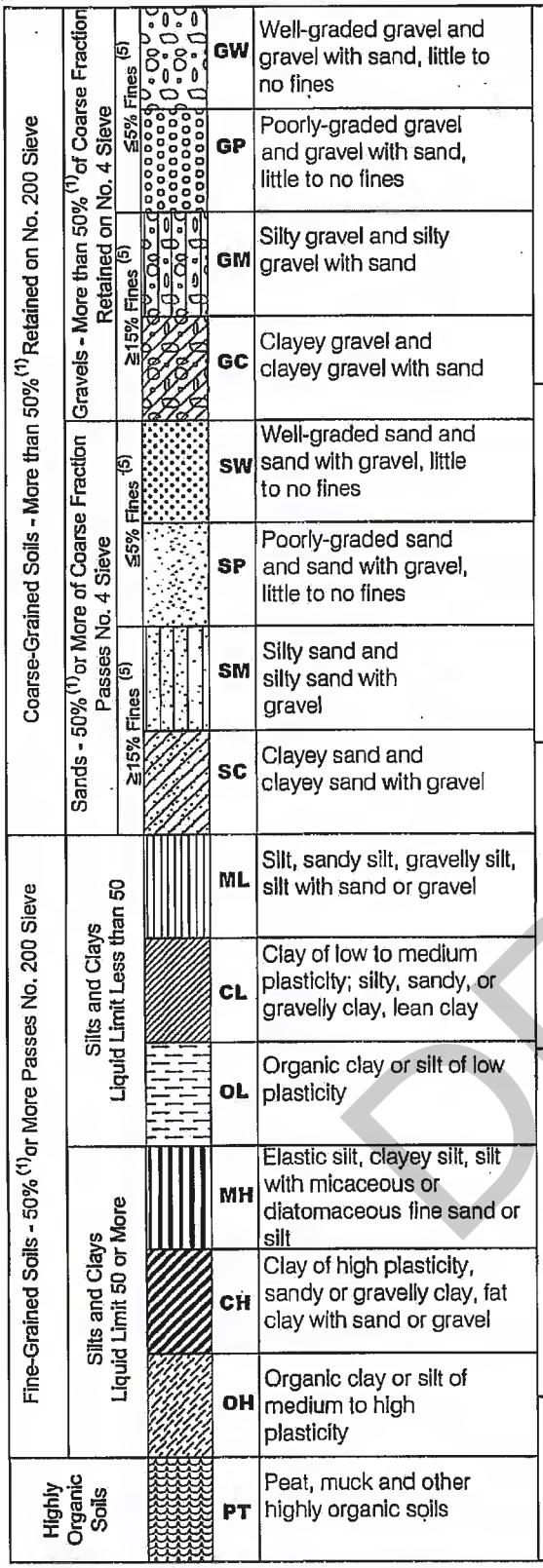
NORTH CREEK CULVERT
FEASIBILITY STUDY
GIG HARBOR, WASHINGTON

SITE &
EXPLORATION PLAN

DRAWN BY:	FIGURE NO.:
CF	2
CHECK BY:	PROJECT NO.:
JLG	2022-105-21

APPENDIX A

PREVIOUS FIELD INVESTIGATIONS



Terms Describing Relative Density and Consistency

	Density	SPT (2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT (2) blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

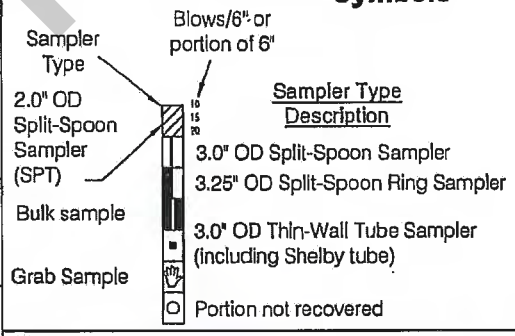
(3) Estimated Percentage

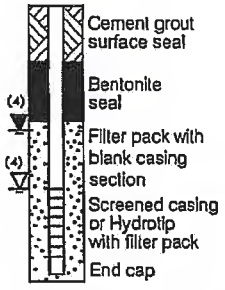
Component	Percentage by Weight
Trace	<5
Few	5 to 10
Little	15 to 25
With	- Non-primary coarse constituents: ≥ 15% - Fines content between 5% and 15%

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of ground water
ATD = At time of drilling
Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 15%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

Associated Earth Sciences, Inc.

EXPLORATION LOG KEY

FIGURE A1

blocks\log_key.dwg LAYOUT: Layout2

Associated Earth Sciences, Inc.

Exploration Log

Project Number	Exploration Number	Sheet
TE100281A	EB-8	1 of 1

Project Name: Donkey Creek and Austin Estuary Restoration
Location: Gig Harbor, WA
Driller/Equipment: Geologic Drill/Trailer Mounted HSA
Hammer Weight/Drop: 140# / 30"

Ground Surface Elevation (ft): ~45 feet (MSA data)
Datum: N/A
Date Start/Finish: 10/11/10,10/11/10
Hole Diameter (in):

Depth (ft)	ST	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/6"	Blows/Foot (10 20 30 40)	Other Tests
				Fill?					
		S-1		Moist, dark brown to brown, fine to medium SAND, fine gravel.			6 5 7	▲12	
		S-2		Moist, light gray, fine to medium SAND, few fine gravel, slight orange oxidation staining.			8 12 11	▲23	
5		S-3		Moist, light gray, fine to medium SAND, few gravel, slight orange oxidation staining.			7 9 12	▲21	
		S-4					7 10 9	▲19	
10		S-5		Moist, light gray, fine to medium SAND, few gravel, slight orange oxidation staining.			8 8 11	▲19	
15		S-6		Moist, gray, fine to medium SAND, few gravel, slight orange oxidation staining.			7 8 8	▲16	
				Vashon Advance Outwash					
20		S-7		Moist, gray, fine to medium SAND, with gravel.			21 20 23	▲43	
				Bottom of exploration boring at 21.5 feet No ground water seepage.					
25									

Sampler Type (ST):
- 2" OD Split Spoon Sampler (SPT)
- 3" OD Split Spoon Sampler (D & M)
- Grab Sample
- No Recovery
- Ring Sample
- Shelby Tube Sample

M - Moisture
Water Level ()
Water Level at time of drilling (ATD)

Logged by: MT
Approved by:

AESIBOR 100281A.GPJ April 8, 2011

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS	
Coarse Grained Soils	Gravel and Gravelly Soils	Clean Gravel (little or no fines)	GW	Well-graded GRAVEL
	More than 50% of Coarse Fraction Retained on No. 4 Sieve		GP	Poorly-graded GRAVEL
		Gravel with Fines (appreciable amount of fines)	GM	Silty GRAVEL
			GC	Clayey GRAVEL
	Sand and Sandy Soils	Clean Sand (little or no fines)	SW	Well-graded SAND
			SP	Poorly-graded SAND
	50% or More of Coarse Fraction Passing No. 4 Sieve	Sand with Fines (appreciable amount of fines)	SM	Silty SAND
			SC	Clayey SAND
Fine Grained Soils	Silt and Clay	Liquid Limit Less than 50%	ML	SILT
			CL	Lean CLAY
			OL	Organic SILT/Organic CLAY
50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit 50% or More	MH	Elastic SILT
			CH	Fat CLAY
			OH	Organic SILT/Organic CLAY
Highly Organic Soils			PT	PEAT

TEST SYMBOLS

%F	Percent Fines	
AL	Atterberg Limits:	PL = Plastic Limit LL = Liquid Limit
CBR	California Bearing Ratio	
CN	Consolidation	
DD	Dry Density (pcf)	
DS	Direct Shear	
GS	Grain Size Distribution	
K	Permeability	
MD	Moisture/Density Relationship (Proctor)	
MR	Resilient Modulus	
PID	Photolonization Device Reading	
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)	
SG	Specific Gravity	
TC	Triaxial Compression	
TV	Torvane Approx. Shear Strength (tsf)	
UC	Unconfined Compression	

SAMPLE TYPE SYMBOLS

- 2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
- Shelby Tube
- 3-1/4" OD Split Spoon with Brass Rings
- Small Bag Sample
- Large Bag (Bulk) Sample
- Core Run
- Non-standard Penetration Test (3.0" OD split spoon)

GROUNDWATER SYMBOLS

- Groundwater Level (measured at time of drilling)
- Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)
Components are arranged in order of increasing quantities.	

