Central Waterfront Basin (Basin 69) Combined Sewer Overflow Control Project

Preliminary Basis of Design Report

Seattle Public Utilities
City of Seattle

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Section 1

Introduction

This Basis of Design Report outlines the design configuration, intent, applicable code requirements for controlling Central Waterfront Basin 69 (herein referred to as Basin 69) to the State combined sewer overflow (CSO) performance standard of an average of no more than one CSO event per year. This report is organized in sections covering the project introduction, pre-design and background, design criteria, individual discipline sections, and construction impacts.

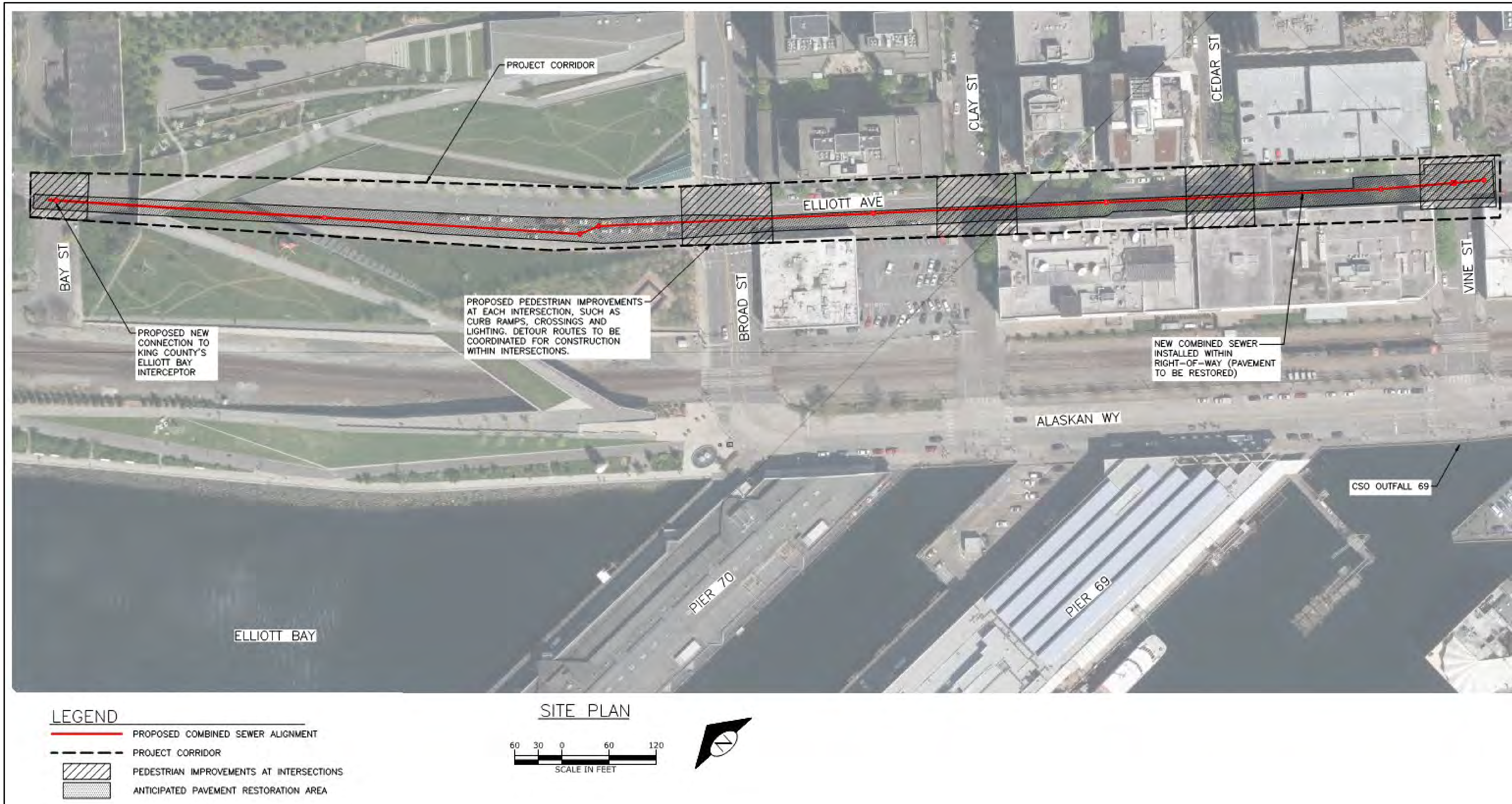
1.1 Project Background, Purpose and Goals

Seattle Public Utilities (SPU) operates and maintains a combined sewer system within the City of Seattle. During large storm events, the combined system can overflow at designated locations, resulting in combined sewer overflows (CSOs) of raw sewage and untreated stormwater. In 2013, the City of Seattle entered into a Consent Decree with the U.S. Environmental Protection Agency (EPA), U.S. Department of Justice (DOJ), and the Washington State Department of Ecology (Ecology), requiring the City to control each combined sewer outfall to the State CSO performance standard. Per the Consent Decree and SPU's wastewater NPDES permit, control is assessed based on a 20 year moving average.

Basin 69 is located at the north end of the City's downtown waterfront and includes an area of approximately 150 acres. During the period 1999-2018, Basin 69 averaged 1.8 CSOs per year[1], exceeding the State's CSO performance standard of no more than one CSO event per year. An Engineering Report was developed and submitted to Ecology that included the evaluation of multiple alternatives to control CSOs in Basin 69 and identified a recommended alternative. The recommended alternative from the Engineering Report is the project identified and discussed in this Basis of Design Report (BODR). This project (the recommended project) will control CSOs in Basin 69 by redirecting a portion of sewer flows through a new combined sewer that discharges to a new connection point on King County's (KC) Elliott Bay Interceptor (EBI), which ultimately conveys flows to KC's West Point Wastewater Treatment Plant. **Figure 1-1** shows an overview of the project area and sewer alignment.

[1] Based on CSO flow monitoring and supplemented modeled data, Aqualyze, 2019.

Figure 1-1
Basin 69 Project Overview



1.2 Applicable Codes, Standards, and Regulations

1.2.1 Codes

- 2016 Seattle Stormwater Code (Title 22, Subtitle VII of the Seattle Municipal Code)
  - http://www.seattle.gov/Documents/Departments/SDCI/Codes/2016StormwaterCode.pdf
- Seattle Department of Transportation (SDOT) Director's Rule 01-2017: Right-of-Way Opening and Restoration Rule (ROWORR)
  - http://www.seattle.gov/Documents/Departments/SDOT/About/DocumentLibrary/ROWORR_Manual.pdf

1.2.2 Standards

- City of Seattle Standard Plans and Specifications, 2017 Edition
  - http://www.seattle.gov/utilities/construction-and-development/standard-specs-plans
- City of Seattle Design Standards and Guidelines, 2018 Edition
  - https://www.seattle.gov/utilities/construction-and-development/design-standards
- Seattle Right-of Way Improvements Manual
  - https://streetsillustrated.seattle.gov/
- SDOT Street Tree Manual
  - http://www.seattle.gov/Documents/Departments/SDOT/About/DocumentLibrary/StreetTreeManualWEB.pdf
- SDOT 2018 Traffic Control Manual for In-Street Work
  - http://www.seattle.gov/Documents/Departments/SDOT/About/DocumentLibrary/TrafficControlManual/2018_Traffic_Control_Manual.pdf

1.2.3 Regulations

- City of Seattle's 2013 Consent Decree
- SPU's wastewater NPDES permit (Permit No. WA 0031682)

Section 2

Pre-Design Investigations and Work

2.1 Survey

No field survey data has been collected for this project to date. Basemaps and background information for project layout were done using existing GIS data currently available to SPU. Prior to final design, field survey and corresponding base mapping should be completed for the project area.

2.2 Potholing

No utility locating investigations (potholing) specific to this project have been completed to date. For this project, there is a risk of encountering vertical or horizontal spacing conflicts with other utilities located within the right-of-way (ROW). Below-grade utility locations should be investigated, and field verified where survey data indicates potential conflicts identified during detailed design.

2.3 Geotechnical and Geologic Conditions

At the initiation of the Vine Basin CSO Control Project in 2018 (Contract #SU0-18-007-S), SPU provided available geotechnical and geologic information for Basin 69. This geotechnical information is included as **Appendix A1** and **Appendix A2**. The available geotechnical information along the proposed alignment is scarce along Elliott Avenue between the intersections with Vine Street and Broad Street. More information is available along Elliott Avenue between Broad Street and Bay Street. The geotechnical borehole logs that are available have exploration dates ranging from 1978 to 1999. Information from some of these boreholes may not represent the upper layers of the proposed sewer alignment due to development after the explorations were performed, particularly along Elliott Avenue between Broad Street and Bay Street.

A preliminary review of the geotechnical information along Elliott Avenue indicates that the soils within the potential depths of excavation consist of an upper layer of fill that ranges from very stiff silt and clay with gravel and organics (observed in the one borehole between the intersection with Vine Street and the intersection with Cedar Street), to very loose to dense silty sand with varying amount of silt and gravel between the intersection with Clay Street and intersection with Broad Street. Soft sandy silt to very loose to medium dense silty sand with varying amount of silt and gravels is expected between the intersection with Broad Street and the end of the alignment. Organics, root fragments, wood debris, and brick fragments have been reported in this fill. Hydrocarbon odors were also reported in several boreholes from Broad Street to Bay Street; it is unknown if the soils were tested for hydrocarbons. It is noted that the area between Broad Street and Bay Street is the site of the former Unocal Cleanup Site, which was completed in 2007 and is expected to have removed most of the contamination in the top 8 to 12 feet of soil.

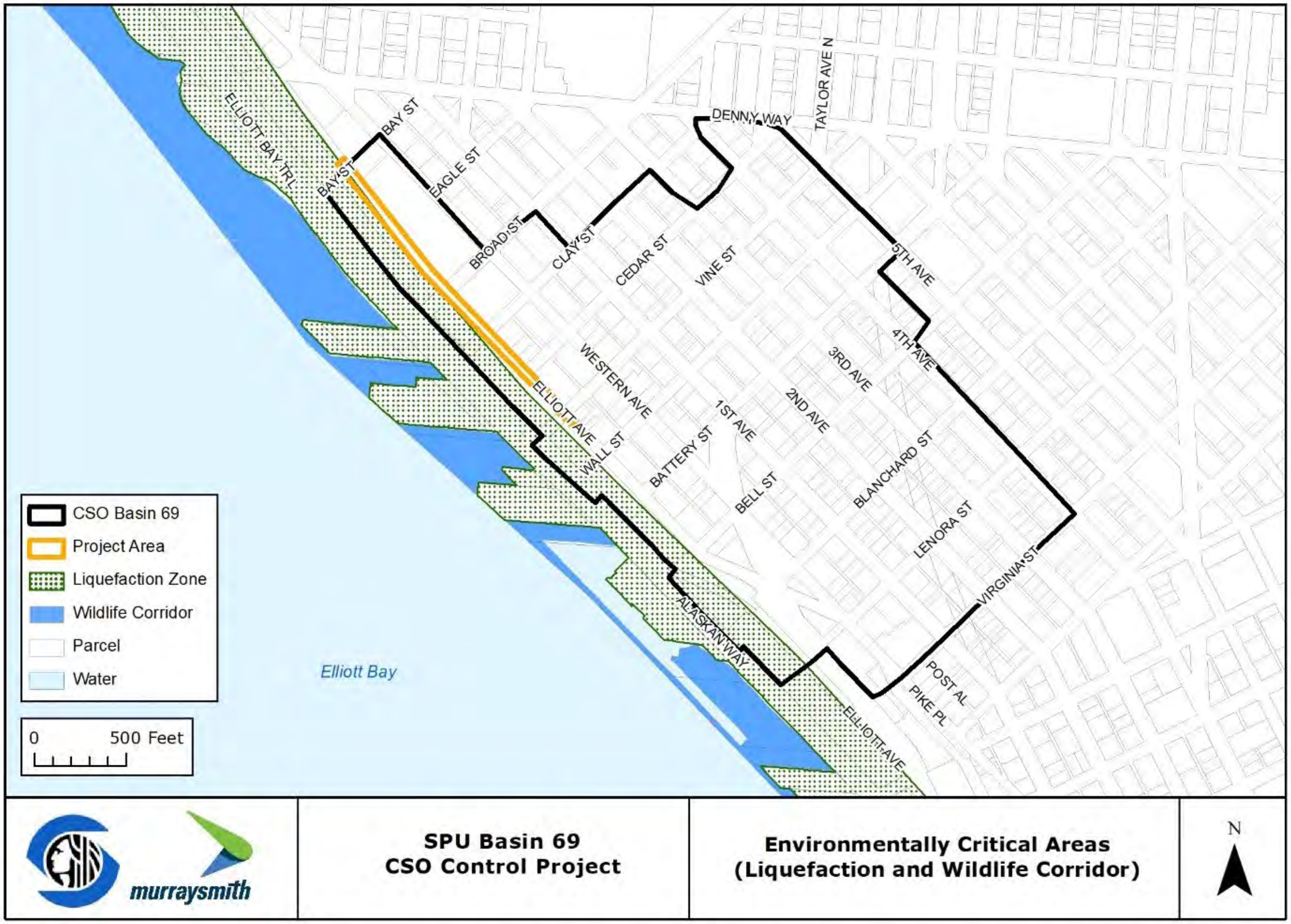
Underlying the fill, subsurface materials include dense to very dense silty sand, hard silty clay, very dense sandy silt and dense to very dense sand with varying amount of silt and gravels. The base of excavation is expected to be in material that varies from dense, very dense granular materials, or hard silty clay. Liquefaction hazards along the proposed alignment are expected to be low if the base of the excavation is in dense or very dense granular material. However, if loose or soft saturated soils are encountered at or below the base during excavation or during additional geotechnical borings, liquefaction hazards need to be reviewed. **Figure 2-1** shows identified liquefaction areas in the vicinity of Basin 69 and the project area.

Historical groundwater levels along Elliott Avenue from the intersection with Clay Street to the intersection with Broad Street vary from approximately the ground surface (February 1991) to 8 feet below the ground surface (July 1990). From Broad Street to Bay Street, groundwater levels vary from near the ground surface (June 1995) to approximately 20 feet below the ground surface (June 1995). The groundwater was thought to be perched on top of dense, lower permeability soils.

No geotechnical explorations have been conducted specifically for this project. To provide the geotechnical information and recommendations for design, it is recommended that geotechnical borings be performed along Elliott Avenue from the intersection with Vine Street to the intersection with Bay Street; typical recommendations are for one boring every 300 feet unless subgrade conditions are anticipated to vary at a greater frequency. The depths of these borings should extend approximately 30 feet (at least 10 feet below the proposed pipe invert). Where groundwater is encountered, groundwater monitoring wells should be installed.

A wildlife corridor is also identified within the bounds of Elliott Bay as shown in **Figure 2-1**; no in-water work is anticipated for this project, so this corridor will not be disturbed or impacted by the project.

Figure 2-1
Liquefaction and Wildlife Corridor - Environmentally Critical Areas



2.4 Hydraulic and Hydrologic Modeling

The EPA Storm Water Management Model version 5.1.012 (SWMM5) for Basin 69 was updated and calibrated in 2018 using available GIS data, precipitation data and flow monitoring data. As part of the preliminary analysis and project development, hydraulic and hydrologic analyses were conducted, including an uncertainty analysis, projected climate change impacts using the year 2035 scaled climate perturbed rainfall, and long-term hydraulic modeling simulations to assess system sizing, configuration, and anticipated performance for controlling CSO events to the State performance standard. Boundary conditions were used to simulate downstream water surface elevations. A model representing the proposed capital project was created and results were used to demonstrate that the CSO performance standard could be achieved. For more information regarding preliminary modeling analyses, refer to **Appendix B** and **Appendix C**.

Model updates and additional long-term simulation modeling should be conducted prior to design to account for anticipated changes in the Basin. Population is expected to increase in the Basin in the coming decades, which will impact dry weather flows. Additionally, sewerage changes are expected near the Battery Street Tunnel. Neither of these changes is anticipated to have a significant impact on the project's ability to control CSOs in the basin, however verification is highly recommended prior to detailed design.

2.5 Environmental Review

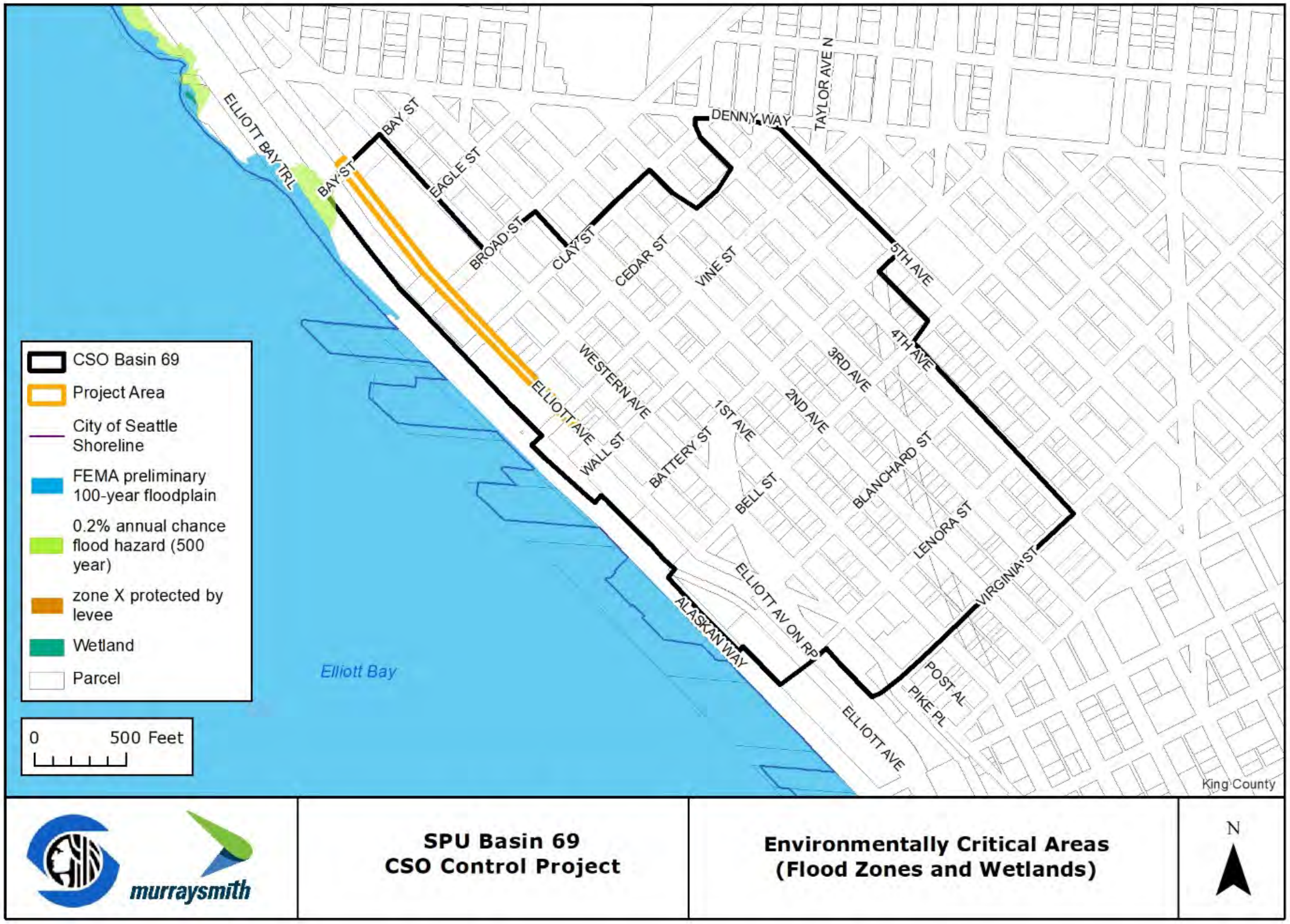
SPU is currently conducting a State Environmental Policy Act (SEPA) review of the project; the project SEPA checklist is provided as **Appendix D**. This project lies largely within the area previously analyzed by the Seattle Department of Transportation for the Elliott Bay Seawall Project, for which a Final Environmental Impact Statement (FEIS) and Final Supplemental Environmental Impact Statement (FSEIS) were issued. These documents were incorporated into the SEPA checklist for this project by reference.

Construction work is expected to be within the public right-of-way (ROW), thus limiting environmental impacts. There are no flood zones or wetlands located within the anticipated project limits and the proposed alignment is located more than 100 feet from the shoreline of Elliott Bay as shown in **Figure 2-2**. This project is not anticipated to require any in-water work and is not anticipated to impact the wildlife corridor also identified in **Figure 2-1**.

No significant long-term environmental impacts are expected for this project after construction has been completed, other than the positive improvements to Elliott Bay as a result of reducing CSO event frequency and volume.

Figure 2-2

Flood Zones and Wetlands - Environmentally Critical Areas



2.6 Permitting Review

Table 2-1 provides a list of permits and approvals that are required for this project. No federal permits are anticipated since there is no in-water work and the total excavation area for the project is anticipated to be less than one acre. All excavation is anticipated to be located within the boundaries of existing public ROW which has been previously disturbed, therefore no artifacts are anticipated to be discovered during construction.

Table 2-1
Required Permits and Approvals

Jurisdiction	Anticipated Permit or Approval	Trigger and Notes	Anticipated Time to Obtain following Application Submittal
Local			
SPU	State Environmental Policy Act (SEPA) Review and Threshold Determination *(expected to be a SEPA checklist and Determination of Non-Significance)*	A threshold determination is required for any project or non-project action that exceeds or does not meet the City of Seattle's criteria for categorical exemption.	In progress.
SDOT	Street Improvement Permit (SIP)	Installation of major new permanent improvements within the City of Seattle ROW.	6 to 7 months, generally concurrent with the SDOT SIP design review process. Review times are expected to vary depending on project complexity.
SDOT	Construction Street Use Permit (includes review and permitting for the contractor's temporary ROW use, traffic control plan, pedestrian mobility plan, shoring, tree removal, etc.)	Required when performing construction activities that impact public access to the ROW. When work will last longer than 6 months in duration, a project notification is required, which must be posted on-site at each closure location and visible to the public.	2 to 3 months.
SDCI	Noise Variance *(potential based on construction plan and equipment)*	Required if construction activities are outside of the normal hours identified in Seattle Municipal Code 25.08 - typically, 10 PM to 7:00 AM. Also required if construction activities exceed 85 dB(A), measured at the property line of adjacent receiving properties.	Approximately 4 months for major projects.
SDCI/King County	SDCI Side Sewer Permit for Temporary Dewatering, including an Industrial Waste Program Wastewater Discharge Authorization from King County.	Required when discharging construction site water to a public combined or sanitary sewer system. Also required for deep excavations (greater than 12 feet), an acre or more of land disturbance, or if surface/subsurface water is encountered during construction. A temporary dewatering plan, subject to review and approval by SPU, will be required.	2 to 3 months. Dependent on project complexity.
State			
Department of Archaeology and Historic Preservation (DAHP)	DAHP Concurrence	Although ground disturbance is not expected to reach native soils and earlier cultural resources surveys in the area suggest that fill has a very low potential for significant cultural materials, DAHP may require a cultural resources survey, which would be submitted for their review and approval. If ground disturbance would extend into native soils, early consultation with DAHP is highly recommended.	Typically, 2 months depending on DAHP staff availability.
Washington State Department of Ecology (Ecology)	National Pollutant Discharge Elimination System Construction Stormwater General Permit	Required for land-disturbing activities exceeding 1 acre and with construction stormwater or groundwater discharge to waters of the state.	2 to 3 months.

Section 3

Design Criteria

3.1 Project Description

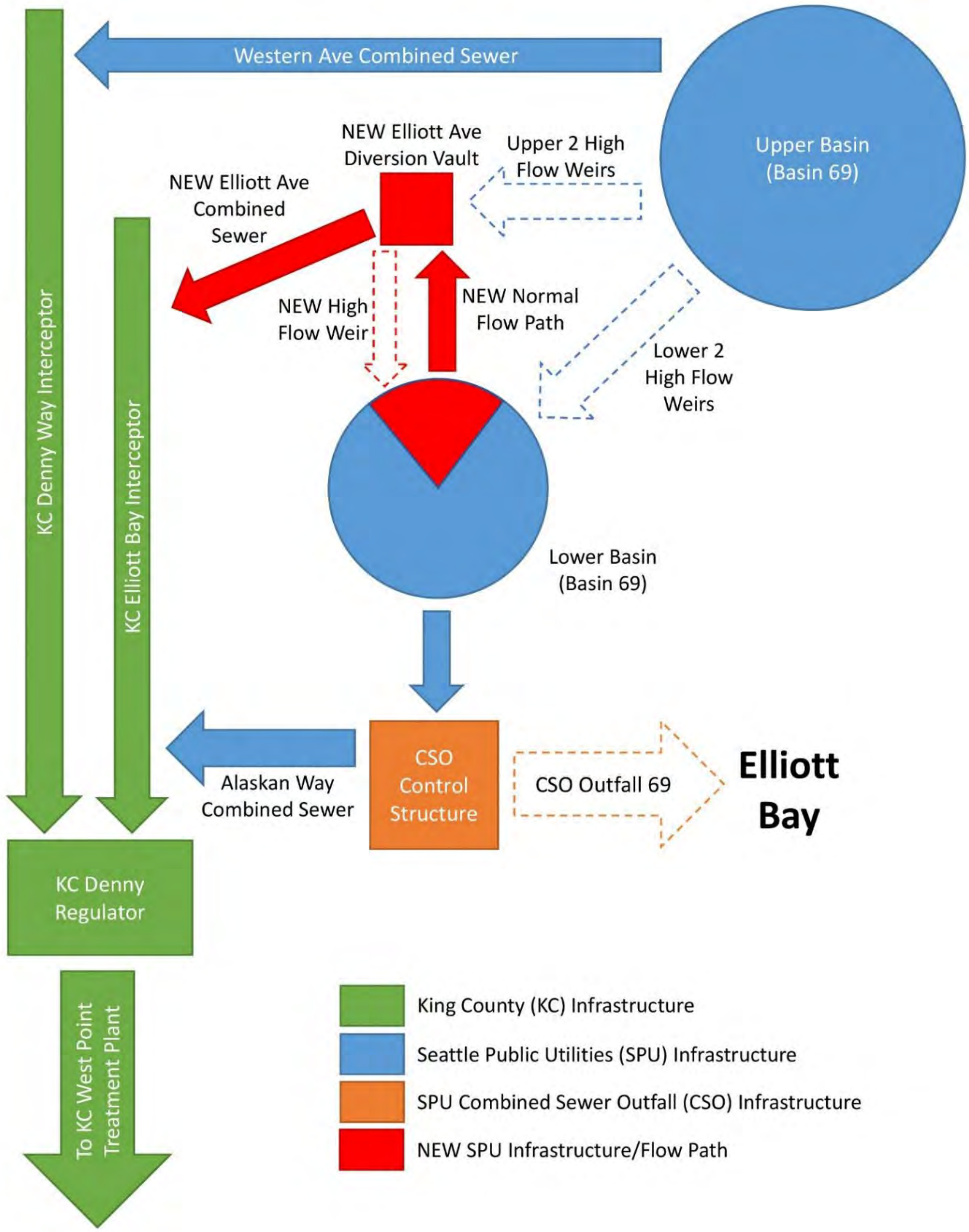
This project aims to control CSO event frequency by increasing combined sewer system conveyance capacity upstream of the existing CSO Control Structure with a new discharge connection to KC's Elliott Bay Interceptor; a record drawing of the CSO Control Structure is included in **Appendix E**. This project will increase peak flows and total discharged flows to KC's Elliott Bay Interceptor. The combined sewer system currently experiences a CSO event when the HGL in the existing Alaskan Way sewer and CSO Control Structure is elevated above the CSO overflow weir elevation. This project provides additional conveyance capacity by adding a new sewer in Elliott Avenue and diversion structure upstream of the CSO Control Structure to divert flows away from the CSO Control Structure. This delays the HGL from rising above the CSO weir elevation, resulting in a reduction in CSO event frequency.

Key features of this project include:

- Approximately 1,800 linear feet of 24 inch diameter gravity sewer pipe in Elliott Avenue
- A 24-inch diameter discharge connection to KC's Elliott Bay Interceptor,
- Passive flow control orifice at the connection to KC's Elliott Bay Interceptor, and
- A sewer diversion vault and weir where the existing sewer crosses the intersection of Vine Street and Elliott Avenue.

A flow schematic of Basin 69 indicating the project modifications in red is provided in **Figure 3-1**. Normal flows in the Vine Street sewer will be directed into the new Elliott Avenue sewer. Additionally, sewer flows in Elliott Avenue to the south of Vine Street will also be directed into the new Elliott Avenue sewer. The new flow diversion vault will be constructed at the intersection of Vine Street and Elliott Avenue to redirect normal flows from the two existing sewers into the new Elliott Avenue sewer. During a wet weather event, the HGL in the Vine Street sewer and Elliott Avenue sewer will rise. A weir in the new diversion vault will allow the high flows to be diverted down Vine Street sewer into the CSO Control Structure and the Alaskan Way sewer, matching the current flow path. Since only the high flows from Vine Street and Elliott Avenue will go to the CSO Control Structure, the total flow is reduced as compared to the existing condition, and correspondingly, the number of times the HGL would exceed the CSO weir (i.e. a CSO event) decreases also. The rest of the Basin will continue to operate as before.

Figure 3-1
Basin 69 Flow Schematic with Project Modifications



Note: Solid outlines represent normal flow paths. Dashed outlines represent high flow paths, only active when flow through normal pathways is limited such as during heavy wet weather events.

3.2 Design Flows

This project relies on increasing the flow conveyed to downstream KC facilities (KC's Elliott Bay Interceptor) to control CSO events from Basin 69. A long-term hydraulic modeling simulation, as discussed in **Section 2.4**, was performed to assess system sizing, configuration and anticipated performance for reducing CSO events. As a result, this project is projected to meet the State performance standard of no more than one CSO event per year during a 20 year moving average following construction. The desired performance standard for this project should be re-evaluated prior to final design (SPU may elect to pursue a project that achieves less than one CSO event per year during a 20 year moving average).

The new diversion structure and weir located upstream of the existing CSO Control Structure was optimized during the system modeling to limit peak flows to KC's Elliott Bay Interceptor, while still meeting the State performance standard. However, by diverting the flows through the new diversion structure, sewers upstream of the structure can be impacted, in particular, the existing sewer along Elliott Avenue to the south of Vine Street. The diversion structure was configured during the hydraulic modeling such that flow in the existing sewer south of Vine Street would not surcharge and result in an unintended Sewer Overflow (SSO).

A comparison of flows to KC Elliott Bay Interceptor (EBI) for the baseline configuration and the new Elliott Avenue sewer configuration is provided in **Table 3-1.** The flows identified in Table 3-1 do not account for population increase or other sewerage changes within the basin that could impact system flows. These conditions should be reevaluated prior to final design.

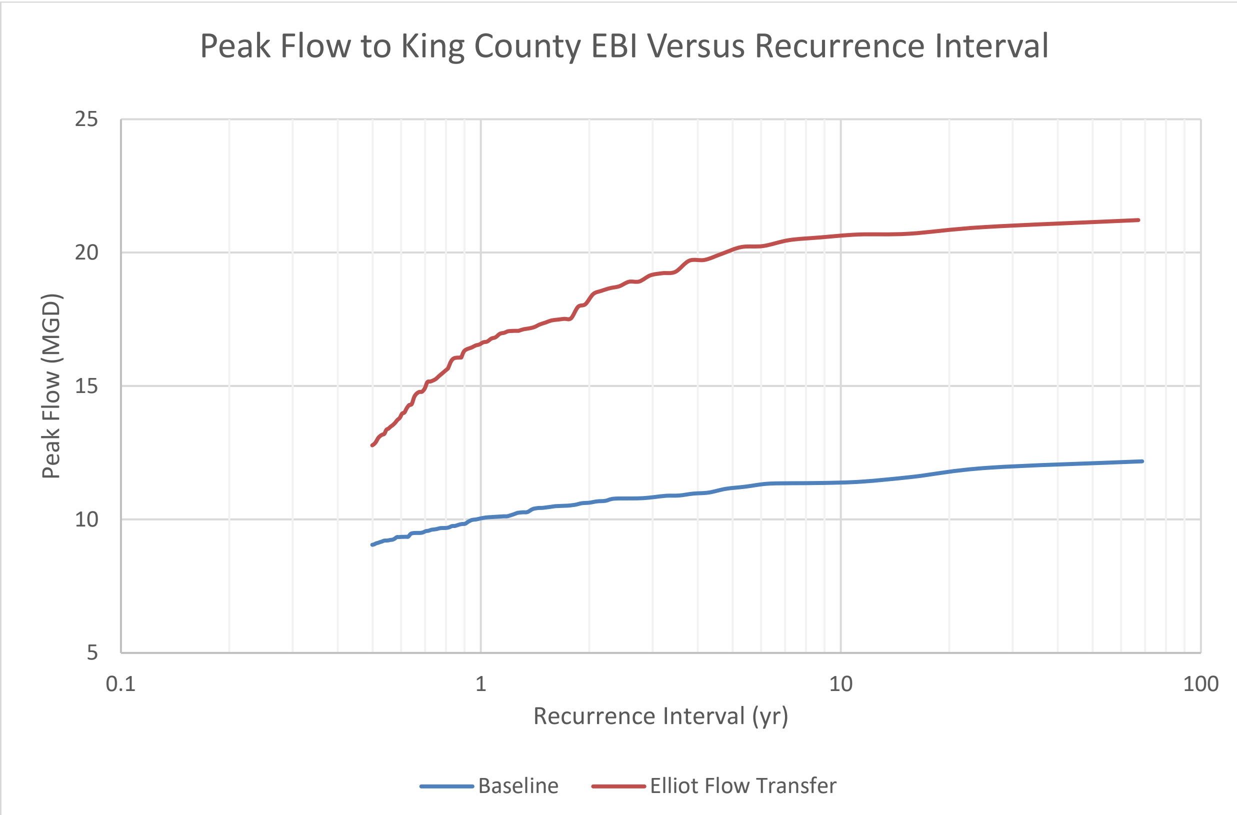
Table 3-1
Anticipated Project Downstream Impact Comparison

	Average Annual Peak Flow Rate (MGD)			Average Annual Flow Volume (MG)		
	Alaskan Way Existing Sewer	Elliott Avenue Proposed Sewer	Western Avenue Existing Sewer	Alaskan Way Existing Sewer	Elliott Avenue Proposed Sewer	Western Avenue Existing Sewer
Baseline	10.06	N/A	18.13	127.2	N/A	371.1
Project	8.76	8.12	18.13	89.0	38.5	371.1

Projected peak flows conveyed to the KC EBI are plotted against their corresponding recurrence interval for the baseline and proposed project configurations in **Figure 3-2**. The sum of the flow series for the connection points at Alaskan Way and Elliott Avenue for the new Elliott Avenue sewer were used to develop the recurrence interval curve.

Figure 3-2

Peak Flow Versus Recurrence Interval for the New Elliott Avenue Sewer and Baseline Configurations at Alaskan Way and Elliott Connection Points



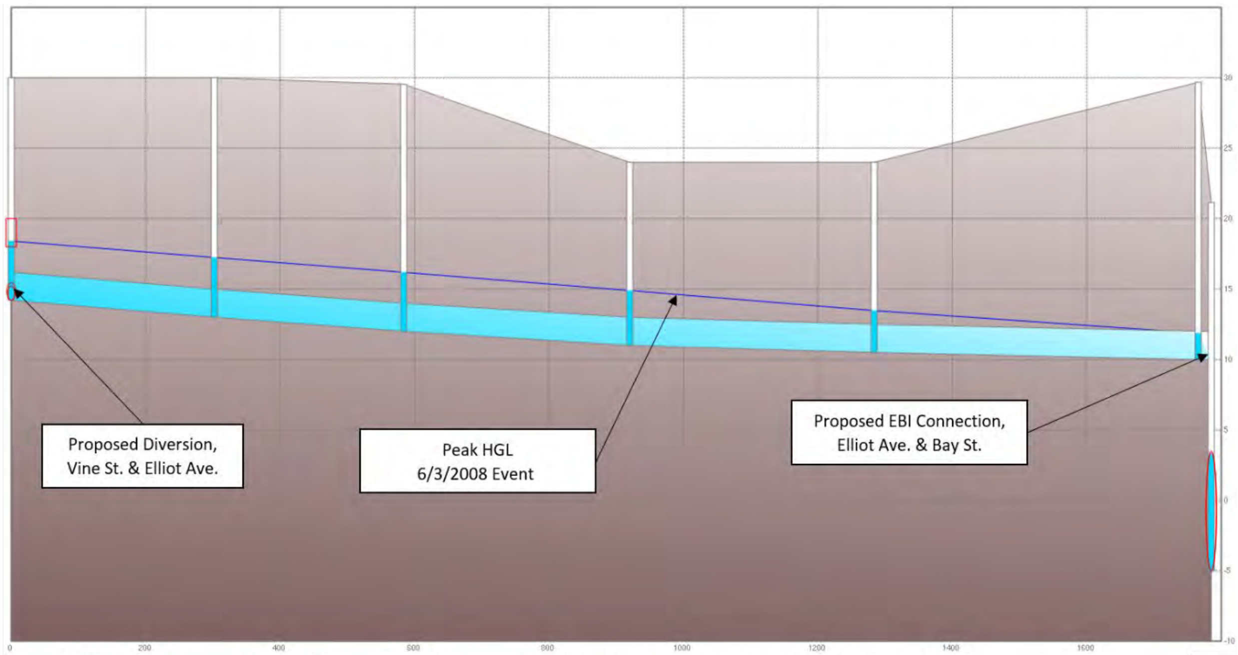
The selected CSO event frequency target (one CSO per year on a 20 year moving average) and flow transfer volumes should be reviewed prior to design to ensure the project can still meet the defined objectives. Flow transfer into the Elliott Bay Interceptor was modeled using a 2-foot diameter passive orifice (no active flow control). If SPU were to select a different level of control or recurrence interval, the sizing of conveyance and diversion structure could be impacted.

3.3 Hydraulic Grade Line

To assess the effect of the new diversion structure on upstream hydraulic grade lines (HGLs), the maximum head was evaluated at MH 039-062 and MH 039-063. These locations are the first upstream MHs from the new diversion structure and are expected to be the most impacted by the system changes.

Figure 3-3 shows the HGL of the new Elliott Avenue sewer during the control volume wet-weather event (6/3/2008). The new diversion vault is shown at the left-hand side of the HGL, and the new connection to KC's Elliott Bay Interceptor is shown at the right-hand side of the HGL.

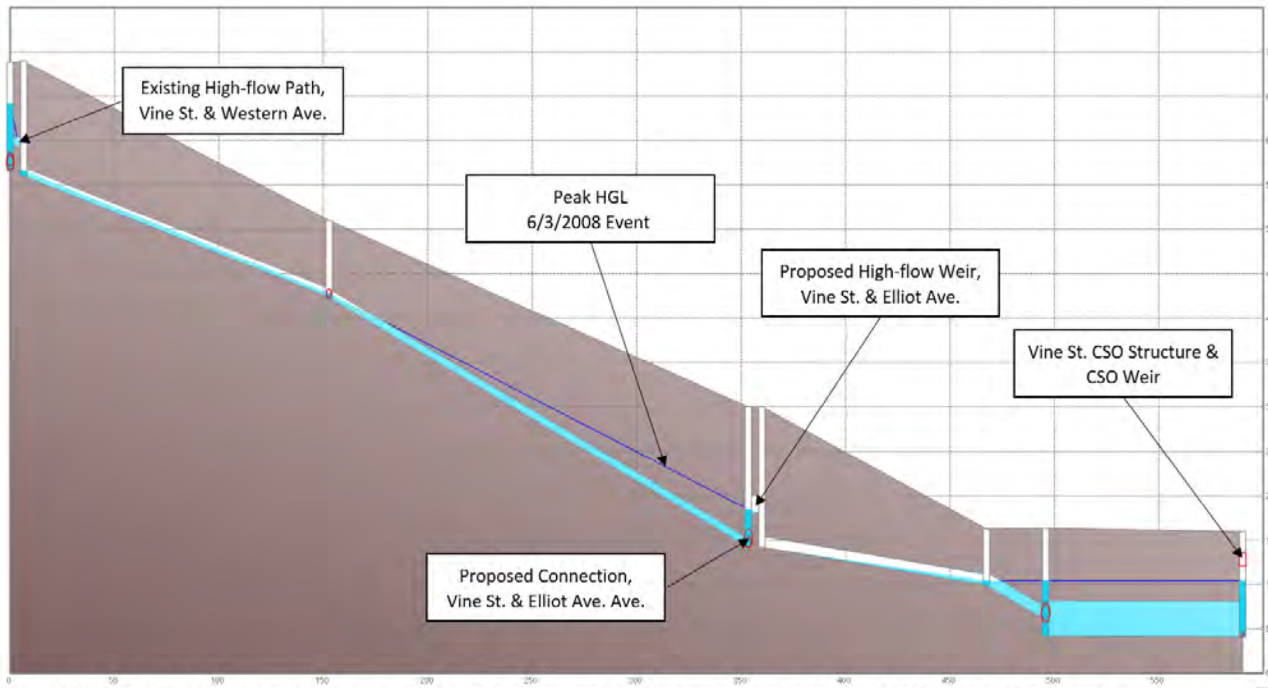
Figure 3-3
High Flow HGL for New Elliott Avenue Sewer



The 6/3/2008 event, in the existing conditions configuration, generates a CSO volume approximately equivalent to the selected flow transfer CV.

Figure 3-4 shows the HGL of the existing Vine Street sewer (flowing from east to west towards Elliott Bay) with the system modifications for the control volume wet-weather event (6/3/2008). The new diversion vault is shown at the left-hand side of the HGL, and the existing CSO Control Structure is shown at the right-hand side of the HGL.

Figure 3-4
High Flow HGL for Vine Street Sewer Between Western Avenue and Alaskan Way



The 6/3/2008 event, in the existing conditions configuration, generates a CSO volume approximately equivalent to the selected flow transfer CV.

A desktop review of existing lateral connections to the combined sewer in Elliott Avenue upstream of the new diversion vault was conducted to identify potential upstream impacts of the changes in HGL. Two laterals between Vine Street and Battery Street are believed to connect to the sewer at an elevation below the planned diversion vault weir elevation, however, both are shown as inactive in the City's GIS system. The status of the laterals should be field verified prior to design (Side Sewer Asset Number 3220299 and 3220298). Side sewer cards for the assets identified in Table 3-2 are provided in Appendix F.

Table 3-2
Sewer Laterals on Elliott Avenue Between Vine Street and Battery Street

Property Address	Side Sewer Asset Number (GIS)	Side Sewer Card Number	Lateral Elevation at Main (ft)	Notes
2516 Elliott Ave	3220720	5883	26.3	Active lateral to Belltown Cottages.
2516 Elliott Ave	3220299	3390	15.0	Shown on GIS as inactive.
2500 Elliott Ave	3220298	3390	15.6	Shown on GIS as inactive.
2400 Elliott Ave	3221445	3390	18.7	Shown on side sewer card as a storm drain.
2400 Elliott Ave	3221446	3390	19.9	Noted on side sewer card "assumed capped".
2400 Elliott Ave	3220294	3390	21.1	No depth noted on side sewer card.
2400 Elliott Ave	3220293	3390	22.6	Noted on side sewer card "assumed capped".

Section 4

Project Design Elements

4.1 Sewer Piping and Alignment

The project includes approximately 1,800 linear feet of 24-inch diameter sewer within the ROW of Elliott Avenue between Vine Street and Bay Street to convey peak wet weather flows to the KC Elliott Bay Interceptor. A general route of the sewer alignment is provided in Figure 1-1. For more detailed preliminary alignment drawings refer to Appendix G.

Pipe material will be in accordance with Section 9-05 of the City's Standard Specifications. SPU's standard materials for combined sewers include concrete, clay, and ductile iron, as noted in the Design Standards and Guidelines. Reinforced concrete pipe (RCP) with push-on joints will be utilized as the combined sewer material for this project; this should be verified during the final design process.

Pipe bedding will meet City Standards in accordance with Standard Plan 285, Class B Bedding, which for rigid pipe (DIP and RCP) is Mineral Aggregate Type 9 in Section 9-03.10(3) of the City's Standard Specifications.

4.2 Maintenance Holes

Maintenance holes (MHs) will be located at all changes in sewer slope or direction (horizontal or vertical changes) and are to be spaced no further than 350 feet apart. SPU does not allow any bends in sewer mains between MHs. MHs with 4'-6" interior diameters will be used due to the size of the sewer piping. MHs will be flat-top style in accordance with Standard Plan 204.5b.

4.3 Vaults

A diversion vault will be installed at the connection to the existing sewer at the intersection of Elliott Avenue and Vine Street. The vault is anticipated to be precast-concrete and will contain a rectangular, adjustable plate weir that is 3.5-feet long with a crest elevation of 18.0-feet (NAVD 88). The weir will be constructed of stainless steel and will allow high flows to pass through the vault into the Vine Street sewer to the existing CSO Control Structure at the intersection of Vine Street and Alaskan Way.

The vault will have two access MHs, providing access to each side of the weir, with access ladders in accordance with City of Seattle Standard Plan 232. Each side of the vault will be approximately 4-feet wide by 4-feet long (4 feet by 8 feet total) or larger to allow access for cleaning and maintenance. During design, it should be discussed if the vault should also be equipped with a normally closed slide gate to allow for bypassing the new Elliott Avenue sewer if needed in the future.

Since the project site is in an area which may be subject to soil liquefaction, pipe to vault flexible connections should be considered to allow for ground movement and to release strain due to ground deformation. Piping penetrations will be constructed to be watertight.

The vault should be located outside of traffic lanes as much as is feasible to better facility O&M accessibility after construction and minimize the amount of traffic control required for vault access and staff safety.

4.4 Connection to KC's Elliott Bay Interceptor

KC has provided preliminary approval for the proposed flows to be discharged to the Elliott Bay Interceptor; formal agreement will need to be negotiated and documented during the design phase of this project and will be led by SPU's Drainage and Wastewater Line of Business (LOB).

The connection to KC's Elliott Bay Interceptor will be made at the northern end of the alignment within the intersection of Elliott Avenue and Bay Street. A new MH will be placed near the interceptor and a short drop connection will be made from the MH to the interceptor. An adjustable, static orifice plate may be installed in the MH to control the maximum flowrate discharged to KC's Elliott Bay Interceptor. A core-drilled pipe tap such as an Inserta Tee® connection will be used to connect the new sewer to the interceptor. The connection will require review and approval from KC during design.

It is anticipated that KC will require the following:

1. Invitation to the pre-construction conference.
2. Notice of construction activity within 50-feet of the Elliott Bay Interceptor
3. Review of shoring plans adjacent to the Elliott Bay Interceptor
4. KC will provide oversight while the connection is being made.
5. No debris will be permitted to enter the interceptor during construction while the connection is being made.
6. The connection will not be permitted to be put into service until the tributary sewer has been cleaned, tested, inspected, and approved.

4.5 Construction Method

Construction is expected to be completed using open trench construction methods with appropriate trench safety and stability mechanisms.

Section 5

Civil Design

5.1 Earthwork

5.1.1 Groundwater

Available information on groundwater is summarized in Section 2.3. Groundwater levels are anticipated to be encountered during construction within some portions of the alignment. Groundwater management strategies may include:

- Water-tight shoring systems,
- Dewatering wells, and/or
- Trench dewatering systems.

The groundwater level inside the shoring system should be maintained below the base grade, which is the lowest level of the bedding material that the pipe is placed on. It is anticipated that groundwater will need to be treated prior to discharge to the sewer system. Impacts of dewatering discharge on the combined sewer system capacity should be evaluated during design. An alternate approach may need to be pursued to avoid increased risk of CSOs as a result of construction activities.

5.1.2 Soil Contamination

A review of available geotechnical indicated 11 boreholes and monitoring wells along Elliott Avenue between the intersections with Broad Street and Bay Street indicated the presence of hydrocarbons in various concentrations (from slight to strong). However, significant environmental cleanup activities were completed between Broad Street and Bay Street, the site of the former Unocal Cleanup Project, which was completed in 2007 and is expected to have removed most of the contamination in the top 8 to 12 feet of soil.

Since the geotechnical data currently available indicates the potential for encountering soil and groundwater contamination within the proposed limits of construction, additional geotechnical investigations are recommended for this project to quantify the limits and extent of contamination.

5.1.3 Fill and Compaction

Excavation backfill and compaction is required to be completed in accordance with Sections 2-10 and 2-11 of the City's Standard Specifications. The excavated soils from the project area are not anticipated to be suitable for use as backfill.

5.2 Right-of-Way Restoration

5.2.1 Roadway, Sidewalk, and Curb Ramps

The Elliott Avenue roadway is believed to be concrete with asphalt overlay; the width of the concrete and asphalt overlays based on historical geotechnical boring data (refer to test boring TB-3 in Appendix A1). Roadway materials and thickness are to be investigated and confirmed with SDOT during design. For the preliminary OPCC included in Appendix H, it was assumed that the asphalt paving was 2-inches thick and the concrete was 10-inches thick. The roadway will be restored to its current condition, matching materials and thicknesses in accordance with the City's Standard Plan 404a or 404b as applicable.

When crossing intersections, replacement of the existing curb ramps that are not ADA compliant is required per SDOT's Right of Way Opening and Restoration Rules (ROWORR). Curb ramps and pedestrian crossings along the alignment will be improved to the maximum extent feasible (MEF). This may require relocating Seattle City Light (SCL) utility handholes, signs, or other obstructions as required by SDOT.

5.2.2 Landscaping

Elliott Avenue has mature trees lining both sides of the street and proposed sewer alignment. Coordination with the Seattle Department of Urban Forestry will be required to minimize harm to the health of the trees. There may be opportunities to add or improve landscaping as part of the project.

5.2.3 Stormwater Management

Stormwater management will be included in the project to the extent required by the Seattle Stormwater Code. This project must meet the Minimum Requirements for Roadway Projects due to the nature and funding of the work. Approximately 12,000 square feet of replaced hard surface (roadway) will be created by the project, therefore large Project Drainage Control Review will be required. The replaced hard surface exceeds the 2,000 square foot threshold for On-site Stormwater Management. Opportunities and locations for On-site Stormwater Management have not yet been evaluated. Since the purpose of the project is to increase the capacity of the combined sewer system by reducing CSO events, the project may not be required to meet the Peak [flow] Control Standard if SPU determines the combined sewer system capacity is sufficient. A water quality report may be required to receive this adjustment. Treatment is not anticipated to be required since projects discharging to a combined sewer system are exempt. A formal request for relief from flow control requirements will be required as part of the design process.

