



## **Technical Memorandum**

<b>Date:</b>	May 20, 2022	<b>From:</b>	Jennifer H. Saltonstall, L.Hg.
<b>To:</b>	Herrera Environmental Consultants, Inc.	<b>Project Manager/ Principal in Charge:</b>	Jennifer H. Saltonstall, L.Hg.
<b>Attn:</b>	Matt Fontaine, P.E.	<b>Project Name:</b>	Manzanita Watershed Hydrogeologic Evaluation
	mfontaine@herrerainc.com	<b>Project No:</b>	20210159H001
<b>Subject:</b>	Infiltration Feasibility Assessment, Subtask 2.1c and Subtask 2.1d		

### **1.0 INTRODUCTION**

Associated Earth Sciences, Inc. (AESI) is pleased to present this technical memorandum for our Preliminary Infiltration Feasibility Study and Geotechnical Recommendations for two sites in the Manzanita Watershed, on Bainbridge Island, Washington. The two sites are referred to in this report as “Site 5 (M&E Farm)” and “Site 7 (Fieldstone).” The site locations within the Manzanita Watershed are shown on the “Vicinity Map,” Figure 1. The locations of the sites, subsurface explorations and LIDAR topography are shown on the “Explorations and Topography Map,” Figure 2. Exploration logs and laboratory testing data are included in Appendix A attached to this technical memorandum. Infiltration feasibility considerations are discussed in relation to guidelines in the Washington State Department of Ecology (Ecology), 2019, *Stormwater Management Manual for Western Washington* (2019 Ecology Manual).

Our understanding of the project is based on information provided during our discussions with Herrera and City of Bainbridge Island staff, subsurface explorations observed by City of Bainbridge Island staff, regional geologic, geomorphic and soils mapping, water supply bulletins, water well reports, City data and publicly available geotechnical explorations, and our in-house project files.

#### **1.1 Key Findings**

Based on the results of the desktop study and subsurface exploration, the key infiltration feasibility/geotechnical considerations and recommendations for each site are summarized below:

##### **Site 5 (M&E Farm)**

- Shallow infiltration is potentially feasible;
- Deep infiltration is infeasible due to saturated soils (regional groundwater); and

- Future shallow infiltration studies should include facility specific exploration, pilot infiltration testing, groundwater level monitoring, and analysis/reporting to address the Site Suitability Criteria in the 2019 Ecology Manual.

#### Site 7 (Fieldstone)

- Shallow infiltration is infeasible due to low permeability (glacial till) soils and presence of perched groundwater;
- Deep infiltration is potentially feasible at depths greater than the exploration boring depth based on regional geologic mapping; and
- Future deep infiltration studies should be phased to include (1) feasibility-level field work and subsurface explorations to document deeper soil and groundwater conditions, and (2) design-level deep infiltration testing, groundwater and slope modeling, and deep Underground Injection Control (UIC) hydrogeologic studies per the 2019 Ecology Manual.

## **2.0 SUBSURFACE CONDITIONS**

### **2.1 Exploration Borings**

Two exploration borings (referred to as B-1 and B-2, located at Site 5 and Site 7, respectively) were drilled by Holt Services, Inc. under subcontract to the City of Bainbridge Island on March 7, 2022. The exploration borings were observed and logged by a City of Bainbridge Island hydrogeologist. The borings were drilled with a Mobile B-60 hollow stem auger drilling rig with 4-inch tooling to depths of 30 feet at the locations shown on Figure 2.

Disturbed but representative samples were obtained by using the Standard Penetration Test (SPT) procedure in accordance with *ASTM International* (ASTM) D-1586. This test and sampling method consists of driving a standard 2-inch, outside-diameter, split-barrel sampler a distance of 18 inches into the soil with a 140-pound hammer free-falling a distance of 30 inches. The number of blows for each 6-inch interval is recorded, and the number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance (“N”) or blow count. If a total of 50 is recorded within one 6-inch interval, the blow count is recorded as the number of blows for the corresponding number of inches of penetration. The resistance, or N-value, provides a measure of the relative density of granular soils or the relative consistency of cohesive soils.

The samples obtained from the split-barrel sampler were classified in the field and representative portions placed in watertight containers. The samples were then transported to AESI’s laboratory for further visual classification and laboratory testing, as necessary. Smaller portions of the samples were placed into trays for visual reference (see Photo 1). The exploration logs presented in Appendix A are based on the N-values, AESI’s review of the samples, field observations and drilling action observations by City of Bainbridge Island staff, and laboratory test results, if conducted.



Photo 1. Reference sample trays created from samples for exploration borings B-1 and B-2.

## 2.2 Regional Geologic and Soils Mapping

Review of the regional geologic map titled Geologic map of the Suquamish 7.5' quadrangle and part of the Seattle North 7.5' x 15' quadrangle, Kitsap County, Washington (2011, Haugerud, R.A., and Troost, K.G., 2011, USGS, Scientific Investigations Map 3181, scale 1:24,000) indicates that both sites are underlain by glacial till. Review of regional soils mapping (McMurphy, C.J, 1980, *Soil Survey of Kitsap County Area, Washington*, U.S. Department of Agriculture [USDA], Soils Conservation Service [SCS] now referred to as Natural Resources Conservation Service [NRCS]) indicates that both sites are underlain by soils formed from the weathering of glacial sediments.

There is also regional geomorphic mapping of the project area (Haugerud, R. A., 2009, Preliminary geomorphic map of the Kitsap Peninsula, Washington: U.S. Geological Survey, Open-File Report 2009-1033, 2 sheets, scale 1:36,000). Geomorphic mapping uses on high-resolution LIDAR to map similar surfaces. The surface in the vicinity of Site 7 is described as fluted glaciated surface (gf). Fluting reflects the basal sliding of the icesheet. At Site 5, the surface is described as rippled fluted glaciated surface (gfr), where locally, transverse ripples are superimposed on fluted and scalloped glaciated surfaces. The origin of the rippled ground is unknown.

Sediments encountered at Site 5 (M&E Farms) varied from the regional mapping in that pre-Vashon nonglacial sediments were encountered near the ground surface. Sediments encountered at Site 7 (Fieldstone) were consistent with the published geologic and soils mapping in that glacial till sediments were encountered near the ground surface.