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch.
MOIST	Damp but no visible water.
WET	Visible free water, usually soil is below water table.

HWA GEOSCIENCES INC.

Gig Harbor WWTP Improvements Project
Gig Harbor, Washington

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

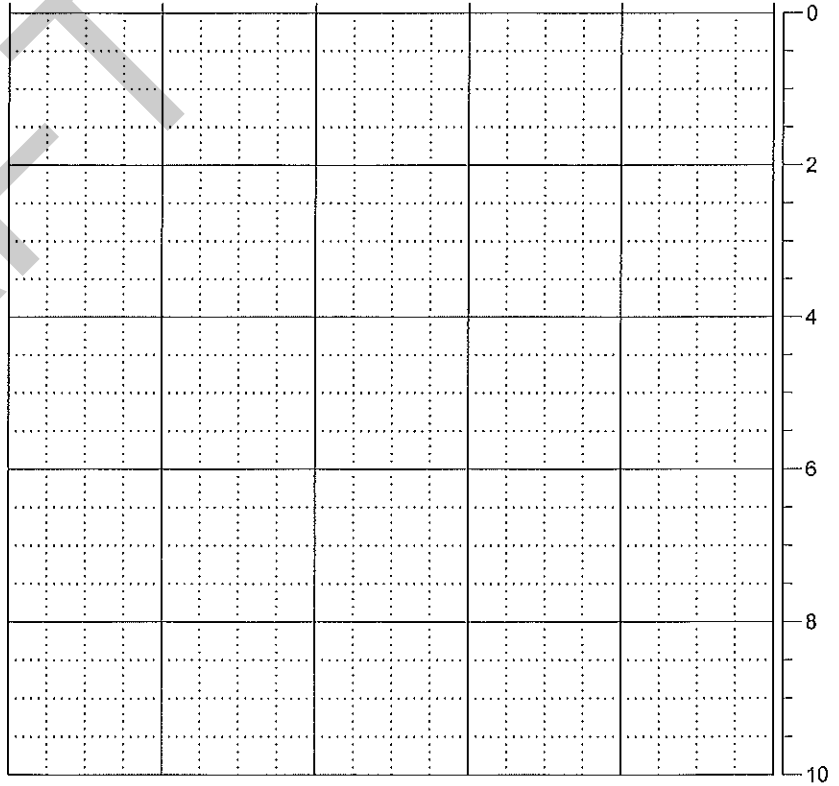
PROJECT NO.: 2007-014 FIGURE: A-1

EXCAVATION COMPANY: Gig Harbor WWTP
EXCAVATING EQUIPMENT: Backhoe
SURFACE ELEVATION: 23 ± Feet

LOCATION: See Figure 2
DATE COMPLETED: 9/17/07
LOGGED BY: S. Hong

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTURE CONTENT (%)	OTHER TESTS	GROUNDWATER
0		SM	Loose, dark brown, silty SAND with organics. [TOPSOIL]					
		SP	Medium dense, brown, fine to medium SAND with fine to coarse gravel, moist. Roots to 5 feet.					
10			Total depth = 8 feet. No ground water seepage observed during excavation.					

SKETCH OF SIDE OF PIT



NOTE: For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report. This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Gig Harbor WWTP
Improvements Project
Gig Harbor, Washington

LOG OF TEST PIT
TP- 9

PROJECT NO.: 2007-014 FIGURE: A-10

EXCAVATION COMPANY: Gig Harbor WWTP
EXCAVATING EQUIPMENT: Backhoe
SURFACE ELEVATION: 25 ± Feet

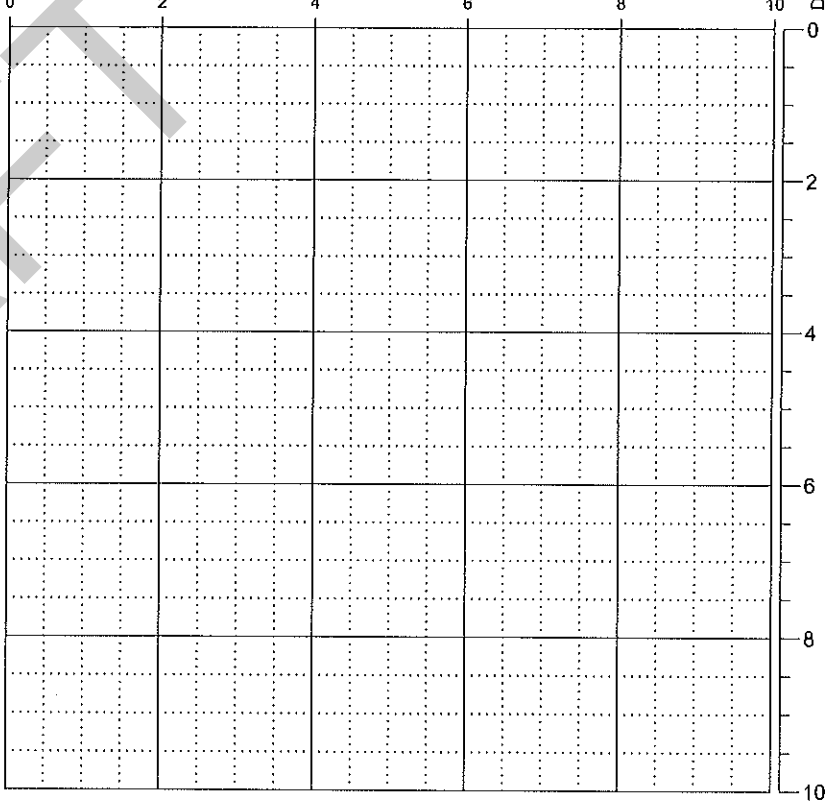
LOCATION: See Figure 2
DATE COMPLETED: 9/17/07
LOGGED BY: S. Hong

DEPTH (feet)	SYMBOL	USCS SOIL CLASS.	DESCRIPTION
0		SM	Loose, dark brown, silty SAND with organics. [TOPSOIL]
2		SP	Loose, brown, fine to medium SAND, moist.
		SP	Medium dense, light brown, fine to medium SAND, moist.
6			
10			

SAMPLE TYPE | SAMPLE NUMBER | MOISTURE CONTENT (%) | OTHER TESTS | GROUNDWATER

Total depth = 6 feet.
No ground water seepage observed during excavation.

SKETCH OF SIDE OF PIT



NOTE: For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report. This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

HWA GEOSCIENCES INC.