5.2.4 Other Improvements and Public Amenities

There is potential for public amenities to be constructed or improved along the alignment. Sidewalk planters, street trees, pedestrian and bike facilities, and wayfinding signs have been considered, but final decisions on the extent of public amenities has not been determined. This project does not include 1% for art.

Both in-person and online open house meetings were held where general project information, as well as information about potential construction impact areas, were made available. Common themes of feedback received from participants included an interest in additional greenery within Basin 69, pedestrian safety improvements (lighting and crosswalks), and a priority to maintain existing parking and car/bike lanes. Long-term community benefits have not been narrowly defined for this project, but various ideas are shown in **Figure 5-1**.

Figure 5-1
Potential Community Benefit Map

Section 6

Construction Impacts

Construction is anticipated to require 12 to 16 months and is expected to occur in one block intervals, to minimize impacts to traffic and the community. The proposed sewer is anticipated to be installed approximately 15 feet below grade using open-trench construction methods.

6.1 Traffic Control During Construction

A total of five intersections will be impacted along Elliott Avenue, including Bay Street, Broad Street, Clay Street, Cedar Street, and Vine Street. It is anticipated that a safety peace officer will be required to be present while work is being conducted within intersections. It is anticipated that a minimum of two traffic lanes will be closed in the block with active construction, in addition to the sidewalk along the west side of Elliott Avenue, street parking located on both sides of the street, and the bicycle lane located on the east side of Elliott Avenue. It is expected that Elliott Avenue will be required to remain open to a minimum of one lane of traffic; SDOT is unlikely to approve plans that require full street closures, as Elliott Avenue is an arterial street that has an average annual weekday traffic count of approximately 15,000 to 19,000 vehicles per day. It is likely that the construction work hours will also be reduced to limit traffic impacts.

There are multiple business and multi-use building entrances located along Elliott Avenue. Construction activity coordination will be required to maintain accessibility for buildings and businesses.

6.2 Vibration and Settlement Monitoring

Buildings along the alignment are generally large, multi-story, mixed-use, and of varying age, with masonry or concrete facades that may be susceptible to damage due to construction vibration and ground settlement. It is recommended that structural monitoring baseline points be established in order to monitor relative vertical and horizontal ground movements during construction. The results of the monitoring points will be monitored by SPU as part of SDCI Special Inspection requirements. The contractor is best suited to install the points and be responsible for preserving and repairing the monitoring points as necessary.

6.3 Noise Monitoring

A noise variance may be required, which would require monitoring of noise levels if construction equipment exceeds threshold levels or if construction activities extend beyond normal hours. Tall buildings line both sides of the proposed sewer alignment may exacerbate construction noise.

Alternative construction techniques may need to be implemented to manage the noise produced by construction activities and limit the impact to adjacent businesses and residences.

6.4 Sewer Bypass During Construction

Sewer flows will need to be bypassed during the connection of the new pipe to existing in the Elliott Avenue and Vine Street intersection while two system modifications are made:

1) During installation of the new diversion vault in the intersection of Vine Street and Elliott Avenue.

    a. The “High Flow” path at MH 039-064 should be temporarily plugged to prevent flows from the Western Avenue sewer from traveling down the Vine Street sewer.

    b. Bypass pumping will likely be achieved from MH 039-063 located within Vine Street upstream of the intersection of Vine Street with Elliott Avenue.

2) During replacement or modification of MH 039-062.

    a. Bypass pumping will likely be achieved from MH 039-080 located within Elliott Avenue.

Sewer bypassing will likely consist of submersible pump(s) placed in maintenance holes upstream of the sewer modification with temporary piping at grade to convey flows around the work area to discharge to a downstream point. A bypass plan is recommended to prevent disruption to service or an uncontrolled spill. Traffic control and bypassing protections will be required to safely carry out bypass pumping activities.

6.5 Side Sewer Bypassing During Construction

Side sewer bypassing may be required during the following two instances:

1) During installation of the new diversion vault in the intersection of Vine Street and Elliott Avenue.

    a. There are two catch basin connections at the intersection of Elliott Avenue and Vine Street and one side sewer connection upstream of where the diversion vault is planned to be located shown on the City’s GIS Sewer Map. The side sewer is a 6-inch diameter sewer that connects to the Belltown Cottages and is owned by the City Parks and Recreation Department (asset number 3220720). During design, it should be investigated if there is a cleanout available on the side sewer connection to allow for bypassing. If no cleanout is available, a cleanout may need to be installed to allow for bypassing.

2) During replacement or modification of MH 039-062.

a. There are two side sewer connections shown on the City's GIS Sewer Map upstream of MH 039-062, however both are noted as not being connected (asset numbers 3220299 and 3220298). The status of these two connections should be investigated and confirmed during final design.

6.6 Overhead Obstructions

Two overhead obstructions were identified. The first is the Seattle Art Museum (SAM) overpass, which is about 150-feet wide across the alignment just south of Bay Street. The second is a skybridge that is approximately 10 to 20 feet wide near Cedar Street. Neither clearance is labeled, and both were constructed relatively recently, so it is assumed that they both meet the 20-foot minimum roadway clearance required by Seattle code.

Excavation under both obstructions is thought to be feasible using conventional excavators with appropriately sized arms. However, an excavator with a telescoping boom may be necessary or preferred by the contractor. Regardless of excavator type, it will not be possible for excavators to load directly into a dump truck while underneath the obstructions. It is assumed that additional equipment on the roadway will be required to move excavated material from a stockpile underneath the obstructions into dump trucks staged outside the obstructions. This will require a larger working area and additional equipment, labor, and time.

6.7 Excavation and Temporary Shoring

Anticipated soils along the proposed alignment are briefly described in Section 2.3. These soil units are broadly described as fill, Vashon glacial till, and advance outwash in the order of deposition. When excavating through the glacial till, cobbles and scattered boulders may be encountered. Large gravels may be encountered when drilling through advanced outwash. At least one borehole was reportedly stopped due to the presence of large cobbles.

Temporary shoring and trench safety systems will be specified to conform with Sections 2-04 and 2-07 of the City's Standard Specifications. Trench shoring and safety systems will need to be installed and maintained without disturbing existing utilities, which may limit or preclude the use of certain systems. All design parameters for temporary shoring methods will be developed by the contractor. It is important to note that almost all manufactured shoring systems such as trench shields, modular aluminum shields, and hydraulic vertical shores are depth-rated based on the assumption that the groundwater level is below the base of excavation. The use of these systems must ensure that the water is below the base of excavation or dewatering should be provided.

6.8 Existing Utility Protections

Existing utilities are to be protected in-place without service disruption. Natural gas, telecommunications lines and duct banks, and potable water mains and services are expected to be encountered during construction. Vibration and settlement monitoring will be required when construction activities are taking place within 20-feet of cast iron water mains.

6.9 Construction Staging and Parking Area

Several potential construction staging and parking areas near the project site have been identified as potential options as shown in Figure 6-1. These options include both City-owned and privately-owned property. Private property may be difficult or costly to lease.

Figure 6-1
Potential Contractor Parking and Staging Areas

Section 7

Level and Flow Monitoring

7.1 Level Sensors and Transmitters

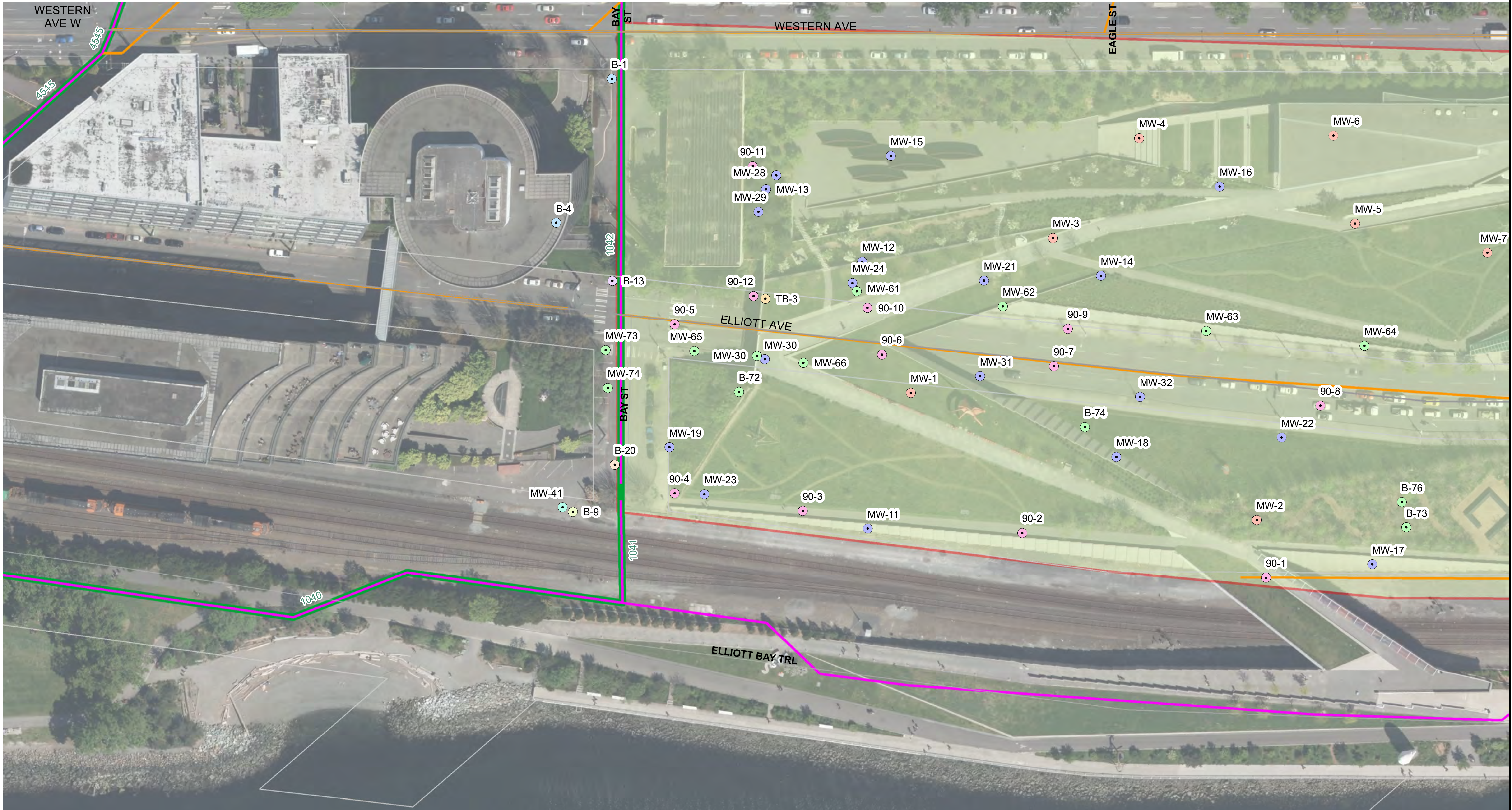
Level sensors and transmitters will allow SPU to remotely monitor levels and flow rates in the new sewer. Currently, SPU contracts flow monitoring services to ADS. It is assumed that SPU will coordinate flow monitoring with ADS separately, therefore no accommodations or provisions for level sensors or transmitters are required for the design of this project.

7.2 Monitoring and Reporting Requirements

Flow monitoring and reporting will likely be requested by King County at or near the new connection to the Elliott Bay Interceptor to quantify the flows discharged to the interceptor. It is anticipated that level sensors placed in the MH upstream of the connection to the interceptor or in the diversion vault will provide the desired information.

Appendix A1

Historical Geotechnical Data Provide by SPU (Bay Street to Broad Street)



Document Path: P:\MatLab\Secure\GEOTECH\Geotechnical Projects\SPU\Drainage\(C317021) Vine Basin CSO Control\Preliminary Engineering\Field & Lab Work\Site Maps\Vine CSO Basin Site Map.mxd

LEGEND

- Vine CSO Basin
- Arterial Streets
- Residential Streets
- Right of Way
- Sanitary Main
- Combined Main
- Drainage Main
- King County Sewer System Mainline

ExistingExplorations

- Applied Geotechnology, Inc.;1990
- Converse Consultants NW;1983
- Converse Consultants NW;1984
- GeoEngineers, Inc.;1986
- GeoEngineers, Inc.;1987
- GeoEngineers, Inc.;1990
- GeoEngineers, Inc.;1995
- Metropolitan Engineers;1965
- Metropolitan Engineers;1966
- Pacific Testing Laboratories;1982

N E S W

NAVD88

40 20 0 40 80

Feet

Vine Basin CSO Control
Seattle, Washington

EXISTING EXPLORATION MAP
SECTION A1

Seattle Public Utilities
Geotechnical Engineering

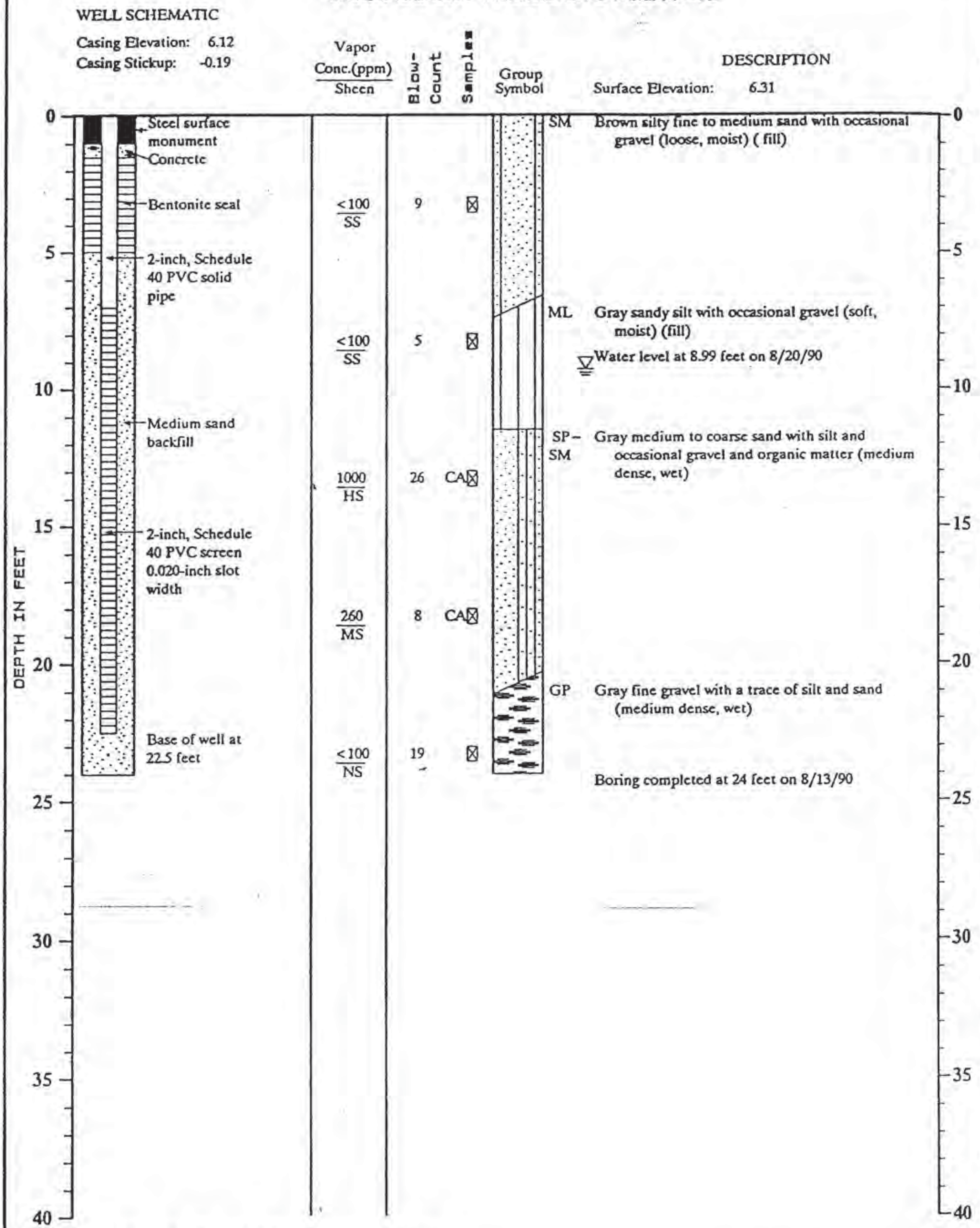
FIGURE 2
August 2018
Project No. C317021

Vine Basin - Summary of Exsiting Explorations

Map Section	Borehole ID	Completed By	Date Completed	Borehole Depth in Feet	Document ID
A1	MW-41	GeoEngineers, Inc.	8/13/1990	24	1109
A1	MW-1	GeoEngineers, Inc.	11/7/1986	20.5	1989
A1	MW-11	GeoEngineers, Inc.	7/6/1987	24.5	1989
A1	MW-12	GeoEngineers, Inc.	7/7/1987	18.5	1989
A1	MW-13	GeoEngineers, Inc.	7/9/1987	39.5	1989
A1	MW-14	GeoEngineers, Inc.	7/7/1987	19	1989
A1	MW-15	GeoEngineers, Inc.	7/23/1987	19.5	1989
A1	MW-16	GeoEngineers, Inc.	7/8/1987	19.5	1989
A1	MW-17	GeoEngineers, Inc.	7/7/1987	19.5	1989
A1	MW-18	GeoEngineers, Inc.	7/7/1987	19.5	1989
A1	MW-19	GeoEngineers, Inc.	7/9/1987	25	1989
A1	MW-2	GeoEngineers, Inc.	11/7/1986	20.5	1989
A1	MW-21	GeoEngineers, Inc.	7/8/1987	14.5	1989
A1	MW-22	GeoEngineers, Inc.	7/7/1987	19.5	1989
A1	MW-23	GeoEngineers, Inc.	7/6/1987	24.5	1989
A1	MW-24	GeoEngineers, Inc.	7/20/1987	19.5	1989
A1	MW-28	GeoEngineers, Inc.	8/1/1987	22	1989
A1	MW-29	GeoEngineers, Inc.	7/23/1987	54.5	1989
A1	MW-3	GeoEngineers, Inc.	11/7/1986	18	1989
A1	MW-30	GeoEngineers, Inc.	11/23/1987	19.5	1989
A1	MW-31	GeoEngineers, Inc.	11/23/1987	20	1989
A1	MW-32	GeoEngineers, Inc.	11/23/1987	20	1989
A1	MW-4	GeoEngineers, Inc.	11/12/1986	20.5	1989
A1	MW-5	GeoEngineers, Inc.	11/12/1986	20.5	1989
A1	MW-6	GeoEngineers, Inc.	11/12/1986	19.5	1989
A1	MW-7	GeoEngineers, Inc.	11/13/1986	19.5	1989
A1	90-10	Applied Geotechnology, Inc.	11/14/1990	38.5	3375
A1	90-11	Applied Geotechnology, Inc.	11/9/1990	63	3375
A1	90-12	Applied Geotechnology, Inc.	11/14/1990	38	3375
A1	90-9	Applied Geotechnology, Inc.	11/12/1990	40.5	3375
A1	90-1	Applied Geotechnology, Inc.	12/12/1990	28	3376
A1	90-2	Applied Geotechnology, Inc.	12/11/1990	31	3376
A1	90-3	Applied Geotechnology, Inc.	12/11/1990	29	3376
A1	90-4	Applied Geotechnology, Inc.	11/13/1990	34	3376
A1	90-5	Applied Geotechnology, Inc.	11/16/1990	35	3376
A1	90-6	Applied Geotechnology, Inc.	11/8/1990	38	3376
A1	90-7	Applied Geotechnology, Inc.	11/8/1990	39	3376
A1	90-8	Applied Geotechnology, Inc.	11/15/1990	38	3376
A1	B-72	GeoEngineers, Inc.	6/13/1995	26.5	3947
A1	B-73	GeoEngineers, Inc.	6/21/1995	29	3947
A1	B-74	GeoEngineers, Inc.	6/14/1995	31.5	3947
A1	B-76	GeoEngineers, Inc.	6/15/1995	29	3947
A1	MW-30	GeoEngineers, Inc.	6/16/1995	31.5	3947
A1	MW-61	GeoEngineers, Inc.	6/14/1995	26.5	3947
A1	MW-62	GeoEngineers, Inc.	6/13/1995	26.5	3947
A1	MW-63	GeoEngineers, Inc.	6/13/1995	26.5	3947

Map Section	Borehole ID	Completed By	Date Completed	Borehole Depth in Feet	Document ID
A1	MW-64	GeoEngineers, Inc.	6/12/1995	31.5	3947
A1	MW-65	GeoEngineers, Inc.	6/16/1995	26.5	3947
A1	MW-66	GeoEngineers, Inc.	6/22/1995	26.5	3947
A1	MW-73	GeoEngineers, Inc.	6/23/1995	26.5	3947
A1	MW-74	GeoEngineers, Inc.	8/24/1995	26	3947
A1	B-13	Metropolitan Engineers	5/3/1965	80	3963
A1	B-20	Metropolitan Engineers	3/4/1966	60	3963
A1	B-1	Converse Consultants NW	5/25/1983	70.2	7232
A1	B-4	Converse Consultants NW	5/27/1983	70.7	7232
A1	B-9	Converse Consultants NW	7/26/1984	45.2	8128
A1	TB-3	Pacific Testing Laboratories	4/12/1982	24	10040

MONITOR WELL NO. MW-41



Note: See Figure A-2 for explanation of symbols

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Log of Monitor Well

Figure A-15

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-83.
2. Soil classification using laboratory tests is based on ASTM D2487-83.
3. Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry – Absence of moisture, dusty, dry to the touch

Moist – Damp, but no visible water

Wet – Visible free water or saturated, usually soil is obtained from below water table

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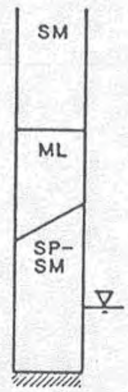
SOIL CLASSIFICATION SYSTEM

FIGURE A-1

LABORATORY TESTS:

AL	Atterberg limits
CP	Compaction
CS	Consolidation
DS	Direct shear
GS	Grain-size analysis
HA	Hydrometer analysis
K	Permeability
M	Moisture content
MD	Moisture and density
SP	Swelling pressure
TX	Triaxial compression
UC	Unconfined compression
CA	Chemical Analysis

SOIL GRAPH:



Soil Group Symbol (See Note 1)

Distinct contact between Soil Strata

Gradual Change between Soil Strata

Water Level

Bottom of Boring

BLOW-COUNT/SAMPLE DATA:

Blows required to drive Dames & Moore sampler 12 inches or other indicated distances using **300** pound hammer falling **18** inches.

"P" indicates sampler pushed with weight of hammer or hydraulics of drill rig.

22 ■ Location of relatively undisturbed sample

12 ☒ Location of disturbed sample

P ☐ Location of sampling attempt with no recovery

10 ◪ Location of sample attempt using Standard Penetration Test procedures

40 ⬓ Location of relatively undisturbed sample using 140 pound hammer falling 30 inches.

NOTES:

1. Soil classification system is summarized in Figure A-1.
2. The reader must refer to the discussion in the report text as well as the exploration logs for a proper understanding of subsurface conditions.

GEI 86-88

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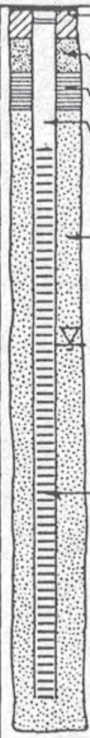
KEY TO BORING LOG SYMBOLS

FIGURE A-2

MONITOR WELL NO. 1

WELL SCHEMATIC
Casing Elevation: 18.31
Casing Stickup: −0.30



DESCRIPTION
Surface Elevation: 18.61

Depth (feet)	Blow-Count	Samples	Group Symbol	Description
0			SP	BROWN FINE TO MEDIUM SAND WITH SILT AND OCCASIONAL GRAVEL (MEDIUM DENSE, DAMP) (FILL)
~2			SM	GRAY SILTY FINE TO MEDIUM SAND WITH GRAVEL AND OCCASIONAL COBBLES (MEDIUM DENSE, DAMP) (FILL) MODERATE HYDROCARBON ODOR AT 3.5 AND 8.5 FEET
~3.5	32	■		
~8.5	40	CA ■		
~11			SP	BROWNISH-GRAY FINE TO MEDIUM SAND WITH OCCASIONAL GRAVEL (LOOSE, WET)
~13.5	5	■		
~17			SP/SM	BROWN FINE TO MEDIUM SAND WITH SILT AND GRAVEL (DENSE, WET)
~18.5	106	■		

BORING COMPLETED AT 20.5 FEET ON 11/7/86

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A-2 for Explanation of Symbols

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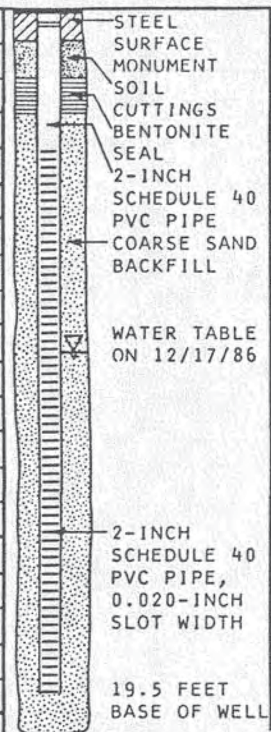
LOG OF MONITOR WELL

FIGURE A-3

MONITOR WELL NO. 2

WELL SCHEMATIC
Casing Elevation: 17.71
Casing Stickup: -0.41



Surface Elevation: 18.12

Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0			SP/SM	BROWN FINE TO MEDIUM SAND WITH SILT AND GRAVEL (MEDIUM DENSE, DAMP) (FILL)
			SM	GRAY AND BROWN SILTY SAND WITH GRAVEL (MEDIUM DENSE, DAMP) (FILL)
	5	■		
5				
	8	⊠		SLIGHT HYDROCARBON ODOR AT 8.5 FEET CHANGES TO WET
10				
			SP	GRAY FINE TO MEDIUM SAND WITH GRAVEL (LOOSE, WET)
	8	CA ■		
15				
				CHANGES TO DENSE WITH LENSES OF SILTY SAND
	20	■		
20				
				BORING COMPLETED AT 20.5 FEET ON 11/7/86
25				
30				
35				
40				

161-16 SEW:JAM:DMP:EL 12/29/86

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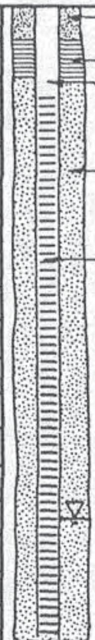
LOG OF MONITOR WELL

FIGURE A-4

MONITOR WELL NO. 3

WELL SCHEMATIC
Casing Elevation: 35.67
Casing Stickup: 1.40

Surface Elevation: 34.27



Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0			SM	BROWN SILTY FINE TO MEDIUM SAND WITH GRAVEL (MEDIUM DENSE, DAMP) (FILL)
			SM	GRAY SILTY SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, DAMP) (FILL) MODERATELY STRONG HYDROCARBON ODOR FROM 1 TO 9 FEET
	19	■		
5				
	44	CA ■		
10				
			SM	GRAY SILTY SAND WITH GRAVEL AND OCCASIONAL LENSES OF SANDY SILT (VERY DENSE, WET)
	52/6"	■		
15				

DRILLING OBSTRUCTION AT 18.0 FEET

BORING COMPLETED AT 18.0 FEET ON 11/7/86

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

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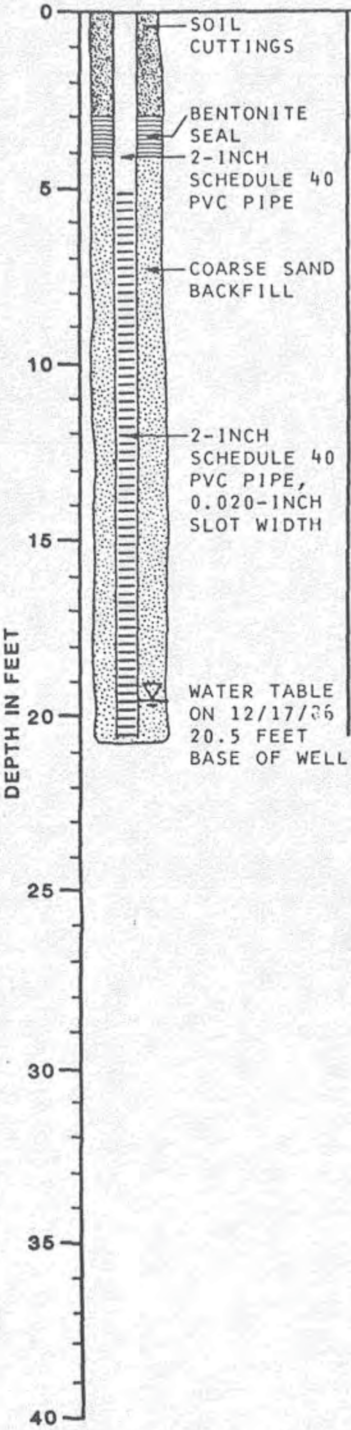
LOG OF MONITOR WELL

FIGURE A-5

161-16 SEW:JAM:DMP:EL 12/29/86

MONITOR WELL NO. 4

WELL SCHEMATIC
Casing Elevation: 40.13
Casing Stickup: 1.85



DESCRIPTION
Surface Elevation: 38.28

Depth (ft)	Blow-Count	Samples	Group Symbol	Description
0			SP	BROWN FINE TO MEDIUM SAND (MEDIUM DENSE, DAMP) (FILL) MODERATE HYDROCARBON ODOR AT 1.5 FEET
	38	■	SM	GRAY SILTY FINE TO MEDIUM SAND WITH GRAVEL (MEDIUM DENSE TO DENSE, DAMP) (FILL)
				SLIGHT HYDROCARBON ODOR AT 4 AND 9 FEET
	25	CA ■		
			SM	BROWNISH-GRAY SILTY FINE TO MEDIUM SAND WITH GRAVEL (DENSE, WET)
	69	■		
				GRADES TO SILTY FINE SAND
20	62	⊠	SP	GRAY MEDIUM SAND (DENSE, WET)
				BORING COMPLETED AT 20.5 FEET ON 11/12/86

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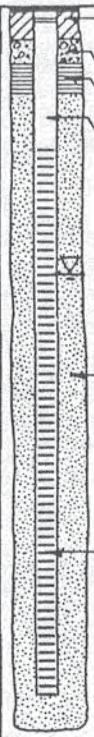
LOG OF MONITOR WELL

FIGURE A-6

MONITOR WELL NO. 5

WELL SCHEMATIC
Casing Elevation: 33.51
Casing Stickup: -0.54

Surface Elevation: 34.05



Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0			SP/SM	BROWN FINE TO MEDIUM SAND WITH SILT AND OCCASIONAL PIECES OF BRICK AND GRAVEL (MEDIUM DENSE, DAMP) (FILL)
			BRICK	BRICK FILL
	21	■	SM	BROWN SILTY FINE TO COARSE SAND WITH OCCASIONAL PIECES OF BRICK AND GRAVEL (MEDIUM DENSE, DAMP) (FILL)
5				
	15	CA ■		
10				
	50	■	SP/SM	BROWN FINE TO MEDIUM SAND WITH SILT (MEDIUM DENSE, WET)
15				
20	62/11"	■	ML	GRAY SANDY SILT WITH GRAVEL (HARD, WET)
				BORING COMPLETED AT 20.5 FEET ON 11/12/86
25				
30				
35				
40				

161-16 SEW:JAM:DMP:EL 12/29/86

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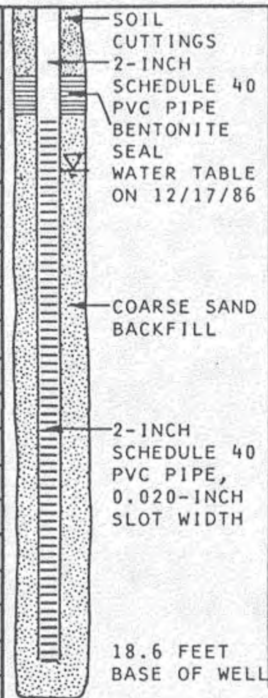
LOG OF MONITOR WELL

FIGURE A-7

MONITOR WELL NO. 6

WELL SCHEMATIC
Casing Elevation: 38.06
Casing Stickup: 1.34



DESCRIPTION
Surface Elevation: 36.72

Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0			GR	CRUSHED ROCK SURFACING
			SP SM	BROWN FINE TO COARSE SAND WITH SILT AND OCCASIONAL GRAVEL (MEIDUM DENSE, DAMP) (FILL)
4	39	■		SLIGHT HYDROCARBON ODOR AT 4.0 FEET
9	72/9"	CA ■	ML	GRAY SANDY SILT WITH GRAVEL (HARD, MOIST TO WET)
14	24	■	ML	GRAY CLAYEY SILT WITH POCKETS OF FINE SAND (HARD, WET)
19	50/6"	⊠		
20				BORING COMPLETED AT 19.5 FEET ON 11/12/86

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

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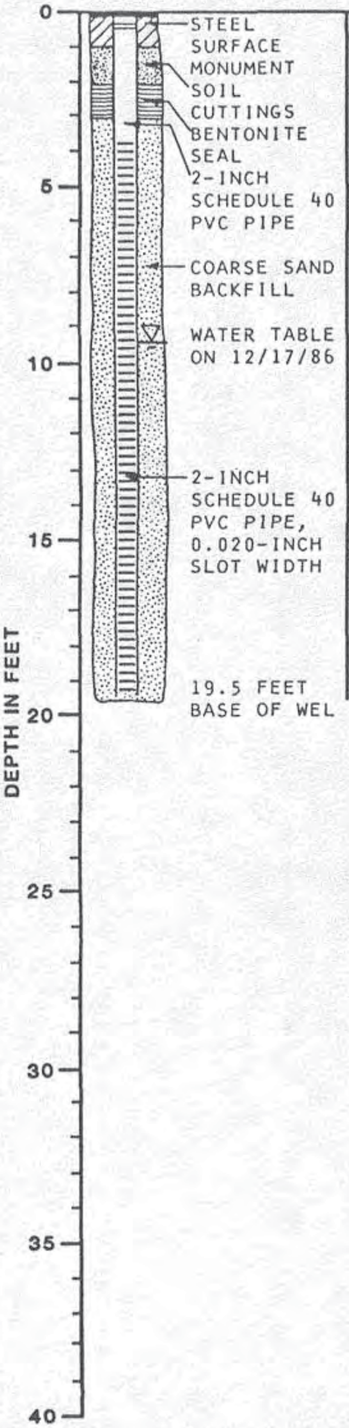
LOG OF MONITOR WELL

FIGURE A-8

MONITOR WELL NO. 7

WELL SCHEMATIC
Casing Elevation: 34.66
Casing Stickup: -0.16



DESCRIPTION
Surface Elevation: 34.82

Blow-Count	Samples	Group Symbol	Description
			3 INCHES ASPHALTIC CONCRETE PAVEMENT
		SM	BROWN SILTY FINE TO MEDIUM SAND WITH GRAVEL (MEDIUM DENSE, DAMP) (FILL)
		SM	GRAY SILTY FINE TO MEDIUM SAND WITH GRAVEL (MEDIUM DENSE, DAMP) (FILL)
14	■	SM	MOTTLED BROWN AND GRAY SILTY FINE SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, DAMP)
24	CA ■	SM	BROWN SILTY FINE TO MEDIUM SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, DAMP)
79/11"	⊠		CHANGES TO VERY DENSE AND WET
50/6"	□	ML	LIGHT GRAY SILT (HARD, WET)
			BORING COMPLETED AT 19.5 FEET ON 11/13/86

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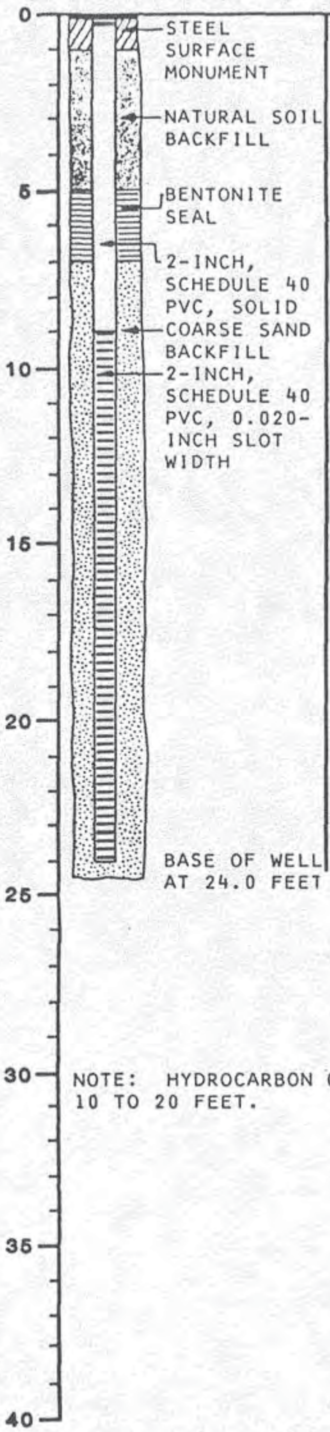
LOG OF MONITOR WELL

FIGURE A-9

MONITOR WELL NO. MW-8

WELL SCHEMATIC
Casing Elevation: 16.74
Casing Stickup: -0.24



DESCRIPTION
Surface Elevation: 16.50

Blow-Count	Samples	Group Symbol	Description
			CONCRETE
		SW	BROWN FINE TO COARSE SAND WITH GRAVEL AND COBBLES (LOOSE, MOIST) (FILL)
7	CA ■		
5	■		WET FROM 10 TO 11 FEET MODERATE HYDROCARBON ODOR
5	CA ■		▽ WATER LEVEL ON 7/13/87 BECOMES GRAY AND WET STRONG HYDROCARBON ODOR
6	■		
			FAINT HYDROCARBON ODOR
		ML	GRAY SANDY SILT WITH GRAVEL (VERY LOOSE, WET) (FILL)
4	■		
			BORING COMPLETED AT 24.5 FEET ON 7/8/87

NOTE: HYDROCARBON ODOR FROM 8 TO 22 FEET DURING DRILLING. VISIBLE SHEEN FROM 10 TO 20 FEET.

Note: See Figure A-2 for Explanation of Symbols

DJK:GCS;EL:KT 0161-16-4 8/4/87

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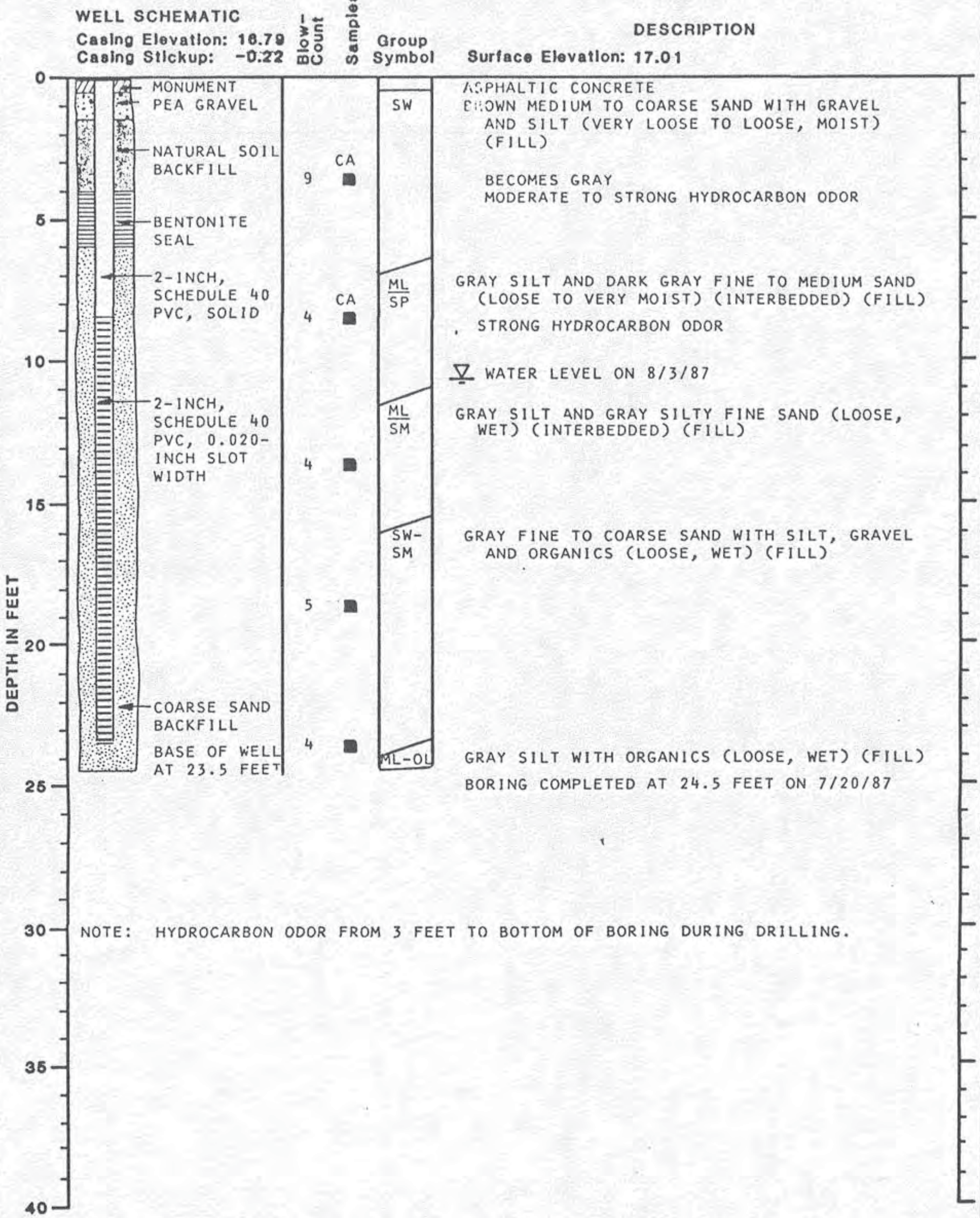
LOG OF MONITOR WELL

FIGURE A-10

MONITOR WELL NO. MW-9



Note: See Figure A-2 for Explanation of Symbols

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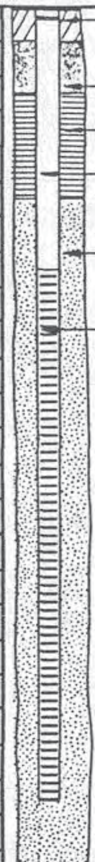
LOG OF MONITOR WELL

FIGURE A-11

0161-16-4 DJK:GCS:EL:kr 8/5/87

MONITOR WELL NO. MW-10

WELL SCHEMATIC
Casing Elevation: 16.84
Casing Stickup: -0.27



DESCRIPTION
Surface Elevation: 17.11

Depth in Feet (approx.)	Blow Count	Samples	Group Symbol	Description
0				CONCRETE
1			SW	BROWN FINE TO COARSE SAND WITH GRAVEL (VERY LOOSE, MOIST) (FILL)
3	5	CA ⊠		
8	32	CA ■		⊻ WATER LEVEL ON 8/3/87 BECOMING MEDIUM DENSE
12				GRADES TO GRAY
13	18	■		BECOMES WET
18	44	■		BECOMES DENSE
19			SM-SW	GRAY SILTY FINE TO COARSE SAND WITH GRAVEL (DENSE, WET) (FILL)
21				DENSITY DECREASING
23	7	□		
25				BORING COMPLETED AT 24.5 FEET ON 7/21/87

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

NOTE: NO HYDROCARBON ODOR DURING DRILLING.

Note: See Figure A-2 for Explanation of Symbols

0161-16-4 DJK:GCS:EL:KT 8/5/87

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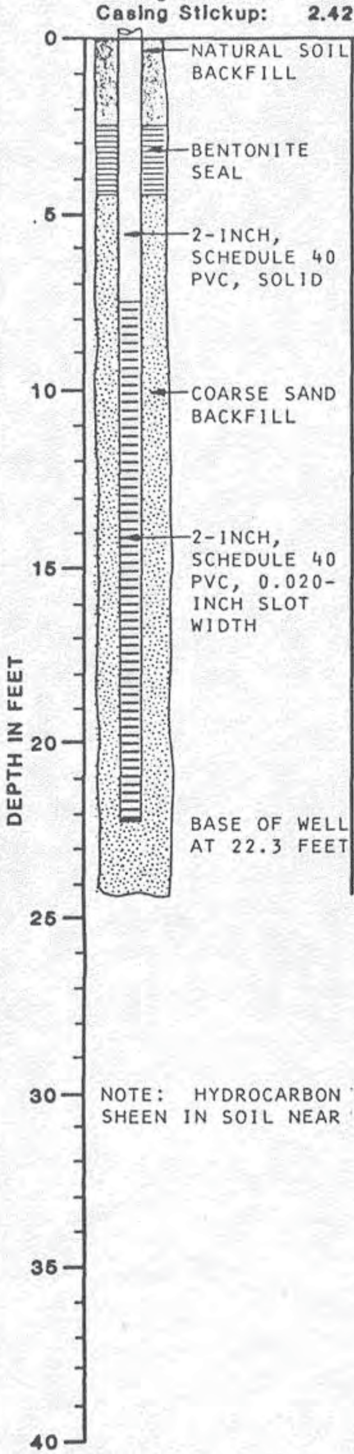
LOG OF MONITOR WELL

FIGURE A-12

MONITOR WELL NO. MW-11

WELL SCHEMATIC
Casing Elevation: 19.34
Casing Stickup: 2.42



Blow-Count	Samples	Group Symbol	DESCRIPTION **Surface Elevation: 16.92**
		ML	BROWN SANDY SILT WITH OCCASIONAL GRAVEL (MEDIUM STIFF, MOIST) (FILL)
36	CA ■	SW-SM	BROWN AND GRAY FINE TO COARSE SAND WITH SILT AND GRAVEL (LOOSE TO MEDIUM DENSE) (FILL)
12	CA ■		MODERATE HYDROCARBON ODOR ▽ WATER LEVEL ON 7/13/87
9	■	SP-SW	GRAY FINE TO MEDIUM SAND WITH OCCASIONAL GRAVEL (LOOSE TO MEDIUM DENSE, WET)(FILL) STRONG HYDROCARBON ODOR
16	■		
11	■		MODERATE HYDROCARBON ODOR

BORING COMPLETED AT 24.5 FEET ON 7/6/87

NOTE: HYDROCARBON ODOR FROM 8 FEET TO BOTTOM OF BORING DURING DRILLING. VISIBLE SHEEN IN SOIL NEAR WATER TABLE.

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

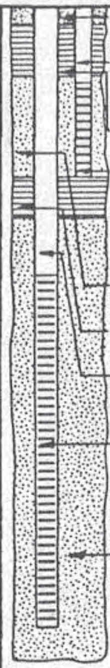
FIGURE A-13

0161-16-4 DJK:GCS:EL:KT 8/4/87

MONITOR WELL NO. MW-12A & B

WELL SCHEMATIC
Casing Elevation: A 36.79 / B 36.51
Casing Stickup: A 2.14 / B 1.81

DESCRIPTION
Surface Elevation: 34.65



Depth (feet)	Blow Count	Samples	Group Symbol	Description
0			SP	BROWN FINE TO COARSE SAND (LOOSE, MOIST) (FILL)
~3–4	9	CA	SP/ SP-SM	WATER LEVEL FOR 12B ON 7/13/87 GRAY FINE TO MEDIUM SAND AND GRAY FINE TO MEDIUM SAND WITH SILT (LOOSE, MOIST) (INTERBEDDED) FAINT HYDROCARBON ODOR
~9	4	CA		WATER LEVEL FOR 12A ON 7/13/87
~11.5				GRAY SILTY SAND WITH ORGANICS AND COBBLES (VERY DENSE, WET) MODERATE TO STRONG HYDROCARBON ODOR
~13.5	50/4"			
~18.5	50/6"			BORING COMPLETED AT 18.5 FEET ON 7/7/87

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

NOTE: HYDROCARBON ODOR FROM 3.5 FEET TO APPROXIMATELY 15 FEET DURING DRILLING.

TWO MONITOR WELLS WERE INSTALLED DUE TO A PERCHED GROUND WATER ZONE AT SHALLOW DEPTH.

THE BORING WAS VERY DIFFICULT DRILLING FROM 11.5 FEET. THIS STRATUM MAY BE GLACIAL TILL. THE HIGH BLOW COUNTS INDICATED GLACIAL TILL WHICH WAS ENCOUNTERED AT A SIMILAR DEPTH IN BORING 4.

FOLLOWING INSTALLATION OF MONITOR WELL 12A, WHAT APPEARED TO BE PRODUCT WAS NOTED FLOATING INTO THE WELL FROM ABOVE THE SCREEN. THEREFORE, A SHALLOW MONITOR WELL 12B WAS INSTALLED TO APPROXIMATELY 5 FEET, WITH THE SCREEN INTERVAL BEGINNING AT THE TOP OF THE INTERBEDDED SAND FOUND FROM 2.5 TO 11.5 FEET. A BENTONITE SEAL MATERIAL WAS PLACED FROM 5.2 TO 6.0 FEET TO SEAL BETWEEN THE SHALLOW AND DEEP MONITOR WELLS. A FIELD CHECK INDICATED THAT THIS SEAL WAS EFFECTIVE IN SEPARATING THE TWO GROUND WATER ZONES.