## 2.3 Stratigraphy

As shown on the attached exploration logs, sediments encountered consisted primarily of a surficial layer of topsoil, fill soils, and natural glacial and nonglacial sediments. The following section presents more detailed subsurface information organized from the oldest to the youngest sediment types.

### Pre-Vashon Nonglacial Sediments – Site 5

Pre-Vashon-age sediments represent an undifferentiated package of nonglacial and glacial sediment that were deposited great than 15,000 years before present. The pre-Vashon-age sediments encountered at depth beneath Site 5 are interpreted as nonglacial due to the presence of organic material and may correlate to the Olympia nonglacial interval or older interglacial periods of deposition.

The pre-Vashon sediments were stratified and consisted of an upper nonglacial fine-grained sequence of fine-grained silt and sandy silt; a coarse-grained sequence of gravelly sand/sandy gravel deposits; and a lower nonglacial fine-grained sequence of gravelly silt and finely layered silt/silty fine sand. The sediments extended beyond the drill depth of 31 feet, ranged from very stiff to dense, and are considered glacially consolidated.

The coarse-grained sediments were present from about 14.5 to 26.5 feet below ground surface in exploration boring B-1. The coarse-grained sediments are potentially suitable for stormwater infiltration if there is adequate separation from groundwater. Groundwater conditions are discussed in Section 2.4.

### Vashon Lodgement Till – Site 7

Deposits from the most recent glaciation of the Puget Lowland have been assigned to the Vashon Stade of the Fraser Glaciation. The Vashon glacier, the last major continental glacier in this area, occupied the region approximately 15,000 years before present.

Vashon lodgement till sediments generally consist of a poorly sorted mixture of sediment that was deposited directly at the base of the Vashon glacier. Natural soils interpreted to represent Vashon lodgement till were encountered to the total depth explored of 31 feet in B-2 at Site 7. The sediment generally consisted of unsorted, dense, slightly moist to moist, grayish brown to gray, silty sand with varying gravel and cobble content. This material was overrun by more than three thousand feet of ice in the project area during the last glacial advance, resulting in a very dense soil possessing high-strength, low-compressibility, and low-permeability characteristics.

The lodgement till encountered in B-2 acts as a hydraulically restrictive layer, causing perched water to accumulate in the overlying fill sediments (described separately below), and is considered unsuitable for stormwater infiltration.

## Fill

Both B-1 and B-2 encountered surficial fill sediments to a depth of 10.5 and 9.5 feet, respectively. The fill sediments in B-1 generally consisted of silty fine sand and sandy silt with variable gravel. The fill sediments in B-2 generally consisted of silty sand with some gravel. Fill thicknesses, density, and grain size can vary over short distances and should be expected near buried utilities and other site improvements. Due to the variable density and content, fill soils are generally not suitable for stormwater infiltration.

## Topsoil

A surficial layer of topsoil was encountered in both exploration borings completed for this study to a depth of approximately 6 inches. Due to the fines and organic material content, these materials are not considered suitable for stormwater infiltration.

## **2.4 Groundwater Conditions**

Groundwater was encountered in two primary intervals: perched groundwater and regional groundwater. Because it takes time for groundwater in an open boring to equilibrate to a static level, groundwater levels observed during drilling may be somewhat lower than actual static conditions.

The depth or occurrence of groundwater seepage may vary in response to changes in season, amount of precipitation, topography and on- and off-site land use. Exploration for this study was conducted on March 7, 2022.

### Perched Groundwater

Perched groundwater was present in the fill above the dense Vashon lodgement till at Site 7 based on wet sediments and seepage filling the borehole after drilling up to 7 feet below ground surface. Perched groundwater is inferred in the fill above the pre-Vashon nonglacial deposits at Site 5 based on the very moist to wet sediments and water on the drilling augers at about 12.5 feet.

Perched water occurs when surface water infiltrates down through relatively permeable soils, such as existing fill, and becomes trapped or “perched” atop a comparatively low-permeability barrier, such as glacial till or pre-Vashon fine-grained nonglacial deposits. When water becomes perched within fill, it may travel laterally and may follow flow paths related to permeable zones that may not correspond ground surface topography. Perched groundwater is often intermittent, present following large storms or during the wet season, and then drying up in the summer and early fall months.

## Regional Groundwater

Groundwater was encountered in B-1 at a depth of 28 feet at the time of drilling and is tentatively interpreted to represent a regional aquifer. At the time of drilling, the groundwater was only present in the lower few feet of the borehole.

Boring B-2 did not encounter the regional groundwater table within the total depth drilling (30.5 feet). The depth to the regional water table at B-2 is interpreted to be about 120 feet below ground surface (elevation 90 feet) based on review of geotechnical documents related to the nearby existing gravel pit. Regional groundwater typically has a large recharge area, may be unconfined or confined, and is present year round.

### **3.0 STORMWATER INFILTRATION CONCLUSIONS AND RECOMMENDATIONS**

#### **3.1 Site 5 (M&E Farm)**

Shallow infiltration potential is considered mixed at Site 5 (M&E Farm) due to low to moderate permeability shallow soils and possible shallow seasonal high groundwater. The target receptor horizon is the unsaturated pre-Vashon coarse-grained sediments present at 14.5 to 26.5 feet. Deep infiltration is considered infeasible due to saturated soils (regional groundwater) at 28 feet.

AESI conducted grain size distribution tests (sieves) on samples of the pre-Vashon coarse-grained sediments at depths of 15 and 20 feet below ground surface. We then compared the sieve results to with AESI's internal pilot infiltration test results database for the following estimated infiltration rates:

- Planning level field infiltration rates: 2 to 5 inches per hour
- Planning level long-term design infiltration rates: 0.5 to 2 inches per hour

The key constraints for shallow infiltration feasibility at Site 5 include (1) the presence of perched groundwater in the fill sediments that may complicate construction sequencing, and (2) an unknown seasonal high groundwater table. Regional groundwater encountered at 28 feet at the time of drilling. The seasonal high groundwater level is interpreted to be shallower than 28 feet. Site suitability criteria for vertical separation is 5 feet from either the seasonal high groundwater level or hydraulically restrictive layer; the separation can be reduced to 3 feet with a groundwater mounding analysis.