Gig Harbor WWTP
Improvements Project
Gig Harbor, Washington

LOG OF TEST PIT
TP-10

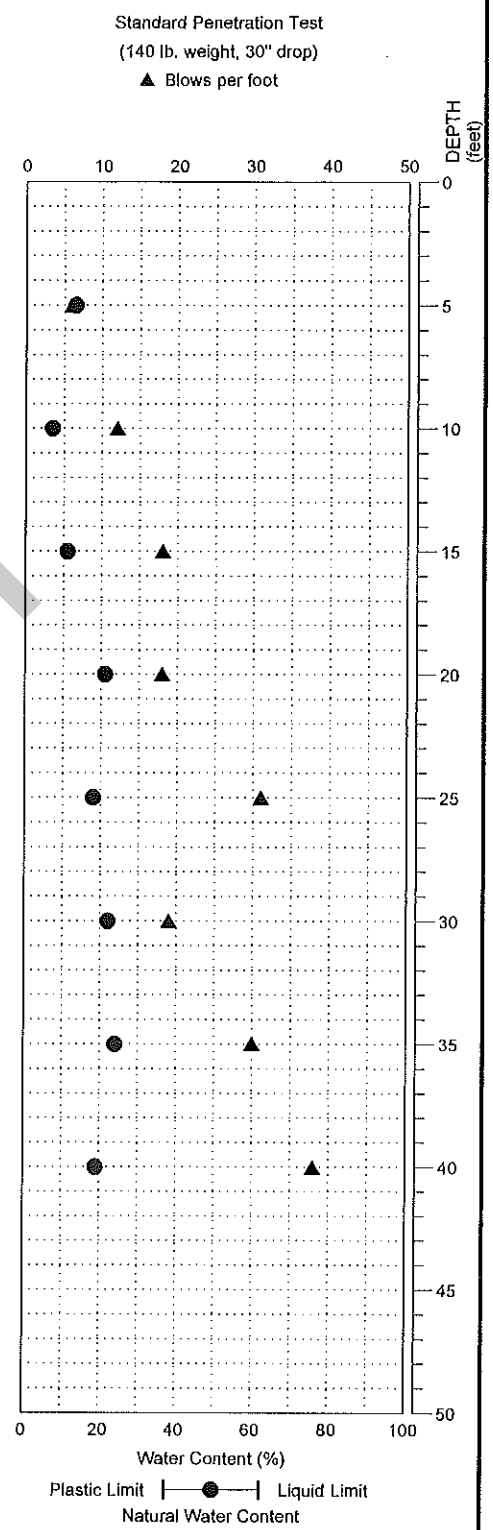
PROJECT NO.: 2007-014 FIGURE: A-11

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 31 ± feet

LOCATION: See Figure 2
DATE STARTED: 9/17/2007
DATE COMPLETED: 9/17/2007
LOGGED BY: B. Hawkins

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		SP SM	Loose, light brown and yellow brown, fine to coarse gravelly, fine to medum SAND, moist.					
5					S-1	1-3-3		
10		SM	Medium dense, olive brown, silty, fine SAND, moist to wet.		S-2	4-6-6		
15					S-3	6-9-9	GS	▽
20					S-4	5-7-11	GS	
25		SP	Medium dense to dense, olive brown, clean, slightly gravelly, fine to medium grading to fine SAND, wet. Approximately 6 inches of sand heave at 25 feet.		S-5	7-11-20	GS	
30			Approximately 12 inches of sand heave at 30 feet.		S-6	2-7-12	GS	
35			Approximately 2-3 feet of sand heave at 35 feet. Heaving sand washed out prior to sampling. Driller kept augers filled with water for remainder of hole.		S-7	4-10-20	GS	
40					S-8	12-18-20		
45								
50								

Total depth = 41.5 feet.
Ground water encountered between 15 and 20 feet during drilling.
Hole caved to 18 feet upon removal of auger flights - likely depth of ground water table.



For a proper understanding of the nature of subsurface conditions, this exploration log should be read in conjunction with the text of the geotechnical report.

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HWA GEOSCIENCES INC.

Gig Harbor WWTP
Improvements Project
Gig Harbor, Washington

BORING:
BH- 3

PAGE: 1 of 1

PROJECT NO.: 2007-014 FIGURE: A-14

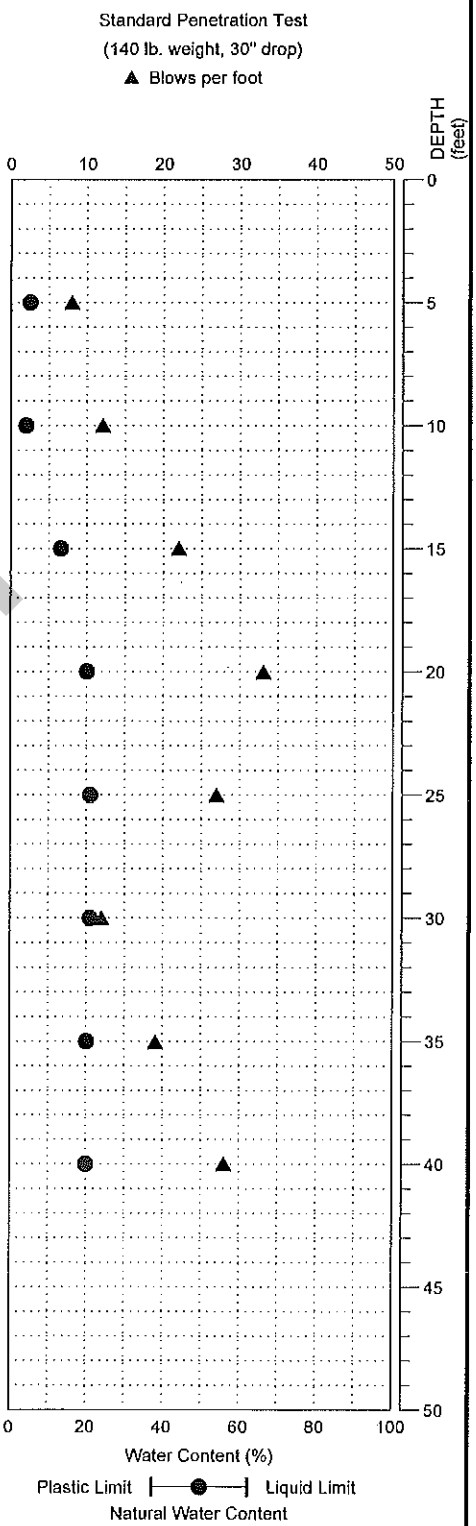
BORING 2007014.GPJ 5/14/08

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: Hollow Stem Auger
SAMPLING METHOD: SPT w/autohammer
SURFACE ELEVATION: 27 ± feet

LOCATION: See Figure 2
DATE STARTED: 9/18/2007
DATE COMPLETED: 9/18/2007
LOGGED BY: B. Hawkins

DEPTH (feet)	SYMBOL	USCS SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/6 inches)	OTHER TESTS	GROUNDWATER
0		GP	4" Asphalt Driveway. Loose, brown to gray brown, fine to coarse sandy, fine to coarse GRAVEL to gravelly SAND, moist.					
5					S-1	3-4-4		
10		SP SM	Medium dense, olive brown, slightly silty, fine to medium SAND, moist.		S-2	3-6-6		
15					S-3	6-10-12	GS	
20		SP SM	Medium dense, olive brown, slightly silty, slightly fine to coarse gravelly, fine to coarse SAND, wet. A 1-inch silt lens (moist) noted near middle of S-4.		S-4	7-12-21	GS	▽
25		SP	Medium dense, olive brown, clean, slightly fine gravelly, fine to medium SAND, wet.		S-5	5-11-16	GS	
30		SP SM	Medium dense, olive brown, slightly silty, fine to medium SAND, wet. Approximately 6 inches of sand heave noted at 30 feet.		S-6	1-4-8	GS	
35			Approximately 12 inches of sand heave noted at 35 feet.		S-7	4-6-13	GS	
40			Approximately 6 inches of sand heave noted at 40 feet.		S-8	4-12-16		
45								
50								

Total depth = 41.5 feet.
Ground water encountered at about 20 feet during drilling.
Ground water level measured at 20 feet when augers removed.