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

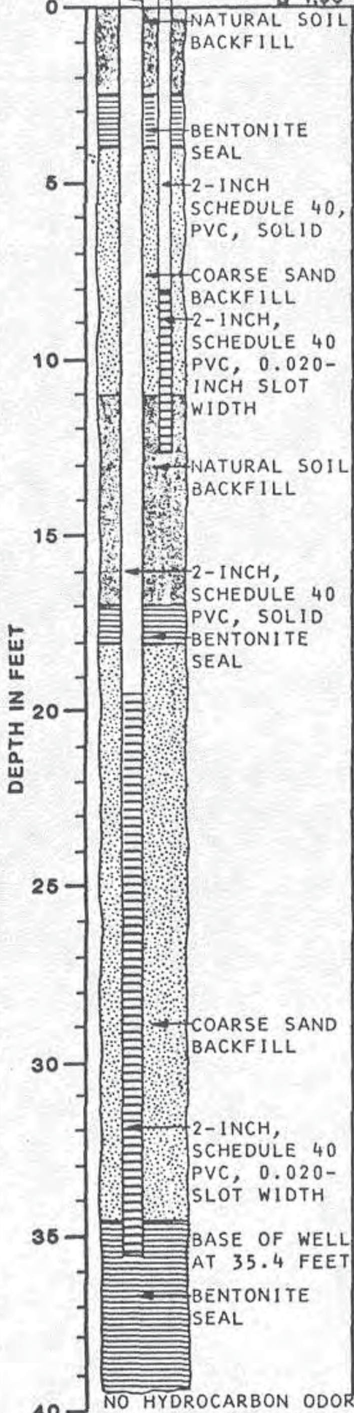
FIGURE A-14

DJK:GCS:EL:KT 8/4/87 0161-16-4

MONITOR WELL NO. MW-13A & B

WELL SCHEMATIC
Casing Elevation: A 55.47, B 55.82
Casing Stickup: A 1.8, B 1.95

Surface Elevation: 53.87



Blow Count	Samples	Group Symbol	DESCRIPTION
		SW	BROWN FINE TO COARSE SAND WITH SILT AND GRAVEL (MEDIUM DENSE, MOIST) (FILL)
16	CA ■		
29	■		
			▽ WATER LEVEL ON 7/13/87 FOR WELL B
		ML	GRAY SANDY SILT (MEDIUM DENSE TO VERY DENSE, MOIST TO WET)
16	■		
82	■		
		SW	GRAY FINE TO COARSE SAND WITH GRAVEL (DENSE TO VERY DENSE, MOIST)
50/6"	■		
50/5"	■		
50/1"	CA ■		
			▽ WATER LEVEL ON 7/13/87 FOR WELL A
		ML	GRAY AND BROWN SANDY SILT (HARD, MOIST) (MOTTLED)
50/6"	■		BORING 13A COMPLETED AT 39.5 FEET ON 7/9/87

NO HYDROCARBON ODOR DURING DRILLING. WATER LEVELS ON 7/13/87 REPRESENT WATER RETAINED FROM THE WELL INSTALLATION PROCESS. WELLS WERE DRY DURING 8/3/87 FIELD MEASUREMENTS.

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

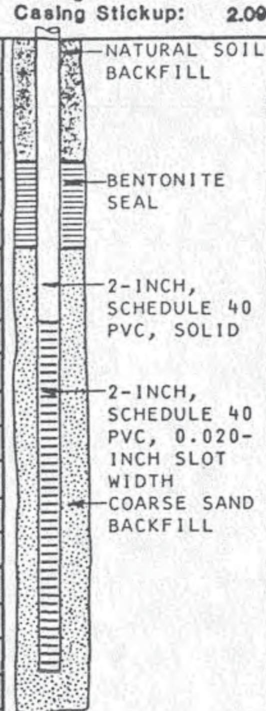
FIGURE A-15

0161-16-4 DJK:GCS:EL:KT 8/4/87

MONITOR WELL NO. MW-14

WELL SCHEMATIC
Casing Elevation: 36.26
Casing Stickup: 2.09

Surface Elevation: 34.17



Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0			SM	BROWN SILTY FINE TO COARSE SAND WITH GRAVEL (VERY LOOSE, MOIST) (FILL)
	4	CA ■	SP-SM	GRAY SILTY FINE TO COARSE SAND WITH GRAVEL (VERY LOOSE, MOIST) STRONG HYDROCARBON ODOR
	33	CA ■		BECOMES DENSE
10				∇ WATER LEVEL ON 7/13/87
	50/5"	■		GRADES TO GRAY FINE TO COARSE SAND WITH SILT (VERY DENSE, WET)
	90/5"	■	ML	BROWN AND GRAY SILT (HARD, MOIST) (MOTTLED)
				BORING COMPLETED AT 19.0 FEET ON 7/7/87

NOTE: HYDROCARBON ODOR FROM 3 FEET TO BOTTOM OF BORING. FAINT SHEEN IN SOIL NEAR WATER TABLE.

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A-2 for Explanation of Symbols

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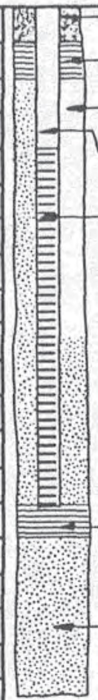
LOG OF MONITOR WELL

FIGURE A-16

0161-16-4 DJK:GCS:EL:KT 8/4/87

MONITOR WELL NO. MW-15

WELL SCHEMATIC
Casing Elevation: 39.51
Casing Stickup: 1.26



DESCRIPTION
Surface Elevation: 38.25

Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0			SP-SM	BROWN FINE TO COARSE SAND WITH SILT (LOOSE, MOIST) (FILL) MODERATE HYDROCARBON ODOR
	13	CA ■		BECOMES WET AND MEDIUM DENSE GRAVEL CONTENT INCREASING
5				▽ WATER LEVEL ON 8/3/87 MODERATE HYDROCARBON ODOR
			SM	GRAY AND BROWN SILTY SAND WITH GRAVEL (VERY DENSE, MOIST) (MOTTLED)
	50/6"	CA ■	SM	BLUISH-GRAY SILTY SAND WITH GRAVEL (VERY DENSE, WET)
10				
	50/5"	■		
15			ML	BLUISH-GRAY SILT WITH SAND (VERY DENSE, WET)
	52	■		
20				BORING COMPLETED AT 19.5 FEET ON 7/23/87

25 NOTE: HYDROCARBON ODOR FROM 0 TO 8.5 FEET DURING DRILLING.

30

35

40

DEPTH IN FEET

Note: See Figure A-2 for Explanation of Symbols

0161-16-4 DJK:GCS;EL:KT 8/5/87

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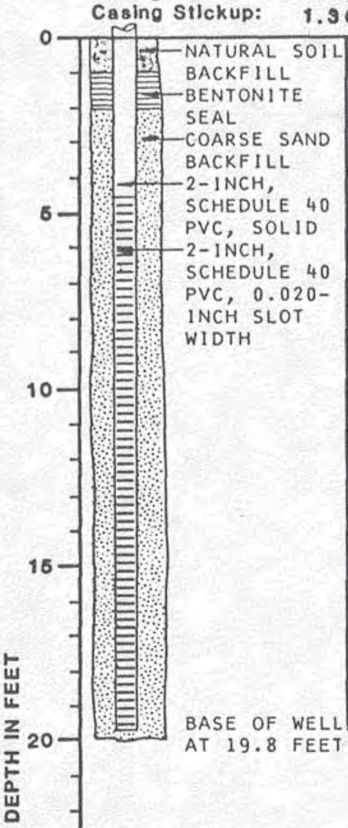
LOG OF MONITOR WELL

FIGURE A-17

MONITOR WELL NO. MW-16

WELL SCHEMATIC
Casing Elevation: 38.00
Casing Stickup: 1.36

DESCRIPTION
Surface Elevation: 36.64



Blow-Count	Samples	Group Symbol	Description
		SW-SM	BROWN FINE TO COARSE SAND WITH SILT AND GRAVEL (VERY LOOSE, MOIST) (FILL)
2	CA ■		
		SP	GRAY FINE TO COARSE SAND WITH ORGANICS (VERY DENSE, WET)(FILL)
72	CA ■		LAYERS OF DARK GRAY SILTY SAND WITH ODOR
			▽ WATER LEVEL ON 7/13/87
		ML	BROWN AND GRAY SANDY SILT WITH GRAVEL AND ORGANICS (DENSE, WET) (MOTTLED)
58	■		
		SM	BROWN AND GRAY SILTY FINE TO COARSE SAND WITH GRAVEL (VERY DENSE, WET) (MOTTLED)
50/3"	■		
			BORING COMPLETED AT 19.5 FEET ON 7/8/87

NOTE: NO HYDROCARBON ODOR WAS DETECTED FROM THIS BORING. A CRESOTE-LIKE ODOR WAS NOTICED ABOUT 9 FEET. WOOD DEBRIS WAS COMMON.

Note: See Figure A-2 for Explanation of Symbols

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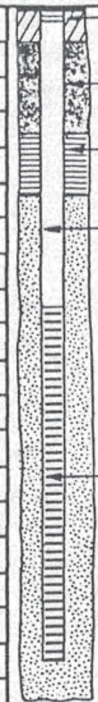
LOG OF MONITOR WELL

FIGURE A-18

0161-16-4 DJK:GCS:EL:KJ 8/4/87

MONITOR WELL NO. MW-17

WELL SCHEMATIC
Casing Elevation: 18.05
Casing Stickup: -0.39



DESCRIPTION
Surface Elevation: 18.44

Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0				CONCRETE
			SM	BLUISH-GRAY SILTY FINE TO MEDUIM SAND WITH GRAVEL (LOOSE, MOIST) (FILL)
	6	CA ■		
5				
	6	CA ■		
10				
				▽ WATER LEVEL ON 8/3/87
	10	■	SP	GRAY FINE TO COARSE SAND (LOOSE, WET) (FILL)
15				
	7	■		
20				BORING COMPLETED AT 19.5 FEET ON 7/7/87
25				
30				
35				
40				

NOTE: NO HYDROCARBON ODOR DETECTED DURING DRILLING OF BORING.

Note: See Figure A-2 for Explanation of Symbols

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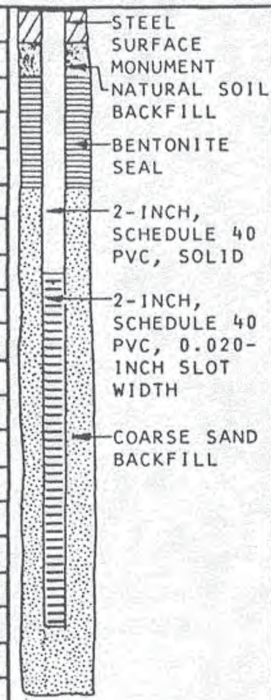
LOG OF MONITOR WELL

FIGURE A-19

0161-16-4 DJK:GCS:EL:KT 8/4/87

MONITOR WELL NO. MW-18

WELL SCHEMATIC
Casing Elevation: 18.27
Casing Stickup: -0.36



DESCRIPTION
Surface Elevation: 18.63

Depth (feet)	Blow-Count	Samples	Group Symbol	Description
0				ASPHALTIC CONCRETE
				BRICK PAVING
				RED BRICK FRAGMENTS (LOOSE, DAMP)
	11	CA ⊠		
5			SP-SM	GRAY FINE TO COARSE SAND WITH SILT AND GRAVEL (MEDIUM DENSE, MOIST) MODERATE HYDROCARBON ODOR
	24	CA ■		
10				∇ WATER LEVEL ON 7/13/87
			SP	GRAY FINE TO COARSE SAND (LOOSE, WET) STRONG HYDROCARBON ODOR
	5	■		
	?	■		BECOMES MEDIUM DENSE
20				BORING COMPLETED AT 19.5 FEET ON 7/7/87

DEPTH IN FEET (scale 0–40)

NOTE: HYDROCARBON ODOR FROM 5 FEET TO BOTTOM OF BORING. VISIBLE SHEEN IN SOIL AFTER BECOMING WET.

Note: See Figure A-2 for Explanation of Symbols

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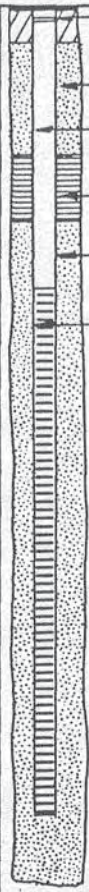
LOG OF MONITOR WELL

FIGURE A-20

0161-16-4 DJK;GCS:EL:KJ 8/4/87

MONITOR WELL NO. MW-19

WELL SCHEMATIC
Casing Elevation: 21.14
Casing Stickup: -0.4



DESCRIPTION
Surface Elevation: 21.54

Blow-Count	Samples	Group Symbol	Description
			ASPHALTIC CONCRETE, BRICK UNDERNEATH ASPHALT
		SW-SM	GRAY FINE TO COARSE SAND WITH SILT AND GRAVEL (MEDIUM DENSE, MOIST) (FILL)
11	⊠	ML	BLUISH-GRAY SANDY SILT WITH GRAVEL (STIFF, MOIST) (FILL)
29	CA ⊠	SM	BROWN SILTY FINE TO COARSE SAND WITH GRAVEL (MEDIUM DENSE, MOIST) (FILL)
17	CA ■	SW-SM	GRAY FINE TO COARSE SAND WITH SILT AND GRAVEL (MEDIUM DENSE, WET) (FILL) ∇ WATER LEVEL ON 7/13/87 - STRONG HYDROCARBON ODOR
10	⊠	SW	GRAY FINE TO COARSE SAND WITH GRAVEL (LOOSE, WET) (FILL) FAINT HYDROCARBON ODOR
12	■		

BORING COMPLETED AT 25.0 FEET ON 7/9/87

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

NOTE: HYDROCARBON ODOR FROM 12 TO 19 FEET DURING DRILLING. CRESOTE-LIKE ODOR AT APPROXIMATELY 24 FEET DURING DRILLING. VISIBLE SHEEN OF PRODUCT AT 14.5 FEET.

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

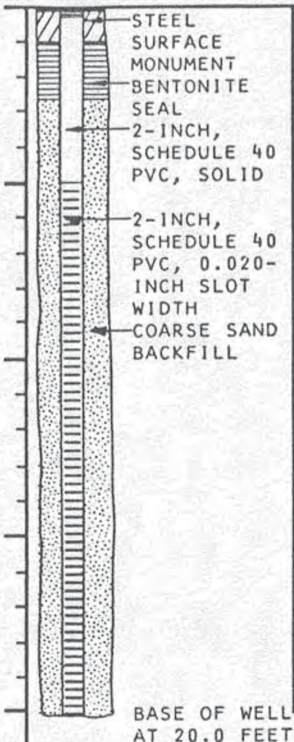
FIGURE A-21

0161-16-4 DJK:GCS:EL:KJ 8/4/87

MONITOR WELL NO. MW-20

WELL SCHEMATIC
Casing Elevation: 17.26
Casing Stickup: -0.25

DESCRIPTION
Surface Elevation: 17.51



Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0				ASPHALTIC CONCRETE
			SW	BROWN FINE TO COARSE SAND WITH GRAVEL (LOOSE TO MEDIUM DENSE, MOIST) (FILL)
	9	CA ■		
5				
	27	■		
10				
				▽ WATER LEVEL ON 7/9/87
	20	CA ■		BECOMES WET STRONG HYDROCARBON ODOR AND VISIBLE PRODUCT
15				
	7	■		INCREASING IN SILT CONTENT
			SM	GRAY SILTY FINE SAND (LOOSE, WET)(FILL)
20				BORING COMPLETED AT 20.0 FEET ON 7/9/87

NOTE: HYDROCARBON ODOR FROM 11 FEET TO BOTTOM OF BORING DURING DRILLING. VISIBLE SHEEN OF PRODUCT FROM 10 TO 15 FEET.

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A-2 for Explanation of Symbols

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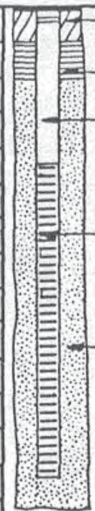
LOG OF MONITOR WELL

FIGURE A-22

MONITOR WELL NO. MW-21

WELL SCHEMATIC
Casing Elevation: 25.19
Casing Stickup: -0.33



DESCRIPTION
Surface Elevation: 25.52

Blow-Count	Samples	Group Symbol	Description
			CONCRETE
		SM	BROWN SILTY SAND WITHG RAVEL (MEDIUM DENSE, MOIST) (FILL)
30	CA	SW-SM	GRAY FINE TO COARSE SAND WITH SILT, GRAVEL AND OCCASIONAL COBBLES (VERY DENSE, MOIST)
			∇ WATER LEVEL ON 7/13/87
50/5"	CA		MODERATE HYDROCARBON ODOR
			BECOMES WET VISIBLE PRODUCT
55			STRONG HYDROCARBON ODOR
		ML	MOTTLED BROWN AND GRAY SILT AND SANDY SILT WITH GRAVEL (VERY DENSE, WET)
			BORING COMPLETED AT 14.5 FEET ON 7/8/87

NOTE: HYDROCARBON ODOR FROM 8 FEET TO BOTTOM OF BORING DURING DRILLING. VISIBLE SHEEN OF PRODUCT AT 13.0 FEET IN SOIL.

Note: See Figure A-2 for Explanation of Symbols

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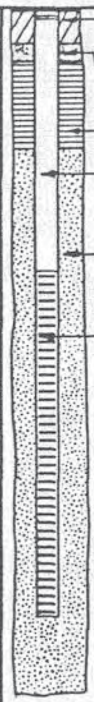
LOG OF MONITOR WELL

FIGURE A-23

MONITOR WELL NO. MW-22

WELL SCHEMATIC
Casing Elevation: 18.61
Casing Stickup: -0.32

Surface Elevation: 18.93



Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0				CONCRETE
			SW-SM	GRAY FINE TO COARSE SAND WITH SILT AND GRAVEL (LOOSE TO MEDIUM DENSE, MOIST) (FILL)
				STRONG HYDROCARBON ODOR
	7	CA ■		INCREASING WOOD FRAGMENTS
	14	CA ■		DECREASING WOOD FRAGMENTS
				▽ WATER LEVEL ON 7/13/87
	20	■		BECOMES WET
	71	■	SW / SP-SM	GRAY FINE TO COARSE GRAVELLY SAND AND BLUISH-GRAY FINE TO COARSE SAND WITH SILT (VERY DENSE, WET) (INTERBEDDED)
				BORING COMPLETED AT 19.5 FEET ON 7/7/87

NOTE: HYDROCARBON ODOR FROM 1.5 FEET TO BOTTOM OF BORING DURING DRILLING. SHEEN PRESENT.

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40 (DEPTH IN FEET)

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

FIGURE A-24

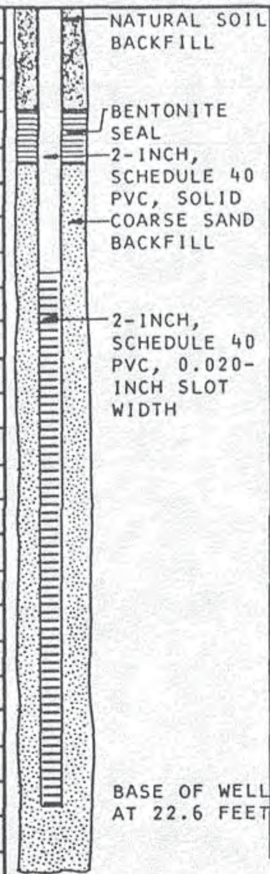
MONITOR WELL NO. MW-23

WELL SCHEMATIC
Casing Elevation: 20.32
Casing Stickup: 3.00

Blow-Count | Samples | Group Symbol

DESCRIPTION
Surface Elevation: 17.32

DEPTH IN FEET



Depth	Blow-Count	Samples	Group Symbol	Description
0			SW	
	6	CA ■	SP	GRAY FINE TO MEDIUM SAND WITH A TRACE OF SILT (LOOSE, MOIST)(FILL) MODERATE HYDROCARBON ODOR
	14	CA ■		
				▽ WATER LEVEL ON 7/13/87
10				STRONG HYDROCARBON ODOR
	9	■		BECOMES WET
	5	■		
20				BECOMES DENSE MODERATE HYDROCARBON ODOR
	35	■		
				BORING COMPLETED AT 24.5 FEET ON 7/6/87

NOTE: HYDROCARBON ODOR FROM 3.5 FEET TO BOTTOM OF BORING DURING DRILLING. VISIBLE SHEEN OF PRODUCT IN SOIL AFTER BECOMING WET.

Note: See Figure A-2 for Explanation of Symbols

DJK:GCS:ELK 8/4/87 0161-16-4

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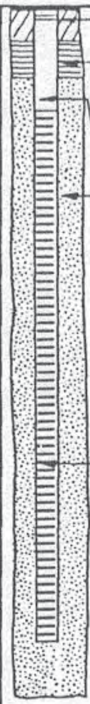
LOG OF MONITOR WELL

FIGURE A-25

MONITOR WELL NO. MW-24

WELL SCHEMATIC
Casing Elevation: 30.01
Casing Stickup: -0.12



DESCRIPTION
Surface Elevation: 30.13

Depth (ft)	Blow-Count	Samples	Group Symbol	Description
0				CONCRETE
			SW	BROWN MEDIUM TO COARSE SAND WITH GRAVEL (DENSE, MOIST) (FILL)
				SILT INCREASING
3.5	57	CA ■		
			SM	GRAY SILTY MEDIUM TO COARSE SAND WITH GRAVEL (DENSE, MOIST) (FILL)
				FAINT HYDROCARBON ODOR
			SW / SP-SM	GRAY FINE TO COARSE SAND WITH GRAVEL AND GRAY FINE TO COARSE SAND WITH SILT (DENSE TO VERY DENSE, WET) (INTERBEDDED)
				STRONG HYDROCARBON ODOR
8.5	5/11"	CA ■		
13.5	57	■		
15				▽ WATER LEVEL ON 8/3/87
				STRONG HYDROCARBON ODOR DIMINISHING
18.5	50/5"	■		
19.5				BORING COMPLETED AT 19.5 FEET ON 7/20/87

DEPTH IN FEET (0–40)

NOTE: HYDROCARBON ODOR FROM 6 TO 18 FEET DURING DRILLING.

Note: See Figure A-2 for Explanation of Symbols

GeoEngineers Incorporated

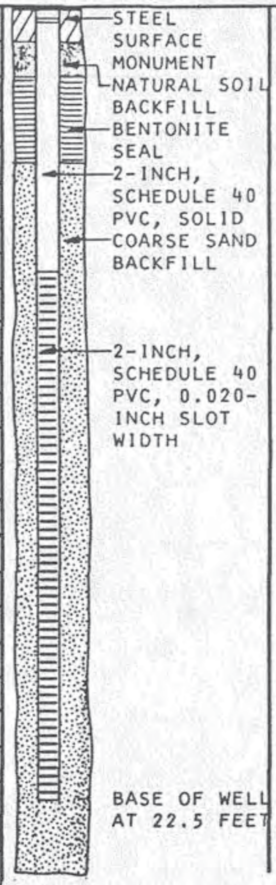
LOG OF MONITOR WELL

FIGURE A-26

0161-16-4 DJK:GCS:EL:KT 8/5/87

MONITOR WELL NO. MW-25

WELL SCHEMATIC
Casing Elevation: 16.65
Casing Stickup: -0.13



DESCRIPTION
Surface Elevation: 16.78

Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0				CONCRETE
			SW	BROWN FINE TO COARSE SAND WITH GRAVEL (MEDIUM DENSE, MOIST) (FILL)
	19	CA ■		
	26	■		GRADING TO GRAY IN COLOR MODERATE HYDROCARBON ODOR
				∇ WATER LEVEL ON 8/3/87
	6	CA ■		SAND BECOMES WET AND LOOSE WITH WOOD FRAGMENTS
	10	■		STRONG HYDROCARBON ODOR AND SHEEN IN SOIL
	12	■		
			SP-SM	GRAY FINE TO COARSE SILTY SAND (MEDIUM DENSE, WET) (FILL)
				BORING COMPLETED AT 24.5 FEET ON 7/21/87

NOTE: HYDROCARBON ODOR FROM 8 FEET TO BOTTOM OF BORING. VISIBLE SHEEN OF PRODUCT IN SOIL.

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

FIGURE A-27

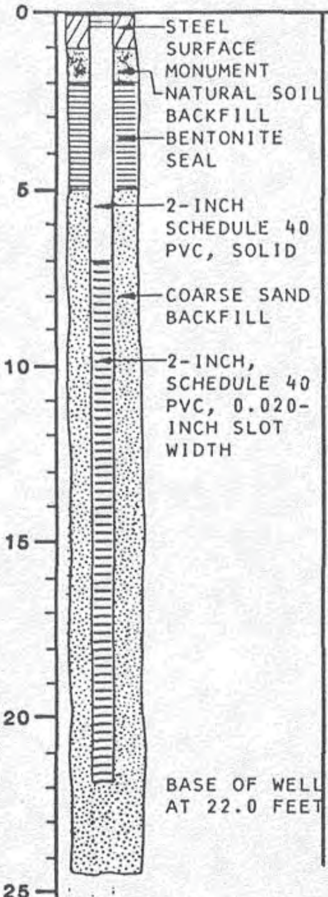
0161-16-4 DJK:GCS:EL:KT 8/5/87

MONITOR WELL NO. MW-26

WELL SCHEMATIC
Casing Elevation: 16.87
Casing Stickup: -0.23

Blow-Count | **Samples** | **Group Symbol**

DESCRIPTION
Surface Elevation: 17.10



DEPTH IN FEET

Depth (ft)	Blow-Count	Samples	Group Symbol	Description
0				CONCRETE
			SW	BROWN FINE TO COARSE SAND WITH GRAVEL AND ORGANICS (MEDIUM DENSE, MOIST) (FILL)
	20	CA ■		
	28	□		
				BECOMING WET
				▽ WATER LEVEL ON 8/3/87
	50/5"	□		VERY DENSE STRATUM
	24	□		
				WOOD FRAGMENTS DECREASING
				DENSITY DECREASING TO LOOSE
	9	□		
	6	CA ■	SW	GRAY FINE TO COARSE SAND WITH GRAVEL (MEDIUM DENSE, WET) (FILL)
				BORING COMPLETED AT 24.5 FEET ON 7/21/87

NOTE: NO HYDROCARBON ODOR DETECTED IN BORING DURING DRILLING.

0161-16-4 DJK:GCS:EL 8/5/87

Note: See Figure A-2 for Explanation of Symbols

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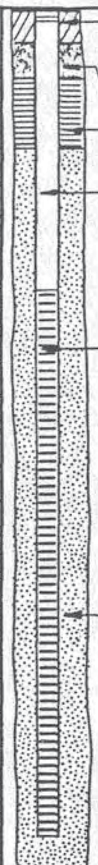
LOG OF MONITOR WELL

FIGURE A-28

MONITOR WELL NO. MW-27

WELL SCHEMATIC
Casing Elevation: 17.28
Casing Stickup: -0.25

DESCRIPTION
Surface Elevation: 17.53



Depth (feet)	Blow-Count	Samples	Group Symbol	Description
0				ASPHALTIC CONCRETE
0–11			SW	BROWN FINE TO COARSE SAND WITH GRAVEL AND COBBLES (MEDIUM DENSE, MOIST) (FILL)
~3.5	16	CA ■		
~8.5	19	■		
11–23.5			SP-SW	GRAY MEDIUM TO COARSE SAND WITH GRAVEL (VERY
~13	72/7"	CA ⊠		▽ WATER LEVEL ON 8/3/87
~18.5	2	☐		
23.5–24.5	11	■	SP-SM	GRAY FINE SAND WITH SILT (MEDIUM DENSE, WET) (FILL)
24.5				BORING COMPLETED AT 24.5 FEET ON 7/20/87

NOTE: NO HYDROCARBON ODOR DETECTED FROM BORING DURING DRILLING. A SLIGHT CRESOTE-LIKE ODOR WAS DETECTED AT APPROXIMATELY 13 FEET DURING DRILLING WHEN WOOD FRAGMENTS WERE FOUND.

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A-2 for Explanation of Symbols

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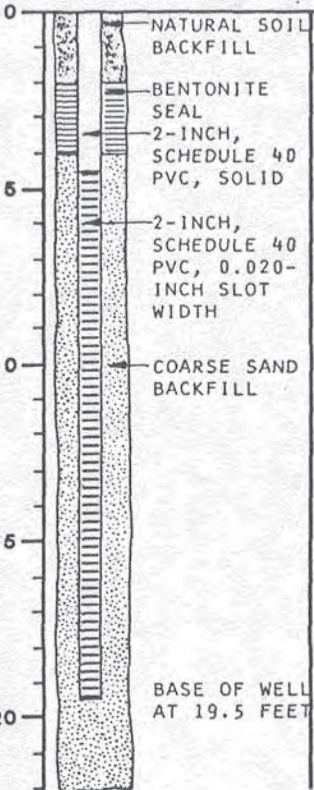
LOG OF MONITOR WELL

FIGURE A-29

MONITOR WELL NO. MW-28

WELL SCHEMATIC
Casing Elevation: 54.30
Casing Stickup: 0.56

DESCRIPTION
Surface Elevation: 53.86



Depth in Feet	Blow-Count	Samples	Group Symbol	Description
0			SP-SW	BROWN FINE TO COARSE SAND WITH SILT AND GRAVEL (LOOSE, MOIST) (FILL)
~11		CA GRAB ⊠	SP	GRAY FINE TO COARSE SAND WITH SILT (DENSE, WET) (FILL) MOISTURE CONTENT INCREASING AND SLIGHT TO MODERATE HYDROCARBON ODOR
~16	56	■	SM	BROWN FINE TO COARSE SILTY SAND (DENSE, MOIST) (FILL)
22				BORING COMPLETED AT 22.0 FEET DUE TO AUGER REFUSAL

NOTE: HYDROCARBON ODOR APPARENTLY FROM 10 TO 13 FEET IN BORING.
NO GROUND WATER ENCOUNTERED

THIS BORING IS APPROXIMATELY 10 FEET EAST OF B-13. THE INTENT WAS TO DRILL TO WATER; HOWEVER, CONCRETE ENCOUNTERED AT 10 FEET CAUSED THE BORING TO BE TERMINATED.

SOIL FROM THE 10 TO 13 FEET RANGE HAD A FAINT HYDROCARBON ODOR AND WAS VERY MOIST. A GRAB SAMPLE WAS COLLECTED FOR CHEMICAL ANALYSIS.

Note: See Figure A-2 for Explanation of Symbols

0161-16-4 DJK:GCS:EL:KJ 8/5/87

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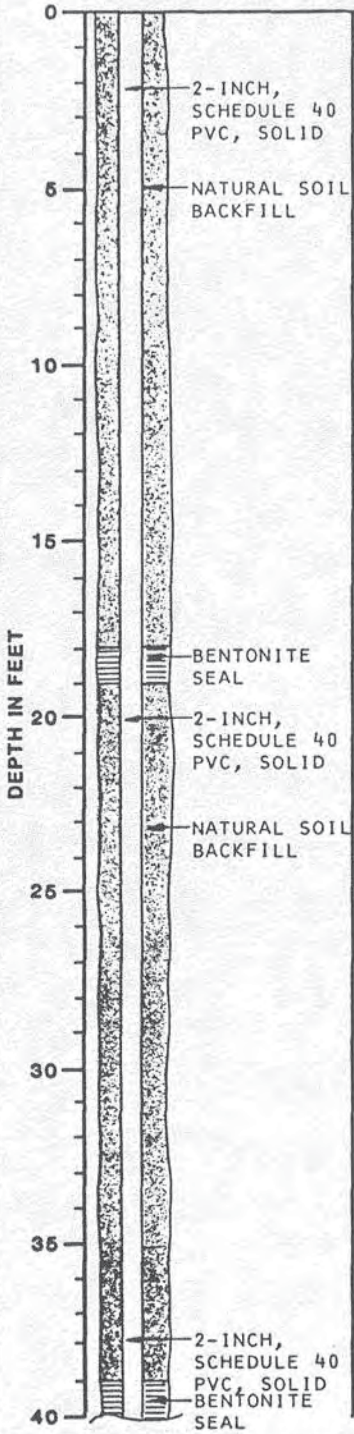
LOG OF MONITOR WELL

FIGURE A-30

MONITOR WELL NO. MW-29

WELL SCHEMATIC
Casing Elevation: 55.19
Casing Stickup: 1.32



Blow-Count	Samples	Group Symbol	DESCRIPTION Surface Elevation: 53.87
			LOOSE GRAVEL AND VEGETATION
		SW	BROWN FINE TO COARSE SAND WITH SILT AND OCCASIONAL GRAVEL (LOOSE, MOIST) (FILL)
		ML	GRAY SANDY SILT BECOMING GRAY, MOISTURE INCREASING MOISTURE DECREASING
		SW	GRAY FINE TO COARSE SAND WITH GRAVEL
		ML	GRAY AND BROWN SANDY SILT

SEE LOG OF MONITOR WELL 13A FOR FURTHER DETAIL

NOTE: NO SOIL SAMPLES TAKEN FROM 0 TO 43.5 FEET BECAUSE INTERVAL PREVIOUSLY SAMPLED DURING DRILLING OF MONITOR WELL 13A.

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

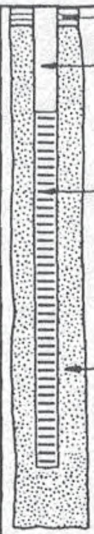
FIGURE A-31

0161-16-4 DJK:GCS:el:KT 8/5/87

MONITOR WELL NO. MW-29
CONTINUED

WELL SCHEMATIC
Casing Elevation:
Casing Stickup: —

DESCRIPTION
Surface Elevation: —



Depth (feet)	Well Schematic	Blow-Count	Samples	Group Symbol	Description
40	BENTONITE SEAL; 2-INCH, SCHEDULE 40 PVC, SOLID			SM/SP	BROWN SILTY FINE TO COARSE SAND AND BROWN MEDIUM TO COARSE SAND (MEDIUM DENSE TO VERY DENSE, MOIST) (INTERBEDDED)
		50/4"	CA ■		∇ WATER LEVEL ON 8/3/87
45	2-INCH, SCHEDULE 40 PVC, 0.020-INCH SLOT WIDTH				
		56	CA ■	SP	GRAYISH-GREEN FINE TO COARSE SAND (VERY DENSE, WET)
50	COARSE SAND BACKFILL				
	BASE OF WELL AT 53.0 FEET	77/11"	■		
55					BORING COMPLETED AT 54.5 FEET ON 7/23/87

DEPTH IN FEET

NOTE: NO HYDROCARBON ODOR DURING DRILLING

MONITOR WELL MW-29 IS APPROXIMATELY 3 FEET WEST OF MW-13. THIS BORING ENCOUNTERED WATER AT 45 FEET AND WAS COMPLETED AT 53 FEET.

DUE TO POSSIBLE CONTAMINATION AT 10 TO 13 FEET IN NEARBY MW-28, A SECOND BENTONITE SEAL WAS INSTALLED FROM 18 TO 19 FEET. THE LOWER SEAL WAS JUST ABOVE THE SCREEN AND OCCURS FROM 39 TO 40.5 FEET.

NO HYDROCARBON ODOR WAS DETECTED HERE AND A SAMPLE AT 43.5 FEET WAS SELECTED FOR CHEMICAL ANALYSIS.

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

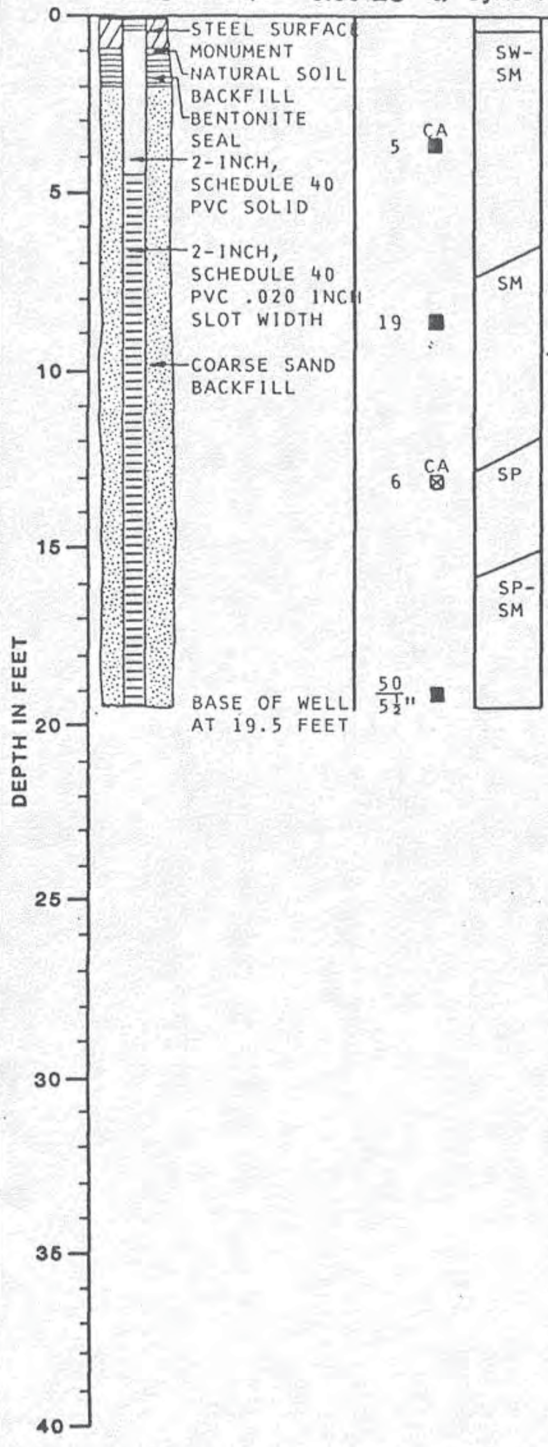
FIGURE A-32

MONITOR WELL NO. MW-30

WELL SCHEMATIC
Casing Elevation: 22.21
Casing Stickup: -0.33

Blow-Count | Samples | Group Symbol

DESCRIPTION
Surface Elevation: 22.54



CONCRETE SIDEWALK
GRAY FINE TO COARSE SAND WITH SILT (LOOSE, MOIST) (FILL)

OCCASIONAL WOOD FRAGMENTS

GRAY SILTY FINE TO MEDIUM SAND WITH OCCASIONAL GRAVEL (MEDIUM DENSE, MOIST)

▽ WATER LEVEL AT 9.50 FEET ON 12/11/87

GRAY FINE SAND WITH A TRACE OF SILT (LOOSE, WET)

FAINT HYDROCARBON ODOR

GRAY MEDIUM TO COARSE SAND WITH SILT AND OCCASIONAL ORGANICS (VERY DENSE, WET)

OCCASIONAL WOOD FRAGMENTS

BORING COMPLETED AT 19.5 FEET ON 11/23/87

NOTE: FAINT HYDROCARBON ODOR FROM APPROXIMATELY 12 FEET TO BOTTOM OF BORING. SHEEN PRESENT.

Note: See Figure A-2 for Explanation of Symbols

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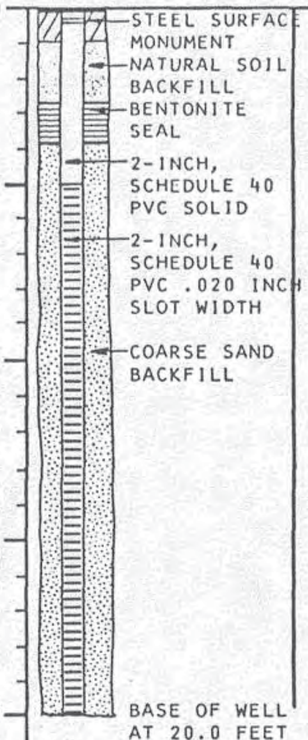
LOG OF MONITOR WELL

FIGURE A-33

MONITOR WELL NO. MW-31

WELL SCHEMATIC
Casing Elevation: 23.37
Casing Stickup: -0.14



DESCRIPTION
Surface Elevation: 23.51

Depth (approx., feet)	Blow-Count	Samples	Group Symbol	Description
0				CONCRETE SIDEWALK
0–2			SM	BROWN SILTY FINE TO MEDIUM SAND (LOOSE, MOIST) (FILL)
2–11	7	CA ■	SP-SM	BROWN MEDIUM TO COARSE SAND WITH SILT AND GRAVEL (LOOSE, MOIST)
	28	■		BECOMES MEDIUM DENSE WATER LEVEL AT 9.37 FEET ON 12/11/87
11–17	30	CA ■	SP-SM	GRAY MEDIUM TO COARSE SAND WITH SILT AND GRAVEL (DENSE, WET) FAINT TO MODERATE HYDROCARBON ODOR
17–20	50/5"	■	SP	GRAY MEDIUM TO COARSE SAND WITH GRAVEL AND A TRACE OF SILT (VERY DENSE, WET)

BORING COMPLETED AT 20.0 FEET ON 11/23/87

NOTE: FAINT TO MODERATE HYDROCARBON ODOR FROM APPROXIMATELY 13 FEET TO BOTTOM OF BORING.

DEPTH IN FEET (scale 0–40)

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

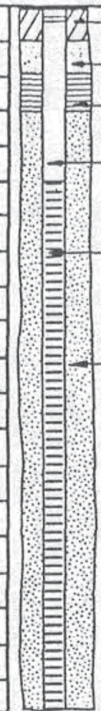
FIGURE A-34

MONITOR WELL NO. MW-32

WELL SCHEMATIC
Casing Elevation: 23.88
Casing Stickup: -0.20

Blow-Count | **Samples** | **Group Symbol** | **DESCRIPTION**

Surface Elevation: 24.08



STEEL SURFACE MONUMENT
NATURAL SOIL BACKFILL
BENTONITE SEAL
2-INCH, SCHEDULE 40 PVC SOLID
2-INCH, SCHEDULE 40 PVC .020 INCH SLOT WIDTH
COARSE SAND BACKFILL
BASE OF WELL AT 20.0 FEET

Depth (feet)	Blow Count	Samples	Group Symbol	Description
0				CONCRETE SIDEWALK
			SP	BROWN MEDIUM TO COARSE SAND WITH GRAVEL (LOOSE, MOIST) (FILL)
			SM	BROWN SILTY MEDIUM TO COARSE SAND (LOOSE, MOIST)
	5	CA ■		
	17	■		▽ WATER LEVEL AT 9.34 FEET ON 12/11/87
	22	CA ■	SP	BROWN MEDIUM TO COARSE SAND WITH GRAVEL (MEDIUM DENSE, WET)
	16	⊠	SM	
	50/5"	■	SP/SM	INTERBEDDED GRAY MEDIUM TO COARSE SAND WITH A TRACE OF SILT AND BROWN SILTY MEDIUM TO COARSE SAND (VERY DENSE, WET) MODERATE HYDROCARBON ODOR
20				

BORING COMPLETED AT 20 FEET ON 11/23/87

NOTE: MODERATE HYDROCARBON ODOR AT APPROXIMATELY 17 FEET TO BOTTOM OF BORING.

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A-2 for Explanation of Symbols

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LOG OF MONITOR WELL

FIGURE A-35

Table B-6. Field Data - Ground Water Level Elevations (Assumed Datum)

Monitor Well Number	7/13/87	8/3/87	8/11/87
MW-1	--	8.19	--
MW-2	--	7.22	--
MW-3	--	21.28	21.09
MW-4	--	18.56	DRY
MW-5	--	24.82	24.65
MW-6	--	31.83	31.72
MW-7	--	24.79	24.62
MW-8	3.04	4.09	--
MW-9	--	6.22	--
MW-10	--	8.42	--
MW-11	7.64	7.49	--
MW-12A	25.83	23.86	23.48
MW-12B	30.71	DRY	--
MW-13A	DRY	DRY	DRY
MW-13B	DRY	DRY	DRY
MW-14	23.05	22.83	22.73
MW-15	--	33.13	33.04
MW-16	28.02	27.59	27.40
MW-17	7.36	7.06	--
MW-18	8.18	8.15	--
MW-19	8.01	7.75	--
MW-20	5.70	5.12	--
MW-21	19.17	18.95	--
MW-22	7.69	7.39	--
MW-23	7.65	7.59	--
MW-24	25.83	14.91	--
MW-25	--	4.95	--
MW-26	--	4.78	--
MW-27	--	4.91	--
MW-28	--	DRY	--
MW-29	--	9.79	10.64

Note: -- = Not measured or drilled at the time of field data acquisition.

Table B-5. Summary of Slug Test Data

Monitoring Well No.	Soil Material Tested	Calculated Hydraulic Conductivity (ft/min)
MW-1	SP/SM	0.0014
MW-2	SP/SM	0.071
MW-9	ML/SM	0.0014
MW-15	SM	0.0072
MW-26	SW	0.022
MW-29	SP	>0.93

Notes:

1. Slug tests were conducted on August 25 and 26, 1987.
2. Data recording was done with a 5 psi pressure transducer.
3. The hydraulic conductivity result from monitor well MW-29 is questionable, since it was greater than the relevant range for this test.

Table B-4. Soil Contamination Summary

	Upper Yard	Lower Yard	Total of Upper and Lower Yards	OffSite	Grand Total
Contaminated Soil Volume (200 ppm or higher)	12,540 cy	25,300 cy	37,840 cy	23,570 cy	61,410 cy
Mean Hydrocarbon Concentration (ppm)	2,660	3,130	--	2,560	--
Pounds of Hydrocarbons	112,500	267,000	379,500	203,600	583,100

Note: Calculations of mean hydrocarbon concentration and pounds of hydrocarbons are based on the estimated volume of soil with a hydrocarbon concentration of 200 ppm or higher. Concentrations used were based on actual laboratory analysis of soil samples for fuel hydrocarbons (EPA Method 8015 Modified).

Table B-3 (continued)

Well Number	7/14/87(1) (%LEL)	8/3/87(1) (%LEL)	8/11/87(2) (ppm)	8/11/87(2) (%LEL)	12/11/87(2) (ppm)
MW-27	--	80	2200	20	140
MW-28	--	--	--	--	<10
MW-29	--	ND	ND	ND	<10
MW-30	--	--	--	--	10,000+
MW-31	--	--	--	--	560
MW-32	--	--	--	--	230

---

(1) Measurements (%LEL) obtained using a Bacharach Model H Explosimeter calibrated to hexane.

(2) Measurements obtained using a Bacharach TLV Sniffer calibrated to hexane (110 ppm = 1% LEL of hexane).

-- = Not measured or drilled at the time of field data acquisition.
ND = Non detectable.

Table B-3. Field Data - Hydrocarbon Vapor Levels

Well Number	7/14/87[1] (%LEL)	8/3/87[1] (%LEL)	8/11/87[2] (ppm)	8/11/87[2] (%LEL)	12/11/87[2] (ppm)
MW-1	---	ND	ND	ND	10,000+
MW-2	---	ND	ND	ND	10,000+
MW-3	---	ND	ND	ND	<10
MW-4	---	ND	ND	ND	<10
MW-5	---	ND	ND	ND	150
MW-6	---	ND	50	<1	120
MW-7	---	ND	ND	ND	210
MW-8	5	ND	ND	ND	40
MW-9	---	ND	10,000+	91+	10,000+
MW-10	---	ND	180	2	4,000
MW-11	100+	100+	10,000+	91+	166
MW-12A	30	ND	ND	ND	50
MW-12B	5	---	400	4	<10
MW-13A	---	---	---	---	<10
MW-13B	---	---	---	---	160
MW-14	6	2	68	1	10
MW-15	---	---	960	9	<10
MW-16	100	40	120	1	<10
MW-17	65	98	10,000+	91+	10,000+
MW-18	100+	100+	3600	33	10,000+
MW-19	90	70	2000	18	160
MW-20	15	ND	60	1	200
MW-21	7	20	ND	ND	480
MW-22	100+	100+	10,000+	91+	10,000
MW-23	80	100+	9800	89	10,000+
MW-24	---	100+	---	---	---
MW-25	---	60	4800	44	5000
MW-26	---	ND	ND	ND	180

Table B-2. Summary of Selected Dissolved Constituents In Ground Water

Well Number	Lead Concentration(1) (ppm)	EDB Concentration(2) (ppb)	Petroleum Hydrocarbon Concentration(3) (ppm)	Benzene Concentration(4) (ppb)
MW-6	0.032	<20.0	---	<0.5
MW-9	<0.002	<20.0	---	470
MW-12	0.016	---	3.2	29
MW-22	<0.002	<20.0	3.7	940
MW-23	<0.002	---	---	200
MW-25	0.87	---	2.0	<2.5
MW-31	<0.002	---	0.74	---

Notes:

(1) Lead analysis by atomic absorption with graphite furnace (AA/GF) using EPA Method 7421.

(2) EDB analysis by GC/ECD using EPA Method 608.1.

(3) Petroleum hydrocarbon analysis by IR Technique using EPA Method 418.1.

(4) Benzene concentrations were determined during Phase 2 studies.

--- Indicates not sampled during Phase 2.

Table B-1 (continued)

Monitor. Well No.	Soil Odor During Drilling	Fuel Hydrocarbon Vapor Levels ppm	%LEL	Depth of Soil Sample Tested (3)	Petroleum Hydrocarbons (EPA Method 8015)(ppm)	Hydrocarbon Range	Hydrocarbons (EPA Method 418.1)	Water Table Conditions	BETX in Ground Water(ppb)(4) (EPA Method 602) B	E	T	X
26	No	ND	ND(1)	3.5	ND	-	7	No sheen	<0.5	<0.5	<0.5	<0.5
				23.5	26	C16-C18	79					
27	No	2,200	20(1)	3.5	ND	-	710	No sheen	2.0	<0.5	140	<0.5
				13.5	71	C9-C11	270					
28	Yes	-	-	12	400	C7-C14	79	-	-	-	-	-
29	No	ND	ND(1)	43.5	ND	-	5	No sheen	<0.5	<0.5	1.1	1.7
				48.5	ND	-	3					
30	Yes	10,000+	91+(2)	3.5	ND	-	46	Sheen	<0.5	<0.5	1.7	<0.5
				13.5	1400	C12-C22	6100					
31	Yes	560	5(2)	3.5	ND	-	23	No sheen	<0.5	<0.5	59	74
				13.5	ND	-	8					
32	Yes	230	2(2)	3.5	ND	-	16	No sheen	1.1	<0.5	29	5.1
				13.5	ND	-	5					

Notes:

(1) Measurements obtained on 8/11/87 using Bacharach TLV Sniffer calibrated to hexane (110 ppm = 1% LEL of hexane). Instrument is affected by water vapor and carbon dioxide. Readings of less than 100 ppm are not considered as reliable indicators of hydrocarbon vapors.

(2) Measurements obtained on 12/11/87 using Bacharach TLV Sniffer calibrated to hexane (110 ppm = 1% LEL of hexane). Instrument is affected by water vapor and carbon dioxide. Readings of less than 400 ppm are not considered to be reliable indicators of hydrocarbon vapors for measurements made in monitor wells.

(3) Selection of soil samples for analysis were based on their olfactory and visual evidence of contamination. The soil samples with the highest degree of apparent contamination at shallow depth in the vadose zone and near the water table for each borehole were tested.