Recommendations for shallow infiltration design:

- Conduct test pit explorations to obtain site-specific information on subsurface variability in shallow soil and groundwater conditions;
- Conduct pilot infiltration testing to estimate preliminary design infiltration data;
- Install groundwater level monitoring well(s) to document depth to groundwater;

- Monitor groundwater levels to understand seasonal aquifer fluctuations;
- Address other site suitability criteria described in the 2019 Ecology Manual.

Practical approaches for a phased geotechnical scope of work could include the following tasks:

- Site specific exploration and pilot infiltration testing: two days of field work with a subcontracted excavation firm experienced in geotechnical work, and with equipment capable of excavating geotechnical test pits to depths of about 18 feet.
  - During the first day, set up an infiltration test near boring B-1. After the test soaking period has begun, use the excavator time to dig a series of geotechnical test pits to understand site variability in the area under consideration for infiltration, and select additional potential infiltration locations and depths.
  - During the second day, conduct a second and possibly third infiltration test, if water supply for testing is adequate to run two tests simultaneously.
  - Each infiltration test should be over-excavated after the falling-head portion of the test to look for post-test seepage or other indicators of hydraulic restrictive layers. Over-excavation should occur on the same day as the infiltration test.
  - All excavation work and sample collection should be observed by a geologist or hydrogeologist with experience in geologic characterization and infiltration testing.
- Monitoring well installation: one to three monitoring wells should be installed to allow for seasonal high water level monitoring. Multiple groundwater monitoring wells installed in a triangular pattern will allow for determination of groundwater flow direction.
- Laboratory testing: selected samples of the potential infiltration receptor horizon should be tested for grain size distribution, cation exchange capacity and percent organic matter content.
- Hydrogeologic and geotechnical analyses/reporting, to estimate preliminary long-term (factored) design infiltration rates, address applicable site suitability criteria in the 2019 Ecology Manual, and provide geotechnical recommendations to support infiltration design.

### **3.2 Site 7 (Fieldstone)**

Shallow infiltration potential is considered infeasible at Site 7 (Fieldstone) due to low permeability (glacial till) soils and the presence of perched groundwater. Infiltrated water would likely perch on and within the low permeability Vashon lodgement till and travel laterally.

Deep infiltration is potentially feasible at depths greater than the exploration boring depth based on regional geologic mapping. The target infiltration receptor horizon is pre-Vashon coarse-grained sediments based on geologic mapping and past sand and gravel mining activities in the site vicinity. The current study documents that the depth to the top of the infiltration receptor horizon is greater than 30.5 feet (the depth drilled in B-2).

Recommendations if deep infiltration is pursued:

- Deep Infiltration Feasibility Study:
  - Conduct targeted reconnaissance of the slopes northeast of B-2 to look for groundwater seepage, hydrophilic vegetation and geologic outcrops or exposures;
  - Conduct exploration boring(s) to obtain information on deeper soil and groundwater conditions;
  - Install groundwater level monitoring well(s) to document depth to groundwater;
  - Monitor groundwater levels to understand seasonal aquifer fluctuations;
- Deep Infiltration Design Study
  - Conduct deep infiltration testing, groundwater and slope modeling, and Deep UIC hydrogeologic studies per the 2019 Ecology Manual.

#### **4.0 GENERAL GEOTECHNICAL CONSIDERATIONS FOR INFILTRATION FACILITIES**

##### **4.1 Temporary Erosion and Sediment Control Considerations**

Care must be taken during construction not to contaminate infiltration or bioretention facilities with stormwater and silt during construction. The stormwater facilities must not be used to manage stormwater during construction. All construction site stormwater should be directed to a suitable location in accordance with temporary erosion and sediment control practices.

Care must also be taken to ensure the free draining backfill products are clean and free of fines. Stockpiled backfill materials must be protected from site soils and run-on from silt-contaminated surfaces.

##### **4.2 Construction Subgrade Observations**

The base of the infiltration facility must be excavated to remove the topsoil, any fill materials, and the overlying relatively finer-grained soils to expose the underlying relatively clean infiltration receptor horizon. From the results of the explorations, this depth is variable, but is generally 10.5 feet from existing grades and must be observed by AESI. We recommend using an excavator with a toothed bucket to strip and scarify the subgrade without tracking over it.

Excavation of the overlying fine-grained soils should be performed in a manner that does not disturb the underlying receptor horizon. Placement of the washed import free-draining gravel aggregate (if applicable) within the infiltration facility footprint should be completed in a manner which minimizes impacts to the framework and density of the native soil. Use of heavy equipment in the areas proposed for infiltration has the potential to compact the subgrade and reduce infiltration potential. Immediately before placing aggregate, remove any accumulation of fine material (if present) with light equipment and scarify the subgrade. Construction activity on the

surface that results in compaction of the native soil will have a detrimental effect on the infiltration rate.

Due to natural variability of the subsurface conditions, the potential for field adjustments should be anticipated based on actual conditions encountered during construction. Depending on the season the infiltration facility is constructed, perched water should be anticipated. The contractor should be prepared to handle the perched water.

#### **4.3 Overflow Path**

We recommend an overflow path be specified such that runoff above the facility's design capacity does not cause flooding of a building or emergency access, erosion or downstream sedimentation, or slope failure.

#### **4.4 Converting Infiltration or Bioretention Facilities to On-Line Status**

During construction, the stormwater facilities must be configured to prevent inflow of turbid, silt-laden construction runoff. Prior to bringing the facility on-line, the following elements must be achieved:

- All planned earthwork must be complete.
- Site stabilization must be complete:
- All permanent groundcover in place.
- No exposed topsoil.
- Hydroseeded areas must have established growth sufficient to fix topsoil in place.
- No visible sediment transport by stormwater during rain events.
- Catch-basin filter socks should no longer be needed and shall be removed.
- Hard surfaces such as paving and sidewalks must be cleaned with no visible sediment or substances that could be transported by stormwater.
- All stormwater collection system components must be cleaned and inspected:
- All catch basins, manholes, and similar structures contributing to the bioretention facility shall be cleaned by rinsing and vacuuming to remove visible sediment. No water used in the cleaning of the upstream system shall be discharged into the biofiltration facility.

After cleaning, we recommend that a video survey be completed of all pipes and structures in the stormwater collection system. The owner and civil/design engineer should be notified prior to the video survey work so they may observe the work in progress if desired. A recording of the video survey should be provided to the owner, civil engineer, and AESI. The survey should include sufficient detail to correlate video images with on-site locations.