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HWA GEOSCIENCES INC.

Gig Harbor WWTP
Improvements Project
Gig Harbor, Washington

BORING:
BH- 4

PROJECT NO.: 2007-014 FIGURE: A-15

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

USCS SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS	
Coarse Grained Soils	Gravel and Gravelly Soils	Clean Gravel (little or no fines)	GW	Well-graded GRAVEL
	More than 50% of Coarse Fraction Retained on No. 4 Sieve		GP	Poorly-graded GRAVEL
		Gravel with Fines (appreciable amount of fines)	GM	Silty GRAVEL
			GC	Clayey GRAVEL
More than 50% Retained on No. 200 Sieve Size	Sand and Sandy Soils	Clean Sand (little or no fines)	SW	Well-graded SAND
	50% or More of Coarse Fraction Passing No. 4 Sieve		SP	Poorly-graded SAND
		Sand with Fines (appreciable amount of fines)	SM	Silty SAND
			SC	Clayey SAND
Fine Grained Soils	Silt and Clay	Liquid Limit Less than 50%	ML	SILT
			CL	Lean CLAY
			OL	Organic SILT/Organic CLAY
50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit 50% or More	MH	Elastic SILT
			CH	Fat CLAY
			OH	Organic SILT/Organic CLAY
Highly Organic Soils			PT	PEAT

TEST SYMBOLS

%F	Percent Fines
AL	Atterberg Limits: PL = Plastic Limit, LL = Liquid Limit
CBR	California Bearing Ratio
CN	Consolidation
DD	Dry Density (pcf)
DS	Direct Shear
GS	Grain Size Distribution
K	Permeability
MD	Moisture/Density Relationship (Proctor)
MR	Resilient Modulus
PID	Photoionization Device Reading
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)
SG	Specific Gravity
TC	Triaxial Compression
TV	Torvane Approx. Shear Strength (tsf)
UC	Unconfined Compression

SAMPLE TYPE SYMBOLS

- 2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
- Shelby Tube
- 3-1/4" OD Split Spoon with Brass Rings
- Small Bag Sample
- Large Bag (Bulk) Sample
- Core Run
- Non-standard Penetration Test (3.0" OD split spoon)

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- Groundwater Level (measured at time of drilling)
- Groundwater Level (measured in well or open hole after water level stabilized)

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
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Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
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Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

COMPONENT PROPORTIONS

PROPORTION RANGE	DESCRIPTIVE TERMS
< 5%	Clean
5 - 12%	Slightly (Clayey, Silty, Sandy)
12 - 30%	Clayey, Silty, Sandy, Gravelly
30 - 50%	Very (Clayey, Silty, Sandy, Gravelly)
Components are arranged in order of increasing quantities.	

NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation.
Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch.
MOIST	Damp but no visible water.
WET	Visible free water, usually soil is below water table.

GeoSciences Inc.

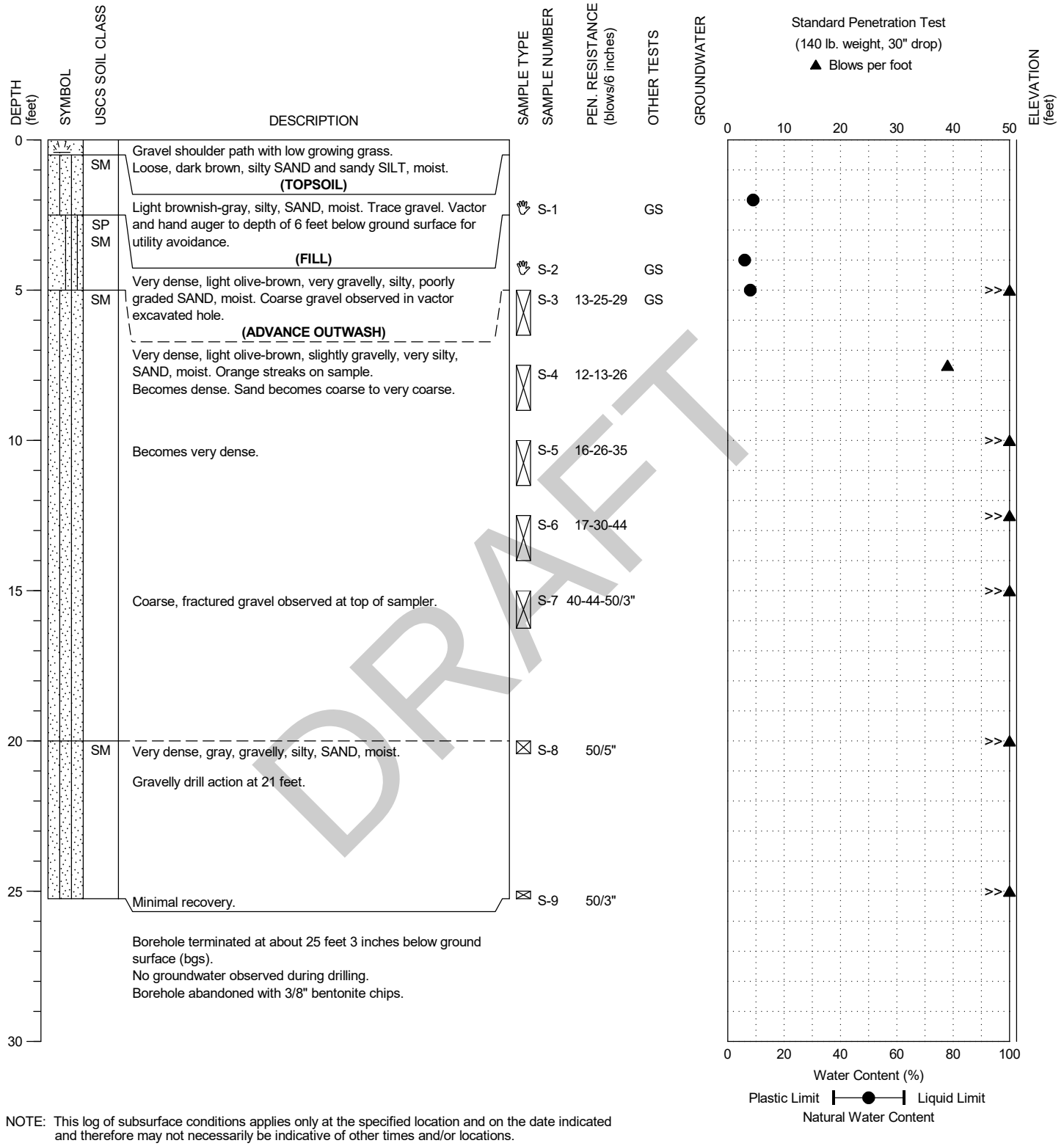
BURNHAM DRIVE AND HARBORVIEW DRIVE IMPROVEMENTS - PHASE 1
GIG HARBOR, WASHINGTON

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 2020-033-21 FIGURE: A-1

DRILLING COMPANY: Holocene Drilling
DRILLING METHOD: HSA, Dietrich D-50 Turbo Track Rig
SAMPLING METHOD: SPT w/ Autohammer
LOCATION: See Figure 2

DATE STARTED: 6/16/2020
DATE COMPLETED: 6/16/2020
LOGGED BY: SKS



NOTE: This log of subsurface conditions applies only at the specified location and on the date indicated and therefore may not necessarily be indicative of other times and/or locations.

GeoSciences Inc.