(4) B = benzene, E = ethylbenzene, T = toluene, X = sum of m, p, o xylenes. BETX detection limits of 0.5 ppb (ug/l).
ND = not detected
- = not tested

P105/878012.TA1

Table B-1 (continued)

Monitor. Well No.	Soil Odor During Drilling	Fuel Hydrocarbon Vapor Levels ppm	%LEL	Depth of Soil Sample Tested (3)	Petroleum Hydrocarbons (EPA Method 8015)(ppm)	Hydrocarbon Range	Hydrocarbons (EPA Method 418.1)	Water Table Conditions	BETX in Ground Water(ppb)(4) (EPA Method 602) B	E	T	X
15	Yes	960	9(1)	3.5	2100	C10-C20	1,200	No sheen	<0.5	<0.5	0.93	1.2
				8.5	ND	-	3					
16	No	120	1(1)	3.5	ND	-	2,600	No sheen	<0.5	<0.5	<0.5	<0.5
				8.5	ND	-	7					
17	No	10,000+	91+(1)	3.5	ND	-	3,980	No sheen	<0.5	<0.5	<0.5	<0.5
				8.5	ND	-	638					
18	Yes	3,600	33(1)	3.5	2100	C9-C14	3,070	Sheen	16	<0.5	42	60
				8.5	3300	C8-C14	4,100					
19	Yes	2,000	18(1)	9.5	ND	C10-C18	57	Sheen	12	22	84	137
				14.5	4900	-	4,100					
20	Yes	60	1(1)	3.5	ND	-	4	Sheen	0.79	<0.5	1.3	<0.5
				13.5	390	C16-C20	1,200					
21	Yes	ND	ND(1)	3.5	ND	-	10	Sheen	<0.5	2.3	2.7	<0.5
				8.5	130	C11-C14	140					
22	Yes	10,000+	91+(1)	3.5	4100	C10-C19	2,090	Sheen	940	<25.0	31	38
				8.5	90	C9-C14	46					
23	Yes	9,800	89(1)	3.5	ND	-	89	Sheen	200	13	94	60.2
				8.5	6400	C11-C18	6,820					
24	Yes	-	-	3.5	ND	-	35	No sheen	<0.5	<0.5	13	25.4
				8.5	3400	C10-C18	4,800					
25	Yes	4,800	44(1)	3.5	ND	-	4	Sheen	<2.5	<2.5	140	41
				13.5	470	C7-C14	320					

P105/878012.TA1

Table B-1. Summary of Subsurface Contamination Data

Monitor. Well No.	Soil Odor During Drilling	Fuel Hydrocarbon Vapor Levels ppm	Fuel Hydrocarbon Vapor Levels %LEL	Depth of Soil Sample Tested (3)	Petroleum Hydrocarbons (EPA Method 8015)(ppm)	Hydrocarbon Range	Hydrocarbons (EPA Method 418.1)	Water Table Conditions	BETX in Ground Water(ppb)(4) (EPA Method 602) B	E	T	X
1	Yes	ND	ND(1)	9	1060	-	-	No sheen	<0.5	1.9	<.05	<0.5
2	Yes	ND	ND(1)	13.5	ND	-	-	Sheen	<5.0	110	36	<5.0
3	Yes	ND	ND(1)	8.5	1100	-	-	Sheen	42	<2.5	25	12
4	Yes	ND	ND(1)	9	ND	-	-	No sheen	<0.5	<0.5	<0.5	<0.5
5	No	ND	ND(1)	9	ND	-	-	No sheen	<0.5	<0.5	<0.5	<0.5
6	Yes	50	<1(1)	9	ND	-	-	No sheen	<0.5	<0.5	<0.5	<0.5
7	No	ND	ND(1)	9	ND	-	-	No sheen	<0.5	<0.5	<0.5	<0.5
8	Yes	ND	ND(1)	3.5	ND	-	20	Sheen	<0.5	<0.5	<0.5	<0.5
				13.5	800	C10-C14	2,000					
9	Yes	10,000+	91+(1)	3.5	ND	-	280	No sheen	470	32	8.5	<5.0
				8.5	3700	C6-C24+	11,000					
10	No	180	2(1)	3.5	ND	-	2	No sheen	<0.5	<0.5	<0.5	<0.5
				8.5	ND	-	3					
11	Yes	10,000+	91+(1)	3.5	1600	C17-C24	11,400	Sheen	48	31	9.5	17.3
				8.5	2400	C9-C14	2,780					
12A	Yes	ND	ND(1)	3.5	5300	C9-C14	1,810	Sheen	29	<5.0	6.6	8.6
12B	Yes	400	4(1)	8.5	8600	C11-C14	9,250	Sheen	16	<0.5	2.7	0.91
13A	No	-	-	3.5	ND	-	15	No sheen	-	-	-	-
13B	No	-	-	33.5	ND	-	11	No sheen	-	-	-	-
14	Yes	68	1(1)	3.5	3400	C12-C22	6,480		2.3	<0.5	12	4.7
				8.5	5300	C11-C22	7,520	Sheen				

P105/878012.TA1

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	GROUP SOIL CLASSIFICATION SYMBOL	DESCRIPTION
		TEST PIT TP-9 (MW-9)
0 - 1.0	SP	BROWN MEDIUM TO COARSE SAND WITH SILT AND WITH GRAVEL
1.0 - 2.5	SP	GRAY MEDIUM TO COARSE SAND WITH GRAVEL
2.5 - 3.0	SM	GRAY SILTY MEDIUM TO COARSE SAND WITH GRAVEL WOOD AT 3.0 FEET
3.0 - 9.0	SP	GRAY MEDIUM TO COARSE SAND WITH GRAVEL
9.0 - 10.0	SP/ML	GRAY MEDIUM TO COARSE SAND WITH GRAVEL INTERBEDDED WITH LENSES OF GRAY SILT
		TEST PIT COMPLETED AT 10.0 FEET ON 2/3/88
		NO SEEPAGE OBSERVED
		SAMPLE COLLECTED AT 10.0 FEET
		TEST PIT TP-12 (MW-12)
0 - 1.5	SP	BROWN MEDIUM TO COARSE SAND WITH SILT
1.5 - 11.0	SM	GRAY SILTY MEDIUM TO COARSE SAND
		TEST PIT COMPLETED AT 11.0 FEET ON 2/3/88
		SEEPAGE OBSERVED AT 4.0 FEET
		SAMPLE COLLECTED AT 11.0 FEET
		TEST PIT TP-23 (MW-23)
0 - 9.0	SP	BLACK MEDIUM TO COARSE SAND WITH GRAVEL GRADES TO GRAY IN COLOR AT 3.0 FEET OCCASIONAL COBBLES AT 7.0 FEET
		TEST PIT COMPLETED AT 9.0 FEET ON 2/3/88
		NO SEEPAGE OBSERVED
		SAMPLE COLLECTED AT 9.0 FEET

THE DEPTHS ON THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FEET, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FEET.

FIGURE D–1
LOG OF TEST PIT
UNOCAL
Seattle, Washington

8/23/88 878012–A–FD–1.0

TABLE E-2. Biotreatability Assessment: Average Petroleum Hydrocarbon Concentration (ug/g) by GC Analysis.

Sample	Time	Without Nutrients	Plus Nutrients	Plus Inoculum	Killed[a] Control
Upper Yard	0 Week	660 (219)	660 (219)	660 (219)	660 (219)
	2 Weeks	150 (112)	64 (68)	66 (67)	---
	4 Weeks	1,100 (637)	57 (45)	ND[b]	350 (35)
Lower Yard	0 Week	2,600 (802)	2,600 (802)	2,600 (802)	2,600 (802)
	2 Weeks	790 (476)	18 (15)	850 (228)	---
	4 Weeks	1,200 (950)	190 (26)	440 (23)	120 (147)
Offsite	0 Week	590 (55)	590 (55)	590 (55)	590 (55)
	2 Weeks	ND	ND	ND	---
	4 Weeks	ND	ND	ND	ND

[a] Killed control refers to sample amended with 2% formalin. Analytical results have shown that formalin interferes with petroleum extraction and quantification. As a result, data are suspect.

[b] ND = non detectable. Detection limit = 9.0 ug/g

NOTE: Standard deviation shown in parentheses. Average of triplicate analysis reported.

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS					TYPICAL NAMES
COARSE GRAINED SOILS MORE THAN HALF IS LARGER THAN NO. 200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LESS THAN 5% FINES	GW		WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES
		GRAVELS WITH OVER 12% FINES	GM		SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			GC		CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LESS THAN 50% FINES	SW		WELL GRADED SANDS, GRAVELLY SANDS
			SP		POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 12% FINES	SM		SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			SC		CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN HALF IS SMALLER THAN NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL		INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL		ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH		INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH		ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT		PEAT AND OTHER HIGHLY ORGANIC SOILS

LEGEND

SAMPLE
- "Undisturbed"
- Bulk/Grab
- Not Recovered
- Recovered, Not Retained

CONTACT BETWEEN UNITS
- Well Defined Change
- Gradational Change
- Obscure Change
- End of Exploration

LABORATORY TESTS

Consol - Consolidation
LL - Liquid Limit
PL - Plastic Limit
Gs - Specific Gravity
SA - Size Analysis
TxS - Triaxial Shear
TxP - Triaxial Permeability
Perm - Permeability
Po - Porosity
MD - Moisture/Density
DS - Direct Shear
VS - Vane Shear
Comp - Compaction

UU - Unconsolidated, Undrained
CU - Consolidated, Undrained
CD - Consolidated, Drained

BLOWS/FOOT

Hammer is 140 pounds with 30-inch drop, unless otherwise noted
S - SPT Sampler (2.0-inch O.D.)
T - Thin Wall Sampler (2.8-inch Sample)
H - Split Barrel Sampler (2.4-inch Sample)

MOISTURE DESCRIPTION

Dry - Considerably less than optimum for compaction
Moist - Near optimum moisture content
Wet - Over optimum moisture content
Saturated - Below water table, in capillary zone, or in perched groundwater

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Soil Classification/Legend
ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

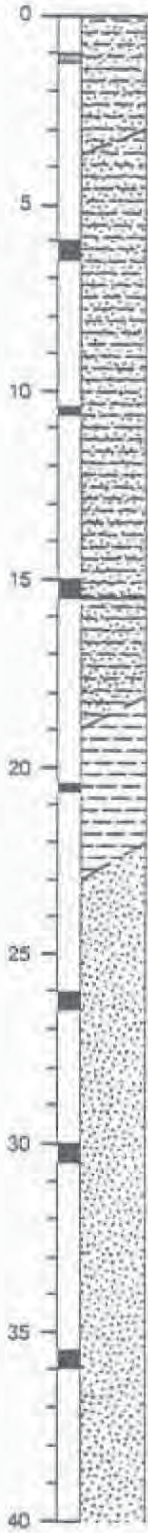
PLATE **A1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	JMS	18 Dec. 90		

Equipment: Mobile B-61

Land Surface Elevation: 14.0 feet * | Date: 11/12/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
	6.2	128	58
			50/5"
	14.1	110	50/6"
SA	12.1		75/10"
	17.0		56
			50/3"
	14.3	114	50/5"



DARK BROWN SILTY SAND (SM) loose, moist; fine to medium grained, with some gravel (Fill).

GRAY BROWN SILTY SAND (SM) very dense, moist; fine to medium grained, with little gravel (Till).

With increasing gravel.

GRAY BROWN SILTY SAND (SM) very dense, moist; fine to medium grained, interbedded silt layers (Till).

GRAY SANDY SILT (ML) very hard, moist; with trace gravel (Till).

BROWN SAND (SP) very dense, saturated; fine grained, with some silt (Advance Outwash).

* Datum: City of Seattle
Note: Sampler driven with 300-pound hammer

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Log of Boring 90-9 (0-40')

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A2a**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	SES	GMA	13 Dec 90		

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)	Sample
			50/4"	40	
				45	
				50	
				55	
				60	
				65	
				70	
				75	
				80	

Equipment Mobile B-61

Land Surface Elevation 14.0 feet Date 11/12/90

Groundwater encountered at a depth of 22-1/2 during drilling.

Boring backfilled with bentonite and sealed with concrete on 11/12/90.

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Log of Boring 90-9 (40'-40.5')
ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE
A2b

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	SES	JMA	13 Dec 90		

Equipment: Mobile B-61

Land Surface Elevation: 13.3 feet   Date: 11/14/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
	7.5	130	144/11.5"
	9.0	135	167/10"
DS	12.3	120	50/5.5"
			50/5"
	16.8	117	94/10"
			50/5.5"
			50/2"
	13.4		50/2"

Note: Sampler driven with 140-pound hammer

BROWN SILTY SAND (SM) dense, moist; fine to medium grained (Fill).

GRAY SILTY SAND (SM) very dense, moist; fine to medium grained, some gravel (Till).

Becomes gray brown, with hydrocarbon odor.

LIGHT BROWN SILTY SAND (SM) very dense, wet; fine to medium grained, with trace gravel (Advance Outwash).

Becomes saturated.

Groundwater encountered at a depth of 19 feet during drilling.

Boring backfilled with bentonite and sealed with concrete on 11/14/90.

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Log of Boring 90-10

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A3**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15.357.002	SES	JMA	13 Dec 90		

Equipment: Mobile B-61

Land Surface Elevation: 40.0 feet   Date: 11/9/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Description
				BROWN SILTY SAND (SM) medium dense, moist; fine to medium grained, with some gravel (Fill).
			14	
				GRAY SILTY SAND (SM) medium dense, moist; fine to medium grained, with trace gravel (Weathered Till).
			28	
	9.2	116	50/5"	RED BROWN SILTY SAND (SM) very dense, moist; fine to medium grained, some fine grained gravel (Till).
			50/4"	Becomes brown gray.
	9.9	117	71/5"	
			75/10"	Becomes fine grained.
	19.7	102	75/5"	
				BROWN GRAY SAND (SW) very dense, moist; fine to coarse grained, with trace silt and gravel (Advanced Outwash).
			78/4"	

Note: Sampler driven with 300-pound hammer.

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Log of Boring 90-11 (0-40')

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A4a**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	SES	[signature]	13 Dec 90		

Equipment: Mobile B-61

Land Surface Elevation: 40.0 feet   Date: 11/14/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)	Description
				40	
	13.8	117	60/10.5"		
				45	
DS	10.6	125	50/5"		BROWN GRAY SILTY SAND (SM) very dense, moist; fine to medium grained with some fine gravel (Advance Outwash).
				50	
			50/4"		
				55	
	7.4	125	50/5"		Becomes silty sand with fine to coarse grained gravel.
				60	
			50/3"		Groundwater not encountered during drilling.
				65	Boring backfilled with bentonite on 11/9/90.
				70	
				75	
				80	

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Log of Boring 90-11 (40-68')

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE A4b

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15.357.002	SES	GMA	13 Dec 90		

Equipment	Mobile B-61		
Land Surface Elevation	40.0 feet	Date	11/14/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)	Description
				0	BROWN SILTY SAND (SM) loose, moist; fine grained, with some gravel (Fill).
					BROWN SILTY SAND (SM) very dense, moist; fine to medium grained, with some gravel (Till).
	8.0	133	82/11"	5	
					BROWN SANDY SILT (ML) hard, moist (Till).
	17.4	118	76/5"	10	
					BROWN SILTY SAND (SM) very dense, wet; fine to coarse grained, with some gravel (Advance Outwash).
SA			50/4"	15	
					BROWN SAND (SP) very dense, wet; fine to medium grained, with trace gravel (Advance Outwash).
			50/4"	20	
DS	11.5	135	50/5"	25	
	8.8	139	50/5.5"	30	
			50/3"	35	Becomes gray.
			50/5"		
				40	

Groundwater encountered at a depth of 10 feet during drilling.
Boring backfilled with bentonite and sealed with concrete on 11/14/90.

Note: Sampler driven with 300-pound hammer.

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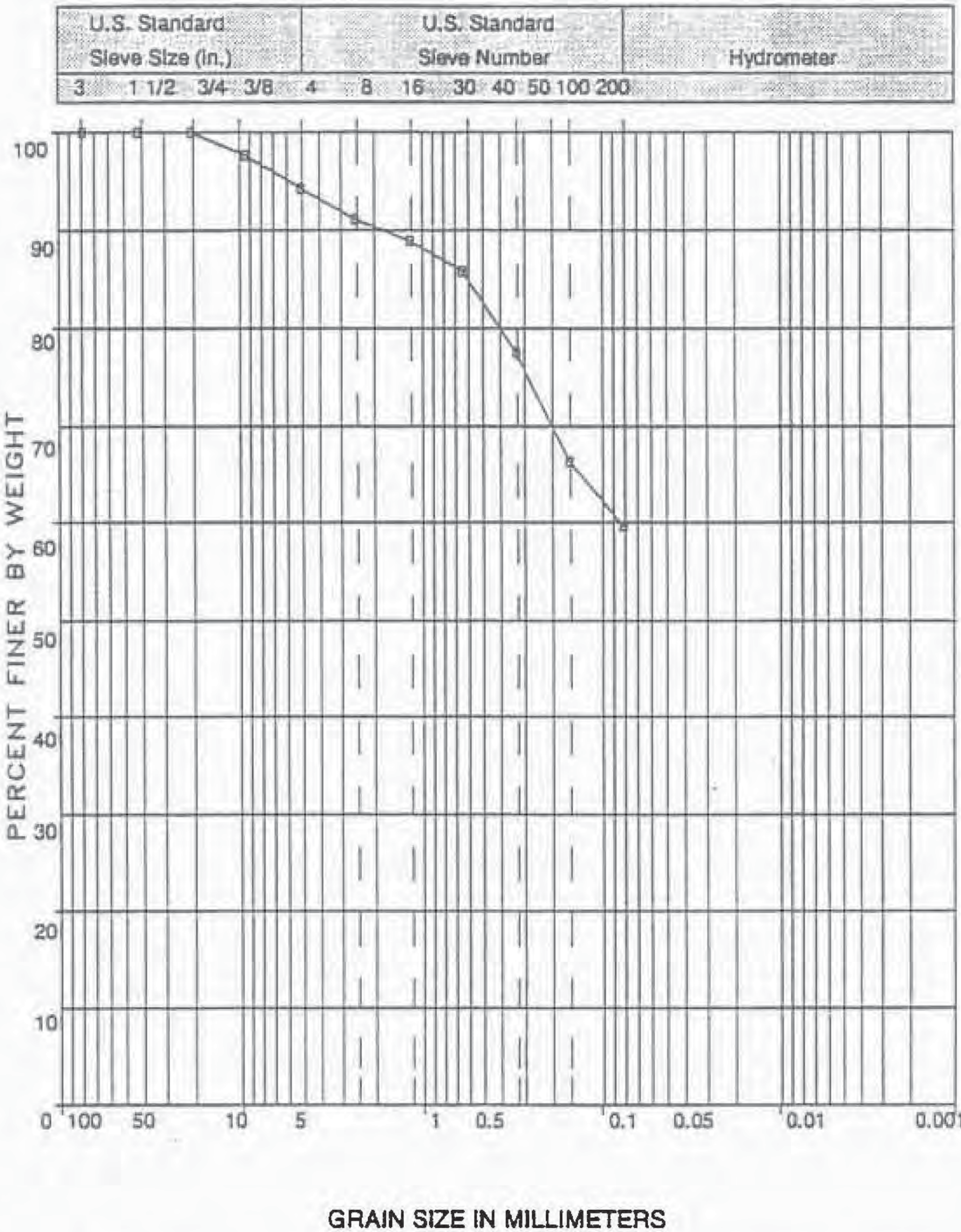
Log of Boring 90-12
ECOVA/ UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A5**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	SES	[signature]	13 Dec 90		



COARSE	FINE	COARSE	MEDIUM	FINE	
GRAVEL		SAND			SILT or CLAY

Sample Source	Classification
90-9 @ 20.5'	Gray Sandy Silt (ML) trace gravel

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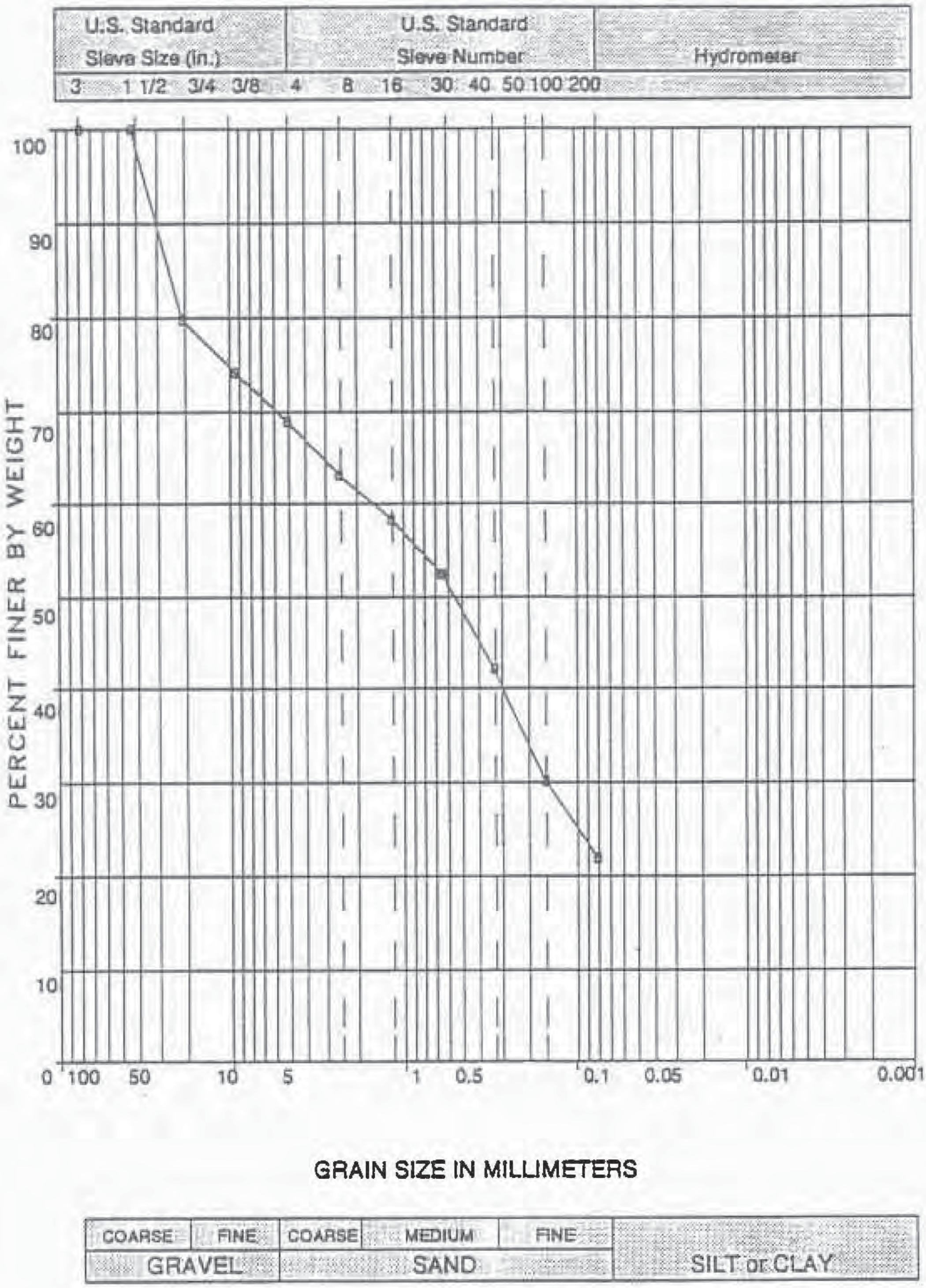
Particle Size Analysis

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **B1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	DFF	TMA	14 Dec. 90		



Sample Source	Classification
90-12@ 15.0'	Brown Silty Sand (SM) fine to coarse grained, with some gravel

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Particle Size Analysis

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **B2**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	DFF	[signature]	14 Dec. 90		

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS MORE THAN HALF IS LARGER THAN NO. 200 SIEVE	GRAVELS MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LESS THAN 5% FINES	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LESS THAN 50% FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN HALF IS SMALLER THAN NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS

LEGEND

SAMPLE

- "Undisturbed"
- Bulk/Grab
- Not Recovered
- Recovered, Not Retained

CONTACT BETWEEN UNITS

- Well Defined Change
- Gradational Change
- Obscure Change
- End of Exploration

LABORATORY TESTS

- Consol - Consolidation
- LL - Liquid Limit
- PL - Plastic Limit
- Gs - Specific Gravity
- SA - Size Analysis
- TxS - Triaxial Shear
- TxP - Triaxial Permeability
- Perm - Permeability
- Po - Porosity
- MD - Moisture/Density
- DS - Direct Shear
- VS - Vane Shear
- Comp - Compaction

- UU - Unconsolidated, Undrained
- CU - Consolidated, Undrained
- CD - Consolidated, Drained

BLOWS/FOOT

Hammer is 300 pounds with 30-inch drop, unless otherwise noted

- S - SPT Sampler (2.0-inch O.D.)
- T - Thin Wall Sampler (2.8-inch Sample)
- H - Split Barrel Sampler (2.4-inch Sample)

MOISTURE DESCRIPTION

- Dry - Considerably less than optimum for compaction
- Moist - Near optimum moisture content
- Wet - Over optimum moisture content
- Saturated - Below water table, in capillary zone, or in perched groundwater

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Geotechnical Engineering
Geology & Hydrogeology

Soil Classification/Legend

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	SES	gma	9 Jan 90		

Equipment	Mobile B-61
Land Surface Elevation	5.1 feet *
Date	12/12/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Description
				BROWN AND GRAY SILTY SAND (SM) loose, moist; fine to coarse grained, with trace of organics, strong hydrocarbon odor noted (Fill).
MD	17.4	103	6	
			16	Becomes medium dense and saturated with trace fine gravel.
				GRAY GRAVELLY SAND (SP) loose, saturated; fine to medium grained, with some silt (Fill).
			9	
SA	13.1		12	Becomes medium dense and grades to fine to coarse grained.
				GRAY SAND (SW) dense, saturated; fine to coarse grained, with some shell fragments and a trace of silt and gravel.
MD	8.7	134	52	
			50/6"	
				Groundwater encountered at a depth of approximately 7-1/2 feet during drilling.
				Boring backfilled with bentonite on 12/12/90.

* Boring elevations on Plates A2 through A9 refer to City of Seattle datum.

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Log of Boring 90-1

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A2**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	JMA	20 Dec. 90		

Equipment: Mobile B-61

Land Surface Elevation: 5.5 feet Date: 12/11/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)	Description
				0	BROWN SILTY SAND (SM) loose, wet; fine to coarse grained, with some fine gravel (Fill).
MD	15.3	110	8	5	Becomes gray, strong hydrocarbon odor noted.
DS	17.5	123	14	10	Becomes medium dense with occasional sandy silt lenses.
MD	13.0	121	12	15	Becomes saturated.
			22	20	GRAY SILTY SAND (SM) medium dense, saturated; fine to medium grained, with some shell fragments.
					Gravel encountered during drilling.
SA	6.6		40	25	BROWN GRAVEL (GP) dense, saturated; fine to coarse grained with some sand and a trace of silt (Advance Outwash).
					BROWN SAND (SW) very dense, saturated; fine to coarse grained with a trace of gravel and silt (Advance Outwash).
			50/6"	30	BROWN SILTY SAND (SM) very dense, saturated; fine grained (Advance Outwash).
				35	
				40	

Groundwater encountered at a depth of approximately 14 feet during drilling.

Boring backfilled with bentonite on 12/11/90.

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Log of Boring 80-2

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A3**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	JMA	20 Dec. 90		

Equipment: Mobile B-61

Land Surface Elevation: 6.0 feet

Date: 12/11/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)	Description
				0	BROWN SILTY SAND (SM) loose, moist; fine to medium grained with wood debris (Fill).
			50/4"*		Strong hydrocarbon odor noted.
				5	
MD	13.8	120	13		GRAY SILTY SAND (SM) medium dense, wet; fine to coarse grained with some gravel and wood debris (Fill).
				10	
MD	18.3	112	12		
				15	
DS	20.1	110	6		GRAY SILTY SAND (SM) loose, saturated; fine grained (Fill?).
				20	GRAY SILTY SAND (SM) medium dense, saturated; fine to medium grained, with some shell fragments.
			20		
				25	BROWN SAND (SW) dense, saturated; fine to coarse grained with some gravel and a trace of silt (Advance Outwash).
MD	18.4	116	80/10"		BROWN SILTY SAND (SM) very dense, saturated; fine grained, with a trace of gravel (Advance Outwash).
				30	
				35	
				40	

Groundwater encountered at a depth of approximately 17 feet during drilling.

Boring backfilled with bentonite on 12/11/90.

* Blow count not representative due to oversize material.

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Log of Boring 90-3

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A4**

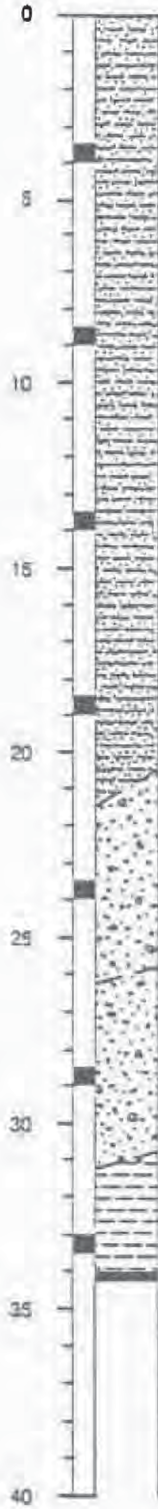
JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	JMA	20 Dec. 90		

Equipment: Mobile B-61

Land Surface Elevation: 7.4 feet

Date: 11/13/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD	14.4	106	14
DS	23.7	98	10
MD	13.0	112	12
SA	21.0		9
			22
			66
MD	21.5		49



DARK BROWN SILTY SAND (SM) medium dense, moist; fine to medium grained (Fill).

With silt lenses.

Becomes saturated, with strong hydrocarbon odor and distinct sheen noted.

Becomes moist and fine grained.

GRAY SAND (SW) medium dense, saturated; fine to coarse grained, with some shell fragments.

BROWN GRAY GRAVELLY SAND (SW) very dense, moist; fine to coarse grained, with some silt (Advance Outwash).

BROWN SILT (ML) moist, hard; with a trace of fine sand (Advance Outwash).

Groundwater encountered at a depth of approximately 16 feet during drilling.

Boring backfilled with bentonite on 11/13/90.

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Log of Boring 90-4

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PLATE **A5**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	JMA	20 Dec. 90		

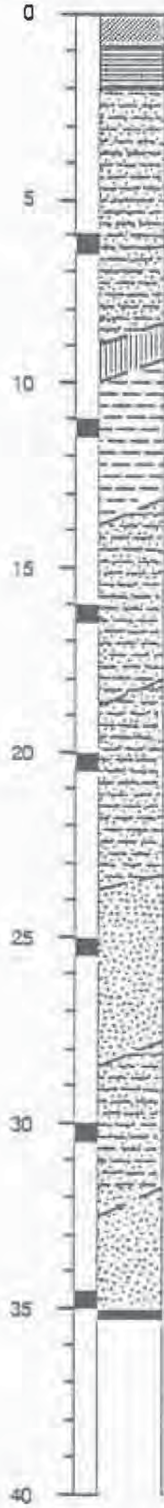
Equipment: Mobile B-61

Land Surface Elevation: 10.5 feet

Date: 11/16/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
MD	8.0	113	13
SA	41.2		9
MD	12.7	129	9
			50/4"
MD	12.0	140	50/4"
			50/5"
			50/4"

Depth (feet) / Sample



Asphalt/Concrete.

Brick.

BLACK-BROWN SILTY SAND (SM) medium dense, moist; fine to medium grained, with charred wood and brick (Fill).

Strong hydrocarbon odor noted.

Wood debris.

GRAY SANDY SILT (ML) medium stiff, moist; with some organic material (Fill).

GRAY BROWN SILTY SAND (SM) loose, wet; fine to medium grained, with a trace of wood debris, and silt lenses (Fill).

BROWN SILTY SAND (SM) very dense, saturated; fine to medium grained, with some fine gravel (Advance Outwash).

BROWN GRAVELLY SAND (SP) dense, saturated; fine to coarse grained, with some fine gravel (Advance Outwash).

GRAY SILTY SAND (SM) very dense, wet; fine to medium grained, with some fine gravel and silt lenses (Advance Outwash).

BROWN SAND (SP) very dense, saturated; fine to medium grained (Advance Outwash).

Note: Sampler driven with a 140-pound hammer with 30-inch drop.

Groundwater encountered at a depth of approximately 19 feet during drilling.

Boring backfilled with bentonite and sealed with cement on 11/16/90.

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Log of Boring 90-5

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PLATE **A6**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	JMA	20 Dec. 90		

Equipment: Mobile B-61

Land Surface Elevation: 12.1 feet   Date: 11/8/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot
			2
MD	5.4	107	56
DS	6.3	108	16
MD	18.6	114	46
			11
MD	20.2	109	83/10"
MD	6.3	146	66/9"
			50/5"

Depth (feet) / Sample

Concrete.

BROWN SILTY SAND (SM) very loose, wet; fine to medium grained (Fill).

GRAY SANDY SILT (ML) very soft, wet; fine grained (Fill).

BROWN SILTY SAND (SM) medium dense, moist to wet; medium to coarse grained, with some gravel (Fill).

Strong hydrocarbon odor.

Becomes dense.

Becomes medium dense.

GRAY SILTY SAND (SM) dense, moist to wet; fine to medium grained, with some gravel, silt lenses, and a trace of cobbles (Advance Outwash).

Becomes brown and medium dense.

Becomes very dense with sandy silt lenses.

BROWN SILTY GRAVEL (GM) very dense, saturated; medium to coarse grained, with some sand (Advanced Outwash).

Groundwater encountered at a depth of approximately 19 feet during drilling.

Boring backfilled with bentonite and sealed with cement on 11/8/90.

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Log of Boring 90-6

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **A7**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	JmA	20 Dec. 90		

Equipment: Mobile B-61

Land Surface Elevation: 12.9 feet   Date: 11/8/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)	Description
				0	Concrete. BROWN GRAY SILTY SAND (SM) medium dense, moist; fine to medium grained (Fill).
MD			16		Becomes brown-black.
				5	
	4.3		30		Becomes brown with some gravel.
				10	
DS	9.6	124	20		Grades with silt lenses.
				15	GRAY SILTY SAND (SM) dense, wet; fine to medium grained, with silt lenses (Advance Outwash.
			80/8"		BROWN SILTY SAND (SM) very dense, wet; fine to medium grained, with some gravel (Advance Outwash).
				20	
MD/SA	23	108	92/11"		BROWN SANDY SILT (ML) hard, wet; with silty sand lenses (Advance Outwash).
				25	BROWN SILTY SAND (SM) very dense, saturated; fine grained, with silt lenses (Advance Outwash).
			70/11.5"		
				30	
MD	17	111	39		Becomes dense.
				35	
			48		Groundwater encountered at a depth of approximately 20 feet during drilling.
				40	Boring backfilled with bentonite and sealed with cement on 11/8/90.

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Log of Boring 90-7

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PLATE **A8**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	JFL	[signature]	20 Dec. 90		

Equipment: Mobile B-61

Land Surface Elevation: 13.8 feet   Date: 11/15/90

Laboratory Tests	Moisture Content (%)	Dry Density (pcf)	Blows per Foot	Depth (feet)	Description
				0	Concrete.
	15.1				BROWN GRAY SILTY SAND (SM) loose, moist; fine to medium grained, with some fine gravel (Fill).
MD	12.7	86.4	6	5	Grades to medium to coarse grained.
DS	18.9	102	13	10	Grades to fine to medium grained with no gravel.
			26	15	Becomes black gray, medium dense, wet, with a trace of organic matter.
MD	11.6	127	70/10"	20	GRAY SANDY SILT (ML) very hard, saturated; fine sand, with a trace of gravel (Advance Outwash).
			50/6"	25	BROWN SILTY SAND (SM) very dense, wet; fine to medium grained, with some gravel and silt lenses (Advance Outwash). Becomes gray.
SA	10.2		50/5.5"	30	Grades to fine to coarse grained.
MD	13.7	122	50/6"	35	
			50/4"		Groundwater encountered at a depth of approximately 19 feet during drilling.
				40	Boring backfilled with bentonite and sealed with concrete on 11/15/90.

Sample

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Log of Boring 90-8
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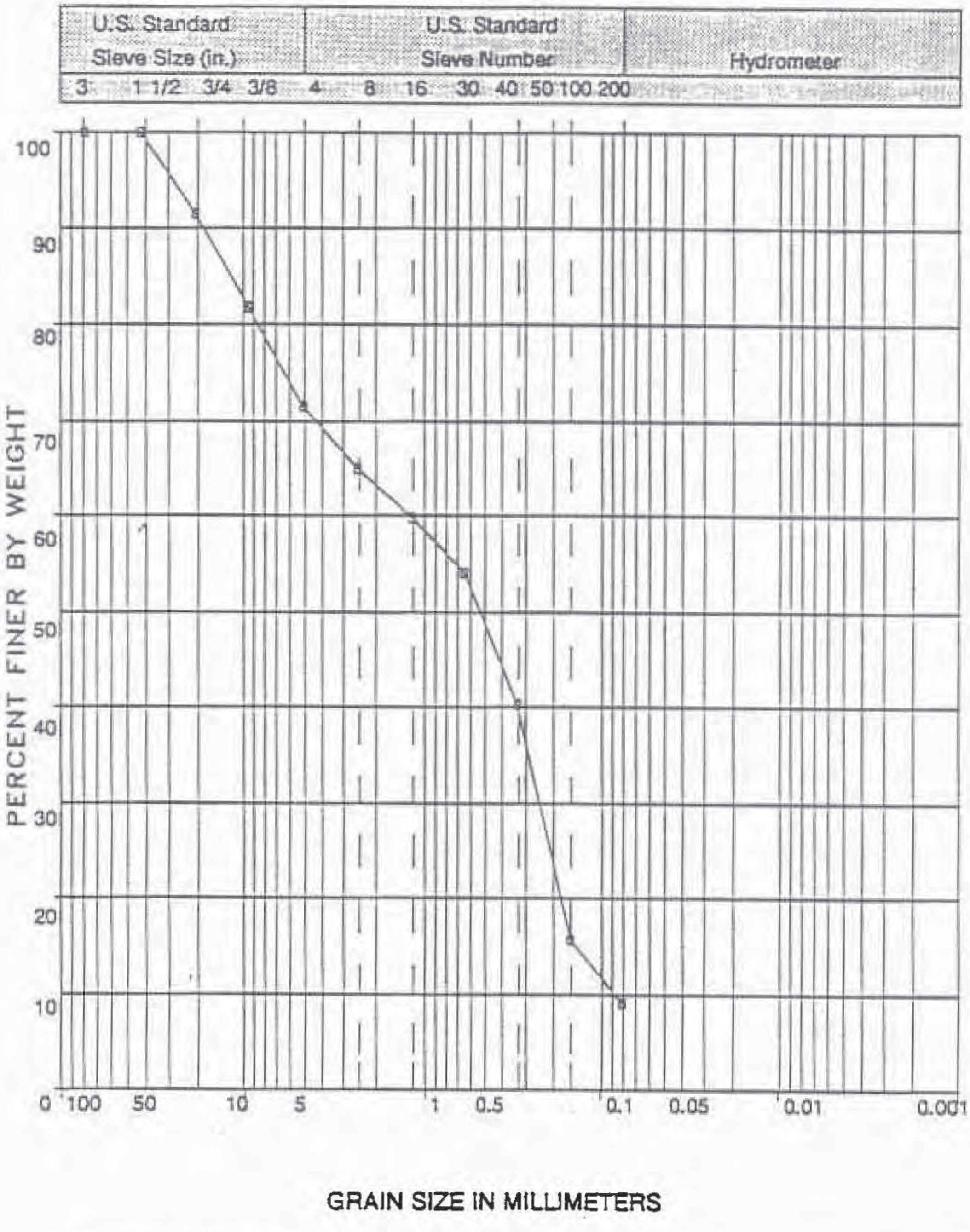
PLATE **A9**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15.357.002	JFL	[signature]	20 Dec. 90		



Sample Source	Classification
90-1 @ 18.5'	Gravelly Sand (SP) fine to coarse grained, with some silt

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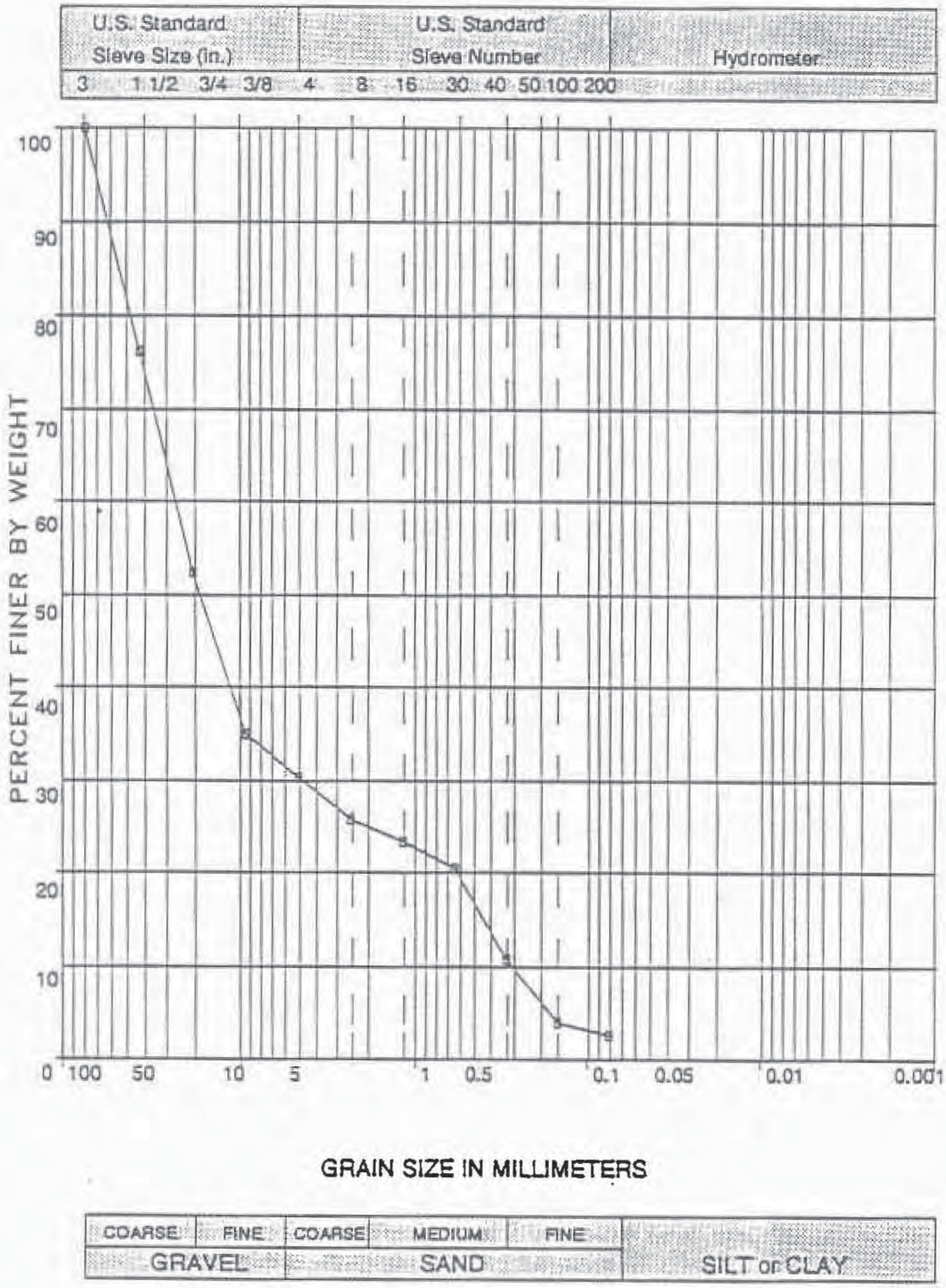
Particle Size Analysis

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **B1**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	BWB	[signature]	2 Jan. 91	-	



Sample Source	Classification
90-2 @ 26.0'	Sandy Gravel (GP) fine to coarse grained, trace of silt

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Particle Size Analysis

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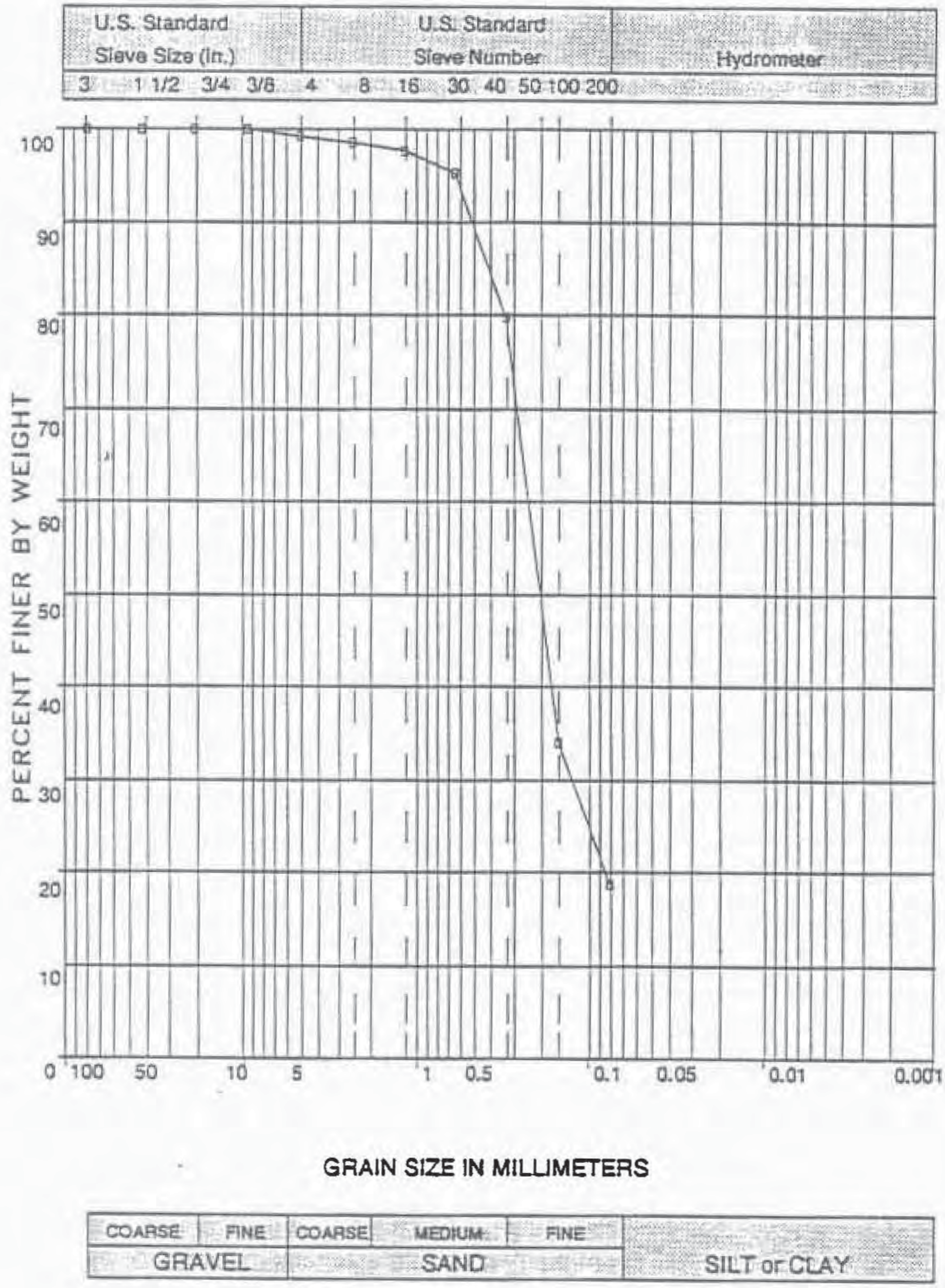
PLATE **B2**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	SWB	AMA	2 Jan. 91	-	



Sample Source	Classification
90-4 @ 18.0'	Silty Sand (SM) fine to medium grained

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Particle Size Analysis

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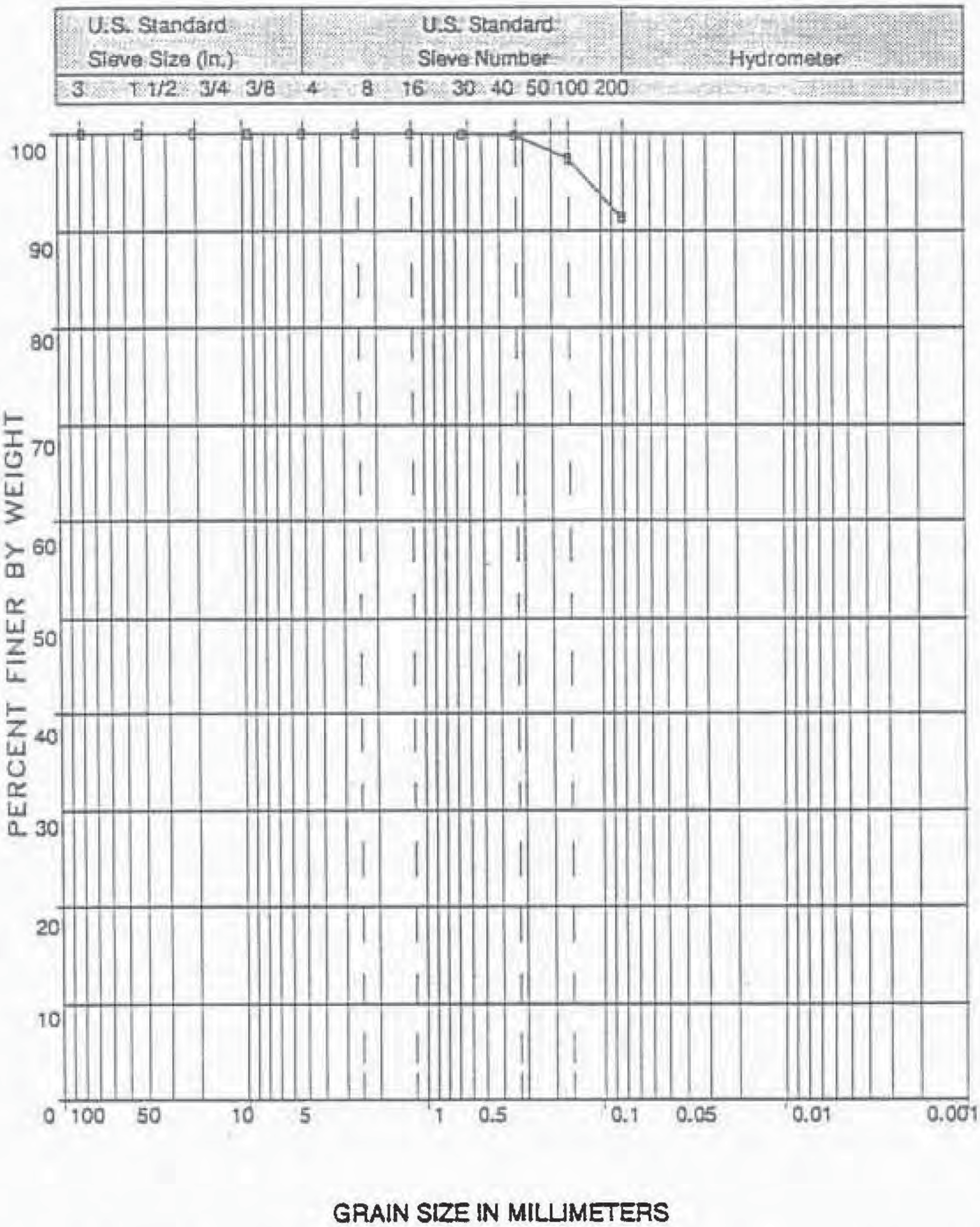
Seattle, Washington