When construction is complete, and the design team should be notified to allow installation of any long-term monitoring components such as water level loggers before water is routed to the stormwater facility. The owner and design team must be notified that the above items have been completed and must concur that the above items have been satisfactorily completed. Written

authorization must be provided from the owner, civil engineer, and AESI to the contractor that water may be routed to the stormwater facility for disposal.

Following the first substantial rain event after the stormwater facility is brought on-line, the system should be visually inspected. The contractor should contact the owner and design team to attend the inspection, and open facility enclosures, catch basins, manholes, and other structures as needed to allow visual inspection.

## 5.0 CLOSURE

We appreciate the opportunity to be of service to you on this project. Should you have any questions regarding this technical memorandum or other hydrogeologic/geotechnical aspects of the project, please call us at 425-827-7701 at your earliest convenience.

Sincerely,  
**ASSOCIATED EARTH SCIENCES, INC.**  
Kirkland, Washington



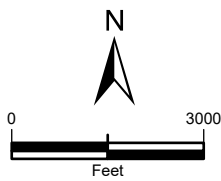
Jennifer H. Saltonstall, L.G., L.Hg.  
Principal Geologist/Hydrogeologist

### Attachments:

- Figure 1. Vicinity Map
- Figure 2. Explorations and Topography Map
- Appendix A: Exploration Logs and Laboratory Test Results (Sieves)



DATA SOURCES / REFERENCES:  
 USGS: 7.5' SERIES TOPOGRAPHIC MAPS, ESRI/I-CUBED/NGS 2013  
 KITSAP CO: STREETS, CITY LIMITS, PARCELS, PARKS 8/20  
 LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



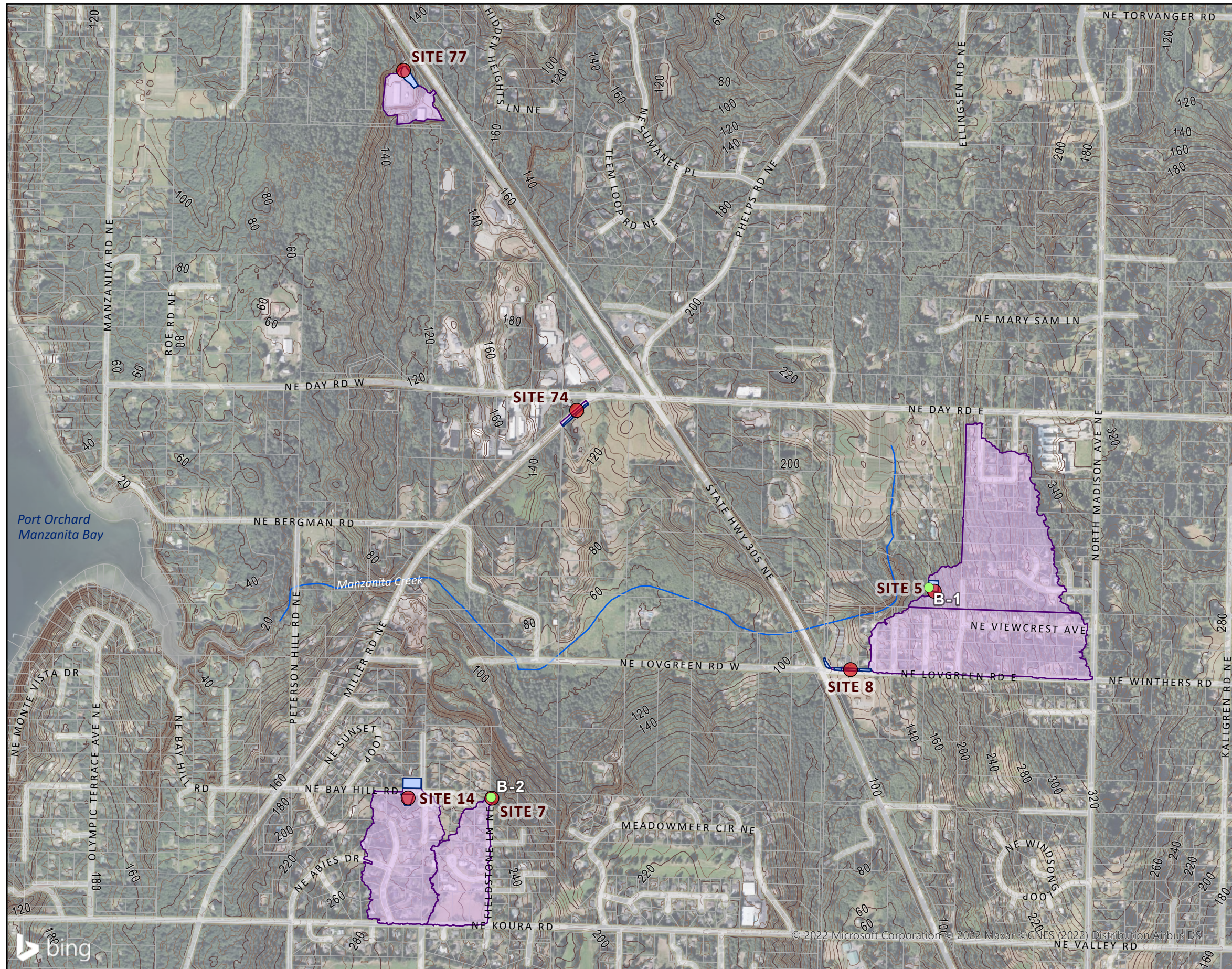
NOTE: BLACK AND WHITE  
 REPRODUCTION OF THIS COLOR  
 ORIGINAL MAY REDUCE ITS  
 EFFECTIVENESS AND LEAD TO  
 INCORRECT INTERPRETATION