BURNHAM DRIVE AND HARBORVIEW DRIVE
IMPROVEMENTS - PHASE 1
GIG HARBOR, WASHINGTON

BORING:
BH-6

PROJECT NO.: 2020-033-21 FIGURE: A-7

BORING-DSM 2020-033.GPJ 7/21/20

Appendix G

Preliminary Alternative Cost Estimates

City of Gig Harbor
North Creek Culvert Feasibility Study
Alternative 1 - Bulb Tee Girder Single Span Bridge
Conceptual Cost Estimate

Estimated By: D. Dinkuhn
Date: 01/17/23

Checked By: S. Seville
Date: 01/17/23

SCHEDULE A - ROADWAY

ITEM NO.	DESCRIPTION OF ITEM	EST. QTY.	UNIT	UNIT PRICE	AMOUNT	NOTES
1	Minor Change	1	CALC	$50,000.00	$50,000.00	
2	Record Drawings	1	LS	$2,000.00	$2,000.00	
3	Structure and Roadway Surveying	1	LS	$11,000	$11,000	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
4	SPCC Plan	1	LS	$1,000.00	$1,000.00	Eng Est
5	Pothole	10	EA	$700.00	$7,000.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
6	Protection and Support of Existing Utilities	1	LS	$13,200	$13,200	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
7	Type B Progress Schedule	1	LS	$2,000.00	$2,000.00	Eng Est
8	Mobilization	1	LS	$395,058.40	$395,058.40	10%
9	Project Temporary Traffic Control	1	LS	$130,000.00	$130,000.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
10	Clearing and Grubbing	1	LS	$17,000.00	$17,000.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
11	Removal of Structures and Obstructions	1	LS	$22,000.00	$22,000.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
12	Sawcut Asphalt Concrete Pavement	75	LF	$18.00	$1,350.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
13	Remove Asphalt Concrete Pavement	681	SY	$20.00	$13,620.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
14	Roadway Excavation Incl. Haul	10,258	CY	$33.00	$338,514.00	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to Octob
15	Unsuitable Foundation Excavation Incl. Haul	100	CY	$45.00	$4,500.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
16	Gravel Borrow Incl. Haul	552	TON	$40	$22,080	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to Octob
17	Structure Excavation Class A Incl. Haul	620	CY	$40.00	$24,800.00	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to Octob
18	Shoring or Extra Excavation Class A Incl. Haul	1	LS	$103,000	$103,000	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
19	Trimming and Cleanup	1	LS	$8,000.00	$8,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
20	Crushed Surfacing Top Course	408	TON	$58.00	$23,664.00	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to Octob
21	Crushed Surfacing Base Course	372	TON	$58.00	$21,576.00	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to Octob
22	HMA CL. 1/2 In. PG 58H-22	267	TON	$210.00	$56,070.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
23	Gravel Backfill for Wall – Bridge	213	CY	$67.00	$14,271.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
24	St. Reinf. Bar for Bridge	27,313	LB	$5.00	$136,565.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
25	Conc. Class 3000 For Bridge (Sidewalks)	42	CY	$867.00	$36,414.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
26	Conc. Class 4000 for Bridge	180	CY	$2,050.00	$369,000.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
27	Furnishing and Installing 41 In. Deck Bulb Tees (85' Span)	595	LF	$760.00	$452,200.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
28	Install Utility Hangers and Supply and Attach Utilities	1	LS	$40,000.00	$40,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
29	Furnishing Steel Piling (20 ea. 18 In. Diam. Pipe Piles)	655	LF	$197.00	$129,035.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
30	Driving Steel Piling	20	EA	$3,500.00	$70,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
31	Four Tube Curb Mount Rail Incl. Approaches	500	LF	$594.00	$297,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
32	Membrane Waterproofing (Deck Seal)	500	SY	$60.00	$30,000.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
33	6 In. Perforated Underdrain Pipe – Bridge	280	LF	$26.00	$7,280.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
34	Gravel Backfill for Drain – Bridge	15	20	$60.00	$900.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
35	Temporary Stream Diversion	1	LS	$70,800	$70,800	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
36	Corrugated Polyethylene Storm Sewer Pipe 12 In. Diam.	280	LF	$68.00	$19,040.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
37	Catch Basin Type 1	3	EA	$2,500.00	$7,500.00	Eng Est
38	Connection to Drainage Structure	1	EA	$1,000.00	$1,000.00	Eng Est
39	Underdrain Cleanout 4 In. Diam.	8	EA	$800.00	$6,400.00	Eng Est
40	Silt Fence	500	LF	$8.00	$4,000.00	Eng Est
41	Temporary Erosion and Sediment Control	1	LS	$16,500.00	$16,500.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
42	High Visibility Fence	1,000	LF	$7.00	$7,000.00	Eng Est
43	Woven Coir ECB	1,170	SY	$11.00	$12,870.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
44	Hydroseed	1,170	SY	$4.00	$4,680.00	Eng Est
45	Fine Compost	100	CY	$80.00	$8,000.00	Eng Est
46	Cement Conc. Traffic Curb and Gutter	340	LF	$39.00	$13,260.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
47	Cement Conc. Sidewalk	25	SY	$63.00	$1,575.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
48	Cement Conc. Curb Ramp Type Single Direction	3	EA	$2,500.00	$7,500.00	Eng Est
49	Quarry Spalls	30	TON	$90.00	$2,700.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
50	Streambed Aggregate	870	TON	$73.00	$63,510.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
51	Large Woody Material	20	EA	$2,000.00	$40,000.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 202
52	Illumination and Electrical System Complete	6	EA	$20,000.00	$120,000.00	6 Luminaires at $20k Each
53	Permanent Signing	1	LS	$5,000.00	$5,000.00	Eng Est
54	Plastic Line	500	LF	$4.00	$2,000.00	Eng Est
55	Soldier Pile Wall for Bridge Abutments	4335	SF	$176.00	$762,960.00	Olympic Discovery Trtail (3/6/17) Escalated to October 2022 (44%)
55	Wood Guardrail with Handrail	470	LF	$110.00	$51,700.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
56	Dewatering	1	LS	$85,000.00	$85,000.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
				Schedule A Total	**$4,163,092.40**	

SCHEDULE B - WATER AND SEWER

ITEM NO.	DESCRIPTION OF ITEM	EST. QTY.	UNIT	UNIT PRICE	AMOUNT	NOTES
1	Temporary Water and Sewer Bypass Plan	1	LS	$ 1,500.00	$ 1,500.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
2	Temporary Water and Sewer Bypass	1	LS	$ 88,000.00	$ 88,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
3	Ductile Iron Class 52 Water Pipe 12 In. Diam.	110	LF	$ 139.00	$ 15,290.00	WSDOT Bid Tabs
4	Connection to Existing Water Main	2	EA	$ 3,500.00	$ 7,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
5	Ductile Iron Gate Valve 12 In.	2	EA	$ 4,500.00	$ 9,000.00	WSDOT Bid Tabs
6	C900 PVC Sanitary Sewer Pipe 12 In. Diam.	110	LF	$ 68.00	$ 7,480.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (
7	Sewer Gate Valve 12 In.	2	EA	$ 4,500.00	$ 9,000.00	WSDOT Bid Tabs
8	Double Ball Flex Tend Coupling, 12 In. Diam.	4	EA	$ 9,970.00	$ 39,880.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
9	Connection to Existing Sanitary Sewer	2	EA	$ 2,700.00	$ 5,400.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62
				Schedule B Subtotal	**$ 182,550.00**	
				Sales Tax (8.8%)	**$ 16,064.40**	
				Schedule B Total	**$ 198,614.40**	