PLATE **B3**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	BWB	JMA	2 Jan. 91		



GRAVEL		SAND			SILT or CLAY
COARSE	FINE	COARSE	MEDIUM	FINE	

Sample Source	Classification
90-5 @ 11.0'	Sandy Silt (ML)

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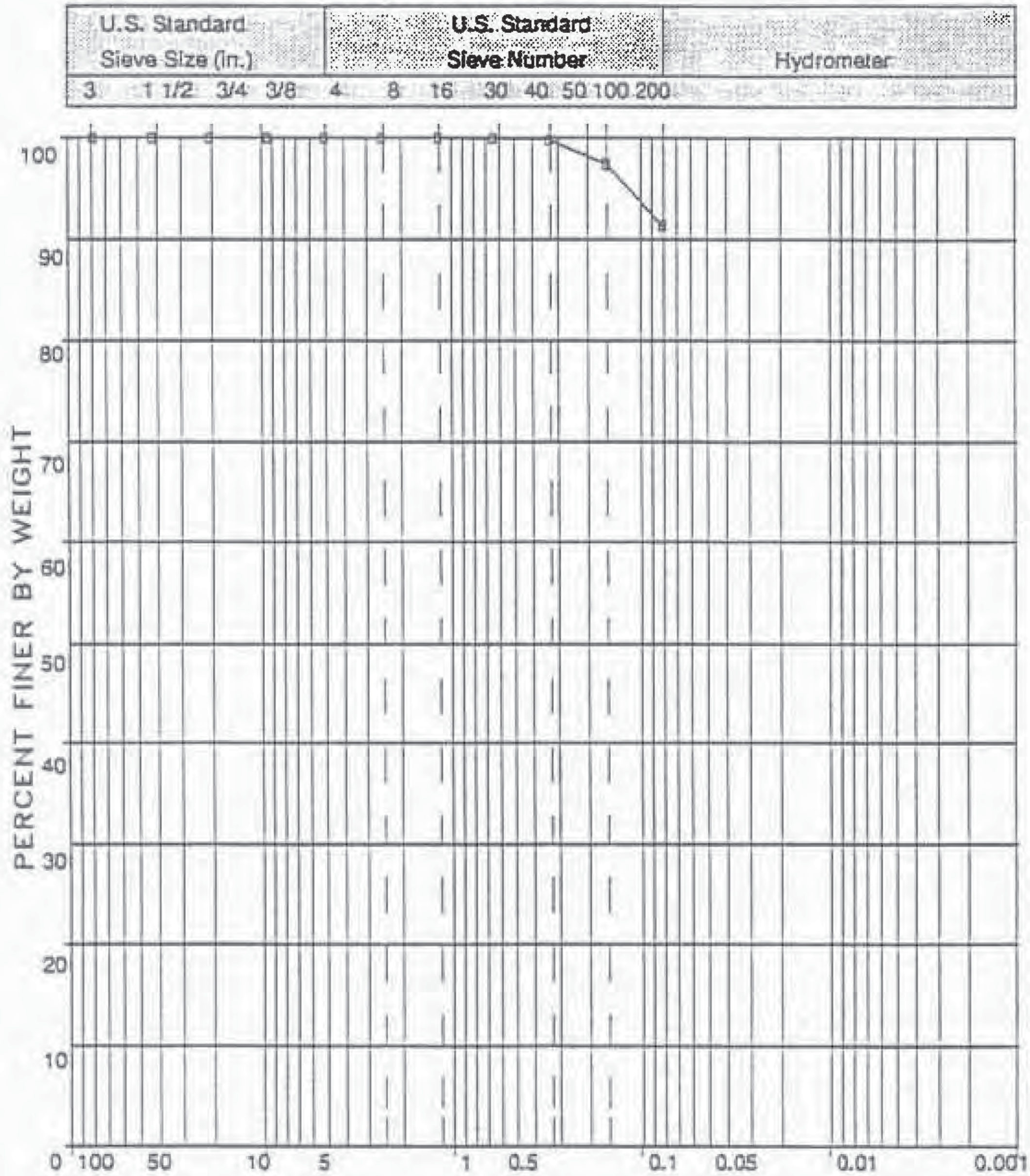
Particle Size Analysis

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **B4**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15.357.002	BWB	[signature]	2 Jan. 91		



GRAIN SIZE IN MILLIMETERS

COARSE	FINE	COARSE	MEDIUM	FINE	
GRAVEL		SAND			SILT or CLAY

Sample Source	Classification
90-7 @ 23.5'	Sandy Silt (ML)

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Particle Size Analysis

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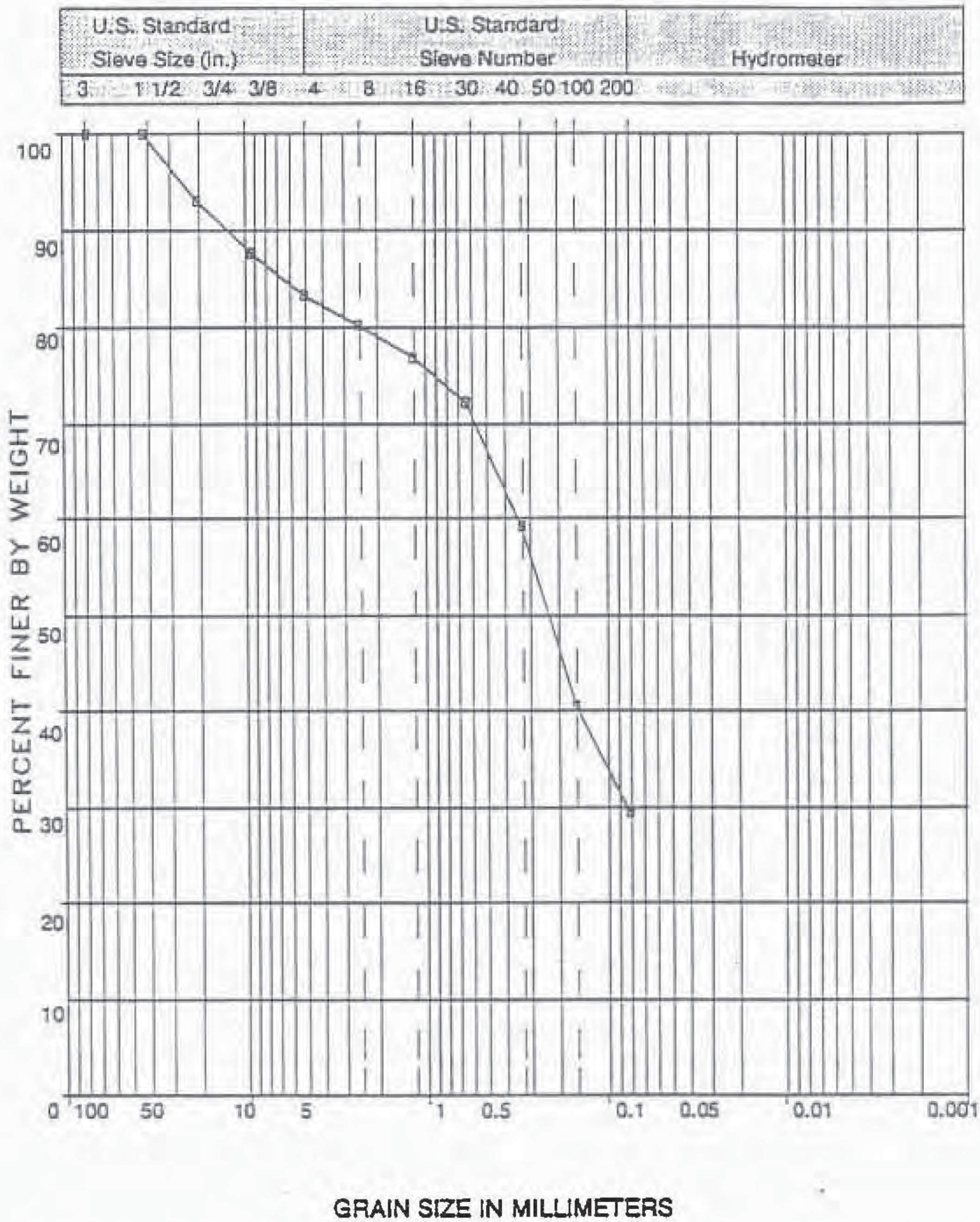
Seattle, Washington

PLATE **B5**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	BWB	[signature]	2 Jan. 91		



COARSE	FINE	COARSE	MEDIUM	FINE	
GRAVEL		SAND			SILT or CLAY

Sample Source	Classification
90-8 @ 30.0'	Silty Sand (SM) fine to coarse grained, with some gravel

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Particle Size Analysis

ECOVA/UNOCAL Marketing Terminal
Seattle, Washington

PLATE **B6**

JOB NUMBER	DRAWN	APPROVED	DATE	REVISED	DATE
15,357.002	BWB	JMA	2 Jan. 91		

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More Than 50% Retained on No. 200 Sieve	GRAVEL More Than 50% of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More Than 50% of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More Than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less Than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or More	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D2487-90.
3. Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water

Wet - Visible free water or saturated, usually soil is obtained from below water table

LABORATORY TESTS:

CA Chemical Analysis

FIELD SCREENING TESTS:

Headspace vapor concentration data given in parts per million

Sheen classification system:

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

SOIL GRAPH:

SM Soil Group Symbol (See Note 2)

Distinct Contact Between Soil Strata

Gradual or Approximate Location of Change Between Soil Strata

Water Level

Bottom of Boring

BLOW COUNT/SAMPLE DATA:

Blows required to drive a 2.4-inch I.D. split-barrel sampler 12 inches or other indicated distances using a 300-pound hammer falling 30 inches.

- 22 ■ Location of relatively undisturbed sample
- 12 ⊠ Location of disturbed sample
- 17 □ Location of sampling attempt with no recovery

Blows required to drive a 1.5-inch I.D. (SPT) split-barrel sampler 12 inches or other indicated distances using a 140-pound hammer falling 30 inches.

- 10 ◧ Location of sample obtained in general accordance with Standard Penetration Test (ASTM D 1586) procedures
- 26 ◫ Location of SPT sampling attempt with no recovery

▤ Location of grab sample

"P" indicates sampler pushed with weight of hammer or against weight of drill rig.

NOTES:

1. The reader must refer to the discussion in the report text, the Key to Boring Log Symbols and the exploration logs for a proper understanding of subsurface conditions.
2. Soil classification system is summarized in Figure A-1.

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KEY TO BORING LOG SYMBOLS

FIGURE A-2

TEST DATA

BORING B-72

DESCRIPTION

Surface Elevation (ft.):

Depth (ft)	Sheen	Vapor Conc. (ppm)	Other Test	Blow Count	Samples	Group Symbol	Description
0						SM	Brown silty sand with fine to coarse gravel
						GP-GM	Gray fine gravel with silt and sand (medium dense, wet) (fill)
16	HS	1,500		50	■		
18.5	HS	--		23	□		Becomes loose
20						SM	Gray-brown silty fine to coarse sand with occasional fine gravel (very dense, wet)
21	SS	<100	CA	60/4"	■		
23	SS	100		117/6"	■		
26	SS	100		120/6"	■		

Boring completed at 26.5 feet on 06/13/95

Trace amounts of petroleum product observed on sampler at 16 and 18.5 feet

Sampling method was 3.25-inch OD heavy-duty sampler used with 140-pound downhole hammer

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A-2 for explanation of symbols

0161-357-R04 Task6.6 :TNV:CMS 8/30/95

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LOG OF BORING

FIGURE A-3

TEST DATA

BORING B-73

DESCRIPTION

Surface Elevation (ft.):

Depth (ft)	Sheen	Vapor Conc. (ppm)	Other Test	Blow Count	Group Symbol	Description
0					SW-SM	Brown fine to coarse sand with silt and occasional fine gravel (medium dense, moist) (fill)
	SS	< 100		24		
5					SM	Dark gray silty fine to coarse sand with occasional fine gravel and wood debris (medium dense, moist) (fill)
	SS	200	CA	17		
	SS	200		15		
10	SS	< 100		10		*Becomes light brown, loose to medium dense*
	SS	< 100	CA	5		
15	SS	< 100		32		Becomes dense
	SS	100		8		Becomes loose and with brick chips
20					SW-SM	Gray fine to coarse sand with silt and occasional fine to coarse gravel, large wood debris and coal shards (loose, wet) (fill)
	SS	160		9		
	SS	100		50		Becomes very dense
					SM	Light brown silty fine to coarse sand with fine to coarse gravel (very dense, wet) (till)
25	NS	< 100	CA	50/3"		
	NS	< 100		50		

Boring completed at 29.0 feet on 06/21/95
Strong, sweet odor noticed at 13.0 feet
Water level at approximately 17.15 feet during drilling

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A-2 for explanation of symbols

0161-357-R04 Task6.6 :TNV:CMS 10/23/95

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LOG OF BORING

FIGURE A-4

TEST DATA

BORING B-74

Sheen	Vapor Conc. (ppm)	Other Test	Blow Count	Samples	Group Symbol	DESCRIPTION Surface Elevation (ft.):
					GW-GM	Gray fine to coarse gravel with silt and sand (loose, wet) (fill)
HS	2,500		18	■		
					SP	Gray fine to medium sand with a trace of silt (medium dense, wet) (fill)
HS	2,000		35	■		
MS	900		42	■		
					SM	Brown silty fine sand (very dense, wet)
MS	100		120/4"	■	GM	Gray coarse sandy fine to coarse gravel and a trace of silt (very dense, wet)
SS	< 100	CA	100/6"	■		
SS	--		60/3"	⊠		
SS	< 100		55	⊠		Becomes medium dense

DEPTH IN FEET (0–40)

Boring completed at 31.5 feet on 06/14/95

Traces of petroleum product observed on drilling tools and sampler at 18.0 feet

Sampling method was 3.25-inch OD heavy-duty sampler used with 140-pound downhole hammer

Note: See Figure A-2 for explanation of symbols

0161-357-R04 Task6.6 :TNV:CMS 8/30/95

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LOG OF BORING

FIGURE A-5

TEST DATA

BORING B-76

DESCRIPTION

Surface Elevation (ft.):

Depth in Feet	Sheen	Vapor Conc. (ppm)	Other Test	Blow Count	Samples	Group Symbol	Description
0						SOD	3 inches sod
						SW-SM	Orange-brown silty fine sand with gravel (medium dense, moist) (fill)
6	HS	100		21	⊠		
10							Becomes greenish gray and loose
11	MS	200		9	■		
13.5						SW-SM	Gray fine to coarse sand with silt, fine to coarse gravel and wood debris (medium dense, wet) (fill)
16	SS	200		13	■		
18							Wood debris absent
19	SS	< 100		12	⊠		
21	SS	150	CA	50	■		Becomes very dense
22						SM	Gray-brown silty fine to coarse sand with fine gravel (very dense, wet)
24	SS	< 100		50	■		
26	--	--		50	⊠		
28.5	SS	< 100		50	■		

Boring completed at 29.0 feet on 06/15/95
Creosote-like odor noticed at 13.5 feet
Water level at approximately 12.5 feet during drilling

Note: See Figure A-2 for explanation of symbols

0161-357-R04 Task6.6 :TNV:CMS 10/23/95

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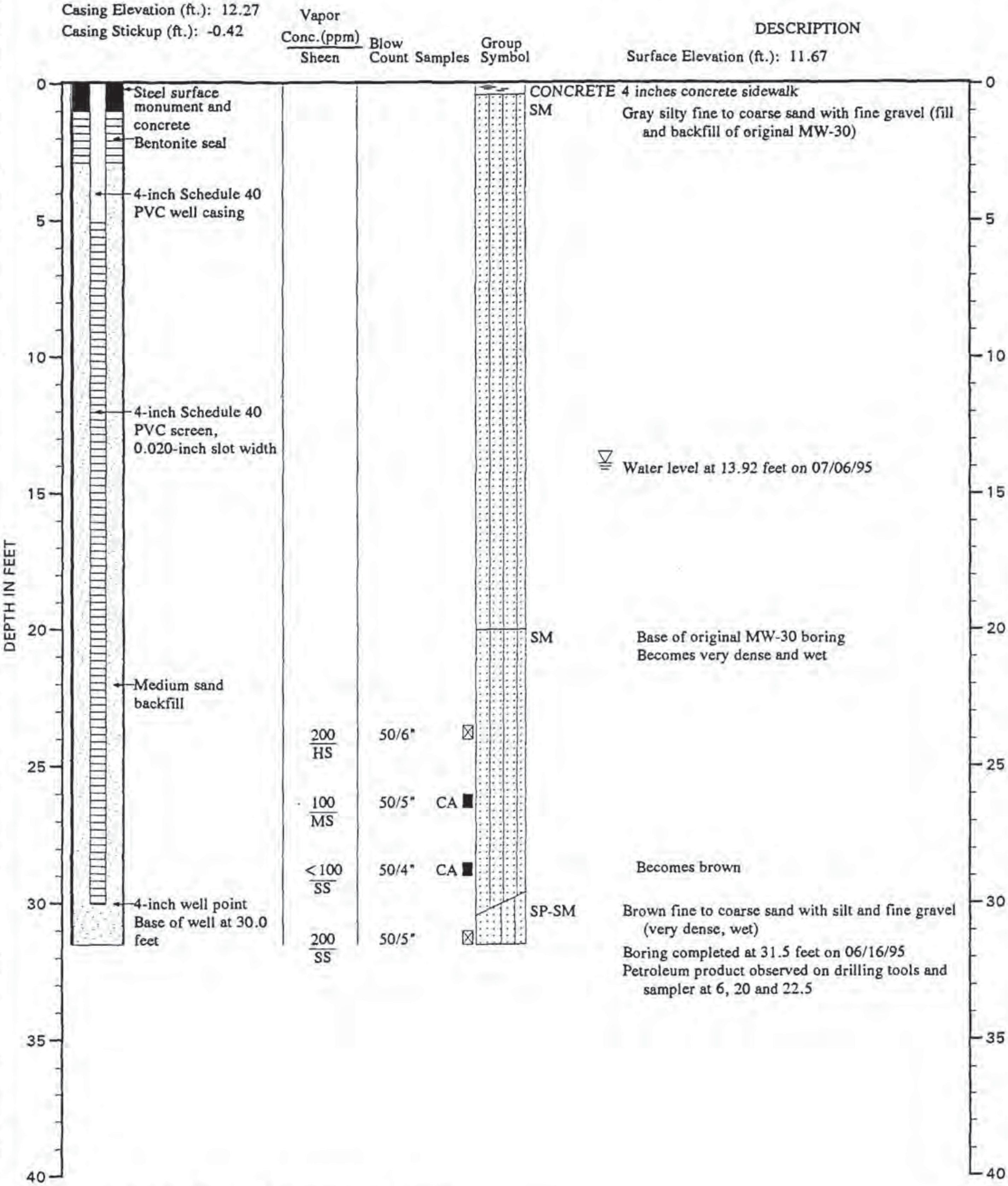
LOG OF BORING

FIGURE A-6

MONITORING WELL MW-30

WELL SCHEMATIC

Casing Elevation (ft.): 12.27
Casing Stickup (ft.): -0.42



Note: See Figure A- 2 for explanation of symbols

0181-357-R04 Task6.6 :TNV:CMS 8/30/95

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LOG OF MONITORING WELL

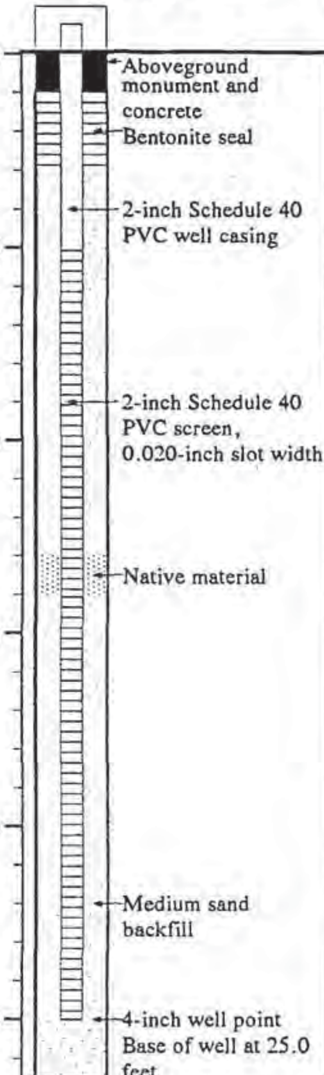
FIGURE A-8

MONITORING WELL MW-61

WELL SCHEMATIC

Casing Elevation (ft.): 12.98

Casing Stickup (ft.): 0.27



DESCRIPTION

Surface Elevation (ft.): 12.71

Depth (ft)	Vapor Conc. (ppm) / Sheen	Blow Count	Samples	Group Symbol	Description
0				SOD	3 inches sod
				SM	Light gray silty fine sand with occasional fine to coarse gravel (very dense, moist) (fill)
	<100 / SS	100/2"	⊠		
	<100 / SS	120/5"	■		Becomes darker gray
	<100 / SS	100/3"	■		
10				SP-SM	Gray fine to medium sand with silt and occasional fine gravel (very dense, moist) (till)
	900 / HS	120/6"	CA ■		
				SM	Gray silty fine to medium sand (dense, moist) (till)
	300 / HS	107	■		∇ Water level at 14.06 feet on 07/06/95
	100 / SS	60/4"	CA ■		
				SW-SM	Gray fine sand with silt (very dense, wet) (outwash)
	<100 / SS	152	⊠		
	<100 / NS	143	■		
					Becomes gray-brown
	<100 / NS	100/5"	CA ■		
	<100 / NS	60/1"	⊠		

Boring completed at 26.5 feet on 06/14/95
Petroleum product odor noticed at 10.0 feet
Sampling method was 3.25-inch OD heavy-duty sampler used with 140-pound downhole hammer

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A- 2 for explanation of symbols

0161-357-R04 Task6.6 :TNV:CMS 10/23/95

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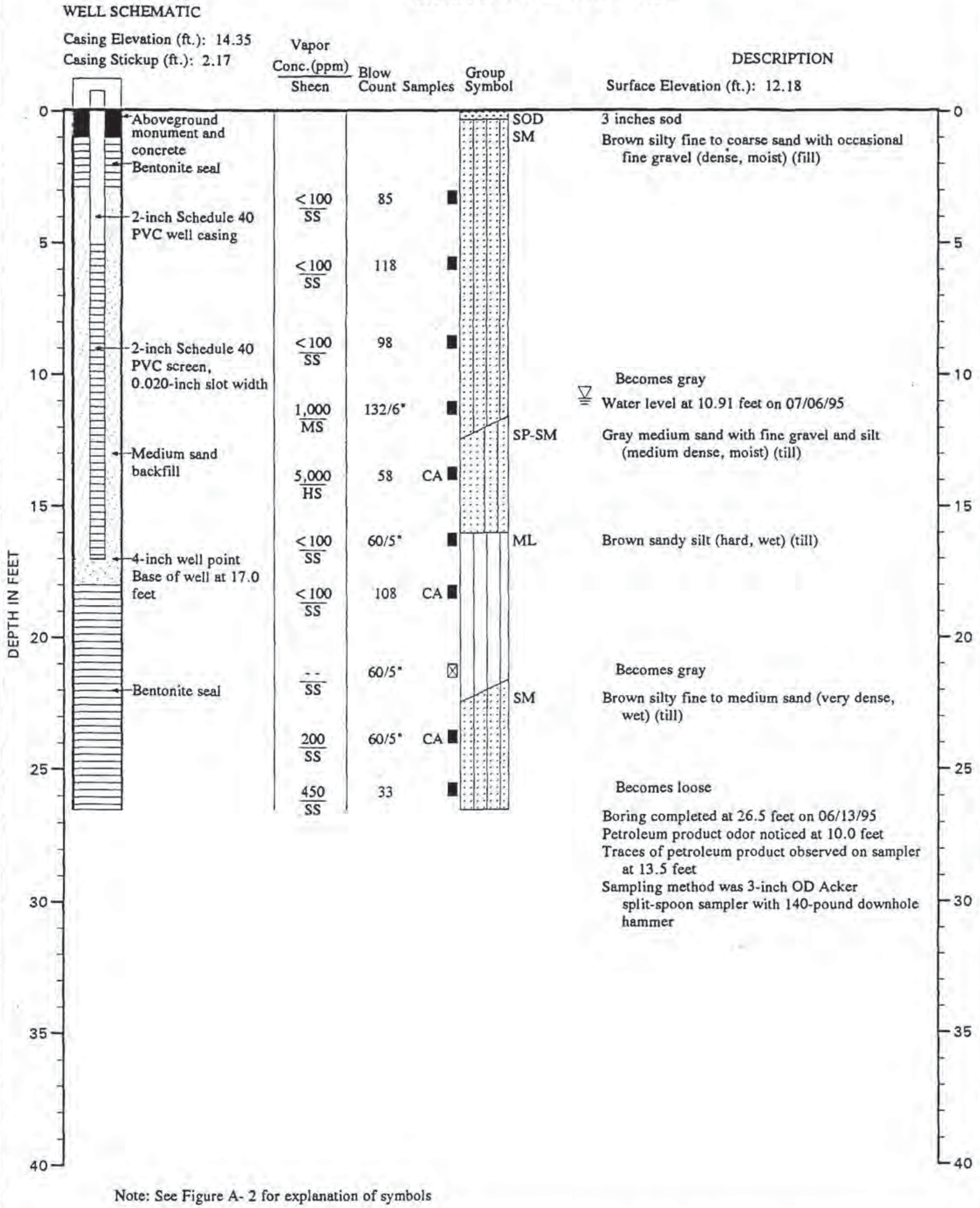
LOG OF MONITORING WELL

FIGURE A-9

MONITORING WELL MW-62



Note: See Figure A- 2 for explanation of symbols

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LOG OF MONITORING WELL

FIGURE A-10

0161-357-R04 Task6.6 :TNV:CMS 8/30/95

MONITORING WELL MW-63

WELL SCHEMATIC

Casing Elevation (ft.): 15.20
Casing Stickup (ft.): 0.75

DESCRIPTION

Surface Elevation (ft.): 14.45

Vapor Conc.(ppm) / Sheen	Blow Count	Samples	Group Symbol	Description
			SOD	3 inches sod
			SM	Brown silty fine sand (loose, moist) (fill)
<100 / SS	24	■		
				Occasional fine gravel
<100 / SS	71	■		
<100 / SS	85	■	GP	Brown fine gravel with silt and sand (dense, moist) (till)
			SM	Brown silty fine sand with occasional fine gravel (very dense, moist) (till)
<100 / SS	120	■		
				Becomes gray
				∇ Water level at 12.83 feet on 07/06/95
<100 / SS	60/1"	CA ⊠		
-- / --	170/5"	□		
<100 / SS	120/7"	■		
<100 / SS	44/3"	■		
-- / --	140/6"	□		
<100 / SS	110	CA ■		Boring completed at 26.5 feet on 06/13/95

Sampling method was 3-inch OD Acker split-spoon sampler used with 140-pound downhole hammer

DEPTH IN FEET: 0, 5, 10, 15, 20, 25, 30, 35, 40

Note: See Figure A- 2 for explanation of symbols

0181-357-R04 Task6.6 :TNV:CMS 8/30/95

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LOG OF MONITORING WELL

FIGURE A-11

MONITORING WELL MW-65

WELL SCHEMATIC

Casing Elevation (ft.): 10.83

Casing Stickup (ft.): -0.41

DESCRIPTION

Surface Elevation (ft.): 11.24

Depth (ft)	Vapor Conc.(ppm) / Sheen	Blow Count	Samples	Group Symbol	Description
0				CONCRETE	4 inches concrete sidewalk
				SM	Orange-brown silty fine sand with occasional fine gravel (loose, moist) (fill)
	< 100 / NS	5	■		
5					Becomes dark brown with coarser sand and asphalt fragments
	< 100 / SS	8	■		
				GP-GM	Dark brown fine gravel with silt, sand and wood debris (medium dense, moist) (fill)
	< 100 / SS	11	■		
10				SP-SM	Light brown fine to medium sand with silt, wood debris and brick (loose, moist) (fill)
	< 100 / SS	7	■		
				SM	Dark brown silty fine sand with wood debris (very loose, moist) (fill) Void space encountered
					Water level at 13.46 feet on 07/06/95
	750 / MS	2	CA ■		
15					rse sand with fine gravel :ry loose, wet) (fill)
	< 100 / HS	3	■		
	< 100 / MS	50/2"	■		wood no longer present
20	< 100 / HS	50/5.5"	■		
					ıarse sand with a trace of ne gravel (very dense,
	< 100 / SS	50/3.5"	CA ■		
25	< 100 / SS	50/5"	■		
					5 feet on 06/16/95
					mpler at 13.5 and 16 feet
30					
35					
40					

log of MW-~~65~~ 64 in 2nd report

DEPTH IN FEET

Note: See Figure A- 2 for explanation of symbols

0161-357-R04 Task6.6 :TNV:CMS 8/30/95

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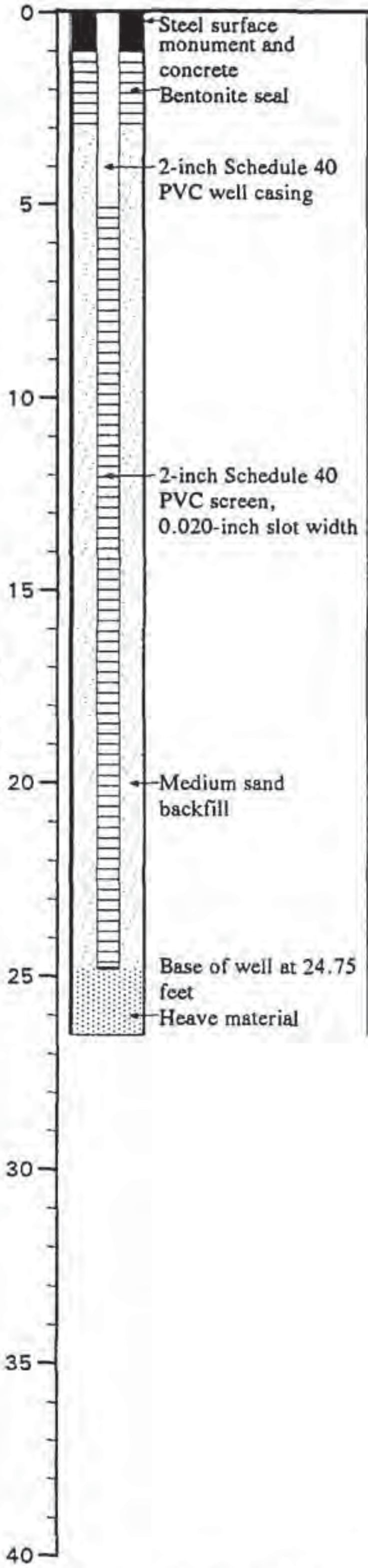
LOG OF MONITORING WELL

FIGURE A-13

MONITORING WELL MW-66

WELL SCHEMATIC

Casing Elevation (ft.): 11.62
Casing Stickup (ft.): -0.33



DESCRIPTION

Surface Elevation (ft.): 11.95

Vapor Conc.(ppm) / Sheen	Blow Count	Samples	Group Symbol	Description
			CONCRETE	3.5 inches concrete sidewalk
			SM	Gray silty fine sand with occasional fine gravel (loose, moist) (fill)
<100 / SS	5	■		
180 / SS	4	■		Becomes siltier and very loose to loose, gravel not present
210 / SS	13	CA ■		Becomes medium dense
				Occasional fine gravel
100 / SS	18	■		
450 / SS	21	■		▽ Water level at 14.05 feet on 07/06/95
1,000 / HS	13	CA ■		
1,500 / HS	50/6"	⊠		Becomes very dense
			SW-SM	Gray fine to coarse sand with silt and fine to coarse gravel (very dense, wet) (outwash)
250 / SS	50/2"	CA ■		
<100 / SS	41	■		Sand becomes finer
<100 / NS	39	■		Becomes reddish brown

Boring completed at 26.5 feet on 06/22/95
Petroleum product odor noticed at 17.5 feet

Note: See Figure A- 2 for explanation of symbols

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LOG OF MONITORING WELL

FIGURE A-14

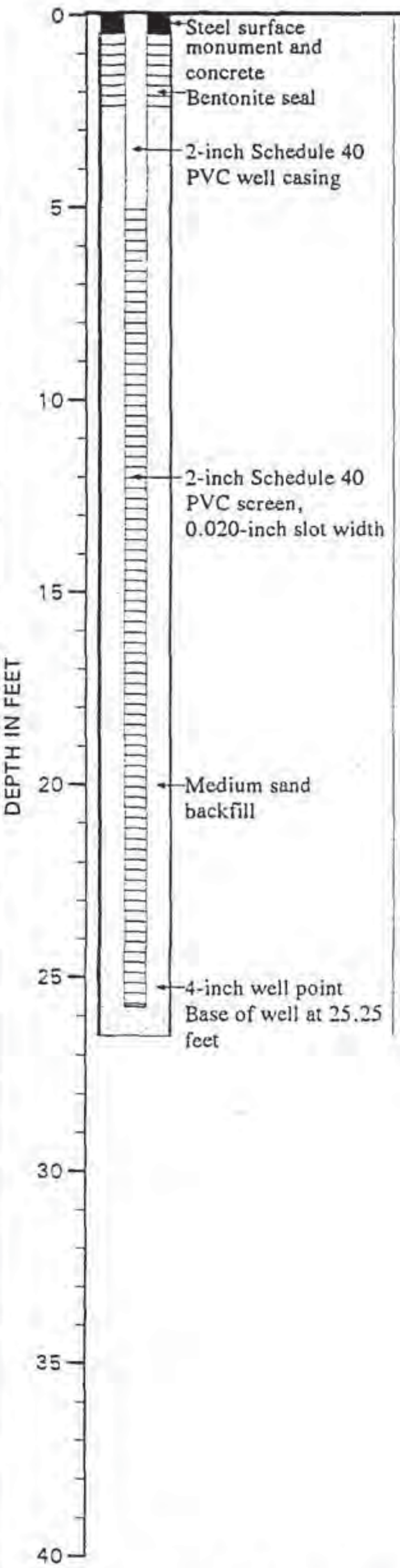
0161-357-R04 Task6.6 :TNV:CMS 8/30/95

MONITORING WELL MW-73

WELL SCHEMATIC

Casing Elevation (ft.): 9.78

Casing Stickup (ft.): -0.60



Vapor Conc.(ppm) / Sheen	Blow Count	Samples
< 100 / SS	10	☒
-- / SS	9	☒
< 100 / SS	3	■
< 100 / NS	12	CA ■
< 100 / SS	14	CA ■
< 100 / NS	27	CA ■
< 100 / NS	50/3"	■
< 100 / NS	50/5.5"	■
< 100 / NS	50/5"	■
< 100 / NS	50/3"	CA ■

DESCRIPTION

Surface Elevation (ft.): 10.38

Group Symbol	Description
ASPHALT	9 inches asphalt concrete and brick
SW-SM	Brown-orange fine to coarse sand with silt, fine to coarse gravel, cobbles, brick and wood debris (loose to medium dense, moist) (fill)
SM	Brown and gray silty fine to coarse sand with fine gravel (very loose, moist) (fill) Traces of charred wood debris Charred wood debris Water level at 12.86 feet on 07/06/95
SW-SM	Dark brown fine to coarse sand with silt and occasional fine gravel (medium dense, wet) (fill)
SM	Greenish gray silty fine to coarse sand with fine gravel (very dense, wet) (till)
SW	Greenish brown fine to medium sand with occasional coarse sand (very dense, wet) (advance outwash)
SW-SM	Greenish brown fine to coarse sand with silt and occasional fine gravel (very dense, wet) (advance outwash) Boring completed at 26.5 feet on 06/23/95

Note: See Figure A- 2 for explanation of symbols

0161-357-R04 Task6.6 :TNV:CMS 12/5/95

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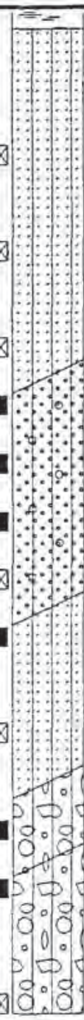
LOG OF MONITORING WELL

FIGURE A-21

MONITORING WELL MW-74

WELL SCHEMATIC

Casing Elevation (ft.): 9.88
Casing Stickup (ft.): -0.40



DESCRIPTION

Surface Elevation (ft.): 10.28

Depth in Feet	Vapor Conc. (ppm) / Sheen	Blow Count	Samples	Group Symbol	Description
0				CONCRETE	5 inches concrete sidewalk
				SM	Grayish brown silty sand with brick fragments, coarse gravel and roots (medium dense, moist) (fill)
	<100 / SS	15	☒		
5					
	<100 / SS	9	☒		
					Becomes medium dense
	<100 / SS	14	☒		
10				SW-SM	Brown fine to coarse sand with silt and fine gravel (medium dense, moist) (fill)
	<100 / SS	17	■		
	<100 / SS	11	■		With wood debris
	<100 / SS	15	CA ■		Becomes gray and wet, wood debris
					With brick fragments and wood debris
15	<100 / SS	14	☒		
	200 / SS	9	■	SM	Greenish gray silty fine to coarse sand with fine to coarse gravel (loose, wet)
					Becomes medium dense, wood debris
	<100 / NS	18	☒		
20				GW-GM	Gray fine to coarse gravel with silt and fine to coarse sand (very dense, wet) (outwash)
	<100 / SS	50/3"	■		
	400 / NS	50/2"	■	GM	Grayish brown silty fine to coarse gravel with fine to coarse sand (very dense, wet) (outwash)
25					
	200 / NS	50/4"	☒		Boring completed at 26.0 feet on 08/24/95
30					
35					
40					

Note: See Figure A- 2 for explanation of symbols

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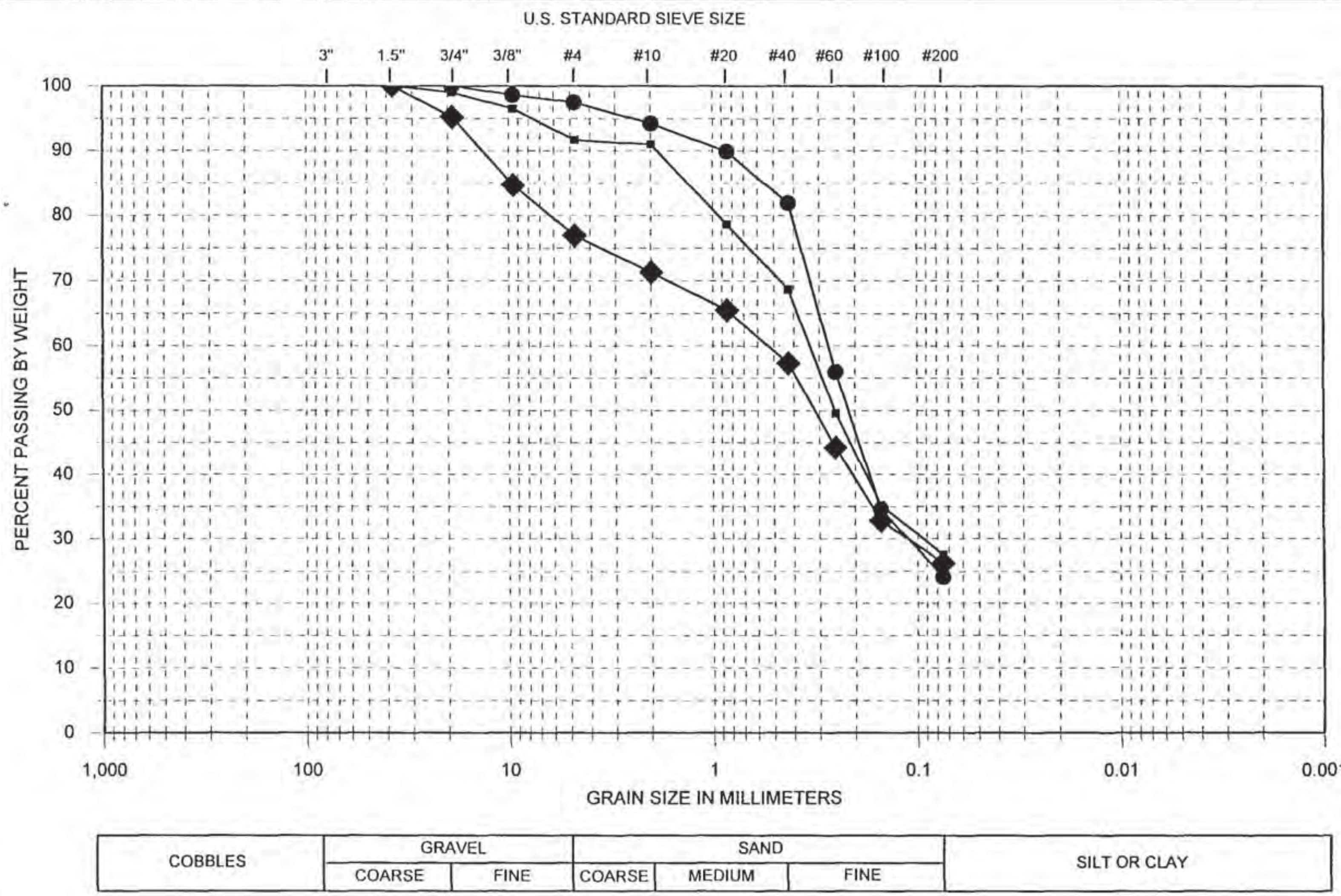
LOG OF MONITORING WELL

FIGURE A-22

0161-357-R04 Task8.6 :TNV:CMS 10/23/95



SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH (FEET)	SOIL DESCRIPTION
●	B-73	Composite: 18 to 29	Gray silty fine to medium sand with occasional coarse sand and fine gravel (SM) (loose, wet)
◆	B-74	Composite: 16 to 31	Gray silty fine to medium sand with fine to coarse gravel (SM) (loose, wet)
■	B-76	Composite: 13 to 29	Gray silty fine to medium sand with occasional coarse sand and fine to coarse gravel (SM) (loose, wet)

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GRADATION CURVES
LOWER YARD SOIL SAMPLES

FIGURE 6

TABLE 2 (Page 1 of 3)
SUMMARY OF SOIL FIELD SCREENING AND PETROLEUM HYDROCARBON CHEMICAL ANALTYICAL DATA

SUPPLEMENTAL EXPLORATIONS

UNOCAL FORMER SEATTLE MARKETING TERMINAL

Sample ID[1]	Date Sampled	Approximate Depth[2] (feet)	Field Screening[3] Headspace Vapors (ppm)	Field Screening[3] Sheen	WTPH-HCID (mg/kg) Gasoline C_7-C_{12}	WTPH-HCID (mg/kg) Diesel C_{12}-C_{24}	WTPH-HCID (mg/kg) Heavy Oil $>C_{24}$	BETX (EPA Method 8020) (mg/kg) B	E	T	X	WTPH-G (mg/kg) Gasoline C_7-C_{12}	WTPH-D Extended (mg/kg) Diesel C_{12}-C_{24}	WTPH-D Extended (mg/kg) Heavy Oil $>C_{24}$
Upper Yard														
MW-61-11	06/14/95	11.0-11.5	900	HS	--	--	--	<0.05	0.14	<0.05	0.90	500	270	120
MW-61-16	06/14/95	16.0-16.5	100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	7.8	14	<25
MW-61-23.5	06/14/95	23.5-24.0	<100	NS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	<25
MW-62-13.5	06/13/95	13.5-14.0	5,000	HS	--	--	--	0.65	3.3	1.1	8.1	840	640	130
MW-62-18	60/13/95	18.0-18.5	<100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	1.8	<10	<25
MW-63-17.5	06/12/95	17.5-18.0	100	SS	<20	<50	<100	--	--	--	--	--	--	--
MW-63-25	06/12/95	25.0-25.5	<100	SS	<20	<50	<100	--	--	--	--	--	--	--
MW-64-8.5	06/12/95	8.5-9.0	<100	SS	<20	<50	<100	--	--	--	--	--	--	--
MW-64-26	06/12/95	26.0-26.5	500	SS	<20	<50	<100	--	--	--	--	--	--	--
Order on Consent Cleanup Targets[5]					NE	NE	NE	0.4	NE	143	NE		200[6]	
Elliott Avenue														
MW-30-26	06/16/95	26.0-26.5	100	MS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	<25
MW-30-28.5	06/16/95	28.5-29.0	<100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	11	<25
MW-65-13.5	06/15/95	13.5-14.0	750	MS	--	--	--	<0.05	<0.05	<0.05	<0.10	9.7	11,000	28,000
MW-65-23.5	06/15/95	23.5-24.0	<100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	<25
MW-66-8.5	06/22/95	8.5-9.0	210	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	27
MW-66-16	06/22/95	16.0-16.5	1,000	HS	--	--	--	<0.40	<0.40	0.47	1.4	1,100[4]	5,000	490
MW-66-20.5	06/22/95	20.5-21.0	250	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	76[4]	77	33
Order on Consent Cleanup Targets[5]					NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Lower Yard														
B-72-21	06/13/95	21.0-21.5	<100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	<25
B-73-6	06/21/95	6.0-6.5	200	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	45
B-73-13.5	06/21/95	13.5-14.0	<100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	34
B-73-26	06/21/95	26.0-26.5	<100	NS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	<25
B-74-26	06/14/95	26.0-26.5	<100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	<25
B-76-21	06/15/95	21.0-21.5	150	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	<25
Order on Consent Cleanup Targets[5]					NE	NE	NE	0.4	NE	143	NE	100	200	

Notes appear on page 3 of 3.

TABLE 2 (Page 2 of 3)

Sample ID[1]	Date Sampled	Approximate Depth[2] (feet)	Field Screening[3] Headspace Vapors (ppm)	Field Screening[3] Sheen	WTPH-HCID (mg/kg) Gasoline C_7-C_{12}	WTPH-HCID (mg/kg) Diesel C_{12}-C_{24}	WTPH-HCID (mg/kg) Heavy Oil $>C_{24}$	BETX (EPA Method 8020) (mg/kg) B	BETX (EPA Method 8020) (mg/kg) E	BETX (EPA Method 8020) (mg/kg) T	BETX (EPA Method 8020) (mg/kg) X	WTPH-G (mg/kg) Gasoline C_7-C_{12}	WTPH-D Extended (mg/kg) Diesel C_{12}-C_{24}	WTPH-D Extended (mg/kg) Heavy Oil $>C_{24}$
Offsite Area														
B-80-16	60/20/95	16.0-16.5	1,000	HS	--	--	--	<0.08	<0.08	<0.08	<0.16	130[4]	8,300	7,200
B-80-31	06/20/95	31.0-31.5	180	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	<10	52
MW-67-16	06/19/95	16.0-16.5	--	SS	--	--	--	0.087	0.071	0.083	0.19	53	85	96
MW-67-23.5	06/19/95	23.5-24.0	1,100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	19	42
MW-68-13.5	06/19/95	13.5-14.0	5,000	HS	--	--	--	<0.08	<0.08	0.33	0.41	230	4,300	3,800
MW-68-30	06/19/95	30.0-30.5	500	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	11	37	65
MW-69-11	06/19/95	11.0-11.5	400	HS	--	--	--	0.53	0.41	1.1	4.7	990	22,000	8,300
MW-69-26.5	06/19/59	26.5-27.0	<100	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	33	67
MW-70-11	06/20/95	11.0-11.5	<100	SS	<20	<50	<100	--	--	--	--	--	--	--
MW-70-23.5	06/20/95	23.5-24.0	<100	NS	<20	<50	<100	--	--	--	--	--	--	--
MW-71-11	06/22/95	11.0-11.5	<100	SS	<20	<50	<100	--	--	--	--	--	--	--
MW-71-26	06/22/95	26.0-26.5	<100	NS	<20	<50	<100	--	--	--	--	--	--	--
MW-72-9.5	06/23/95	9.5-10.0	3,600	HS	--	--	--	<0.08	1.1	0.33	2.3	750	790	700
MW-72-16	06/23/16	16.0-16.5	>10,000	HS	--	--	--	3.4	3.1	<0.40	4.9	1,100	1,000	1,000
MW-72-21	06/23/95	21.0-21.5	1,800	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	7.9	29	54
MW-72-28.5	06/23/95	28.5-29.0	520	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	12	45	140
MW-76-8.5	08/23/95	8.5-9.0	<100	SS	<20	<50	<100	--	--	--	--	--	--	--
MW-76-16	08/23/95	16.0-16.5	--	MS	--	--	--	<0.05	<0.05	<0.05	<0.10	13	24	54
MW-76-28.5	08/23/95	28.5-29.0	2,000	SS	--	--	--	<0.05	0.086	<0.05	0.13	87	88	85
B-77-12.5	03/26/95	12.5-13.0	--	HS	--	--	--	<0.40	1.2	0.54	3.2	1,700[4]	9,000	5,800
B-77-16	03/26/95	16.0-16.5	1,500	HS	--	--	--	<0.40	1.1	<0.40	2.8	1,600[4]	13,000	5,900
B-77A-23.5	03/26/95	23.5-24.0	200	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	15	<25
B-79-8.5	03/26/95	8.5-9.0	110	HS	--	--	--	<0.08	<0.08	<0.08	0.30	190[4]	1,500	360
B-79-21	03/26/95	21.0-21.5	600	SS	--	--	--	<0.05	<0.05	<0.05	<0.10	<1.0	42	42
Order on Consent Cleanup Targets[5]					NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

Notes appear on page 3 of 3.