### VICINITY MAP

MANZANITA WATERSHED HYDROGEOLOGIC EVALUATION  
 BAINBRIDGE ISLAND, WASHINGTON

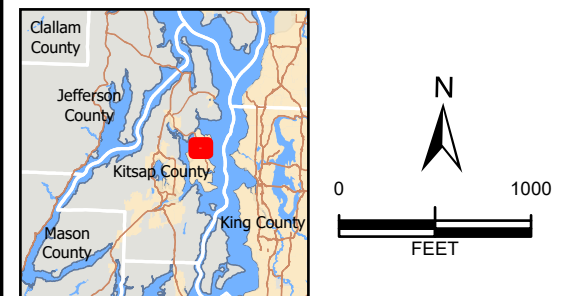
PROJ NO. 20210159H001	DATE: 5/22	FIGURE: 1
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- LEGEND**
- EXPLORATION BORING - CITY OF BAINBRIDGE - 2022
  - STORMWATER OPPORTUNITY POINTS
  - STORMWATER OPPORTUNITY POLYGONS
  - DRAFT DRAINAGE BASINS
  - PARCEL
  - ~ CONTOUR 20 FT
  - ~ CONTOUR 5 FT

**DATA SOURCES / REFERENCES:**  
 HERRERA ENVIRONMENTAL CONSULTANTS, STORMWATER AND DRAINAGE DATA, 2022  
 WADNR LIDAR PORTAL KITSAP CO., OPSW, AREA 1A ACQUIRED 12/17 THRU 2/18, GRID CELL SIZE IS 3' CONTOURS FROM LIDAR  
 KITSAP CO: ROADS, PARCELS 8/20  
 AERIAL: BING IMAGERY 8/20

LOCATIONS AND DISTANCES SHOWN ARE APPROXIMATE



BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION



**EXPLORATIONS AND TOPOGRAPHY**  
 MANZANITA WATERSHED HYDROGEOLOGIC EVALUATION  
 BAINBRIDGE ISLAND, WASHINGTON

PROJ NO. 20210159H001	DATE: 4/22	FIGURE: 2
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# **APPENDIX A**

## **Exploration Logs and Laboratory Test Results**

Project Name	Manzanita Watershed Hydrogeologic Evaluation	Ground Surface Elevation (ft)	
Location	Bainbridge Island, WA	Datum	
Driller/Equipment	Holt / HSA Mobile B-60	Date Start/Finish	3/7/22, 3/7/22
Hammer Weight/Drop	140# / 30	Hole Diameter (in)	8 in. O.D.












Depth (ft)	S T	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/Foot				Other Tests
							10	20	30	40	
				<b>Topsoil - ~6 inches</b> <b>Fill</b>							
5		S-1		Slightly moist to moist, grayish brown, silty, fine SAND, trace gravel; unsorted (SM).		5 3 2	▲5				
		S-2		As above; increase in medium to coarse sand; oxidized/mottled to reddish orange areas in lower few inches of sample.		8 10 16		▲26			
		S-3		Slightly moist, dark brown, silty, fine to coarse SAND, trace gravel to sandy, SILT, trace gravel; possible old topsoil (SM-ML).		4 5 13		▲18			
10		S-4		Upper 6 inches: as above. <b>Pre-Vashon Nonglacial Deposits</b> Very moist, gray to dark gray, SILT; occasional fine organic matter; occasional laminations; faint organic odor (ML).		1 6 16		▲22			
		S-5		Very moist to wet, dark gray to greenish gray, sandy, SILT, trace to some gravel and dark gray, SILT; organic odor; interbedded (ML).		23 26 50/4"					▲50/4"
15		S-6		<b>Pre-Vashon Coarse Grained Deposits</b> Slightly moist, grayish brown, gravelly, medium to coarse SAND to sandy, GRAVEL, trace silt (SP-GP).		45 50/4"					▲50/4"
		S-7		Slightly moist, brown to reddish dark brown, silty, fine SAND/SILT coarsening upward to fine to medium SAND, trace silt (SM-ML/SP).		23 12 26					▲38
20		S-8		Slightly moist, brown to dark brown, fine to coarse SAND, some gravel, trace silt; sand is mostly fine to medium (SP).		40 50/5"					▲50/5"
		S-9		As above; occasional beds of silty, fine sand (SP/SM).		22 32 50/5"					▲50/5"
25		S-10		Slightly moist, dark reddish brown, gravelly, fine to coarse SAND to sandy, GRAVEL, trace silt (SP/GP).		50/5"					▲50/5"
		S-11		<b>Pre-Vashon Nonglacial Fine Grained Deposits</b> Upper few inches: wet, dark brown, gravelly, SILT (ML). Lower portion: wet, gray to dark gray, silty, fine SAND to SILT; finely layered (SM-ML).		13 16 22					▲38
30		S-12				13 20 22					▲42
				Bottom of exploration boring at 31.5 feet Groundwater at 28 feet in augers and perched groundwater at ~12.5 feet ATD. Drilling notes and sample collection performed by City of Bainbridge (CoB) hydrogeologist and updated by AESI during sample review at AESI's soil lab.							

Sampler Type (ST):

- |                                   |                    |   |
|-----------------------------------|--------------------|---|
| 2" OD Split Spoon Sampler (SPT)   | No Recovery        | M - Moisture                            |
| 3" OD Split Spoon Sampler (D & M) | Ring Sample        | ▽ Water Level ( )                       |
| Grab Sample                       | Shelby Tube Sample | ▽ Water Level at time of drilling (ATD) |







Logged by: CoB  
Approved by: JHS

Project Name Manzanita Watershed Hydrogeologic Evaluation Ground Surface Elevation (ft) \_\_\_\_\_  
 Location Bainbridge Island, WA Datum \_\_\_\_\_  
 Driller/Equipment Holt / HSA Mobile B-60 Date Start/Finish 3/7/22, 3/7/22  
 Hammer Weight/Drop 140# / 30 Hole Diameter (in) 8 in. O.D.

Depth (ft)	SPT	Samples	Graphic Symbol	DESCRIPTION	Well Completion	Water Level	Blows/Foot				Other Tests
							10	20	30	40	
				<b>Black Organic Topsoil</b>							
				<b>Fill</b>							
5		S-1		Moist, brown to dark brown, silty, fine to medium SAND, some gravel; angular clasts (SM).		2 2 1	▲3				
		S-2		As above; grayish brown; broken gravel in sample (SM).		18 29 29					▲58
		S-3		Wet, grayish brown, silty, fine to medium SAND, some gravel (SM).		10 12 5	▲17				
10		S-4		<b>Vashon Lodgement Till</b> Dry to slightly moist, grayish brown, silty, fine SAND, trace to some gravel; unsorted (SM).		50/5"					▲50/5"
		S-5		As above.		50/5"					▲50/5"
15		S-6		As above.		31 50/2"					▲50/2"
		S-7		As above.		50/5"					▲50/5"
20		S-8		As above.		50/5"					▲50/5"
				Drill action indicates cobbly drilling; grinding augers.							
25		S-9		As above.		50/5"					▲50/5"
30		S-10		Dry to slightly moist, gray, silty, fine SAND, trace gravel (SM).		34 50/5"					▲50/5"
				Bottom of exploration boring at 31 feet Perched groundwater encountered at 7.5 feet ATD. Filled the borehole to 8.8 feet after augers removed. Drilling notes and sample collection performed by City of Bainbridge (CoB) hydrogeologist and updated by AESI during sample review at AESI's soil lab.							