Notes: All Costs are in 2022 Dollars

SCHEDULE C - CONSTRUCTION ENGINEERING AND MANAGEMENT

ITEM NO.	DESCRIPTION OF ITEM	EST. QTY.	UNIT	UNIT PRICE	AMOUNT	NOTES
1	Construction Engineering (2% of Schedule A +B)	1	LS	$ 87,234.14	$ 87,234.14	Adjusted to position in table aligned with grant fund categories
2	Construction Administration & Management (7% of Sch A+B)	1	LS	$ 305,319.48	$ 305,319.48	Adjusted to position in table aligned with grant fund categories
				Schedule A Total	**$392,553.61**	

Subtotal Schedules A + B + C	**$4,754,260**
Contingency (30%)	**$1,426,278**
Total Construction Cost	**$6,180,539**

Preliminary Engineering (22%)	**$1,359,718**	Survey, Environmental, Permitting, and PS&E
Right of Way	**$0**	

GRAND TOTAL 2022 COST	**$7,540,257**

City of Gig Harbor
North Creek Culvert Feasibility Study
Alternative 2 - Three Sided Box Culvert
Conceptual Cost Estimate

Estimated By: D. Dinkuhn
Date: 01/17/23

Checked By: S. Seville
Date: 01/17/23

SCHEDULE A - ROADWAY

ITEM NO.	DESCRIPTION OF ITEM	EST. QTY.	UNIT	UNIT PRICE	AMOUNT	NOTES
1	Minor Change	1	Est.	$50,000	$50,000	
2	Record Drawings	1	LS	$2,000.00	$2,000.00	
3	Structure and Roadway Surveying	1	LS	$9,500	$9,500	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
4	SPCC Plan	1	LS	$700	$700	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
5	Pothole	10	Each	$700	$7,000	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
6	Protection and Support of Existing Utilities	1	LS	$13,200	$13,200	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
7	Type B Progress Schedule	1	LS	$2,000.00	$2,000.00	Eng Est
8	Mobilization	1	LS	$332,497	$332,497	10%
9	Project Temporary Traffic Control	1	LS	$130,000	$130,000	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
10	Temporary Bypass Road	1	LS	$58,000	$58,000	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
11	Clearing and Grubbing	1	LS	$17,000	$17,000	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
12	Removal of Structure and Obstruction	1	LS	$22,000	$22,000	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
13	Sawcut Asphalt Concrete Pavement	66	LF	$18	$1,188	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
14	Remove Asphalt Concrete Pavement	420	SY	$20	$8,400	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
15	Roadway Excavation Incl. Haul	3,787	CY	$33	$124,971	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to October 2022 (5%)
16	Unsuitable Foundation Excavation Incl. Haul	100	CY	$45	$4,500	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
17	Gravel Borrow Incl. Haul	1,771	TON	$40	$70,840	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to October 2022 (5%)
18	Structure Excavation Class A Incl. Haul	4,094	CY	$40	$163,760	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to October 2022 (5%)
19	Shoring or Extra Excavation Class A Incl. Haul	1	LS	$282,000	$282,000	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
20	Trimming and Cleanup	1	LS	$8,000	$8,000	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62%)
21	Crushed Surfacing Top Course	224	Ton	$58	$12,992	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to October 2022 (5%)
22	Crushed Surfacing Base Course	224	Ton	$58	$12,992	WSDOT Murden Creek Bridge Bid Tabs (3/9/22) Escalated to October 2022 (5%)
23	HMA Class 1/2 inch PG 58H-22	150	Ton	$210	$31,500	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
24	Gravel Backfill for Wall - Culvert	900	Ton	$67	$60,300	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
25	Gravel Backfill for Foundation Class A	60	Ton	$94	$5,640	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
26	Precast Reinf. Conc. Three-sided Structure	1	LS	$1,572,000	$1,572,000	Lake Helena/Wicks Rd Culvert (09/20/22)
27	Temporary Stream Diversion	1	LS	$70,800	$70,800	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
28	Solid Wall PVC Storm Sewer Pipe 12 In. Diam.	280	LF	$68	$19,040	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
29	Connect to Existing Storm Sewer Pipe	1	Each	$1,000	$1,000	Eng Est
30	Catch Basin Type 1	3	Each	$2,500	$7,500	Eng Est
31	Silt Fence	500	LF	$8.00	$4,000.00	Eng Est
31	Temporary Erosion and Sediment Control	1	LS	$16,500	$16,500	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
32	High Visibility Fence	800	LF	$7	$5,600	Eng Est
33	Woven Coir ECB	1,444	SY	$11	$15,884	Eng Est
34	Hydroseed	1,444	SY	$4	$5,776	Eng Est
35	Fine Compost	120	CY	$80	$9,600	Eng Est
36	Cement Conc. Traffic Curb and Gutter	300	LF	$39	$11,700	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
37	Cement Conc. Sidewalk	167	SY	$63	$10,521	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
38	Cement Conc. Curb Ramp Type Single Direction	3	Each	$2,500	$7,500	Eng Est
39	Quarry Spalls	30	Ton	$90	$2,700	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
40	Streambed Aggregate	940	Ton	$73	$68,620	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
41	Large Woody Material	20	EA	$2,000.00	$40,000.00	Brentwood Drive Bridge Bid Tab (4/17/22) Escalated to October 2022 (5%)
42	Illumination and Electrical System Complete	1	LS	$120,000.00	$120,000.00	6 Luminaires at $20k Each
43	Permanent Signing	1	LS	$3,000	$3,000	Eng Est
44	Plastic Line	600	LF	$4	$2,400	Eng Est
45	Dewatering	1	LS	$85,000	$85,000	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
				Schedule A Total	**$3,510,121**	

SCHEDULE B - WATER AND SEWER

ITEM NO.	DESCRIPTION OF ITEM	EST. QTY.	UNIT	UNIT PRICE	AMOUNT	NOTES
1	Temporary Water and Sewer Bypass Plan	1	LS	$ 1,500.00	$ 1,500.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62%)
2	Temporary Water and Sewer Bypass	1	LS	$ 88,000.00	$ 88,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62%)
3	Ductile Iron Class 52 Water Pipe 12 In. Diam.	75	LF	$ 139.00	$ 10,425.00	WSDOT Bid Tabs
4	Connection to Existing Water Main	2	EA	$ 3,500.00	$ 7,000.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62%)
5	Ductile Iron Gate Valve 12 In.	2	EA	$ 4,500.00	$ 9,000.00	WSDOT Bid Tabs
6	C900 PVC Sanitary Sewer Pipe 12 In. Diam.	75	LF	$ 68.00	$ 5,100.00	Kitsap Way Culvert Bid Tab (01/26/21) Escalated to October 2022 (18%)
7	Sewer Gate Valve 12 In.	2	EA	$ 4,500.00	$ 9,000.00	WSDOT Bid Tabs
8	Connection to Existing Sanitary Sewer	2	EA	$ 2,700.00	$ 5,400.00	Donkey Creek Bid Tab (10/17/2012) Escalated to October 2022 (62%)
				Schedule B Subtotal	**$ 135,425.00**	
				Sales Tax (8.8%)	**$ 11,917.40**	
				Schedule B Total	**$ 147,342.40**	

Notes: All Costs are in 2022 Dollars

SCHEDULE C - CONSTRUCTION ENGINEERING AND MANAGEMENT

ITEM NO.	DESCRIPTION OF ITEM	EST. QTY.	UNIT	UNIT PRICE	AMOUNT	NOTES
1	Construction Engineering (2% of Schedule A +B)	1	LS	$ 73,149.26	$ 73,149.26	Adjusted to position in table aligned with grant fund categories
2	Construction Administration & Management (7% of Sch A+B)	1	LS	$ 256,022.41	$ 256,022.41	Adjusted to position in table aligned with grant fund categories
				Schedule A T	**$329,171.67**	