TABLE 2 (Page 3 of 3)

Notes:

[1]Sample identification includes exploration number followed by the sample depth. Exploration locations are shown in Figure 3.

[2]Below ground surface. Each sample is 3 to 4 inches within the depth range shown.

[3]Field screening procedures described in Appendix A. Headspace vapors measured with combustible gas indciator (Bacharach TLV sniffer) calibrated to hexane. The instrument has a lower threshold of significance of 100 ppm in this application. NS = no sheen, SS = slight sheen, MS = moderate sheen, HS = heavy sheen.

[4]Laboratory reports that sample contains diesel-range hydrocarbons that extend into the hydrocarbon range quantified as gasoline.

[5]Order on Consent No. DE 88-N223 and Amendment No. 4 to Order on Consent.

[6]Applies to the sum of fuel hydrocarbon concentrations detected by WTPH-G and WTPH-D extended.

ppm = parts per million

mg/kg = milligrams per kilogram

NE = not established

Shaded concentrations exceed the corresponding Order on Consent Cleanup Target for soil for that area of the site.

Chemical analyses by North Creek Analytical of Bothell, Washington.

TABLE 3 (Page 1 of 4)
SUMMARY OF SOIL PAH AND LEAD CHEMICAL ANALYTICAL DATA
SUPPLEMENTAL EXPLORATIONS
UNOCAL FORMER SEATTLE MARKETING TERMINAL

Site Area	Lower Yard				Offsite Area		
Sample[1]	B-73-6	B-73-13.5	B-73-26	B-76-21	MW-67-16	MW-67-23.5	MW-68-13.5
Sample Depth[1] (feet)	6.0-6.5	13.5-14.0	26.0-26.5	21.0-21.5	16.0-16.5	23.5-24.0	13.5-14.0
Carcinogenic PAHs[2,3] (mg/kg)							
Benzo(a)anthracene	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	6.2
Benzo(a)pyrene	0.018	<0.01	<0.01	<0.01	<0.01	<0.01	<0.20
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.20
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.20
Chrysene	0.010	<0.01	<0.01	<0.01	<0.01	<0.01	0.49
Dibenzo(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.20
Indeno(1,2,3-cd)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.20
Total CPAHs[4]	0.044	NA	NA	NA	NA	NA	6.69
Benzo(a)pyrene-TEC Sum[5]	0.020	NA	NA	NA	NA	NA	0.625
Noncarcinogenic PAHs[2] (mg/kg)							
Acenaphthene	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	1.4
Acenaphthylene	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.20
Anthracene	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	0.52
Benzo(g,h,i)perylene	0.053	<0.01	<0.01	<0.01	<0.01	<0.01	<0.20
Fluoranthene	0.063	<0.01	<0.01	0.013	0.017	<0.15	1.1
Fluorene	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	0.58
Naphthalene	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.50
Phenanthrene	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	0.44
Pyrene	0.086	<0.02	<0.02	<0.02	0.032	0.045	1.3
Other Analyses							
Lead (mg/kg)	--	--	--	--	13	27	60
TPH Gasoline[6] (mg/kg)	<1.0	<1.0	<1.0	<1.0	53	<1.0	230
TPH Diesel[6] (mg/kg)	<10	<10	<10	<10	85	19	4,300
TPH Heavy Oil[6] (mg/kg)	45	34	<25	<25	96	42	3,800

Notes appear on page 4 of 4.

TABLE 3 (Page 2 of 4)

Site Area	Offsite Area						
Sample[1]	MW-68-30	MW-69-11	B-77-12.5	B-77-16	B-77A-23.5	B-79-8.5	B-79-21
Sample Depth[1] (feet)	30.0-30.5	11.0-11.5	12.5-13.0	16.0-16.5	23.5-24.0	8.5-9.0	21.0-21.5
Carcinogenic PAHs[2,3] (mg/kg)							
Benzo(a)anthracene	0.14	<1.0	0.62	0.19	<0.01	<0.02	0.60
Benzo(a)pyrene	0.055	<1.0	0.21	0.12	<0.01	0.021	0.62
Benzo(b)fluoranthene	0.087	<1.0	0.21	<0.10	<0.01	<0.02	0.44
Benzo(k)fluoranthene	0.027	<1.0	<0.10	<0.10	<0.01	<0.02	0.49
Chrysene	0.098	<1.0	1.1	0.49	<0.01	0.04	0.65
Dibenzo(a,h)anthracene	0.019	<1.0	<0.10	<0.10	<0.01	<0.02	0.023
Indeno(1,2,3-cd)pyrene	0.036	<1.0	<0.10	<0.10	<0.01	<0.02	0.24
Total CPAHs[4]	0.462	NA	2.188	0.80	<0.01	0.061	3.06
Benzo(a)pyrene-TEC Sum[5]	0.104	NA	0.31	0.144	<0.01	0.021	0.827
Noncarcinogenic PAHs[2] (mg/kg)							
Acenaphthene	<0.15	2.1	11	3.1	<0.01	<0.02	0.12
Acenaphthylene	<0.15	<1.0	<0.10	<0.10	<0.01	<0.02	0.069
Anthracene	<0.15	1.1	2.7	0.56	<0.01	<0.02	0.42
Benzo(g,h,i)perylene	0.023	<1.0	<0.10	<0.10	<0.01	<0.02	0.24
Fluoranthene	0.26	1.4	4.4	0.71	<0.01	0.052	1.5
Fluorene	<0.15	2.6	<0.10	0.59	<0.01	<0.02	0.10
Naphthalene	<0.15	<1.0	5.4	1.0	<0.01	<0.02	0.061
Phenanthrene	<0.15	1.6	10	4.9	<0.01	0.044	0.90
Pyrene	0.21	1.9	3.0	0.72	<0.01	0.12	1.4
Other Analytes							
Lead (mg/kg)	<10	<10	--	--	--	--	--
TPH Gasoline[6] (mg/kg)	11	990	1,700	1,600	<1.0	190	<1.0
TPH Diesel[6] (mg/kg)	37	22,000	9,000	13,000	15	1,500	42
TPH Heavy Oil[6] (mg/kg)	65	8,300	5,800	5,900	<25	360	42

Notes appear on page 4 of 4.

TABLE 3 (Page 3 of 4)

Site Area	Offsite Area						
Sample[1]	MW-69-26.5	MW-72-9.5	MW-72-21	B-80-16	B-80-31	MW-76-16	MW-76-28.5
Sample Depth (feet)	26.5-27.0	9.5-10.0	21.0-21.5	16.0-16.5	31.0-31.5	16.0-16.5	28.5-29.0
Carcinogenic PAHs[2,3] (mg/kg)							
Benzo(a)anthracene	<0.01	0.21	<0.01	0.41	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	0.46	<0.01	<0.05	<0.05
Benzo(b)fluoranthene	<0.01	0.013	<0.01	<0.01	<0.01	<0.05	<0.05
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05
Chrysene	<0.01	<0.01	<0.01	0.50	<0.01	<0.01	0.12
Dibenzo(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05
Indeno(1,2,3-cd)pyrene	0.010	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05
Total CPAHs[4]	0.010	0.223	NA	1.37	NA	NA	0.12
Benzo(a)pyrene-TEC Sum[5]	0.010	0.022	NA	0.506	NA	NA	0.001
Noncarcinogenic PAHs[2] (mg/kg)							
Acenaphthene	<0.15	3.3	<0.15	<0.15	<0.15	<0.01	1.1
Acenaphthylene	<0.15	<0.15	<0.15	<0.15	<0.15	<0.01	0.017
Anthracene	<0.15	<0.15	<0.15	0.69	<0.15	<0.01	0.26
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05
Fluoranthene	0.020	0.11	0.023	3.7	<0.01	<0.01	0.78
Fluorene	<0.15	0.17	<0.15	0.20	<0.15	<0.01	0.88
Naphthalene	<0.15	1.4	<0.15	<0.15	<0.15	<0.01	2.3
Phenanthrene	<0.15	0.28	<0.15	0.60	<0.15	<0.01	2.4
Pyrene	0.023	0.14	0.036	4.4	<0.02	<0.01	0.53
Other Analytes							
Lead (mg/kg)	11	13	<10	<10	110	<10	25
TPH Gasoline[6] (mg/kg)	<1.0	750	7.9	130	<1.0	13	87
TPH Diesel[6] (mg/kg)	33	790	29	8,300	<10	24	88
TPH Heavy Oil[6] (mg/kg)	67	700	54	7,200	<52	54	85

Notes appear on page 5 of 5.

TABLE 4 (Page 1 of 2)
SUMMARY OF GROUND WATER PETROLEUM HYDROCARBONS AND LEAD CHEMICAL ANALYTICAL DATA
SUPPLEMENTAL EXPLORATIONS
UNOCAL FORMER SEATTLE MARKETING TERMINAL

Monitoring Well[1]	Date Sampled	NAPL[2]	BETX (EPA Method 8020) (µg/l)				WTPH-G (mg/l)	WTPH-D Extended (mg/l)		Lead[3] (EPA Method 7421) (µg/l)	
			B	E	T	X	Gasoline C_7-C_{12}	Diesel C_{12}-C_{24}	Heavy Oil $>C_{24}$	Dissolved	Total
Upper Yard											
MW-61	07/06/95	ND	0.74	<0.5	<0.5	1.1	0.89	3.5	0.87	7.4	58
Duplicate	07/06/95	--	<0.5	<0.5	<0.5	<0.5	1.0	--	--	--	--
	09/15/95	ND	0.50	<0.5	<0.5	1.6	0.63	4.3	1.0	<2.0	--
MW-62	07/06/95	ND	110	110	3.8	190	3.8	12[4]	2.7	<2.0	140
	09/21/95	0.24[7]	--	--	--	--	--	--	--	--	--
MW-63	07/06/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	0.35	<0.75	<2.0	74
	09/21/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	0.34	0.98	<2.0	--
MW-64	07/06/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	0.45	<0.75	<2.0	23
	09/15/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	<0.5	<0.5	<2.0	--
Elliott Avenue											
MW-30	07/07/95	Sheen	<0.5	<0.5	<0.5	<1.0	<0.05	5.2	1.5	<2.0	38
	09/14/95	Sheen	<0.5	<0.5	<0.5	<1.0	<0.05	0.82	0.98	--	--
MW-65	07/07/95	Sheen	<0.5	<0.5	<0.5	<1.0	<0.05	2.7	2.7	<2.0	250
	09/14/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	0.67	0.86	<2.0	--
MW-66	07/07/95	Sheen	<0.5	<0.5	<0.5	2.9	2.0[5]	6.9	<0.75	<2.0	22
	09/14/95	ND	<0.5	<0.5	<0.5	<1.0	0.43	1.9	<0.75	<2.0	--
MW-73	07/07/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	1.1	3.6	<2.0	620
	09/15/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	0.56	3.1	<2.0	--
MW-74	09/15/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	1.2	6.4	<2.0	--
MW-75	09/15/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	1.5	12	<2.0	--
Order on Consent Cleanup Targets		No visible sheen	40	1,400	14,300	4,400	1.0	10	15	50	NE

Notes appear on page 2 of 2.

TABLE 4 (Page 2 of 2)

Monitoring Well[1]	Date Sampled	NAPL[2]	BETX (EPA Method 8020) (µg/l)				WTPH-G (mg/l)	WTPH-D Extended (mg/l)		Lead[3] (EPA Method 7421) (µg/l)	
			B	E	T	X	Gasoline C_7-C_{12}	Diesel C_{12}-C_{24}	Heavy Oil $>C_{24}$	Dissolved	Total
Offsite Area											
MW-67	07/07/95	ND	<2.0[6]	6.5[6]	<2.0[6]	11[6]	3.4	3.3	1.5	<2.0	360
	09/14/95	Sheen	0.54	1.7	0.60	2.8	1.6	2.4	1.4	<2.0	--
MW-68	07/07/95	Sheen	30[6]	17[6]	7.7[6]	20[6]	1.2[5]	21	17	<2.0	40
MW-69	07/07/95	Sheen	<2.0[6]	<5.0[6]	<2.0[6]	<5.0[6]	0.28	17	11	<2.0	56
MW-70	07/07/95	ND	<2.0[6]	<5.0[6]	<2.0[6]	<5.0[6]	<0.05	1.0	1.1	<2.0	81
	09/14/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	0.40	0.83	<2.0	--
MW-71	07/07/95	ND	<2.0[6]	<5.0[6]	<2.0[6]	<5.0[6]	<0.05	1.1	0.77	<2.0	150
	09/14/95	ND	<0.5	<0.5	<0.5	<1.0	<0.05	0.59	1.9	<2.0	--
MW-72	07/07/95	Sheen	2.7[6]	<5.0[6]	<2.0[6]	7.3[6]	0.68	3.4	2.5	<2.0	200
Duplicate	07/07/95	--	4.8	2.0	1.4	7.3	0.85	--	--	--	--
MW-72	09/15/95	Sheen	5.2	4.1	1.5	5.6	0.69	2.6	3.4	<2.0	--
Duplicate	09/15/95	--	5.3	4.5	1.7	5.9	0.74	2.5	3.4	--	--
MW-76	09/15/95	Sheen	0.82	1.2	<0.5	2.4	2.1	6.5	14	<2.0	--
Duplicate	09/15/95	--	0.72	1.8	<0.5	2.8	1.9	3.0	<0.75	--	--
Trip Blank	07/06/95	--	<0.5	<0.5	<0.5	<1.0	<0.05	--	--	--	--
Trip Blank	07/07/95	--	<0.5	<0.5	<0.5	<1.0	<0.05	--	--	--	--
Trip Blank	07/07/95	--	<2.0[6]	<5.0[6]	<2.0[6]	<5.0[6]	--	--	--	--	--
Trip Blank	09/14/95	--	<0.5	<0.5	<0.5	<1.0	<0.05	--	--	--	--
Order on Consent Cleanup Targets		No visible sheen	40	1,400	14,300	4,400	1.0	10	15	50	NE

Notes:

[1]Monitoring well locations shown in Figure 3.

[2]NAPL = nonaqueous phase liquid. Field procedures for evaluating NAPL are described in Appendix A.

[3]Total lead analysis completed on unfiltered samples. Samples analyzed for dissolved lead were filtered in the field as described in Appendix A.

[4]Laboratory reports that fuel hydrocarbon chromatogram resembles gasoline and weathered diesel mixture.

[5]Laboratory reports that sample contains diesel-range hydrocarbons that extend into the hydrocarbon range quantified as gasoline.

[6]EPA Method 8240; refer to Table 5 for complete VOC results.

[7]Product was sampled on 09/21/95 and analyzed by modified EPA Method 8015 for a fuel fingerprint. According to the laboratory's interpretation of the chromatogram, sample contains a mixture of gasoline and weathered kerosene or heating oil.

µg/l = micrograms per liter

"--" = not tested

Shaded concentrations exceed order on consent cleanup target.

TABLE 5 (Page 1 of 2)
SUMMARY OF GROUND WATER PAH CHEMICAL ANALYTICAL DATA
SUPPLEMENTAL EXPLORATIONS - OFFSITE AREA
UNOCAL FORMER SEATTLE MARKETING TERMINAL

Monitoring Well[1]	MW-67		MW-68	MW-69	MW-70		MW-71		MW-72		MW-76	RAL
	07/07/95	09/14/95	07/07/95	07/07/95	07/07/95	09/14/95	07/07/95	09/14/95	07/07/95	09/15/95	09/14/95	(μg/l)
Carcinogenic PAHs[2,3] (μg/l)												
Benzo(a)anthracene	8.4	3.6	<0.10	0.46	<0.10	<0.10	<0.10	<0.10	0.19	<0.10	12	0.031
Benzo(a)pyrene	3.3	<4.0	1.0	0.96	<0.10	<0.20	<0.10	<0.20	0.24	<0.20	<4.0	0.031
Benzo(b)fluoranthene	1.7	<4.0	<0.10	<0.10	<0.10	<0.20	<0.10	<0.20	<0.10	<0.20	<4.0	0.031
Benzo(k)fuoranthene	0.90	<4.0	<0.10	<0.10	<0.10	<0.20	<0.10	<0.20	<0.10	<0.20	<4.0	0.031
Chrysene	<0.10	4.0	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	11	0.031
Dibenzo(a,h)anthracene	<0.10	<4.0	<0.10	<0.10	<0.10	<0.20	<0.10	<0.20	<0.10	<0.20	<4.0	0.031
Indeno(1,2,3-cd)pyrene	<0.10	<4.0	<0.10	<0.10	<0.10	<0.20	<0.10	<0.20	<0.10	<0.20	<4.0	0.031
Total CPAHs[4]	14.3	7.6	1.0	1.42	<0.10	<0.20	<0.10	<0.20	0.43	<0.20	23	NE
Noncarcinogenic PAHs[2] (μg/l)												
Acenaphthene	85	40	30	19	<5.0	<0.10	<5.0	0.91	24	0.48	130	NE
Acenaphthylene	<5.0	<2.0	<5.0	<5.0	<5.0	<0.10	<5.0	<0.10	<5.0	<0.10	6.3	NE
Anthracene	57	22	<5.0	<5.0	<5.0	<0.10	<5.0	<0.10	<5.0	<0.10	30	NE
Benzo(g,h,i)perylene	<0.10	<4.0	<0.10	<0.10	<0.10	<0.20	<0.10	<0.20	<0.10	<0.20	<4.0	NE
Fluoranthene	77	19	5.8	7.9	<0.10	<0.10	0.29	0.19	2.8	<0.10	84	NE
Fluorene	80	35	11	<5.0	<5.0	<0.10	<5.0	0.44	<5.0	<0.10	110	NE
Naphthalene	580	230	<5.0	<5.0	<5.0	<0.10	<5.0	<0.10	<5.0	<0.10	120	NE
Phenanthrene	220	67	<5.0	<5.6	<5.0	<0.10	<5.0	0.70	5.1	<0.10	250	NE
Pyrene	55	25	<0.50	4.9	0.50	<0.10	<0.50	0.19	2.5	<0.10	60	NE

Notes appear on page 2 of 2.

TABLE 6 (Page 1 of 2)
SUMMARY OF GROUND WATER VOC CHEMICAL ANALYTICAL DATA
SUPPLEMENTAL EXPLORATIONS - OFFSITE AREA
UNOCAL FORMER SEATTLE MARKETING TERMINAL

Monitoring Well[1]	MW-67	MW-68	MW-69	MW-70	MW-71	MW-72	MW-72 Duplicate	Trip Blank
VOCs[2] (µg/l)								
Acetone	23	130	<10	<10	<10	35	40	<10
Benzene	<2.0	30	<2.0	<2.0	<2.0	2.7	2.5	<2.0
Bromodichloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Bromoform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Bromomethane	<10	<10	<10	<10	<10	<10	<10	<10
2-Butanone	<10	160	<10	<10	<10	<10	<10	<10
Carbon disulfide	<10	<10	<10	<10	<10	<10	<10	<10
Carbon tetrachloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chlorobenzene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Chloroethane	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Chloromethane	<10	<10	<10	<10	<10	<10	<10	<10
Dibromochloromethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1-Dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-Dichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1-Dichloroethene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
cis 1,2-Dichloroethene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
trans 1,2-Dichloroethene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-Dichloropropane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
cis 1,3-Dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
trans 1,3-Dichloropropene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ethylbenzene	6.5	17	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
2-Hexanone	<10	<10	<10	<10	<10	<10	<10	<10
Methylene chloride	<10	<10	<10	<10	<10	<10	<10	<10
4-Methyl-2-pentanone	<10	<10	<10	<10	<10	<10	<10	<10
Styrene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Notes appear on page 2 of 2.

TABLE 6 (Page 2 of 2)

Monitoring Well[1]	MW-67	MW-68	MW-69	MW-70	MW-71	MW-71	MW-72 Duplicate	Trip Blank
1,1,2,2-Tetrachloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Tetrachloroethene	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Toluene	<2.0	7.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,1,1-Trichloroethane	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,1,2-Trichloroethane	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Trichloroethene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Vinyl chloride	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Xylenes	11	20	<5.0	<5.0	<5.0	7.3	6.6	<5.0

Notes:

[1]Samples obtained on 07/07/95.

[2]EPA Method 8240.

VOC = volatile organic compound

$\mu g/l$ = micrograms per liter

TABLE 7
SUMMARY OF GROUND WATER ELEVATIONS[1]
SUPPLEMENTAL EXPLORATIONS
UNOCAL FORMER SEATTLE MARKETING TERMINAL

Well Number	Date Measured	Time Measured (hours:minutes)	Depth to Ground Water[2] (feet)	Ground Water Elevation[3] (feet)	Dissolved Oxygen Concentration (mg/l)
MW-30	07/06/95	11:55	13.50	-2.21	NM
	09/13/95	12:20	13.77	-2.48	NM
MW-61	07/06/95	12:20	14.33	-1.35	1.6
	09/13/95	13:05	14.58	-1.60	2.8
MW-62	07/06/95	12:25	13.08	1.27	2.0
	09/13/95	12:55	14.44	0.13[4]	NM
MW-63	07/06/95	12:30	13.58	1.62	4.5
	09/13/95	12:54	13.83	1.37	3.0
MW-64	07/06/95	12:35	11.12	5.75	2.4
	09/13/95	12:50	11.65	5.22	2.8
MW-65	07/06/95	11:45	13.05	-2.22	2.6
	09/13/95	12:00	13.33	-2.50	2.8
MW-66	07/06/95	12:00	13.72	-2.14	2.1
	09/13/95	12:30	13.97	-2.35	2.8
MW-67	07/06/95	10:20	11.65	-5.91	2.2
	09/13/95	09:35	10.30	-4.56	3.0
MW-68	07/06/95	10:30	10.84	-4.86	NM
	09/13/95	09:45	10.68	-4.70	NM
MW-69	07/06/95	10:40	10.65	-4.83	2.2
	09/13/95	08:58	10.28	-4.46	NM
MW-70	07/06/95	10:50	9.59	-4.01	2.6
	09/13/95	08:46	10.00	-4.42	3.2
MW-71	07/06/95	11:00	8.88	-3.62	2.2
	09/13/95	09:05	9.60	-4.34	3.2
MW-72	07/06/95	11:30	10.70	-5.16	NM
	09/13/95	09:25	10.10	-4.56	NM
MW-73	07/06/95	11:34	12.26	-2.48	1.7
	09/13/95	11:48	12.47	-2.69	2.4
MW-74	09/13/95	11:43	12.55	-2.67	2.4
MW-75	09/13/95	11:54	13.29	-2.47	4.3
MW-76	09/13/95	09:30	9.80	-4.32	NM

Notes:

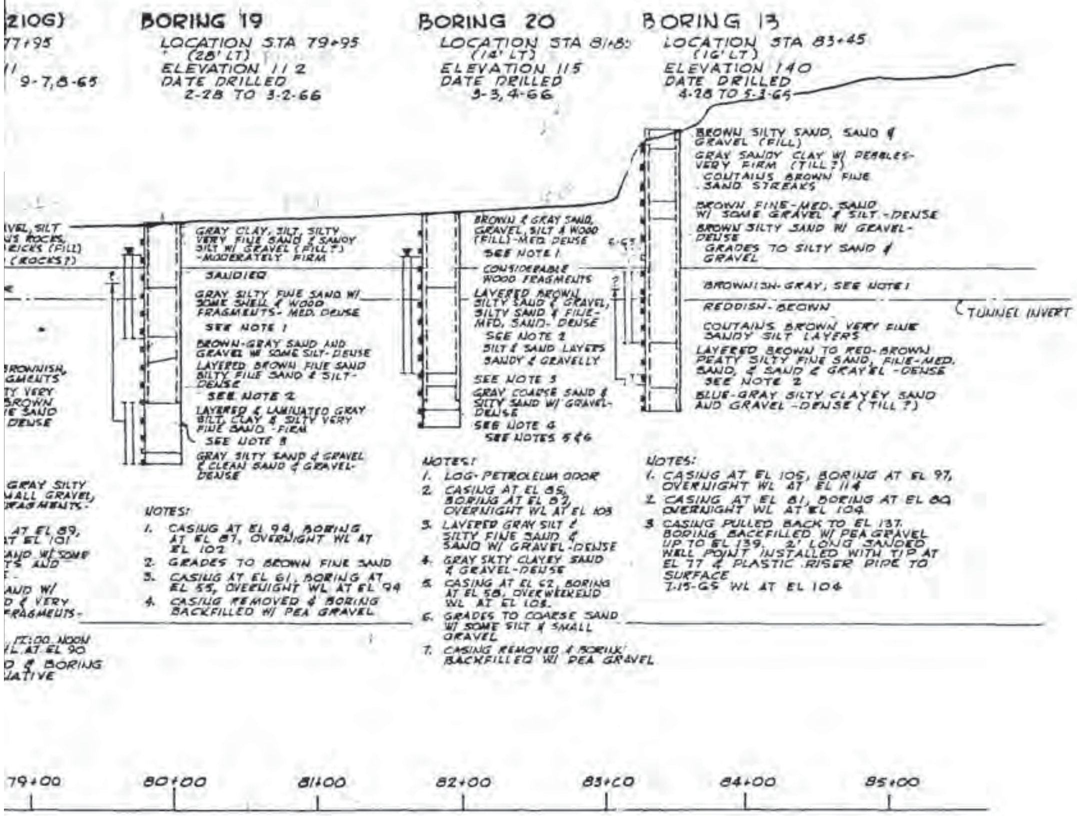
[1]Field procedures described in Appendix A.

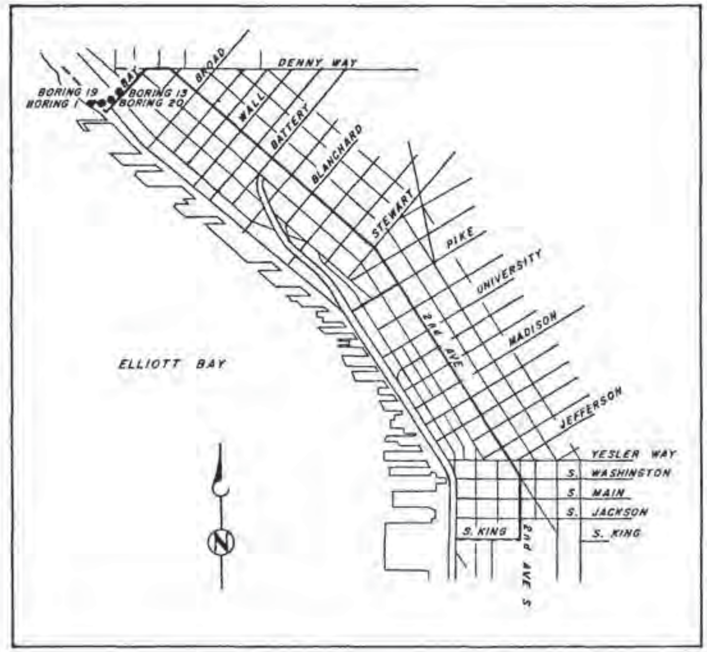
[2]Below casing rim.

[3]Elevation referenced to City of Seattle datum.

[4]Product present in well casing (Table 4). Elevation corrected to account for the thickness of product. A specific gravity of 0.90 was assumed for the product.

NM = not measured





VICINITY MAP

LEGEND:

- UNDISTURBED SAMPLE TAKEN WITH 2.5" I.D. DRIVE SAMPLER (O.D. 3 1/4")
- SAMPLE MISSED
- DEPTH TO WHICH CASING WAS REQUIRED DURING DRILLING
- CASING LEFT IN PLACE
- MEASURED HYDROSTATIC HEAD
- WATER BEARING ZONE
- MEASURED HYDROSTATIC HEAD, BUT PRESUMED HIGHER
- LIMITS OF ZONE UNDETERMINED

LOG OF BORINGS

ELLIOTT BAY INTERCEPTOR - SECTION 6

PLATE 2

DATE DRILLED 5/25/83

SUMMARY: BORING NO. 1

ELEVATION Approx. 47.0

Depth in Feet	Sample No.	Blows/6"	Other Tests**	Field Moisture % of Dry Weight	Dry Density PCF	Description	Symbol	Moisture	Consistency
0						SAND (Fill); yellowish-brown, fine to medium, trace fine gravel, trace silt	SP	slightly moist	dense
5	1C	9 19 45		8.2					
						SILTY SAND (Glacial Till); gray, fine to medium, little coarse sand and fine to coarse gravel	SM	slightly moist	very dense
10	2C	29 62 69		9.7	123	occasional lenses of very moist to wet silty sand			
15									
						CLAYEY SILT (Glacio/Lacustrine); gray, thinly bedded to laminated, thin laminations of silt	ML	dry	hard
20	3C	23 48 54	T A	20.6 LL=45.4 PL=35.7 PI=10.7	107				
25									
30	4C	21 32 48	C A	26.7 LL=48.4 PL= 9.5 PI=38.9	101	thin interbeds of Silty Clay and wet, fine, Silty Sand	ML/ CL/ SM	dry	hard
						APPROXIMATE LEVEL OF LOWEST FINISHED FLOOR			
35	5C	22 35 85		21.0	113	grades brown, medium, interbeds of very moist, fine sand	SP	dry	hard
						gravelly drill action (Continued)			
40									

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler E. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

PROPOSED AIRBORNE BUILDING
Seattle, Washington
for Martin Selig Real Estate

Project No. 83-5141

Drawing No. 3

Converse Consultants Geotechnical Engineering and Applied Sciences

10189

DATE DRILLED: 5/25/83

SUMMARY: BORING NO. 1 (Cont.)

ELEVATION:

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

Depth in feet	Sample No.*	Blows/6"	Other tests**	Field moisture % of dry weight	Dry density PCF	Description	Symbol	Moisture	Consistency
40	6C	37 66 87/3"		11.2	112	CLAYEY SILT/SILTY CLAY (Glacio/Lacustrine); brown, interbeds of fine to coarse, wet Gravelly Sand	ML/ CL/ SW	dry	hard
45									
						SAND (Outwash); gray-brown, fine to coarse, some fine gravel, trace silt	SW	wet	very dense
50	7C	27 70/4½"		12.5					
55									
						GRAVELLY SAND; gray-brown, fine to coarse, little to some silt	SW	very moist to wet	very dense
60	8C	70/5"		25.1					
						occasional interbeds of sand			
65									
70	9X	200/2½"							
						Bottom of boring at depth 70.2' No groundwater encountered Completed 5/25/83			

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner
D. 2-1/2" O.D. split barrel sampler X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level; impervious seal; piezometer tip

PROPOSED AIRBORNE BUILDING
Seattle, Washington
for Martin Selig Real Estate

Project No. 83-5141

Converse Consultants — Geotechnical Engineering and Applied Sciences

Drawing No. 3 (CONT.)

3101 Western Ave
610784

DATE DRILLED: 5/27/83

SUMMARY: BORING NO. 4

ELEVATION: Approx. 40.0

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

Depth in Feet	Sample No.*	Blows/6"	Other Tests**	Field Moisture % of Dry Weight	Dry Density pcf	Description	Symbol	Moisture	Consistency
0						GRAVELLY SAND (Fill); gray-brown, fine to coarse	GP		
						SILTY SAND; yellowish-brown/gray, very fine to fine, grading to silt	SM	moist	medium dense
5	1C	4 8 17		15.4	112				
						SILTY SAND (Till gradational to Outwash); brown, fine, trace fine gravel, occasional thin lenses of fine to medium wet sand	SM	slightly moist	very dense
10	2C	19 30 41		16.4	113				
15						gravelly			
						fine to medium, some gravel		slightly moist	very dense
20	3C	29 51 81	T	10.2	125				
						SILTY SAND (Outwash); gray-brown, fine, thin interbeds of sandy silt	SM		
25	4C	22 55 81	C	13.7	119	GRAVELLY SAND; gray-brown, fine to medium, little to some silt, interbeds of fine silty sand and laminations of silt	GW	wet	very dense
30	5C	200/4"		18.6		APPROXIMATE LEVEL OF LOWEST FINISHED FLOOR		wet	very dense
35	6C	98		12.6	111	SAND; gray-brown, fine to medium, some silt, little fine gravel	SP	very moist	very dense
						gravelly zones (Continued)			
40									

*A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler X. sample not recovered

**A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level; impervious seal; piezometer tip

PROPOSED AIRBORNE BUILDING
Seattle, Washington
for Martin Selig Real Estate

Project No. 83-5141

Converse Consultants — Geotechnical Engineering and Applied Sciences

10192

Drawing No. 6

SUMMARY: BORING NO. 4 (Cont.)

DATE DRILLED: 5/27/83 — ELEVATION:

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
40	7C	200/ 4"		15.5	93	GRAVELLY SAND (Outwash) Continued gray-brown, fine to medium, little to some silt	SW	very moist	very dense
45									
						gravelly; hard drilling			
50	8C	200/ 4½"				little silt; cobbly		very moist	very dense
55									
60	9C	100 100/ 2"		12.7	104	fine to coarse, trace silt		wet	very dense
65									
70	10C	125 70/2"		9.5	128	little to some silt, lenses of wet sand			
						Bottom of boring at depth 70.7'			

Piezometer installed to depth 45', with 20" slotted interval at bottom; backfilled with pea gravel to depth 16', backfilled with cuttings to surface, concrete seal at surface.
Completed 5/27/83
Groundwater measured on 6/8, 6/14/83 and 8/18/83 at a depth of 42.5'.

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level / impervious seal / piezometer tip

PROPOSED AIRBORNE BUILDING
Seattle, Washington
for Martin Selig Real Estate

Project No. 83-5141

Converse Consultants — Geotechnical Engineering and Applied Sciences

3101 Western Ave
410784

Drawing No. 6 (CONT.)

DATE DRILLED: 7/26/84

SUMMARY: BOR[redacted]

ELEVATION: Approx. 6

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF
0–5	1A	6, 4, 4			
5	2C	5, 7, 8			
5–10	3A	2, 3, 6			
10	4C	7, 71, 34			
10–15	5A	17, 39, 42			
15	6X	24, 21, 18			
15–20	7X	11, 11, 12			
20	8A	0, 13, 11			
20–25	9A	18, 30, 34			
25	10A	20, 33, 51			
30	11A	38, 50/3"			
35	12A	60/4"			

DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
12" Railroad ballast	GP	damp	loose
FILL **SILTY SAND**: brown, fine to medium	SM	moist	loose
CLAYEY SILT: gray, little fine sand and occasional chunks of harder silt	MH	v.moist	stiff
COAL/CINDERS: black to brown, little f/c sand, oil odor and feel		wet	m.dense
SILTY SAND: gray, f/c, some gvl	SM		
BEACH DEPOSITS **SANDY GRAVEL**: (from drill action)	GP-GM		m.dense
SILTY SAND: gray, fine to medium (from cuttings)	SM		
zone of gray to black **SILT** and organic **SILT**	OH	wet	
SAND: gray, fine to medium, little silt, trace shell fragments grades to fine to coarse, trace silt & gravel, occasional shell fragments	SM-SP	wet	dense
GLACIAL OUTWASH **SANDY SILT TO SILTY SAND**: tan-gray, fine with occasional medium to coarse sand, little gravel, thinly laminated to thinly bedded	ML-SM	moist	v.dense

40

(Continued)

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler
C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler
X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear, G - grain size, T - triaxial, P - permeability

water level
impervious seal
piezometer tip

GRINNELL PROJECT
Seattle, Washington
for Curtis L. Beattie and Associates

Project No. 84-5180

Drawing No. 14

Converse Consultants Geotechnical Engineering and Applied Sciences

DATE DRILLED: 7/26/84

SUMMARY: BORING NO. B-9 (Cont.) ELEVATION:

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLE NO.*	SAMPLE	BLOWS/6"	OTHER TESTS**	FIELD MOISTURE % OF DRY WEIGHT	DRY DENSITY PCF	DESCRIPTION	SYMBOL	MOISTURE	CONSISTENCY
40	13X		100/2"				SANDY SILT (Cont.)	ML-SM	moist	v.dense
45	14A		100/2"							
							Bottom of boring at depth 45.2' Completed 7/26/84			

* A. 2" split-spoon sampler
B. 3" O.D. thin-wall sampler C. 3-1/4" O.D. x 2-1/2" liner
D. 3-1/2" O.D. split barrel sampler X. sample not recovered

** A - Atterberg, C - consolidation, DS - direct shear,
G - grain size, T - triaxial, P - permeability

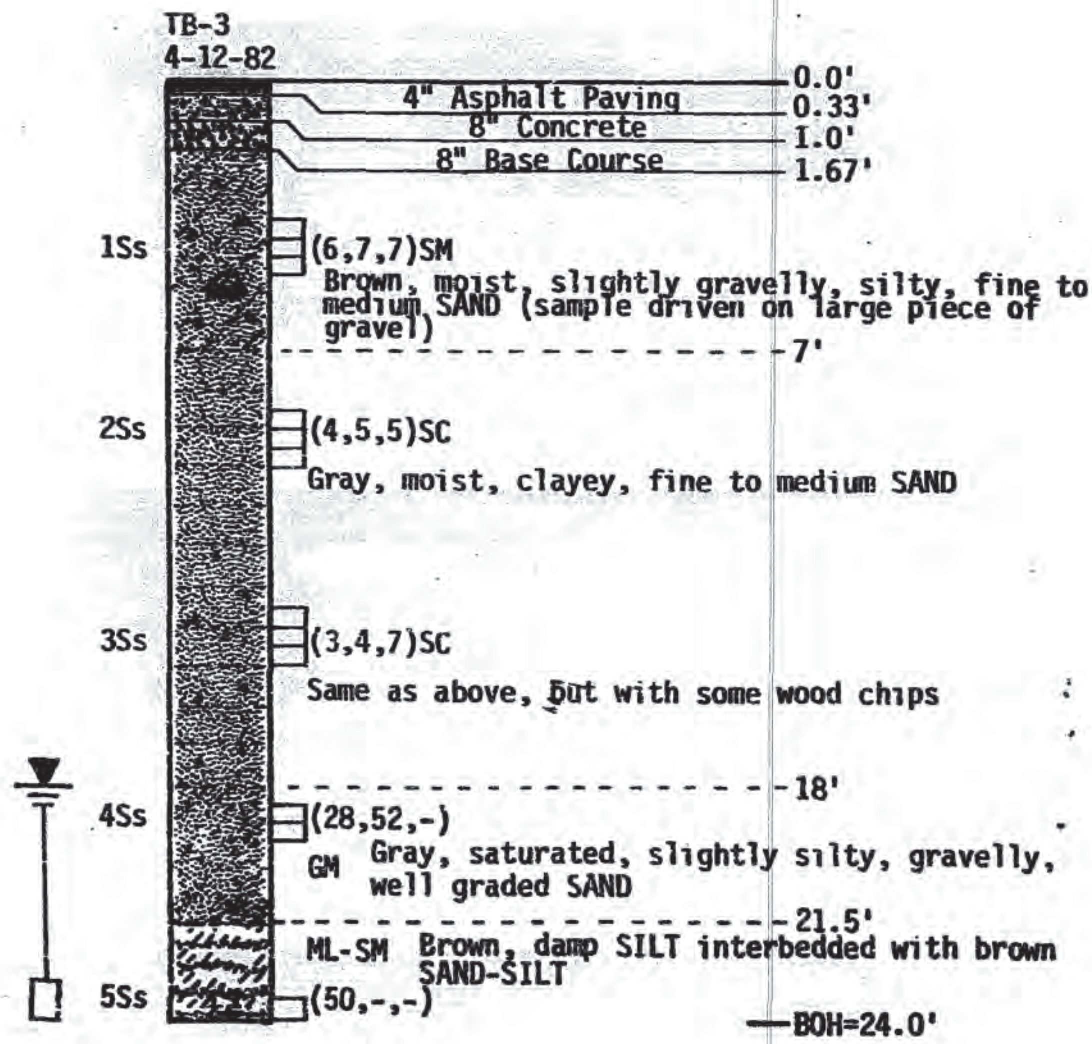
water level
impervious seal
piezometer tip

GRINNELL PROJECT
Seattle, Washington
for Curtis L. Beattie and Associates

Project No. 84-5180

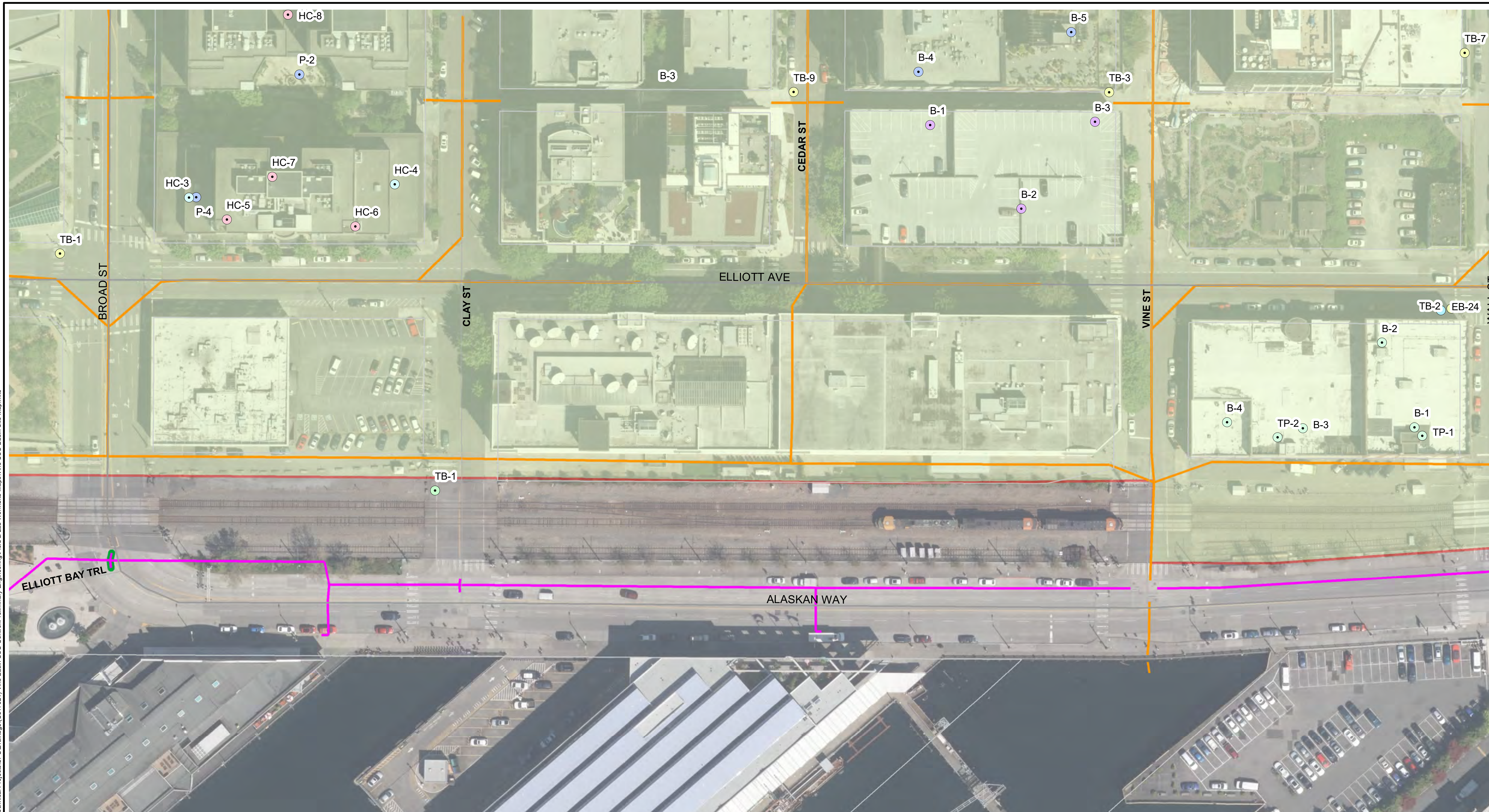
Converse Consultants — Geotechnical Engineering and Applied Sciences

Drawing No. 14 (Cont.)



PACIFIC TESTING LABORATORIES 3220 17th AVE. W. SEATTLE, WA. 98119 206-282-0666	TEST BORING LOG for Seattle Engineering Dept. Site located on street near 3130 Elliott Ave. Seattle, Washington	PROJECT NO. 8204-3010 DATE 4-14-82 DRAWN JEM ENGR./GEOL. MVS APPROVED

Appendix A2 – Historical Geotechnical Data Provide by SPU (Broad Street to Wall Street)



LEGEND

- Vine CSO Basin
- Arterial Streets
- Residential Streets
- Right of Way
- Sanitary Main
- Combined Main
- Drainage Main
- King County Sewer System Mainline

ExistingExplorations

- Golder Associates;1999
- Hart-Crowser and Associates, Inc.;1990
- Hart-Crowser and Associates, Inc.;1991
- Pacific Testing Laboratories;1982
- Rittenhouse-Zeman and Associates, Inc.;1978
- Seattle Engineering Department;1985
- Shannon and Wilson, Inc.;2002
- Terra Associates, Inc.;1999

NAVD88

40 20 0 40 80
Feet

Vine Basin CSO Control
Seattle, Washington

EXISTING EXPLORATION MAP
SECTION A2

Seattle Public Utilities
Geotechnical Engineering

FIGURE 3
August 2018
Project No. C317021

Document Path: P:\MatLab\Secure\GEOTECH\Geotechnical Projects\SPU\Drainage\(C317021) Vine Basin CSO Control\Preliminary Engineering\Field & Lab Work\Site Maps\Vine CSO Basin Site Map.mxd

Vine Basin - Summary of Exsiting Explorations

Map Section	Borehole ID	Completed By	Date Completed	Borehole Depth in Feet	Document ID
A2	HC-3	Hart-Crowser and Associates, Inc.	7/23/1990	58	1609
A2	HC-4	Hart-Crowser and Associates, Inc.	7/23/1990	59	1609
A2	HC-5	Hart-Crowser and Associates, Inc.	2/7/1991	16.5	1609
A2	HC-6	Hart-Crowser and Associates, Inc.	2/7/1991	15.5	1609
A2	HC-7	Hart-Crowser and Associates, Inc.	2/8/1991	29	1609
A2	HC-8	Hart-Crowser and Associates, Inc.	2/7/1991	39	1609
A2	B-1	Rittenhouse-Zeman and Associates, Inc.	7/31/1978	44	1660
A2	B-2	Rittenhouse-Zeman and Associates, Inc.	7/31/1978	16.5	1660
A2	B-3	Rittenhouse-Zeman and Associates, Inc.	7/31/1978	32	1660
A2	P-2	Golder Associates	8/11/1999	51.5	3139
A2	P-4	Golder Associates	8/11/1999	15.8	3139
A2	TB-1	Seattle Engineering Department	4/18/1985	59.5	3816
A2	TB-2	Pacific Testing Laboratories	8/18/1982	19	3875
A2	TB-3	Pacific Testing Laboratories	8/18/1982	19	3875
A2	TB-7	Pacific Testing Laboratories	8/19/1982	18	3875
A2	TB-9	Pacific Testing Laboratories	8/19/1982	20.5	3875
A2	B-4	Golder Associates	8/26/1999	31.5	5440
A2	B-5	Golder Associates	8/26/1999	41.5	5440
A2	B-3	Shannon and Wilson, Inc.	10/1/1998	15.8	8055
A2	TB-1	Pacific Testing Laboratories	4/9/1982	25.4	10040
A2	EB-24	Shannon and Wilson, Inc.	9/9/2002	140.5	11094
A2	B-1	Terra Associates, Inc.	12/28/1999	12.8	17185
A2	B-2	Terra Associates, Inc.	12/28/1999	15.5	17185
A2	B-3	Terra Associates, Inc.	12/29/1999	11	17185
A2	B-4	Terra Associates, Inc.	12/29/1999	9.6	17185
A2	TP-1	Terra Associates, Inc.	12/20/1999	10	17185
A2	TP-2	Terra Associates, Inc.	12/21/1999	3	17185

Key to Exploration Logs

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling

BORING SAMPLES

- Split Spoon
- Shelby Tube
- Cuttings
- Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

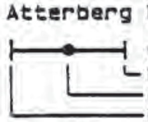
- Grab (Jar)
- Bag
- Shelby Tube

Ground Water Observations

- Surface Seal
- Ground Water Level on Date (ATD) At Time of Drilling
- Observation Well Tip or Slotted Section
- Ground Water Seepage (Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits



Water Content in Percent
- Liquid Limit
- Natural
- Plastic Limit

HARTCROWSER
J-3041 8/90
Figure A-1

Boring Log HC-3

Soil Descriptions

Ground Surface Elevation in Feet 0.0

Loose to medium dense, moist, brown, gravelly, silty SAND. (FILL?)