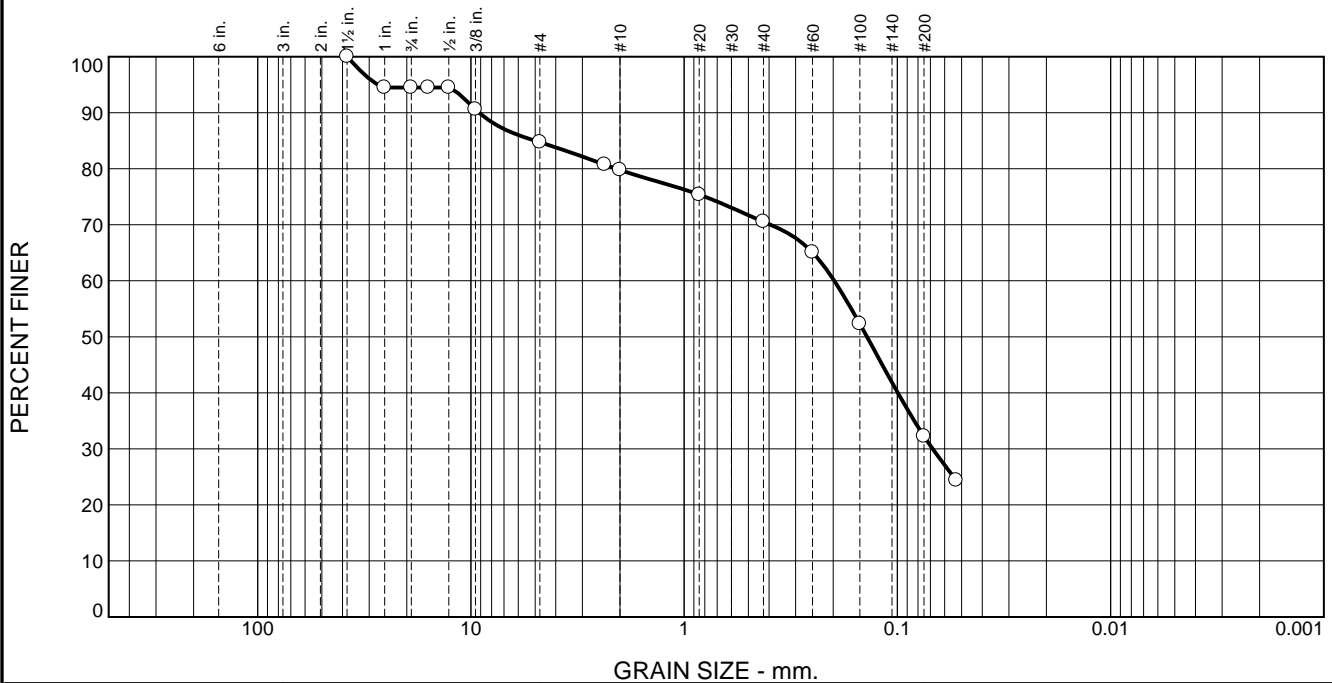
AESIBOR 20210159H001.GPJ April 21, 2022

**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:** CoB  
**Approved by:** JHS

# Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	5.5	9.8	4.9	9.3	38.2	32.3	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.5"	100.0		
1"	94.5		
3/4"	94.5		
5/8"	94.5		
1/2"	94.5		
3/8"	90.6		
#4	84.7		
#8	80.7		
#10	79.8		
#20	75.4		
#40	70.5		
#60	65.1		
#100	52.3		
#200	32.3		
#270	24.4		

**Material Description**

very silty, gravelly SAND

**Atterberg Limits (ASTM D 4318)**

PL= NP                      LL= NV                      PI=

**Classification**

USCS (D 2487)= SM                      AASHTO (M 145)= A-2-4(0)

**Coefficients**

D<sub>90</sub>= 9.1587                      D<sub>85</sub>= 4.9958                      D<sub>60</sub>= 0.1977  
D<sub>50</sub>= 0.1389                      D<sub>30</sub>= 0.0683                      D<sub>15</sub>=  
D<sub>10</sub>=                                      C<sub>u</sub>=                                      C<sub>c</sub>=

Remarks

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Date Received: 4/19/2022                      Date Tested: 4/21/2022

Tested By: CI

Checked By: JHS

Title: \_\_\_\_\_

\* (no specification provided)

Location: Onsite (S-3)  
Sample Number: B-1

Depth: 7.5'