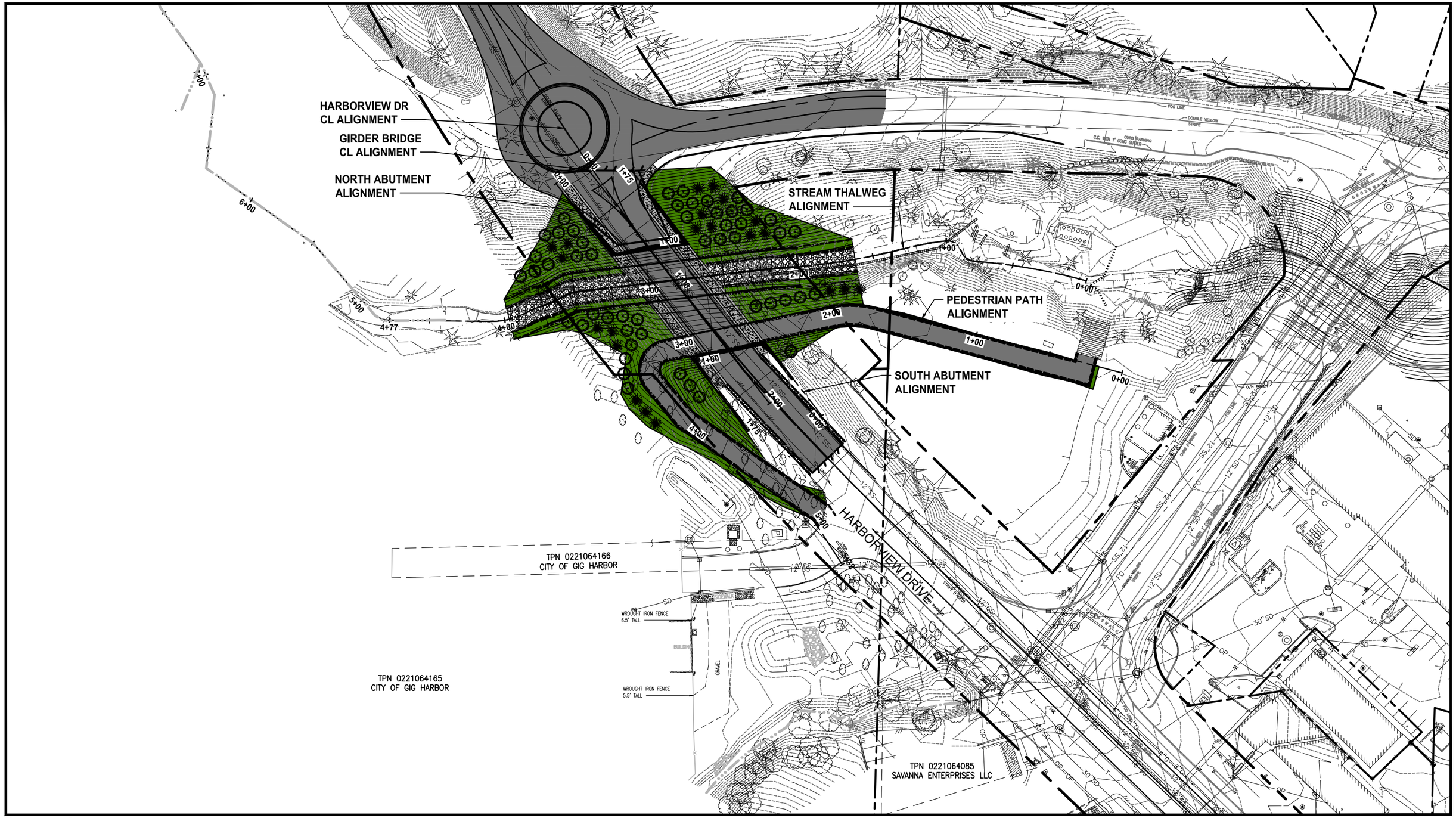
Subtotal Schedules A + B + C	**$3,986,635**
Contingency (30%)	**$1,195,990**
Total Construction Cost	**$5,182,625**

Preliminary Engineering (20%)	**$1,036,525**	Survey, Environmental, Permitting, and PS&E
Right of Way	**$0**	

GRAND TOTAL 2022 COST	**$6,219,150**

Appendix H

Preliminary Design Drawings



Parametrix DATE: January 10, 2023 FILE: FIGURES_BRIDGE

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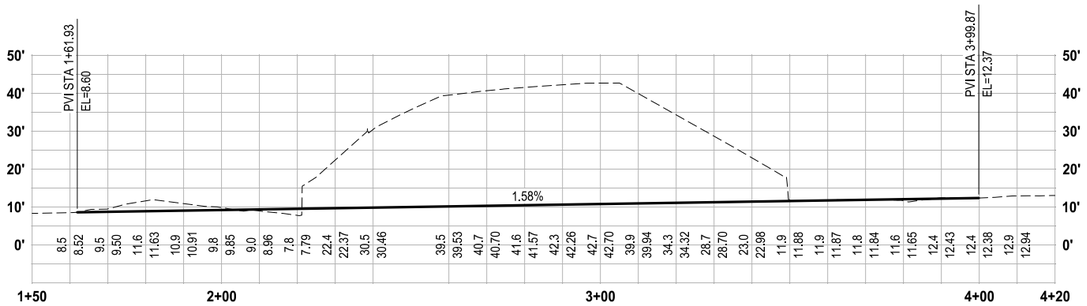
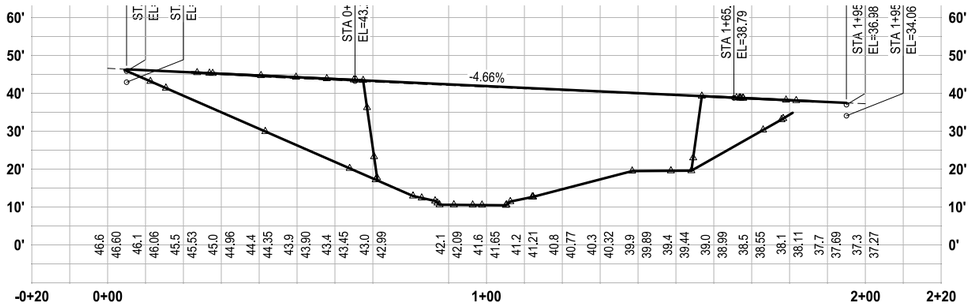
SCALE IN FEET

Figure 3 - Bridge with Roundabout

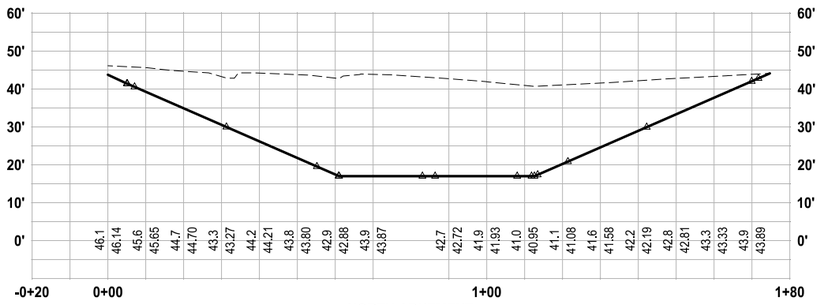
North Creek Culvert Feasibility Study



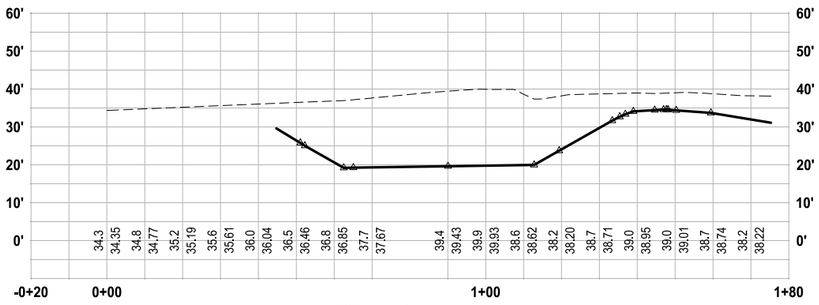
STREAM THALWEG
PROFILE
HORIZ: 1"=20'
VERT: 1"=20'