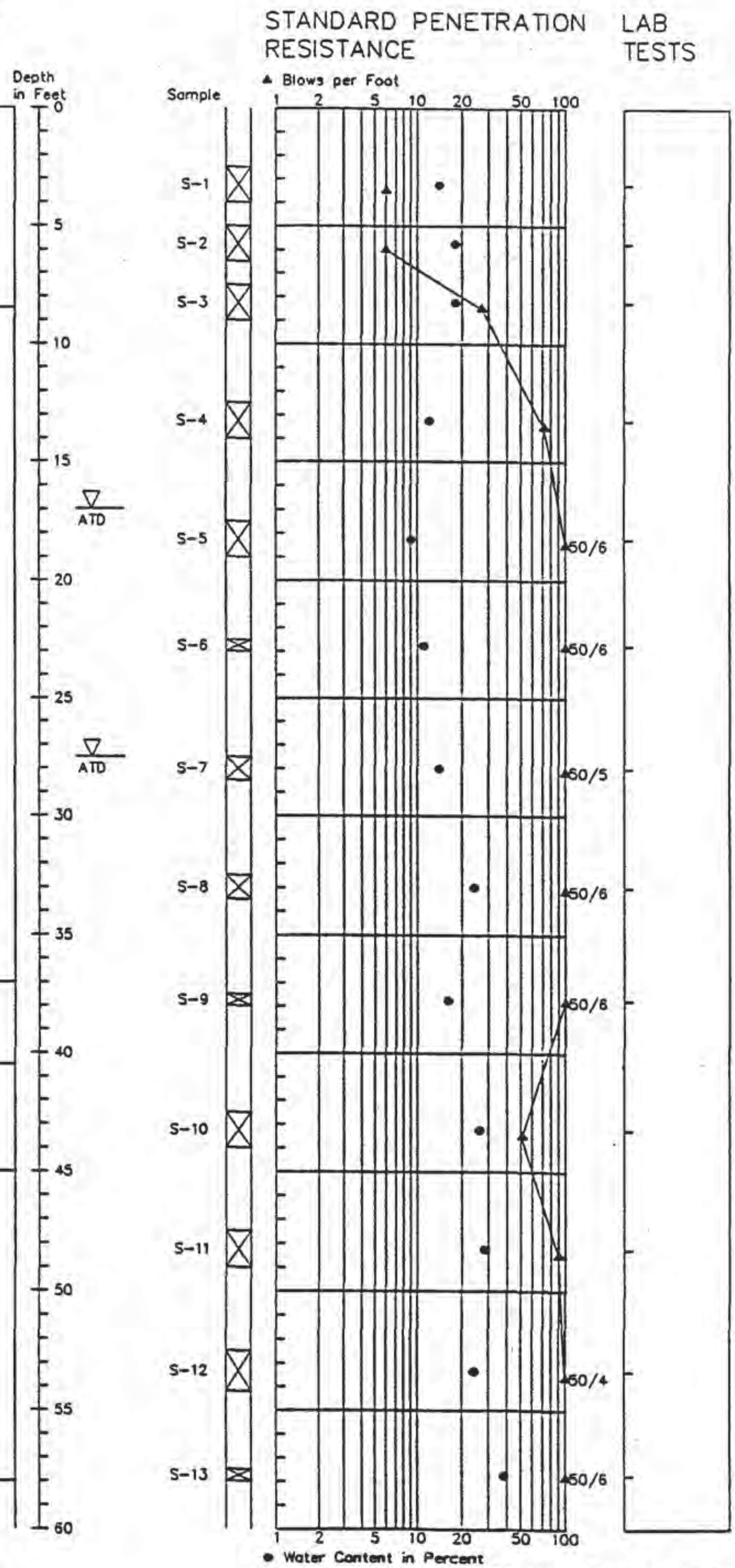
Very dense, moist to wet, gray, slightly gravelly, very silty SAND to gravelly, very silty SAND.

Hard, moist, gray, sandy SILT.

Hard, moist, gray CLAY.

Very dense, wet, gray, very silty, fine SAND.

Bottom of Boring at 58.0 Feet.
Completed 7/23/90.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3041 7/90

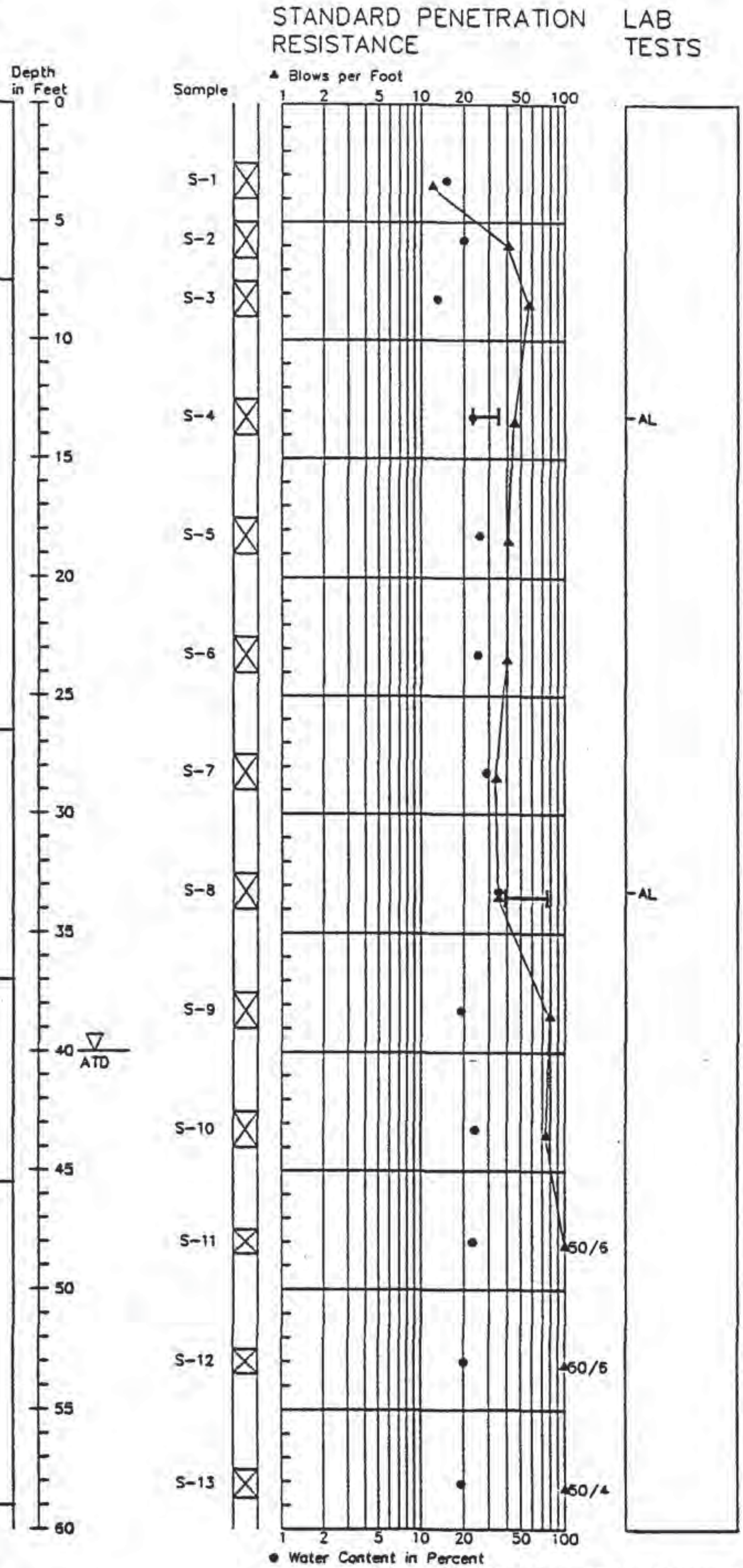
Figure A-5 1/1

Boring Log HC-4

Soil Descriptions

Ground Surface Elevation in Feet 0.0

Depth in Feet	Soil Description
0	2 inches of asphalt over 5 inches of concrete over medium dense to dense, damp to moist, brown, slightly gravelly, very silty SAND to silty SAND with trace organics. (FILL?)
7.5	Hard, damp, gray, silty CLAY.
22.5	— Occasional thin sand layers.
26	Hard, damp, gray, clayey SILT with slickensides and silt partings.
36.5	Hard, damp to moist, gray, slightly sandy SILT.
45.5	Very dense, moist to wet, gray SAND with SILT lenses.
57	— Grades to slightly gravelly, slightly silty SAND.
59	Bottom of Boring at 59.0 Feet. Completed 7/23/90.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-3041 7/90
Figure A-6 1/1

Boring Log HC-5

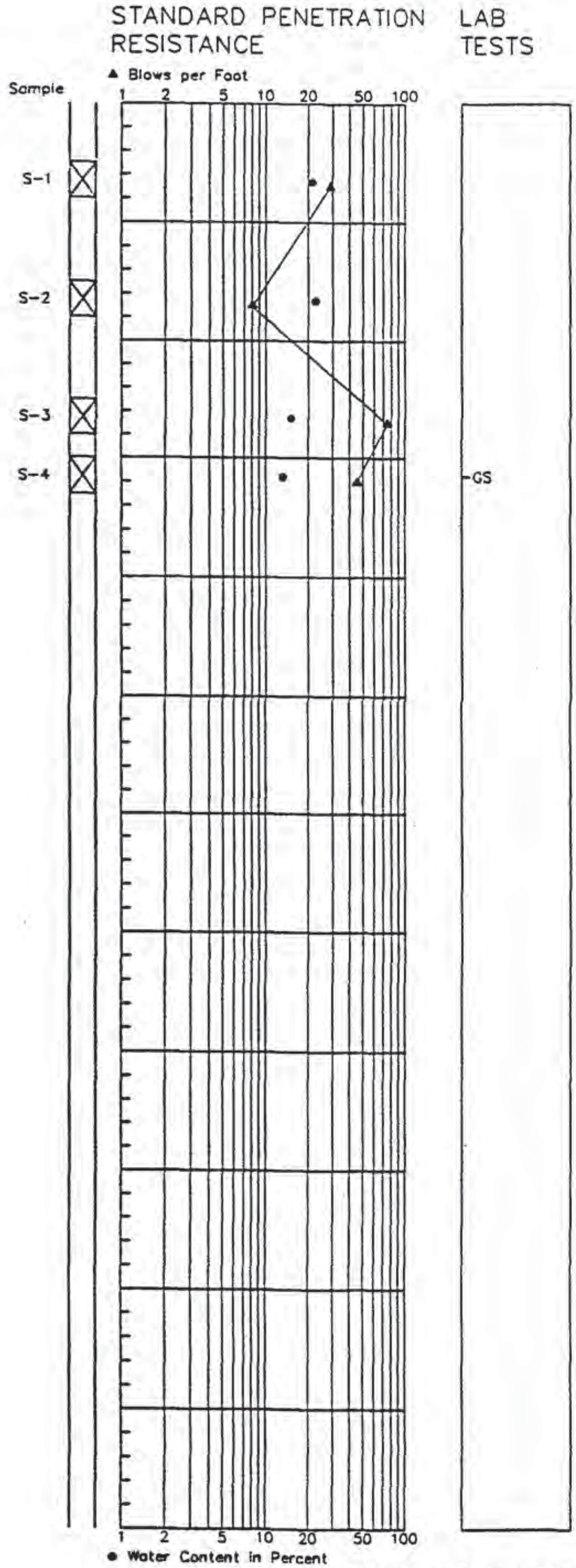
Soil Descriptions

Ground Surface Elevation in Feet 21.0

Soil Description	Depth in Feet
1 inch asphalt over 4 inches concrete over medium dense, wet, brown to gray, gravelly, very silty SAND with abundant wood fragments. (FILL)	0
Medium stiff, wet, brown, sandy to very sandy SILT with abundant wood fragments and shell fragments. (FILL)	5
Very dense, wet, gray, gravelly, silty sandy SILT.	
Very dense, wet, brown, slightly gravelly, silty SAND.	
Bottom of Boring at 16.5 Feet. Completed 2/7/91.	

Depth scale (in Feet): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60

Groundwater: ATD (at approximately 11 feet)



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3041 2/91

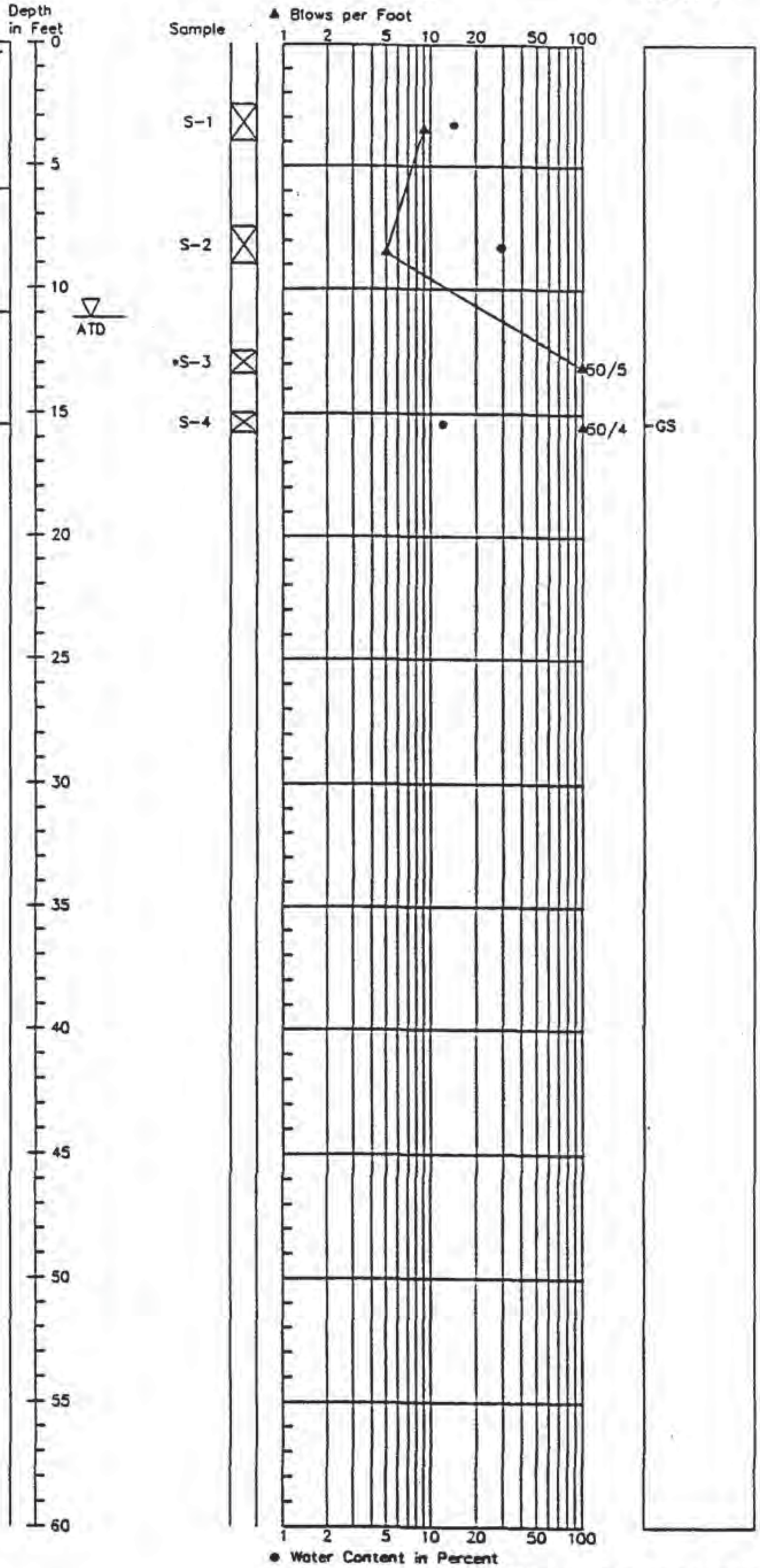
Figure A-7 1/1

Boring Log HC-6

Soil Descriptions

Ground Surface Elevation in Feet 21.0

Soil Description	Depth in Feet
2 inches asphalt over 5 inches concrete over loose, wet, brown, slightly gravelly, very silty SAND with wood fragments. (FILL)	0
Medium stiff, wet, brown and black, sandy SILT with scattered gravels and wood fragments. (FILL)	5
Very dense, moist, tan, slightly gravelly, very silty SAND.	10 (ATD)
Bottom of Boring at 15.5 Feet. Completed 2/7/91.	15



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3041 2/91

Figure A-8 1/1

Boring Log HC-7

Soil Descriptions

Ground Surface Elevation in Feet 22.0

2 inches asphalt over 5 inches of concrete over 1 inch crushed rock over very loose, wet, brown, slightly gravelly, silty to very silty SAND. (FILL?)

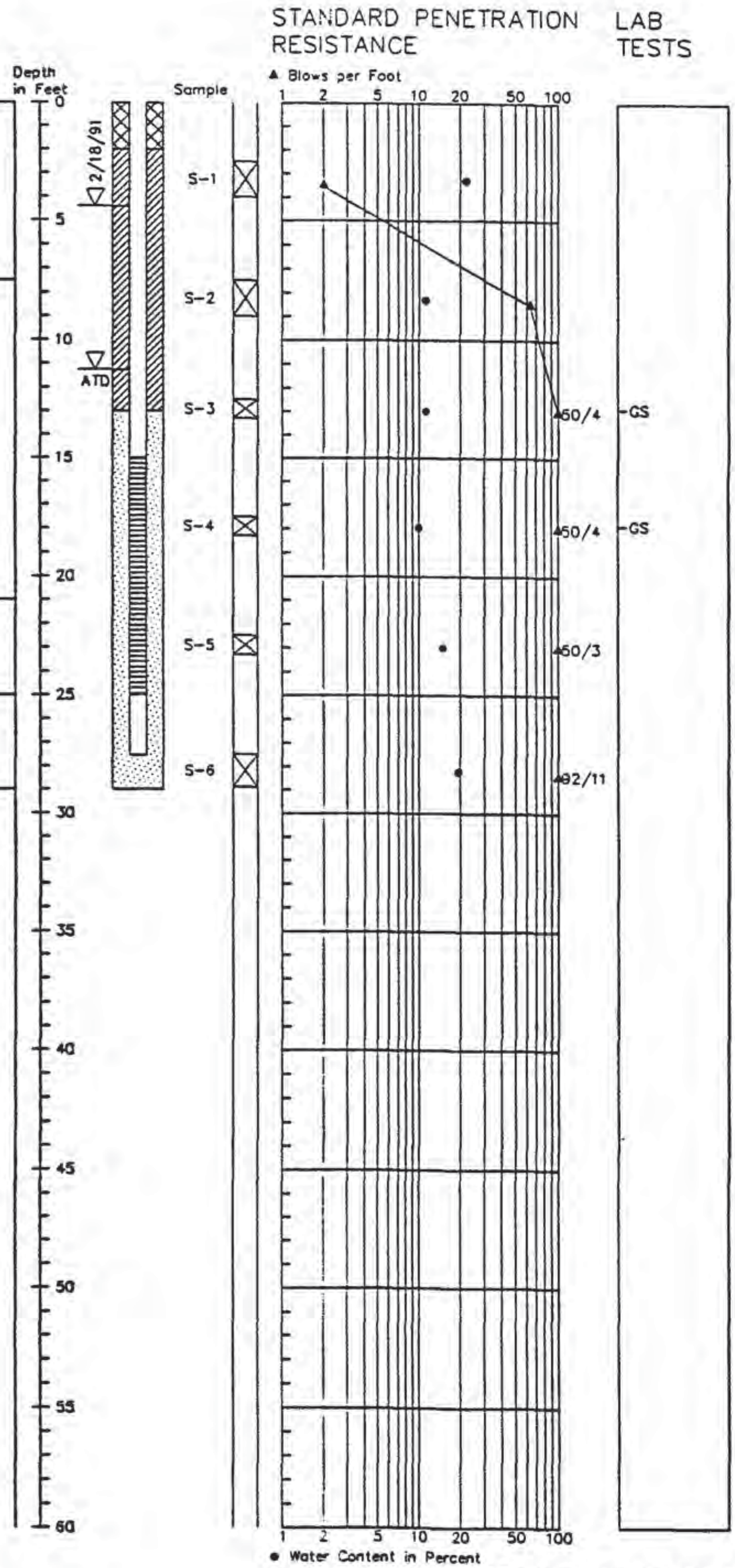
Very dense, moist, brown-gray, gravelly, silty SAND.

— Becomes wet.

Very dense, wet, gray SAND with SILT interbeds and scattered gravels.

Hard, wet, gray SILT with slickensides(?).

Bottom of Boring at 29.0 Feet.
Completed 2/8/91.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-3041 2/91

Figure A-9 1/1

Boring Log HC-8

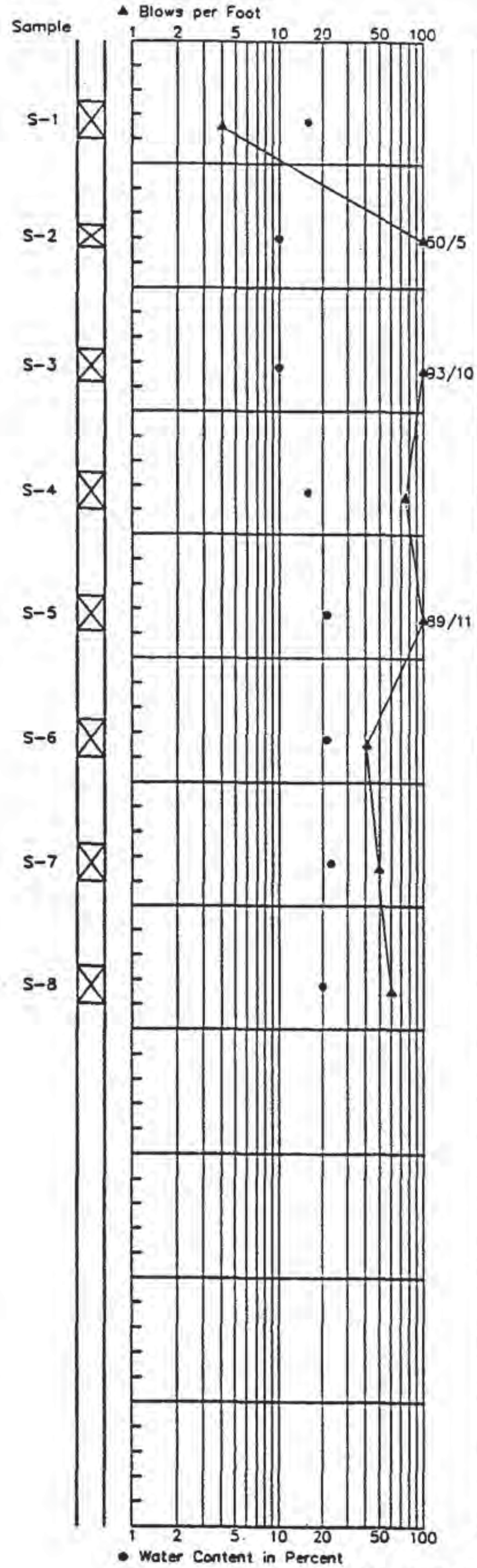
Soil Descriptions

Ground Surface Elevation in Feet 45.0

Depth in Feet	Soil Description
0	4 inches concrete over loose, wet, brown, slightly gravelly, very silty SAND.
~6.8	Very dense, damp to moist, brown, slightly gravelly, silty SAND.
~17.8	Very dense, moist, gray, silty, fine SAND with scattered gravels.
~21	Grades out of gravels. SILT interbeds observed.
~26.3	Hard, moist, gray SILT with occasional thin sandy interbeds.
39.0	Bottom of Boring at 39.0 Feet. Completed 2/7/91.

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

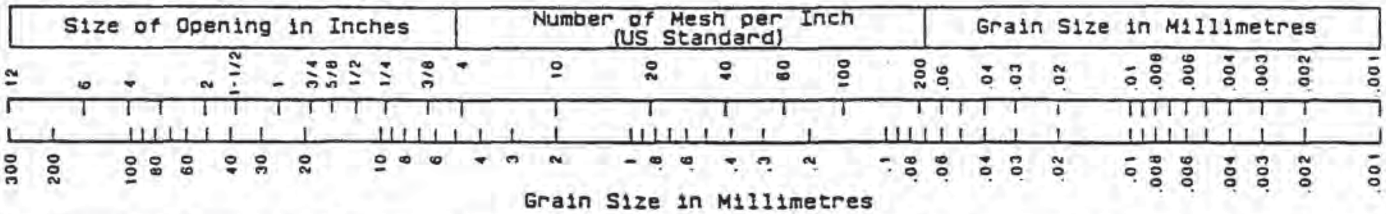
HARTCROWSER

J-3041 2/91

Figure A-10 1/1

Unified Soil Classification (USC) System

Soil Grain Size



COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines		* GRAVEL with >12% fines		Clean SAND <5% fines		* SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right)$ >4 for G W, >6 for S W & $1 \leq \left(\frac{(D_{30})^2}{D_{10} \times D_{60}}\right) \leq 3$

G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A Line with PI <4

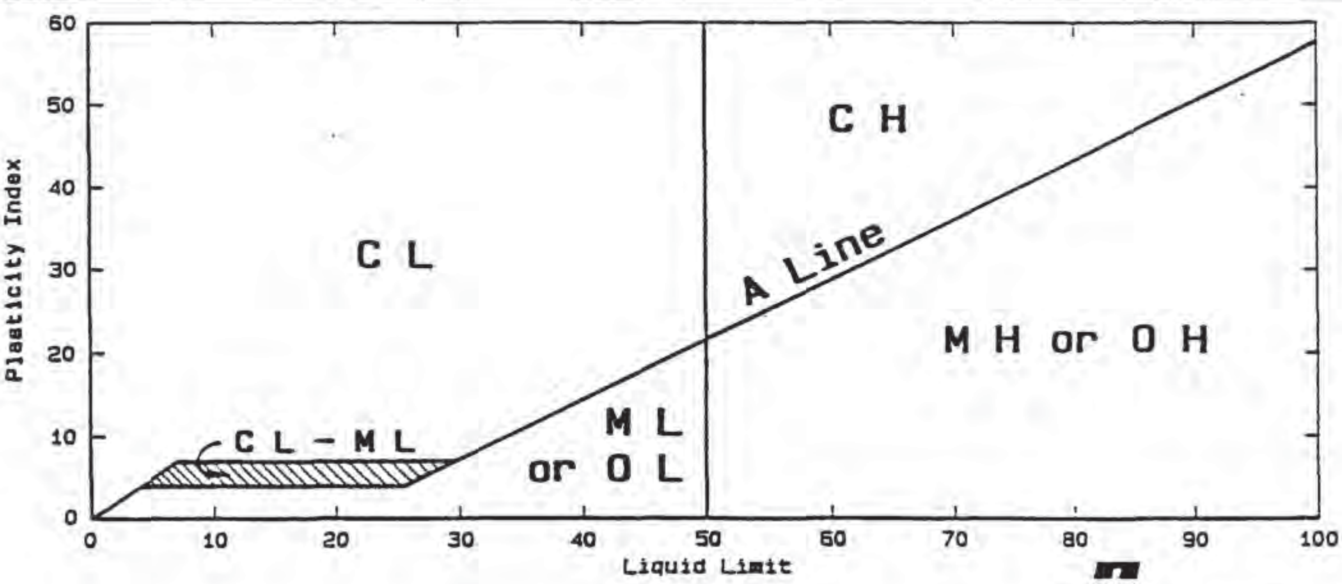
G C and S C Atterberg limits above A Line with PI >7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

D_{10}, D_{30}, and D_{60} are the particle diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						

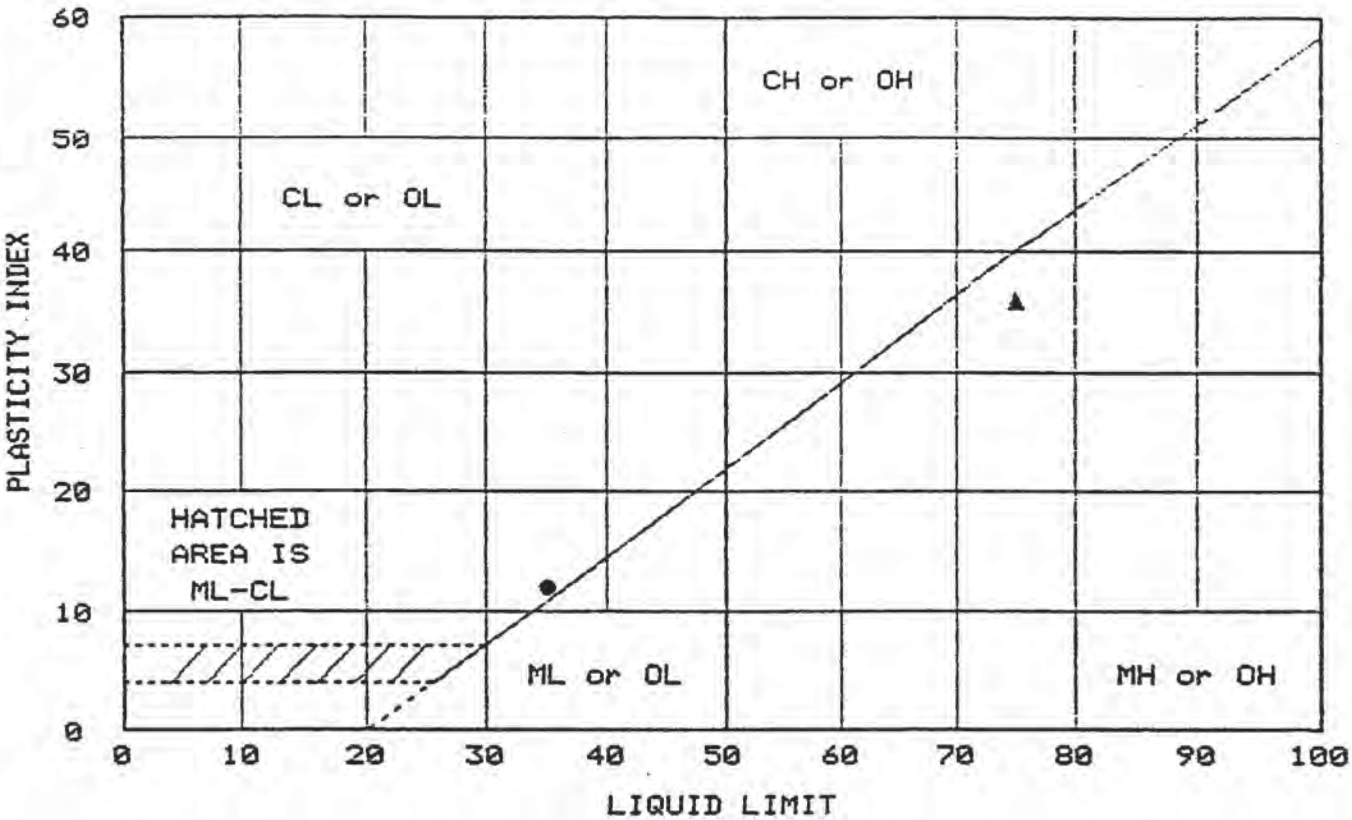


HARTCROWSER

J-3041 8/90

Figure B-1

LIQUID AND PLASTIC LIMITS TEST REPORT



	Location + Description	LL	PL	PI	-200	ASTM D 2487-85
●	HC-4, S-4 DEPTH 12.5-14.0' NATURAL W.C.=22%	35	23	12		CL, Lean clay
▲	HC-4, S-8 DEPTH 32.5-34.0' NATURAL W.C.=36%	75	39	36		MH, Elastic silt

Remarks:

Project: BROAD & ELLIOT CONDOMINIUM DEVELOPEMENT

Client: GSL PROPERTIES

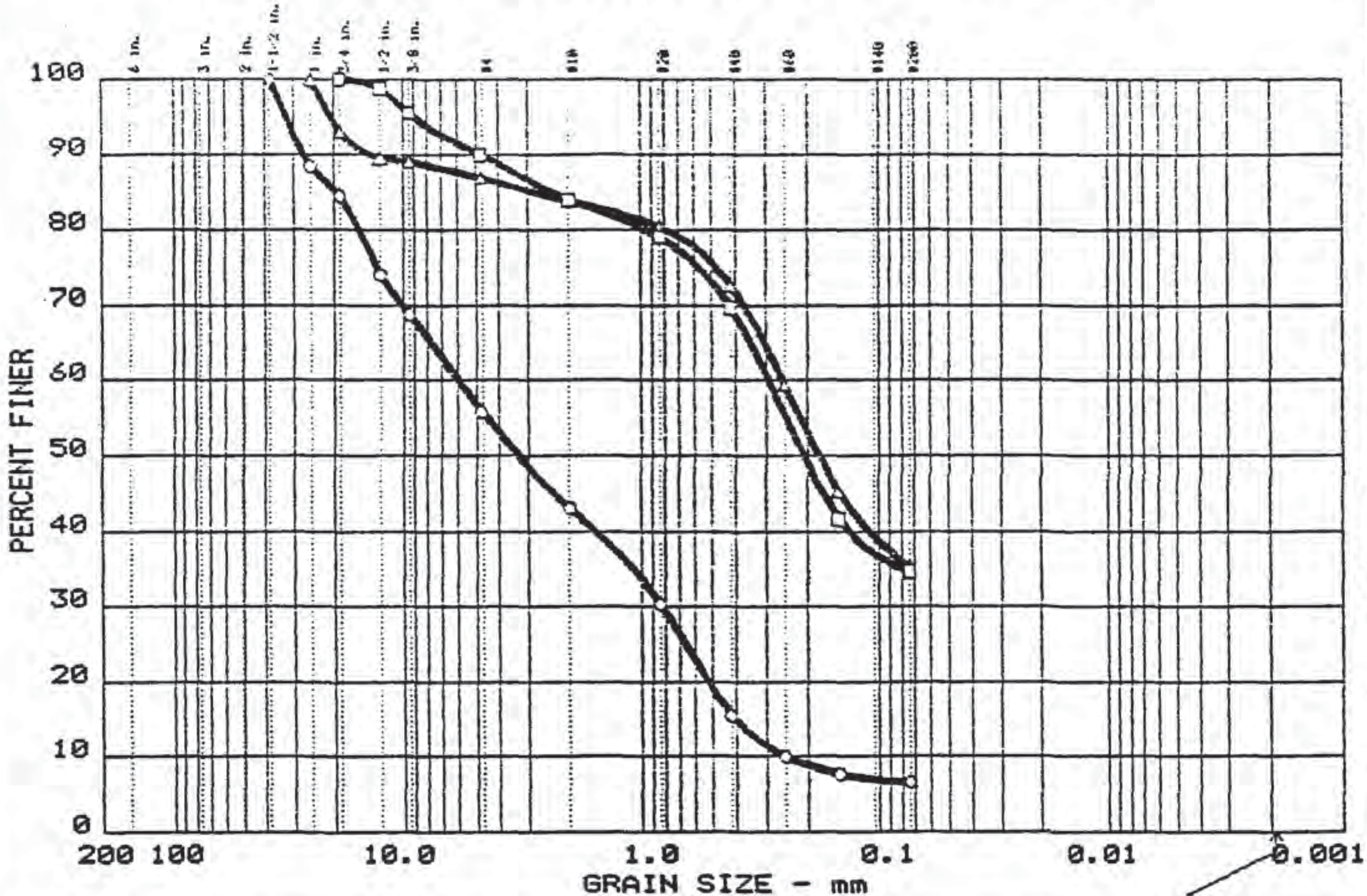
Location: BROAD & ELLIOT ST. SEATTLE, WA.

HART CROWSER

J-3041 08/02/90

Figure B-3

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	44.1	49.3	6.6	
△	0.0	13.1	51.6	35.3	
□	0.0	10.0	55.4	34.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			19.72	5.89	3.31	0.822	0.4074	0.2483	0.46	23.7
△			2.82	0.25	0.18					
□			2.34	0.29	0.21					

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Slightly silty, very gravelly, SAND	SP-SM	9%
△ Gravelly, very silty, medium-fine SAND	SM	14%
□ Slightly gravelly, very silty, SAND	SM	9%

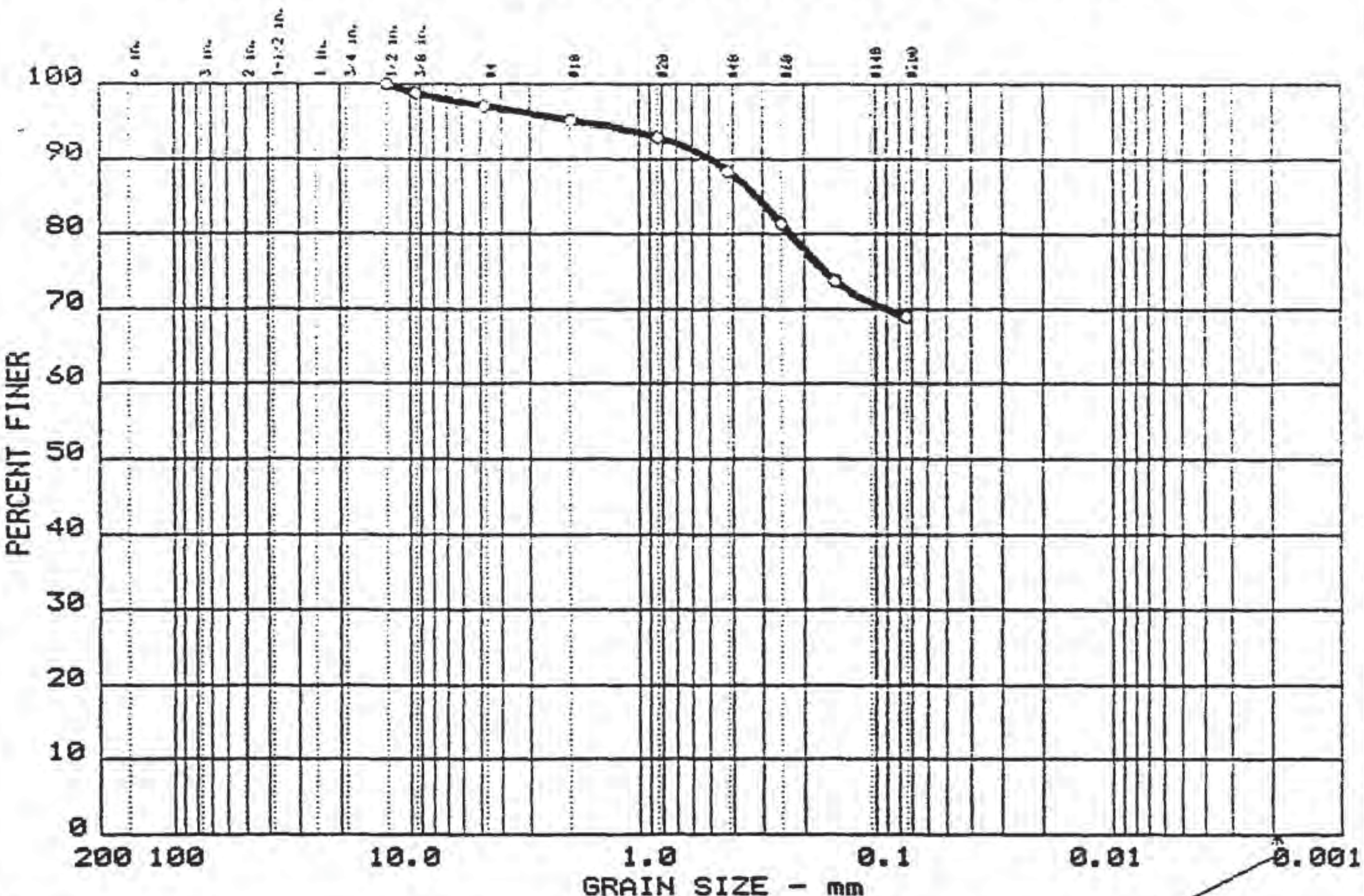
Remarks:

Project: BROAD & ELLIOT
○ Location: HC-02, S-04 DEPTH 17.5-19.0'
△ Location: HC-03, S-03 DEPTH 7.5-9.0'
□ Location: HC-03, S-05 DEPTH 17.5-18.5'

HARTCROWSER J-3041 08/17/90

Figure B-4

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
o	0.0	2.9	28.1	69.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
o			0.32							

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
o Sandy SILT	ML	16%

Remarks:

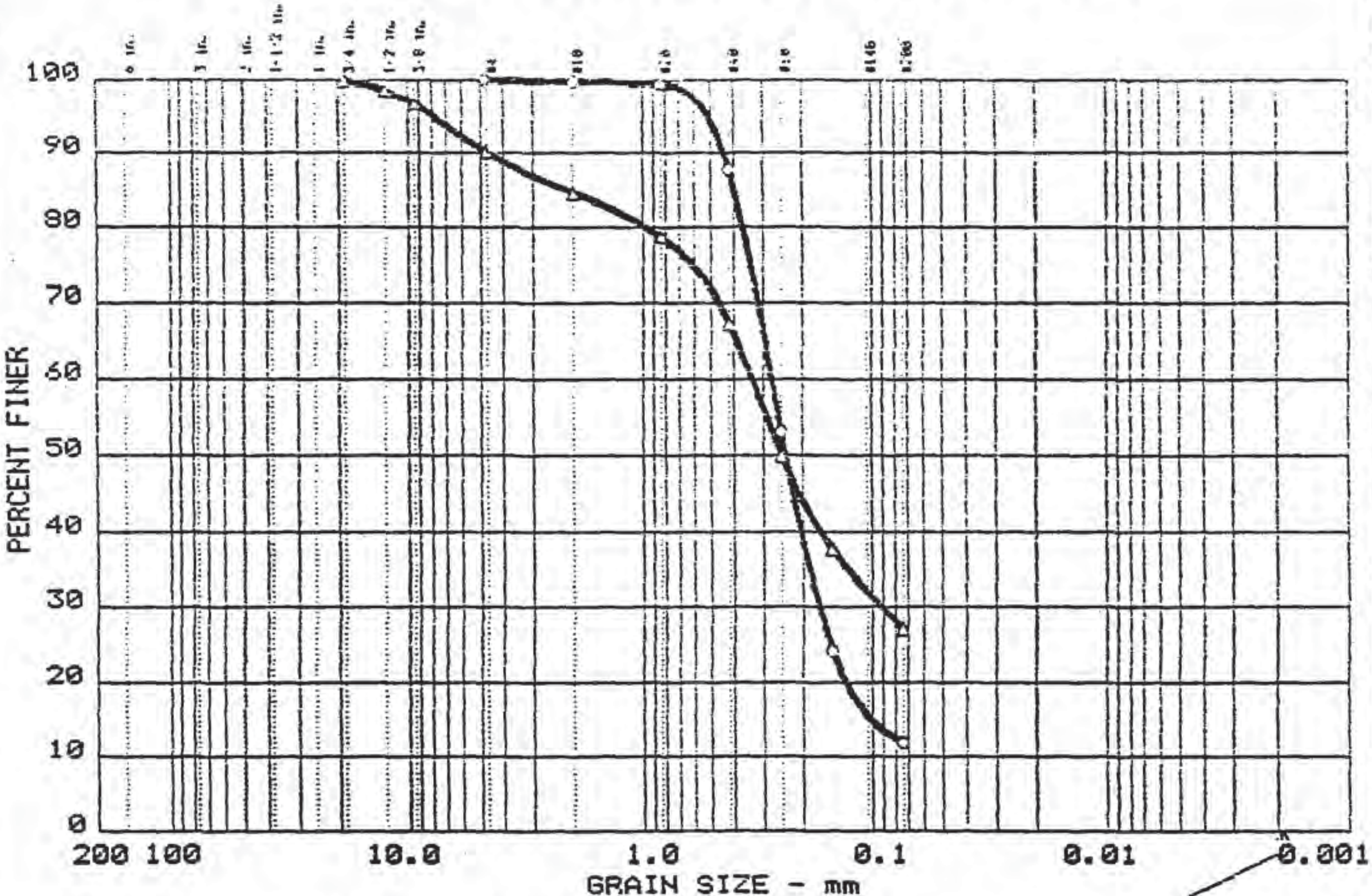
Project: BROAD & ELLIOT
o Location: HC-04, S-02 DEPTH 5.0-6.5'

HARTCROWSER

J-3041 08/17/90

Figure B-5

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	88.1	11.9	
△	0.0	9.9	63.0	27.1	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.40	0.27	0.24	0.171	0.1016			
△			2.11	0.33	0.25	0.091				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Silty, fine to medium SAND	SP-SM	21%
△ Slightly gravelly, silty, SAND	SM	12%

Remarks:

Project: BROAD & ELLIOTT

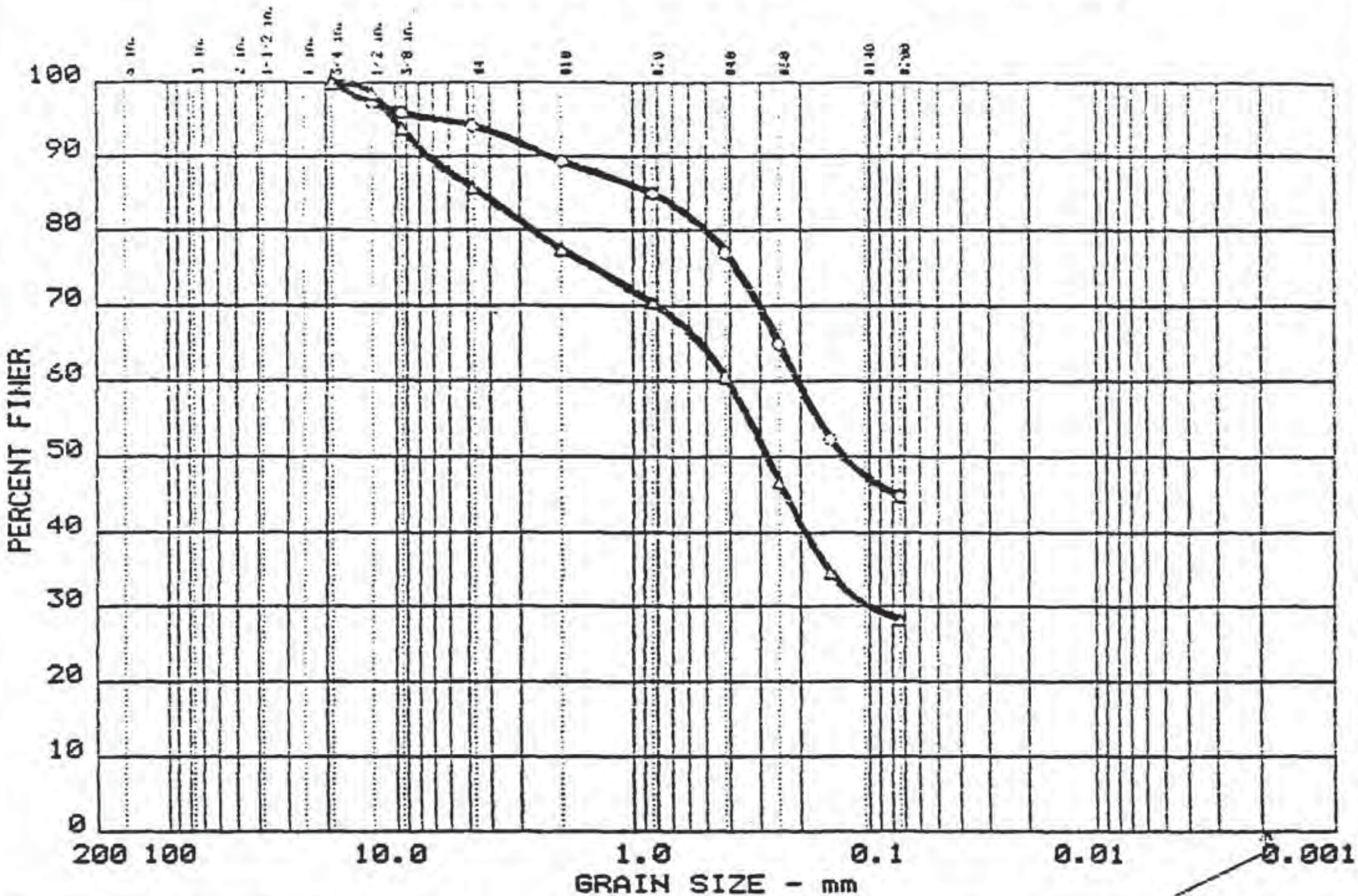
○ Location: HC-1, S-9, 42.5'-44.0'

△ Location: HC-5, S-4, 15.0'-16.5' *

HART CROWSER J-3041 2/14/91

Figure B-6

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	5.9	49.2	44.9	
△	0.0	14.2	57.6	28.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.84	0.21	0.13					
△			4.37	0.41	0.28	0.100				

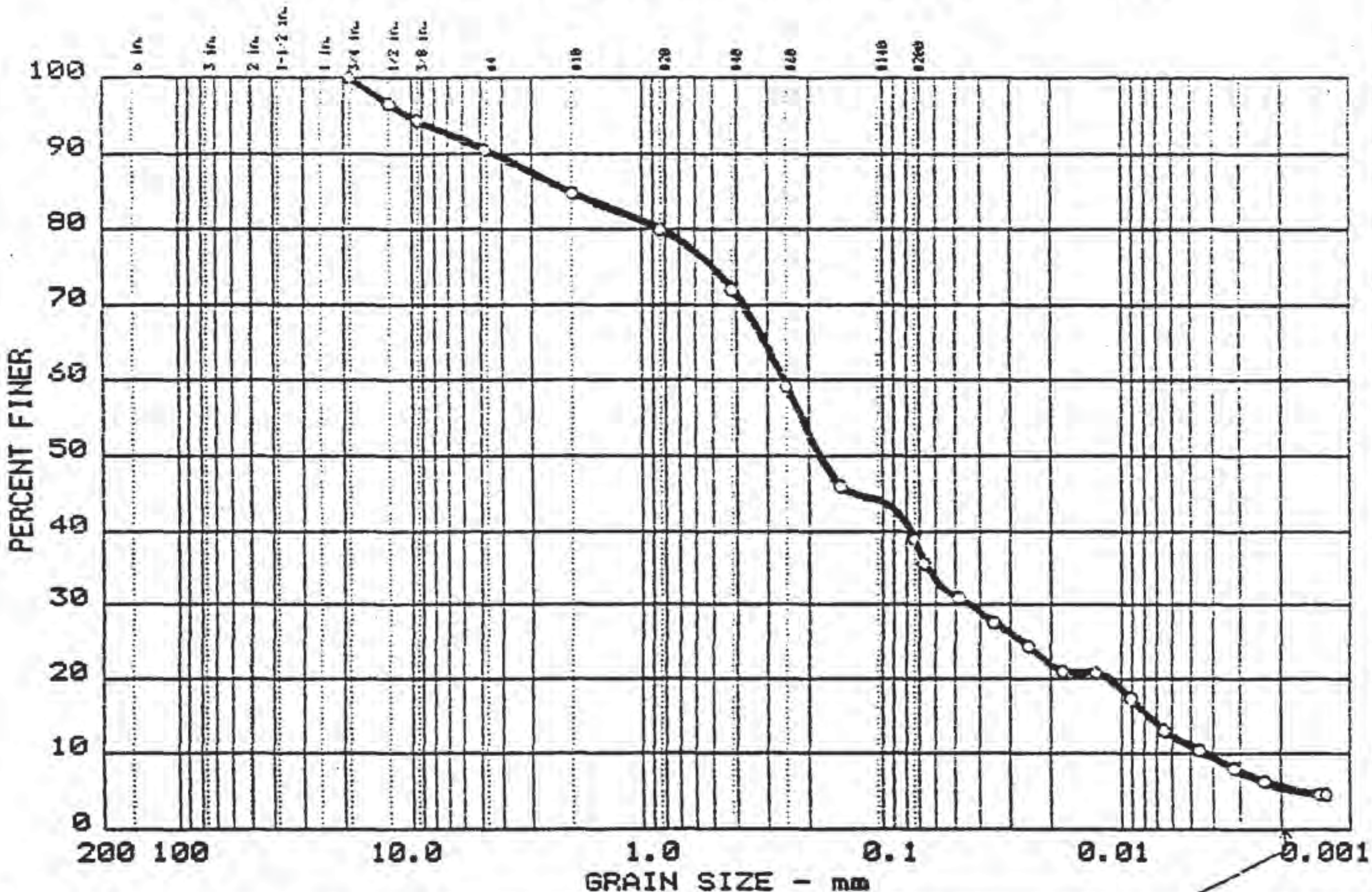
MATERIAL DESCRIPTION	USCS	NAT. MOIST.
○ Slightly gravelly, very silty, SAND	SM	12%
△ Gravelly, silty, SAND	SM	11%

Remarks:

Project: BROAD & ELLIOTT
○ Location: HC-6, S-4, 15.0'-15.8'
△ Location: HC-7, S-3, 12.5'-14.0'

HART CROWSER J-3041 2/14/91
Figure B-7

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
o	0.0	9.4	51.7	33.3	5.6

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
o			2.04	0.26	0.18	0.044	0.0076	0.0043	1.78	60.3

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
o Gravelly, very silty, SAND	SM	9%

Remarks:

SAMPLE CONTAINED A PIECE OF 1" GRAVEL, WHICH WAS NOT INCLUDED IN THE TEST

Project: BROAD & ELLIOTT

o Location: HC-7, S-4, 17.5'-19.0'

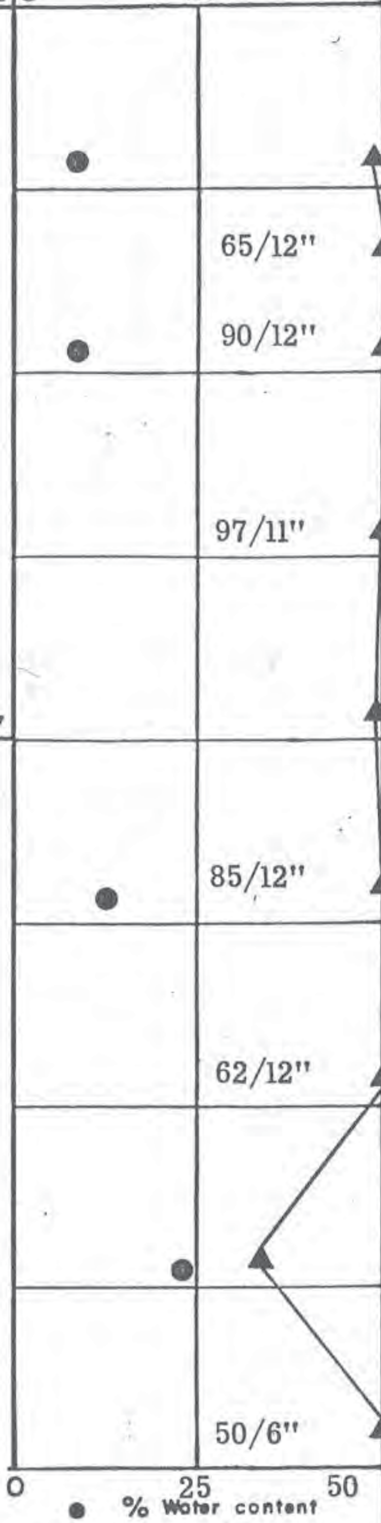
HART CROWSER

J-3041 2/14/91

Figure B-8

DEPTH, feet	USC	SOIL ESCRIPTION Surface Elevation: Elevation 40'	SAMPLES	DEPTH, feet
0–5		Loose to very dense, moist, brown, silty sand with gravel (Fill)		
5–11		Very dense, wet, gray, silty sand with gravel (Glacial Till)		
11–17.5		Very dense, moist, gray, silty, clayey sand with gravel (Glacial Till)		
17.5–31.5		Very dense, wet, gray, silty, fine to medium sand with coarse sand and gravel lenses		▽
31.5–36		Hard, moist, gray silt and clay		
36–40		Very dense, moist, gray, silt, clay and gravel with sand (Glacial Till)		

STANDARD PENETRATION RESISTANCE (140 lb. weight, 30" drop)



LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- ✱ Sample not recovered
- Impervious seal
- ▽ Water level
- Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification
- Atterberg limits: Liquid limit, Natural water content, Plastic limit

Trade Center Parking Garage

LOG OF BORING NO. B-1

W-2576

RITTENHOUSE - ZEMAN & ASSOC.