Date Sampled: 3/7/2022



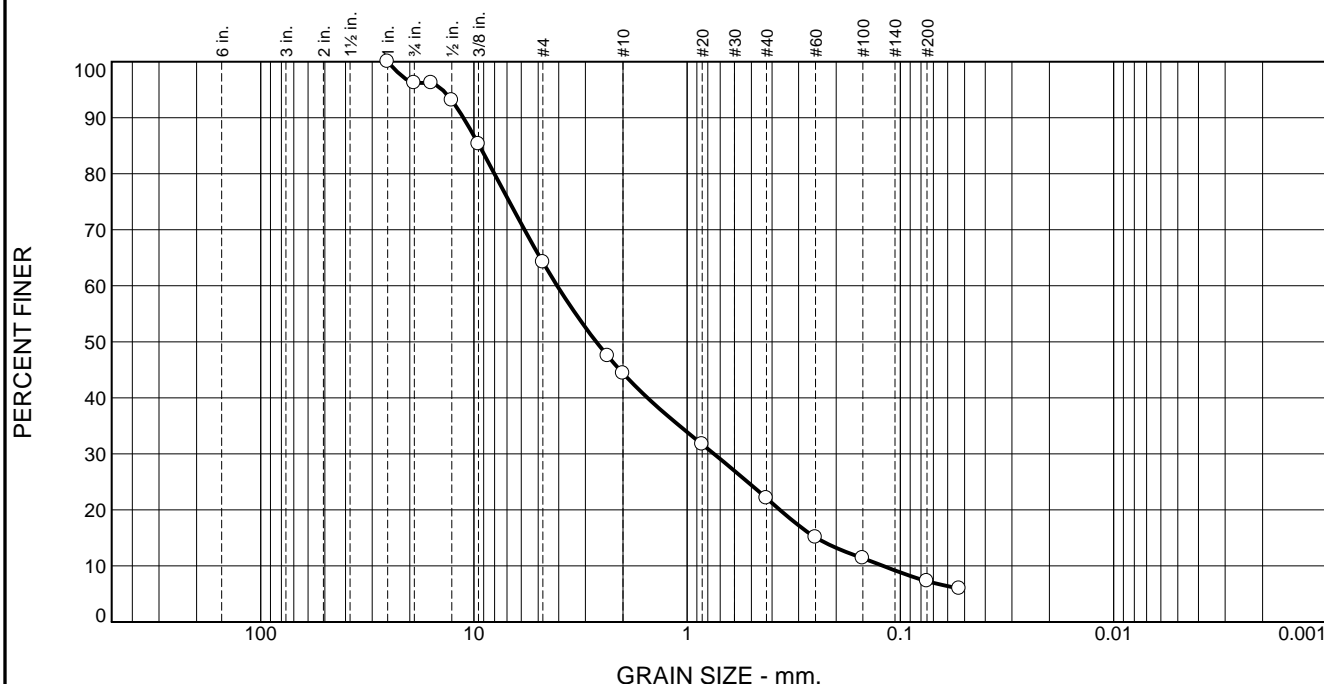
a s s o c i a t e d  
e a r t h s c i e n c e s  
i n c o r p o r a t e d

Client: Herrera Environmental Consultants  
Project: Manzanita Watershed Hydrogeologic Assessment

Project No: 20210159 H001

Figure

# Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.8	32.0	19.8	22.3	14.8	7.3	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	96.2		
5/8"	96.2		
1/2"	93.1		
3/8"	85.3		
#4	64.2		
#8	47.5		
#10	44.4		
#20	31.7		
#40	22.1		
#60	15.1		
#100	11.4		
#200	7.3		
#270	6.0		

**Material Description**  
very gravelly SAND, some silt

**Atterberg Limits (ASTM D 4318)**  
 PL= NP                      LL= NV                      PI=

**Classification**  
 USCS (D 2487)= SW-SM    AASHTO (M 145)= A-1-a

**Coefficients**

D <sub>90</sub> = 11.2059	D <sub>85</sub> = 9.4348	D <sub>60</sub> = 4.0701
D <sub>50</sub> = 2.6682	D <sub>30</sub> = 0.7489	D <sub>15</sub> = 0.2475
D <sub>10</sub> = 0.1205	C <sub>u</sub> = 33.77	C <sub>c</sub> = 1.14

Remarks

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Date Received: 4/19/2022      Date Tested: 4/21/2022

Tested By: CI

Checked By: JHS

Title: \_\_\_\_\_

\* (no specification provided)

Location: Onsite (S-6)  
Sample Number: B-1

Depth: 15'

Date Sampled: 3/7/2022



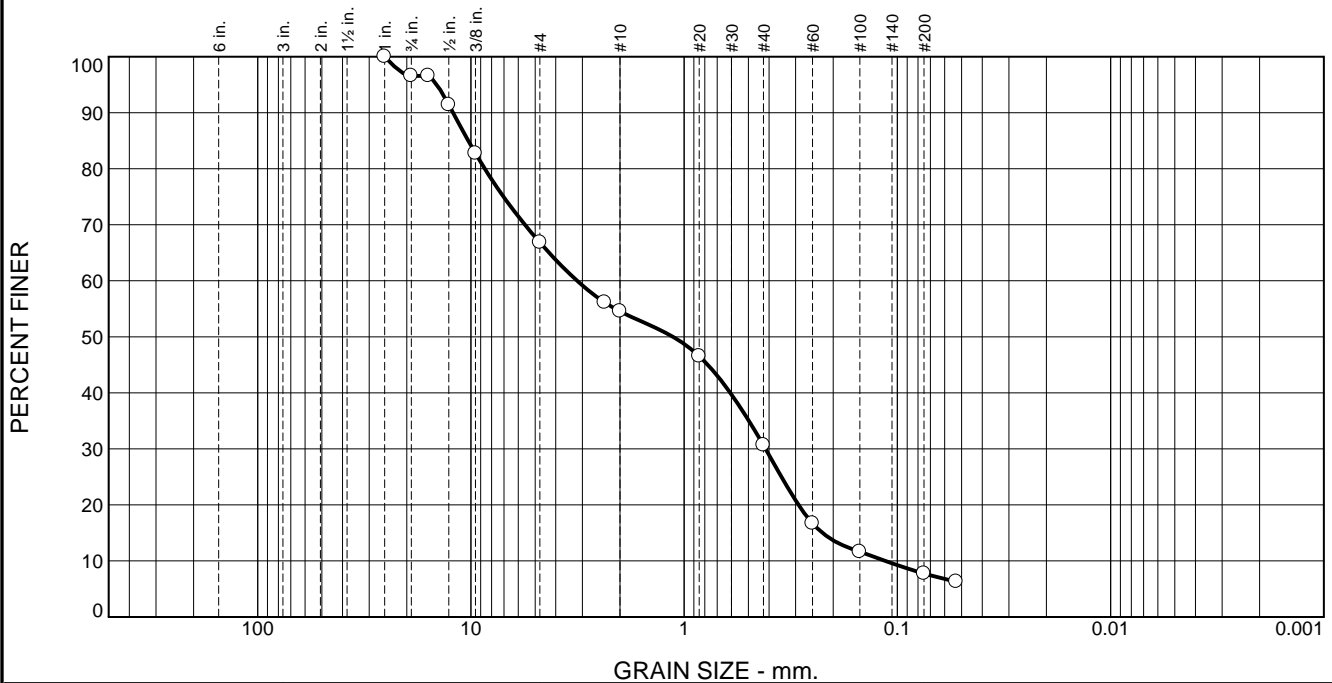
a s s o c i a t e d  
e a r t h s c i e n c e s  
i n c o r p o r a t e d