GIRDER BRIDGE CL
PROFILE
HORIZ: 1"=20'
VERT: 1"=20'



NORTH ABUTMENT
PROFILE
HORIZ: 1"=20'
VERT: 1"=20'



SOUTH ABUTMENT
PROFILE
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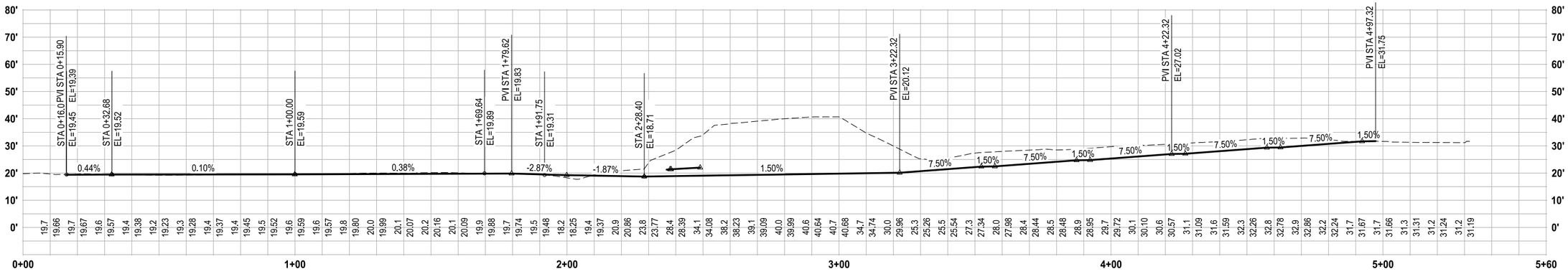
VERT: 1"=20'

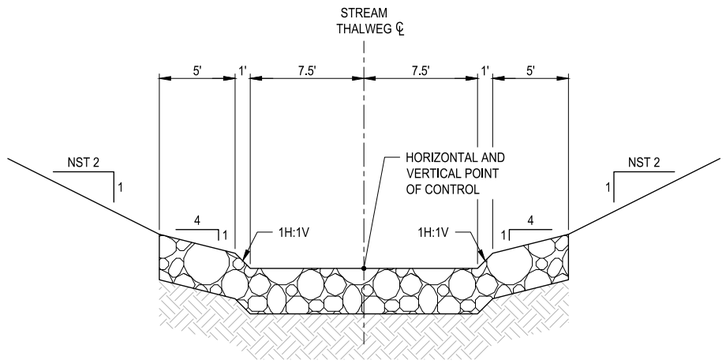


PEDESTRIAN PATH
PROFILE
HORIZ: 1"=20'
VERT: 1"=20'

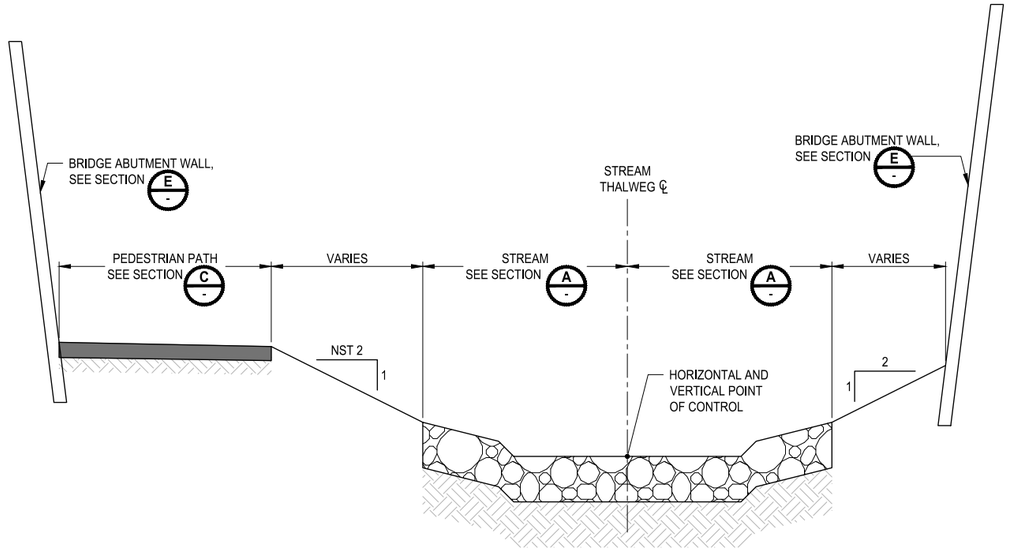
Parametrix DATE: January 10, 2023 FILE: FIGURES_BRIDGE

0 40
SCALE IN FEET

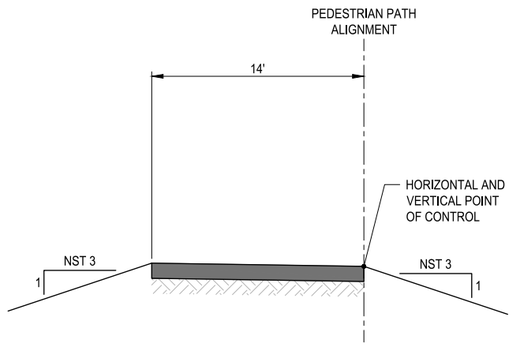
Figure 4 - Profiles
North Creek Culvert Feasibility Study



STREAM
TYPICAL SECTION A
NO SCALE -



STREAM BELOW BRIDGE
TYPICAL SECTION B
NO SCALE -



PEDESTRIAN PATH
TYPICAL SECTION C
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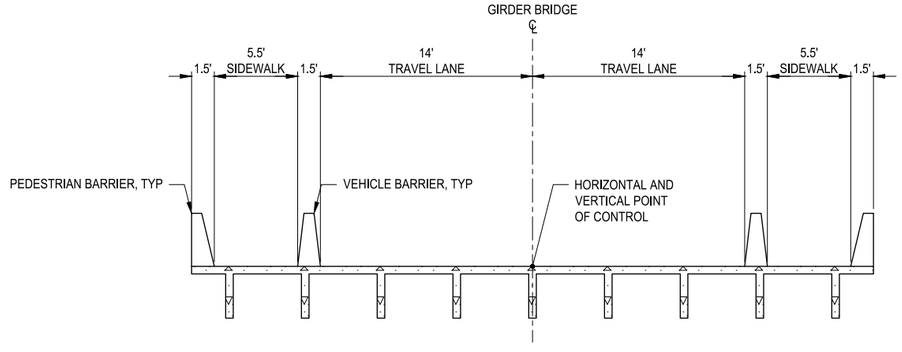
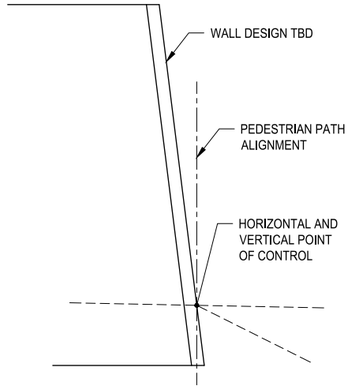


GIRDER BRIDGE
TYPICAL SECTION D
NO SCALE -



BRIDGE ABUTMENT
TYPICAL SECTION E
NO SCALE -

Figure 5 - Sections
North Creek Culvert Feasibility Study