Client: Herrera Environmental Consultants  
Project: Manzanita Watershed Hydrogeologic Assessment

Project No: 20210159 H001

Figure

# Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	3.4	29.8	12.3	23.8	23.0	7.7	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1"	100.0		
3/4"	96.6		
5/8"	96.6		
1/2"	91.4		
3/8"	82.8		
#4	66.8		
#8	56.1		
#10	54.5		
#20	46.5		
#40	30.7		
#60	16.7		
#100	11.6		
#200	7.7		
#270	6.3		

**Material Description**  
very gravelly SAND, some silt

**Atterberg Limits (ASTM D 4318)**  
 PL= NP                      LL= NV                      PI=

**Classification**  
 USCS (D 2487)= SP-SM      AASHTO (M 145)= A-1-b

**Coefficients**  
 D<sub>90</sub>= 12.1349      D<sub>85</sub>= 10.2922      D<sub>60</sub>= 3.1775  
 D<sub>50</sub>= 1.1282      D<sub>30</sub>= 0.4153      D<sub>15</sub>= 0.2247  
 D<sub>10</sub>= 0.1138      C<sub>u</sub>= 27.93      C<sub>c</sub>= 0.48

Remarks

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Date Received: 4/19/2022      Date Tested: 4/21/2022

Tested By: CI

Checked By: JHS

Title: \_\_\_\_\_

\* (no specification provided)

Location: Onsite (S-8)  
 Sample Number: B-1

Depth: 20'

Date Sampled: 3/7/2022



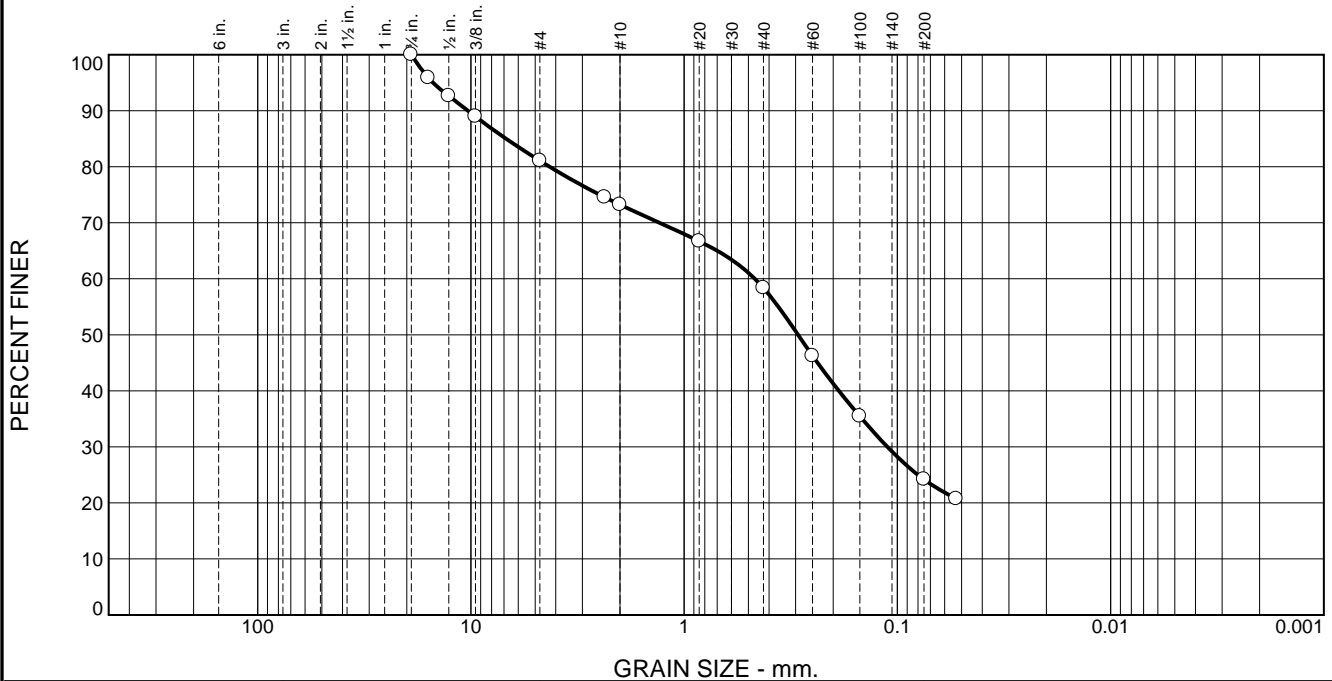
associated  
 earth sciences  
 incorporated

Client: Herrera Environmental Consultants  
 Project: Manzanita Watershed Hydrogeologic Assessment

Project No: 20210159 H001

Figure

# Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	18.9	7.9	14.8	34.2	24.2	

TEST RESULTS			
Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
3/4"	100.0		
5/8"	95.9		
1/2"	92.6		
3/8"	89.0		
#4	81.1		
#8	74.6		
#10	73.2		
#20	66.7		
#40	58.4		
#60	46.3		
#100	35.5		
#200	24.2		
#270	20.7		

**Material Description**  
gravelly, silty SAND

**Atterberg Limits (ASTM D 4318)**  
 PL= NP                      LL= NV                      PI=

**Classification**  
 USCS (D 2487)= SM                      AASHTO (M 145)= A-2-4(0)

**Coefficients**  
 D<sub>90</sub>= 10.3381                      D<sub>85</sub>= 6.8425                      D<sub>60</sub>= 0.4664  
 D<sub>50</sub>= 0.2924                      D<sub>30</sub>= 0.1114                      D<sub>15</sub>=  
 D<sub>10</sub>=                      C<sub>u</sub>=                      C<sub>c</sub>=

Remarks

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Date Received: 4/19/2022                      Date Tested: 4/21/2022

Tested By: CI

Checked By: JHS

Title: \_\_\_\_\_

\* (no specification provided)

Location: Onsite (S-4)  
 Sample Number: B-2

Depth: 10'

Date Sampled: 3/7/2022



a s s o c i a t e d  
 e a r t h s c i e n c e s  
 i n c o r p o r a t e d

Client: Herrera Environmental Consultants  
 Project: Manzanita Watershed Hydrogeologic Assessment

Project No: 20210159 H001

Figure