FOUNDATION AND SOILS ENGINEERING, GEOLOGY

DEPTH, feet	USC	SOIL ESCRIPTION Surface Elevation: Elevation 40'	SAMPLES	DEPTH, feet	STANDARD PENETRATION RESISTANCE (140 lb. weight, 30" drop) ▲ Blows per foot 0 25 50
		(continued)			
		——?——————?——			
		Very dense, wet, brown, silty, fine to medium sand with gravel	I		100/4" ▲
45					

0 ● % Water content

LEGEND

I 2.0" O.D. split spoon sample
II 3.0" O.D. thin-wall sample
* Sample not recovered

Atterberg limits:
Liquid limit
Natural water content
Plastic limit

Impervious seal
Water level
Piezometer tip
P Sampler pushed
USC Unified Soil Classification

Trade Center Parking Garage

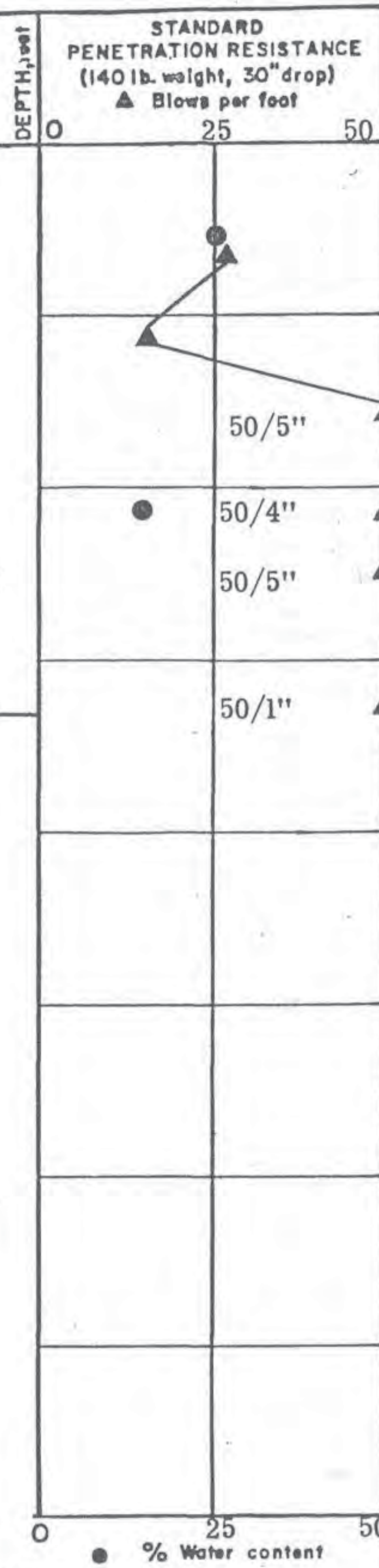
LOG OF BORING NO. B-1 (con't)

W-2576

RITTENHOUSE - ZEMAN & ASSOC.

FOUNDATION AND SOILS ENGINEERING, GEOLOGY

DEPTH, feet	USC	SOIL DESCRIPTION Surface Elevation: Elevation 23'	SAMPLES
		Asphalt	
		Crushed rock	
5		Very stiff, moist, gray silt and clay with gravel and organics (Fill)	I I
10		Hard, moist, brown, medium silty sand grading to silt and fine sand	I I I
15		Very dense, moist, light gray silty sand with gravel (Glacial Till)	
20		Refusal at 16.5 feet on large cobble	



LEGEND

I 2.0" O.D. split spoon sample
II 3.0" O.D. thin-wall sample
✱ Sample not recovered
Atterberg limits:
Liquid limit
Natural water content
Plastic limit

Impervious seal
Water level
Piezometer tip
P Sampler pushed
USC Unified Soil Classification

Trade Center Parking Garage

LOG OF BORING NO. B-2

W-2576

RITTENHOUSE - ZEMAN & ASSOC.

FOUNDATION AND SOILS ENGINEERING, GEOLOGY

DEPTH, feet	USC	SOIL DESCRIPTION Surface Elevation: Elevation 40'	STANDARD PENETRATION RESISTANCE (140 lb. weight, 30" drop) ▲ Blows per foot
0–3.5		Loose, moist, brown silty sand with organics (Fill)	
3.5–11.5		Very dense, moist, gray silty sand with clay, silt, sand and gravel lenses 4 to 6 inches thick (Glacial Till)	88/9" 31/0" 55/12"
11.5–23.5		Very dense, moist, brown with gray silty sand with gravel zones and silt lenses	76/12" 50/1"
23.5–32		Very dense, moist to wet, brown, silty sand and gravel (Glacial Till)	50/4" 50/1" 50/1"
32		Refusal at 32 feet on large boulder	

Scale: 0 25 50 ● % Water content

LEGEND

- I 2.0" O.D. split spoon sample
- II 3.0" O.D. thin-wall sample
- ✱ Sample not recovered
- Atterberg limits: Liquid limit; Natural water content; Plastic limit
- Impervious seal
- ∇ Water level
- Piezometer tip
- P Sampler pushed
- USC Unified Soil Classification

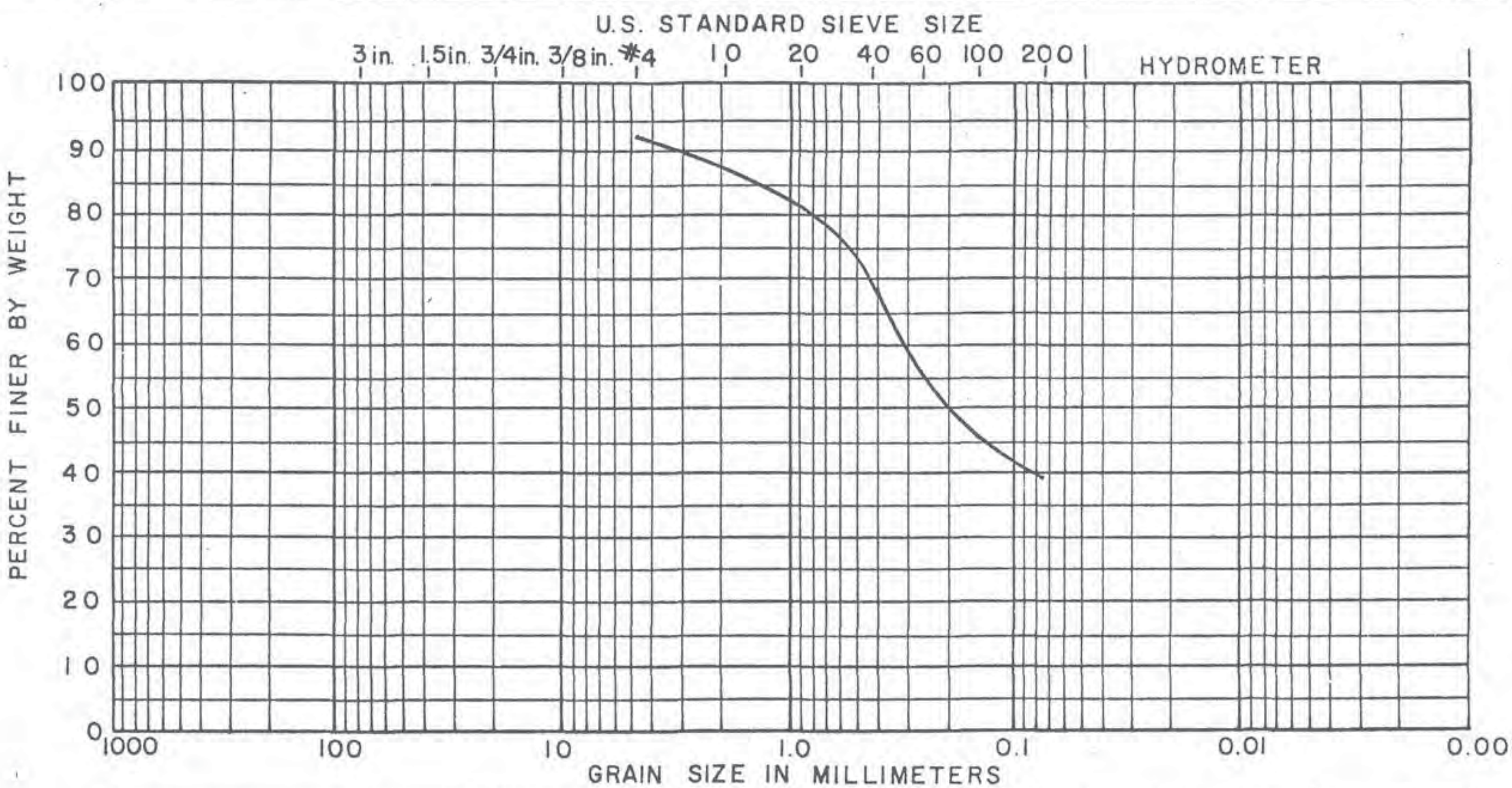
Trade Center Parking Garage

LOG OF BORING NO. B-3

W-2576

RITTENHOUSE - ZEMAN & ASSOC.

FOUNDATION AND SOILS ENGINEERING, GEOLOGY



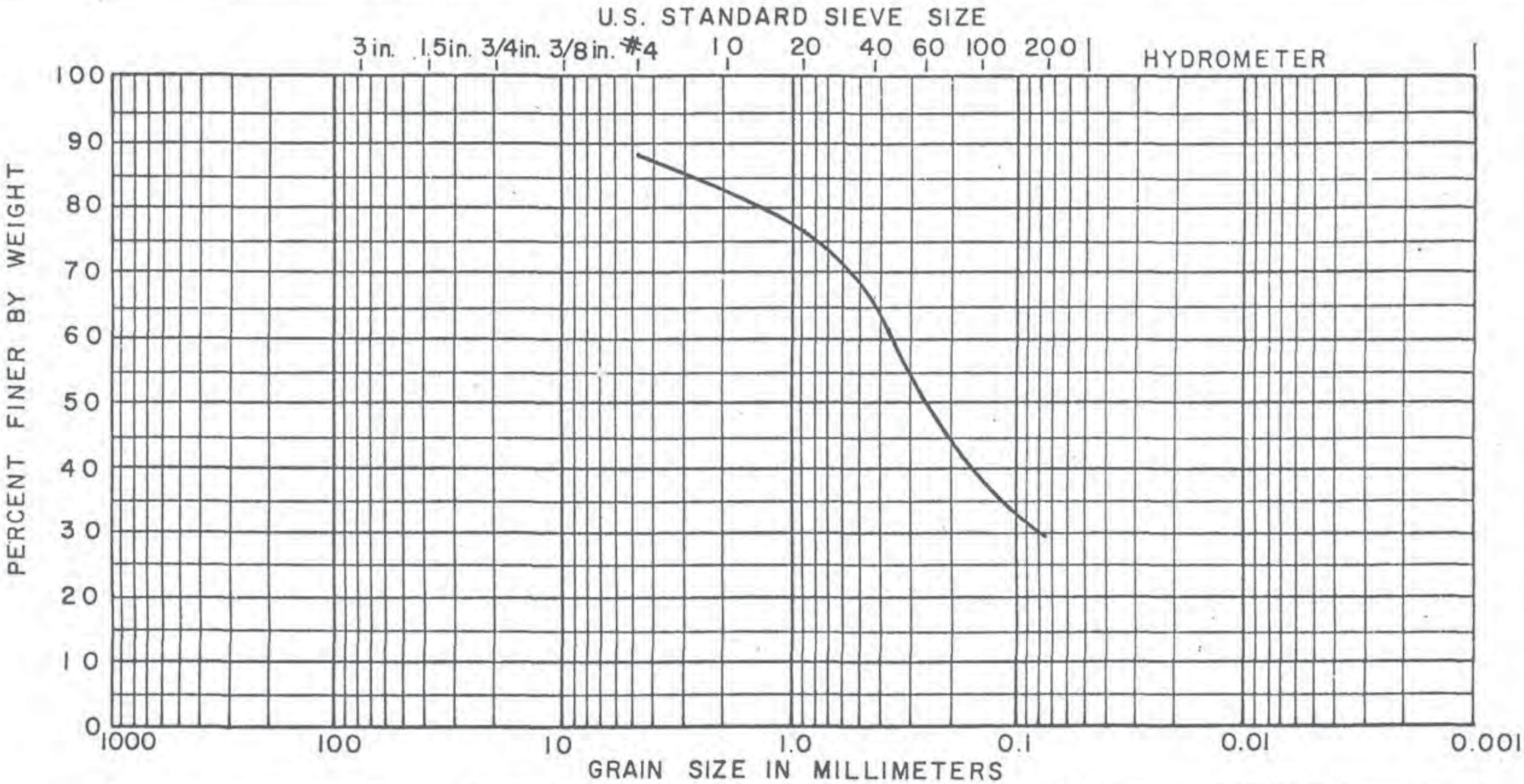
COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

PROJECT _Parking Garage Site_ WORK ORDER _2576_

Boring _1_ Sample _1_ Depth _3.5'-4.7'_ Dust Ratio ____ % Passing 200 _39.2_

GRAIN SIZE DISTRIBUTION

RITTENHOUSE-ZEMAN & ASSOC., INC.
GEOTECHNICAL ENGINEERING



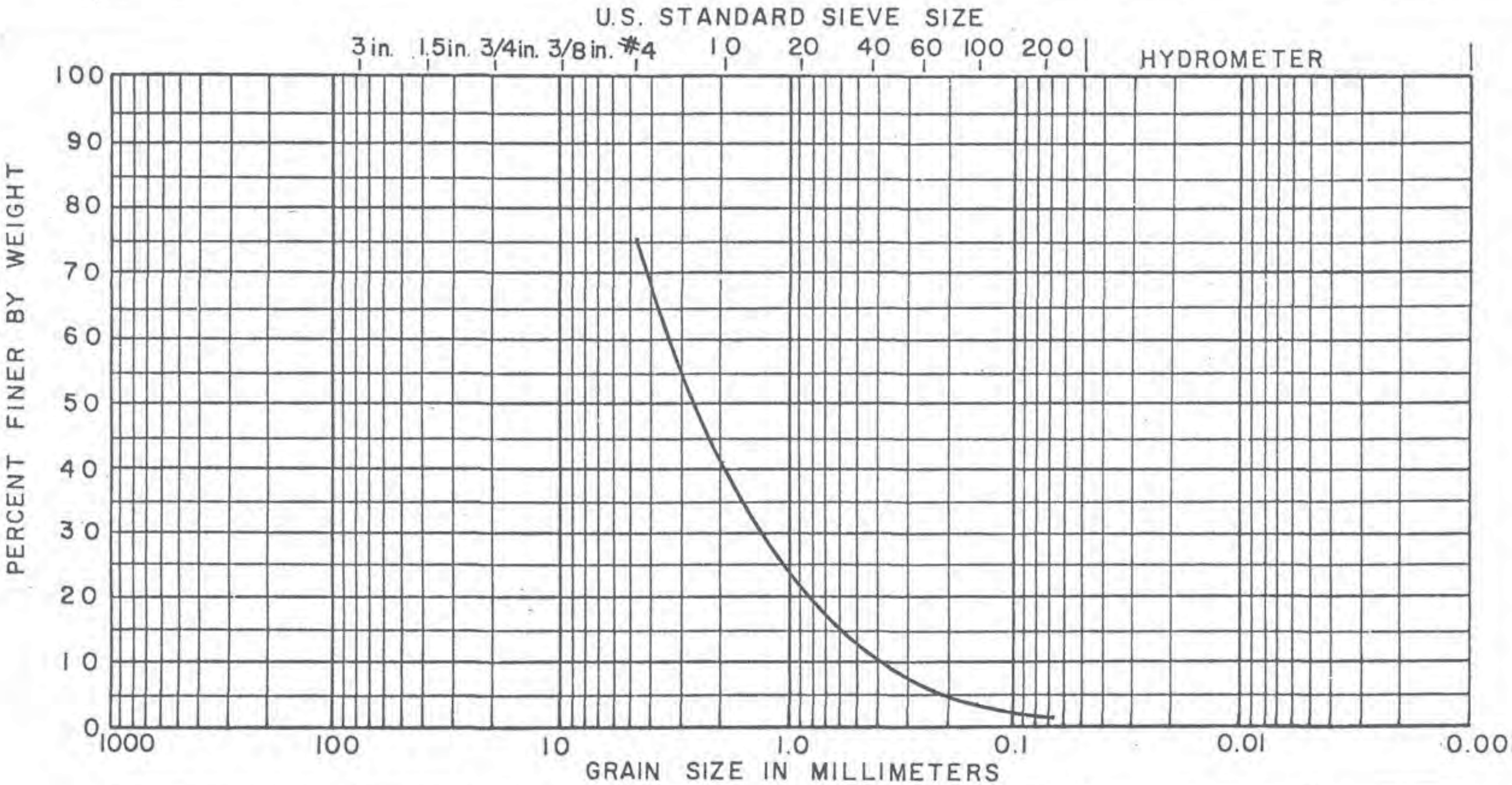
COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

PROJECT Parking Garage Site WORK ORDER 2576

Boring 1 Sample 3 Depth 8.5'-9.7' Dust Ratio ____ % Passing 200 29.5

GRAIN SIZE DISTRIBUTION

RITTENHOUSE-ZEMAN & ASSOC., INC.
GEOTECHNICAL ENGINEERING



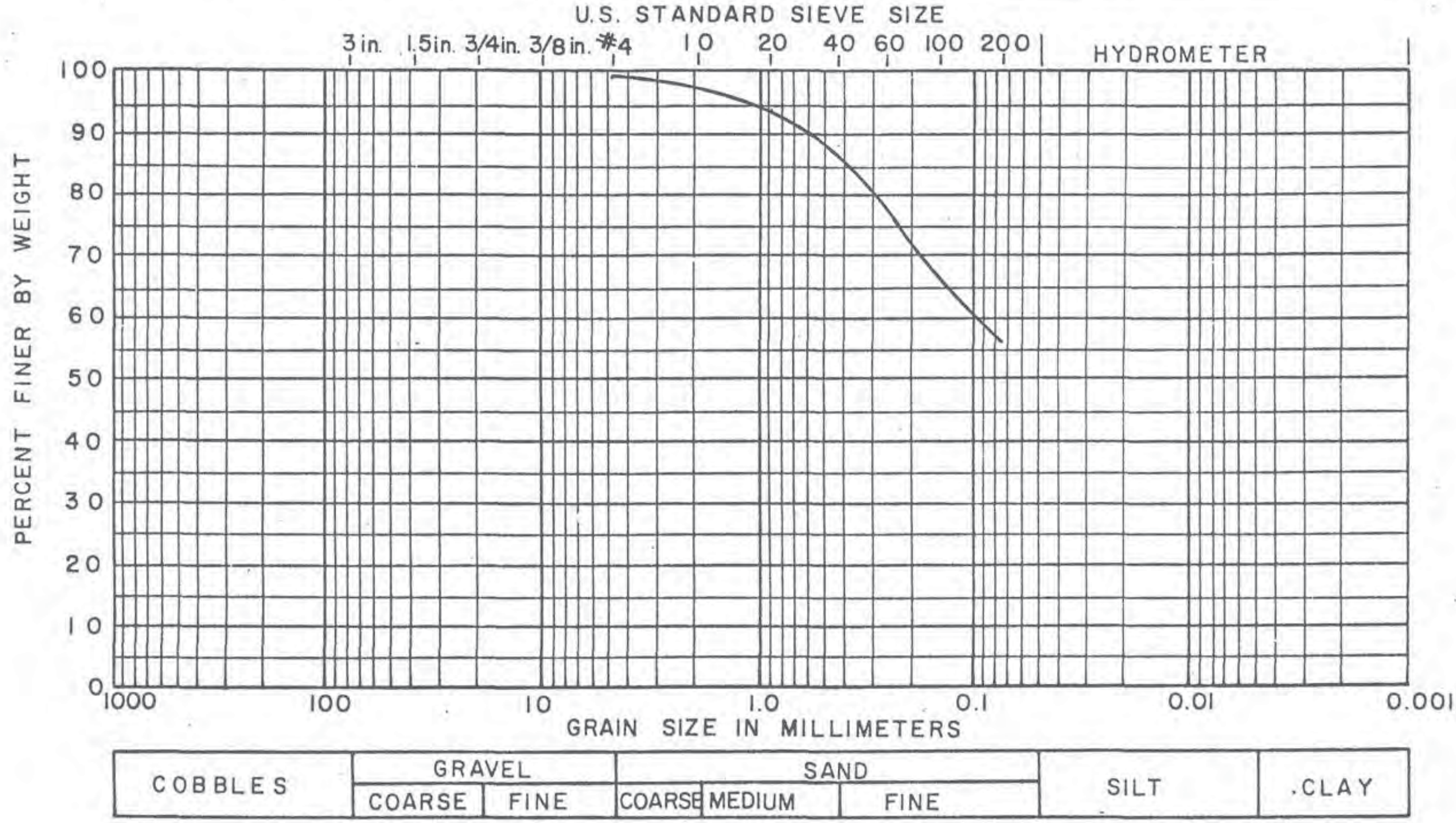
COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

PROJECT *Parking Garage Site* WORK ORDER *2576*

Boring *1* Sample *6* Depth *23.5'-25.0'* Dust Ratio ____ % Passing 200 *1.7*

GRAIN SIZE DISTRIBUTION

RITTENHOUSE-ZEMAN & ASSOC., INC.
GEOTECHNICAL ENGINEERING

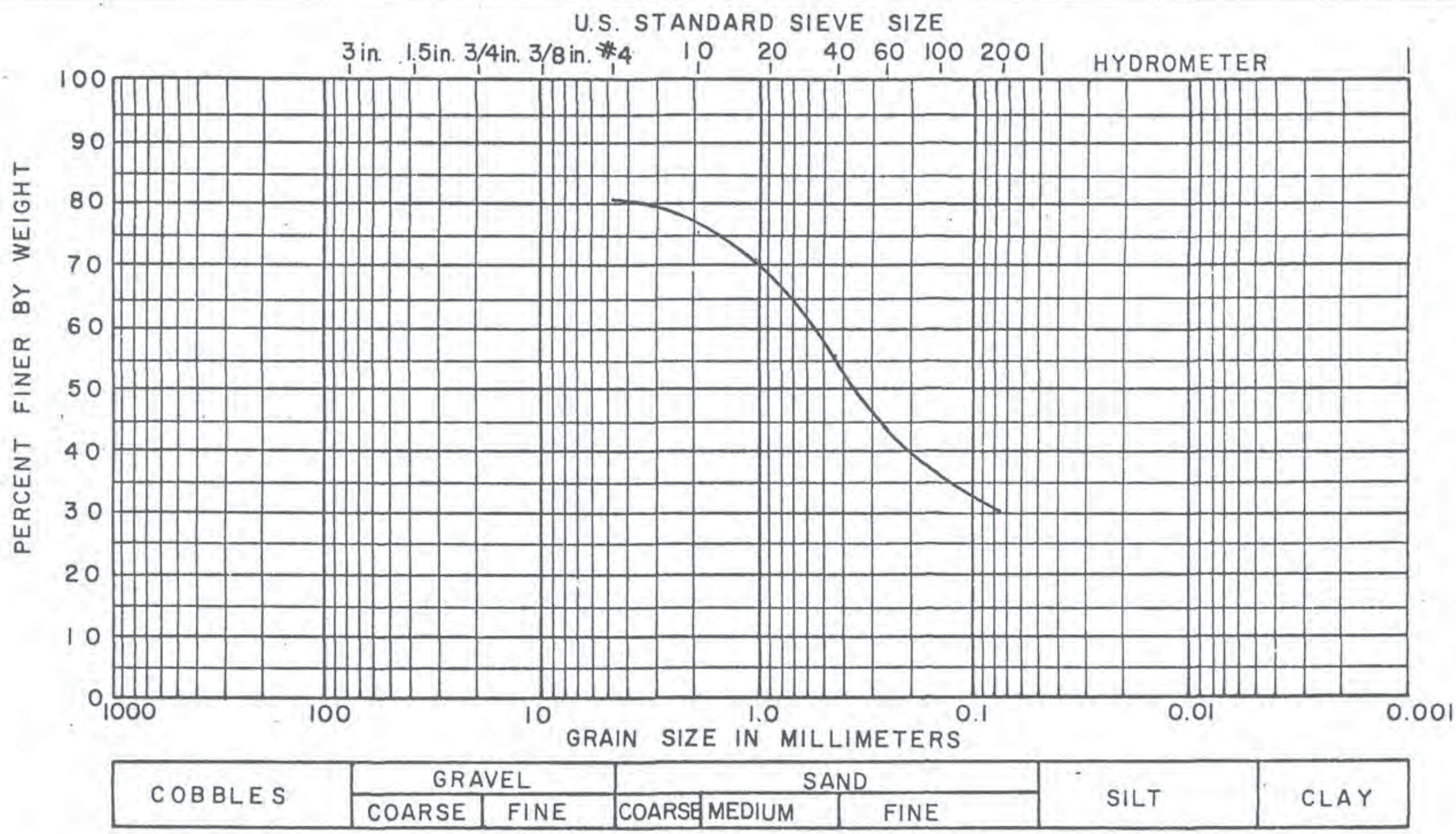


PROJECT Parking Garage Site WORK ORDER 2576

Boring 3 Sample 3 Depth 8.5'-9.0' Dust Ratio ____ % Passing 200 56.3

GRAIN SIZE DISTRIBUTION

RITTENHOUSE-ZEMAN & ASSOC., INC.
GEOTECHNICAL ENGINEERING

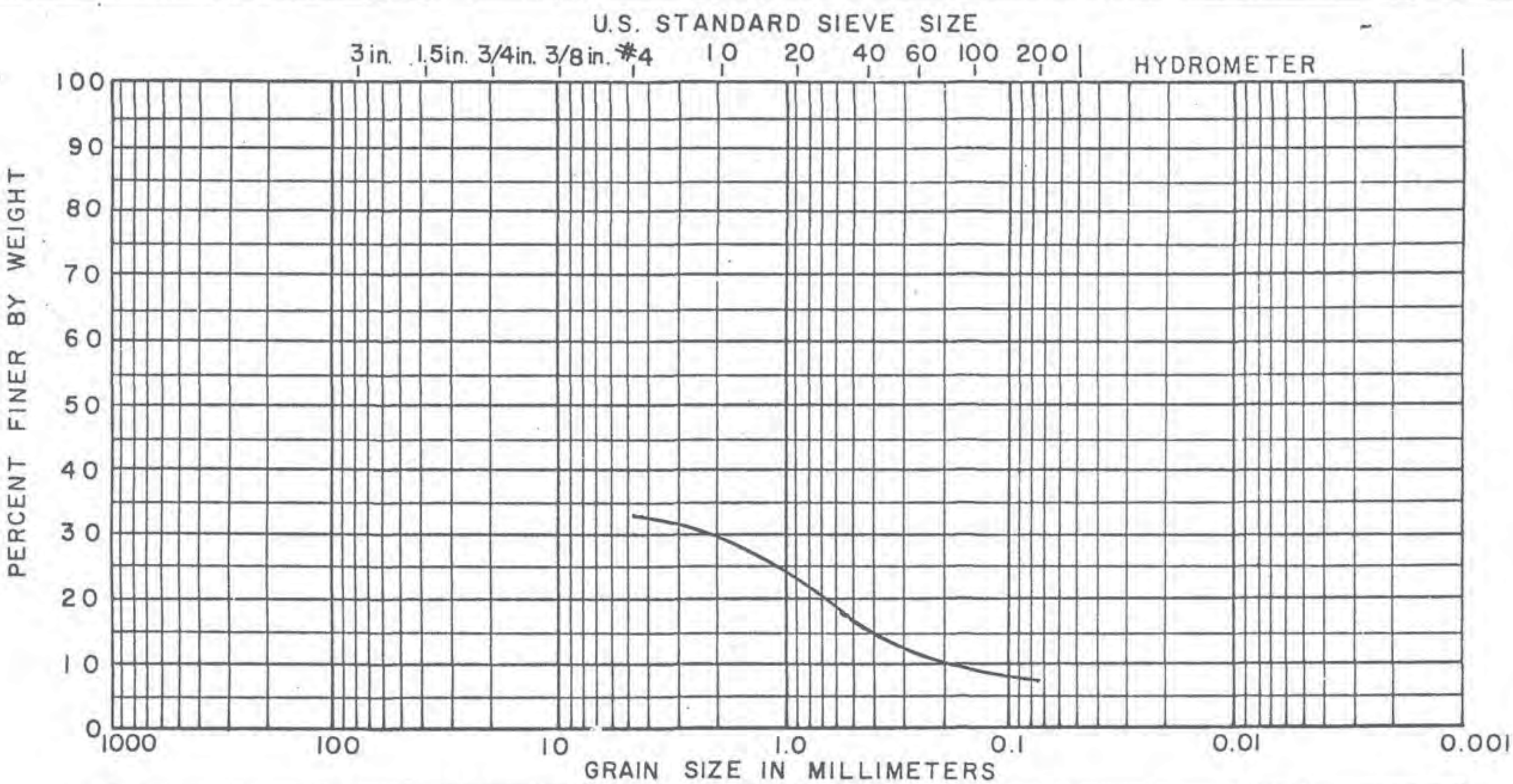


PROJECT Parking Garage Site WORK ORDER 2576

Boring 3 Sample 5 Depth 18.5'-19.2' Dust Ratio ____ % Passing 200 30.3

GRAIN SIZE DISTRIBUTION

RITTENHOUSE-ZEMAN & ASSOC., INC.
GEOTECHNICAL ENGINEERING



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

PROJECT Parking Garage Site WORK ORDER 2576

Boring 3 Sample 7 Depth 28.5'-29.2 Dust Ratio ____ % Passing 200 7.4

GRAIN SIZE DISTRIBUTION

RITTENHOUSE-ZEMAN & ASSOC., INC.
GEOTECHNICAL ENGINEERING

Unified Soil Classification System

Criteria for Assigning Group Symbols and Names			Soil Classification	Generalized Group Descriptions
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	GRAVELS More than 50% of coarse fraction retained on No. 4 Sieve	CLEAN GRAVELS Less than 5% fines	GW	Well-graded Gravels
			GP	Poorly-graded gravels
		GRAVELS WITH FINES More than 12% fines	GM	Gravel and Silt Mixtures
			GC	Gravel and Clay Mixtures
	SANDS 50% or more of coarse fraction passes No. 4 Sieve	CLEAN SANDS Less than 5% fines	SW	Well-graded Sands
			SP	Poorly-graded Sands
		SANDS WITH FINES More than 12% fines	SM	Sand and Silt Mixtures
			SC	Sand and Clay Mixtures
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	SILTS AND CLAYS Liquid limit less than 50	INORGANIC	CL	Low-plasticity Clays
			ML	Non-plastic and Low-Plasticity Silts
		ORGANIC	OL	Non-plastic and Low-Plasticity Organic Clays Non-plastic and Low-Plasticity Organic Silts
	SILTS AND CLAYS Liquid limit greater than 50	INORGANIC	CH	High-plasticity Clays
			MH	High-plasticity Silts
		ORGANIC	OH	High-plasticity Organic Clays High-plasticity Organic Silts
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat

Component Definitions by Gradation

Component	Size Range
Boulders	Above 12 in.
Cobbles	3 in. to 12 in.
Gravel	3 in. to No. 4 (4.76mm)
Coarse gravel	3 in. to 3/4 in.
Fine gravel	3/4 in. to No. 4 (4.76mm)
Sand	No. 4 (4.76mm) to No. 200 (0.074mm)
Coarse sand	No. 4 (4.76mm) to No. 10 (2.0mm)
Medium sand	No. 10 (2.0mm) to No. 40 (0.42mm)
Fine sand	No. 40 (0.42mm) to No. 200 (0.074mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

Samples

SS	SPT Sampler (2.0" OD)
HD	Heavy Duty Split Spoon
SH	Shelby Tube
P	Pitcher Sampler
B	Bulk
C	Cored

Unless otherwise noted, drive samples advanced with 140 lb. hammer with 30 in. drop.

Relative Density or Consistency Utilizing Standard Penetration Test Values

Cohesionless Soils (a)			Cohesive Soils (b)		
Density (c)	N, blows/ft. (c)	Relative Density (%)	Consistency	N, blows/ft. (c)	Undrained Shear Strength (psf) (d)
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
Compact	10 to 30	35 - 65	Firm	4 to 8	500-1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000-2000
Very Dense	over 50	>85	Very Stiff	15 to 30	2000-4000
			Hard	over 30	>4000

(a) Soils consisting of gravel, sand, and silt, either separately or in combination, possessing no characteristics of plasticity, and exhibiting drained behavior.

(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.

(c) Refer to text of ASTM D 1586-84 for a definition of N; in normally consolidated cohesionless soils Relative Density terms are based on N values corrected for overburden pressures.

(d) Undrained shear strength = 1/2 unconfined compression strength.

Laboratory Tests

Test	Designation
Moisture	(1)
Density	D
Grain Size	G
Hydrometer	H
Atterberg Limits	(1)
Consolidation	C
Unconfined	U
UU Triax	UU
CU Triax	CU
CD Triax	CD
Permeability	P

(1) Moisture and Atterberg Limits plotted on log.

Silt and Clay Descriptions

Description	Typical Unified Designation
Silt	ML (non-plastic)
Clayey Silt	CL-ML (low plasticity)
Silty Clay	CL
Clay	CH
Plastic Silt	MH
Organic Soils	OL, OH, Pt

Descriptive Terminology Denoting Component Proportions

Descriptive Terms	Range of Proportion
Trace	0-5%
Little	5-12%
Some or Adjective (a)	12-30%
And	30-50%

(a) Use Gravelly, Sandy or Silty as appropriate.

Golder Associates

Figure

SOIL CLASSIFICATION/LEGEND

773-1064/FORM 573

PROJECT: Legacy/Broad & Western/WA

RECORD OF BOREHOLE P-2

SHEET 1 **OF** 2

DATUM: MSL

PROJECT NUMBER: 993 1579.100 **BORING LOCATION:** Broad & Western Lot III

BORING DATE: 8/11/99

Boring method: 4 1/4" I.D. HSA

Sample w/ 2" O.D. spoon driven w/ 140 lb auto-hammer

Blows / 6 in.: 140 lb. hammer, 30 inch drop

Boring completed with flush monument and locking cap on PVC

Depth (feet)	Description	USCS	Elev. / Depth	Sample Number	Type	Blows / 6 in.	N	Rec/Att
0	Concrete							
	Very loose, brown to light olive brown, nonstratified, mottled SILT, little to some fine to coarse sand, trace fine gravel, ranging to silty SAND, trace fine gravel, trace organics (wood fragments) moist (FILL))	SM/ML						
5				1	SS	1-1-3	4	1.5/1.5
	Compact, light gray to brownish orange, nonstratified, iron oxide stained, fine to medium SAND, little to some silt, little rounded gravel (FILL?)	SP/SM	30.0 / 8.0					
10				2	SS	8-12-13	25	1.5/1.5
	Dense, light olive brown to light olive gray, massive to stratified, fine to medum SAND, little to some silt, little fine to coarse rounded gravel, grades downward to fine SAND, trace to some silt, trace to little rounded gravel, iron-oxide stained in places, moist to wet (ADVANCE OUTWASH)	SP/SM	24.0 / 14.0					
15				3	SS	8-14-25	39	1.5/1.5
	Dense to light olive brown to light olive gray, massive to stratified, fine to medium SAND, little to some silt, little fine to coarse rounded gravel, grades downward to fine SAND, trace to some silt, trace to little rounded gravel, iron-oxide stained in places, moist to wet (ADVANCE OUTWASH)	SP	19.0 / 19.0					
20				4	SS	10-18-25	43	1.5/1.5
	Very dense and hard, light bluish gray, stratified CLAYEY SILT, trace fine to coarse sand, trace rounded gravel dropstones, contains thin interbeds and laminae of fine SAND, also thin (<1mm) SILT partings, damp, ppen > 4.5 tsf (GLACIOLACUSTRINE DEPOSIT)	CL-ML	14.5 / 23.5					
25				5	SS	22-44-50	94	1.5/1.5
	Dense, light bluish gray to light greenish gray, stratified, fine to coarse SAND, trace to some silt, some fine to coarse, subrounded to rounded gravel, varies to sandy GRAVEL, trace to some silt, moist (ADVANCE OUTWASH)	SM/GM	10.0 / 28.0					
30								

Log continued on next page

Penetration Resistance Blows/ft. ■ (scale 0, 10, 20, 30, 40, 50); Water Content, Percent (Wp — W — Wl)

Piezometer graphic / water level:
- 1 bag Jet set
- 1 bag concrete
- 16-50lb sacks Pure Gold Medium Bentonite Chips
- ▽ 8/13/99 14.2' BGS
- 6-100 lb sacks #2/12 Silica Sand
- 2-inch Sch 40 PVC 0.010 slot screen w/ flush threaded joints

DRILL RIG: CME 75

DRILLING CONTRACTOR: Cascade

DRILLER: B. Gose

LOGGED: F. Mocker

CHECKED:

DATE: 8/24/99

Golder Associates

PROJECT: Legacy/Broad & Western/WA

RECORD OF BOREHOLE P-2

SHEET 2 **OF** 2

DATUM: MSL

PROJECT NUMBER: 993 1579.100

BORING LOCATION: Broad & Western Lot III

BORING DATE: 8/11/99

DEPTH FEET	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	ELEV. / DEPTH	SAMPLE NUMBER	TYPE	BLOWS / 6 IN. (140 lb. hammer, 30 inch drop)	N	REC/ATT	PIEZOMETER GRAPHIC / WATER LEVEL
30	4 1/4" I.D. HSA	Dense, light bluish gray to light greenish gray, stratified, fine to coarse SAND, trace to some silt, some fine to coarse, subrounded to rounded gravel, varies to sandy GRAVEL, trace to some silt, moist (ADVANCE OUTWASH)	SM/GM		6	SS	16-23-23	46	1.5/1.5	
		Dense, light bluish gray, stratified, fine SAND, trace silt, ranging to fine SAND and SILT, moist to wet (TRANSITIONAL BEDS)	SP	5.0 / 33.0						6-100 lb sacks #2/12 Silica Sand
35					7	SS	14-22-14	36	1.5/1.5	2-inch Sch 40 PVC 0.010 slot screen w/ flush threaded joints
		Dense and hard, light bluish gray, interbedded, laminated SILT ranging to CLAYEY SILT with SILTY CLAY laminae and interbeds of fine to medium SAND, trace silt, damp to moist, ppen ≥ 4.5 tsf (TRANSITIONAL BEDS)	CL-ML	-0.5 / 38.5						
40					8	SS	10-17-21	38	1.5/1.5	4-50 lb sacks Pure Gold Medium Bentonite Chips
45					9	SS	11-16-20	36	1.5/1.5	
		Hard, dark gray, jointed, laminated CLAY ranging to SILTY CLAY, damp to moist (GLACIOLACUSTRINE DEPOSIT)	CH	-10.5 / 48.5						
50					10	SS	10-12-17	29	1.5/1.5	
		Total depth 51.5' sampled Note: No contamination observed during drilling. Zero ppm headspace readings on all samples.		-13.5 / 51.5						
55										
60										

PENETRATION RESISTANCE BLOWS/FT. ■ (0, 10, 20, 30, 40, 50); WATER CONTENT, PERCENT (Wp, W, Wl)

DRILL RIG: CME 75

DRILLING CONTRACTOR: Cascade

DRILLER: B. Gose

LOGGED: F. Mocker

CHECKED:

DATE: 8/24/99

Golder Associates

PROJECT: Legacy/Broad & Western/WA

RECORD OF BOREHOLE P-4

SHEET 1 **OF** 1

DATUM: MSL

PROJECT NUMBER: 993 1579.100

BORING LOCATION: Broad & Western Lot I

BORING DATE: 8/11/99

DEPTH FEET	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT	PENETRATION RESISTANCE BLOWS/FT. ■ (0 10 20 30 40 50) / WATER CONTENT PERCENT (Wp —W— Wl)	PIEZOMETER GRAPHIC / WATER LEVEL
0	4 1/4" I.D. HSA				-22.0							
		Asphalt			0.0	Used 2.5" split spoon driver with 300 lb hammer					Finished piezo with flush mon cemented in place with lbg JetSet. Locking Cap @ top of PVC	
		Loose to compact, light olive green, nonstratified, fine to coarse SAND, little to some silt, trace rounded gravel, moist becoming wet @ ~7.5' bgs (FILL) @ 2.5': zero ppm headspace Finished piezo with flush mon cemented in place with lbg JetSet Locking Cap @ top of PVC	SM									1-50lb sacks Pure Gold Chips (1.5-4' bgs)
						1	SS	7-9-5	14	1.5/1.5	■	
5												4-100 lb sacks #2/12 Silica Sand 2 inch Sch. 40 PVC 0.010 slot screen w/flush joints
		@ 7.5': color change to brownish black, trace organics, petroleum odor, 15.8 ppm headspace				2	SS	2-3-3	6	1.5/1.5	■	▽ 8/12/99 8.0' BGS
10												
		Very dense, light olive brown, nonstratified, fine to coarse SAND, some rounded, fine to coarse gravel, little to some silt, varies to SILT and SAND, little rounded gravel, moist, iron oxide stained (ADVANCE OUTWASH) very light petroleum odor 2.6 – 5.2 ppm headspace	SM/ ML		9.5 12.5	3	SS	37-30-35	65	1.5/1.5	■ →	
15						4	SS	12-50/4"	>50	0.8/0.8	■ →	Bottom Cap
		Total Depth 15.8' sampled 1 drum of moist cuttings – PID ~4ppm			6.1 15.9							Sample Hole
20												
25												
30												

DRILL RIG: CME 75

DRILLING CONTRACTOR: Cascade

DRILLER: B. Gose

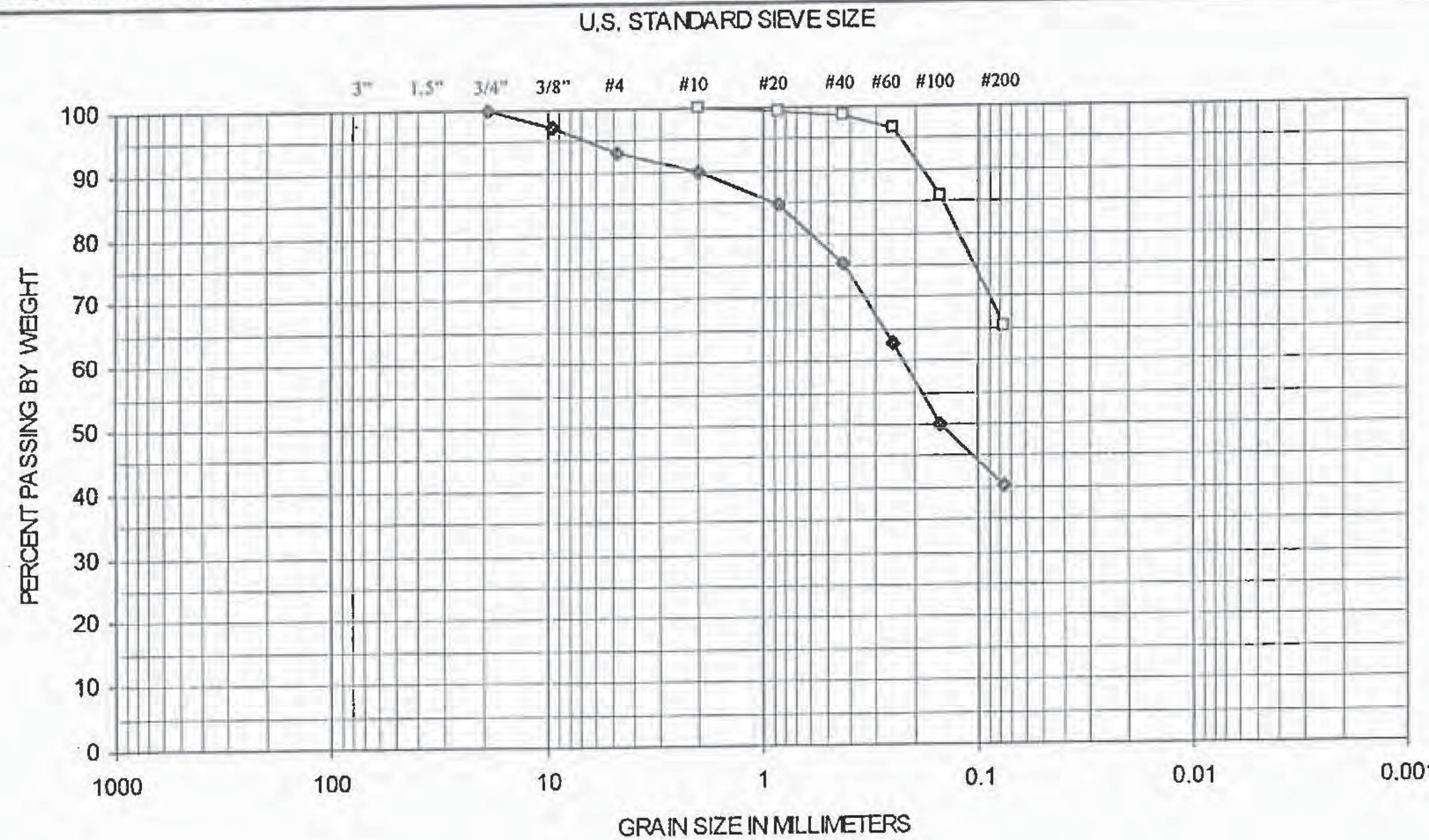
LOGGED: F. Mocker

CHECKED:

DATE: 8/24/99

Golder Associates

0314-035-00 (993-1579.100) JRS:MBB:mbb 9/8/99 (Sieves.ppt)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

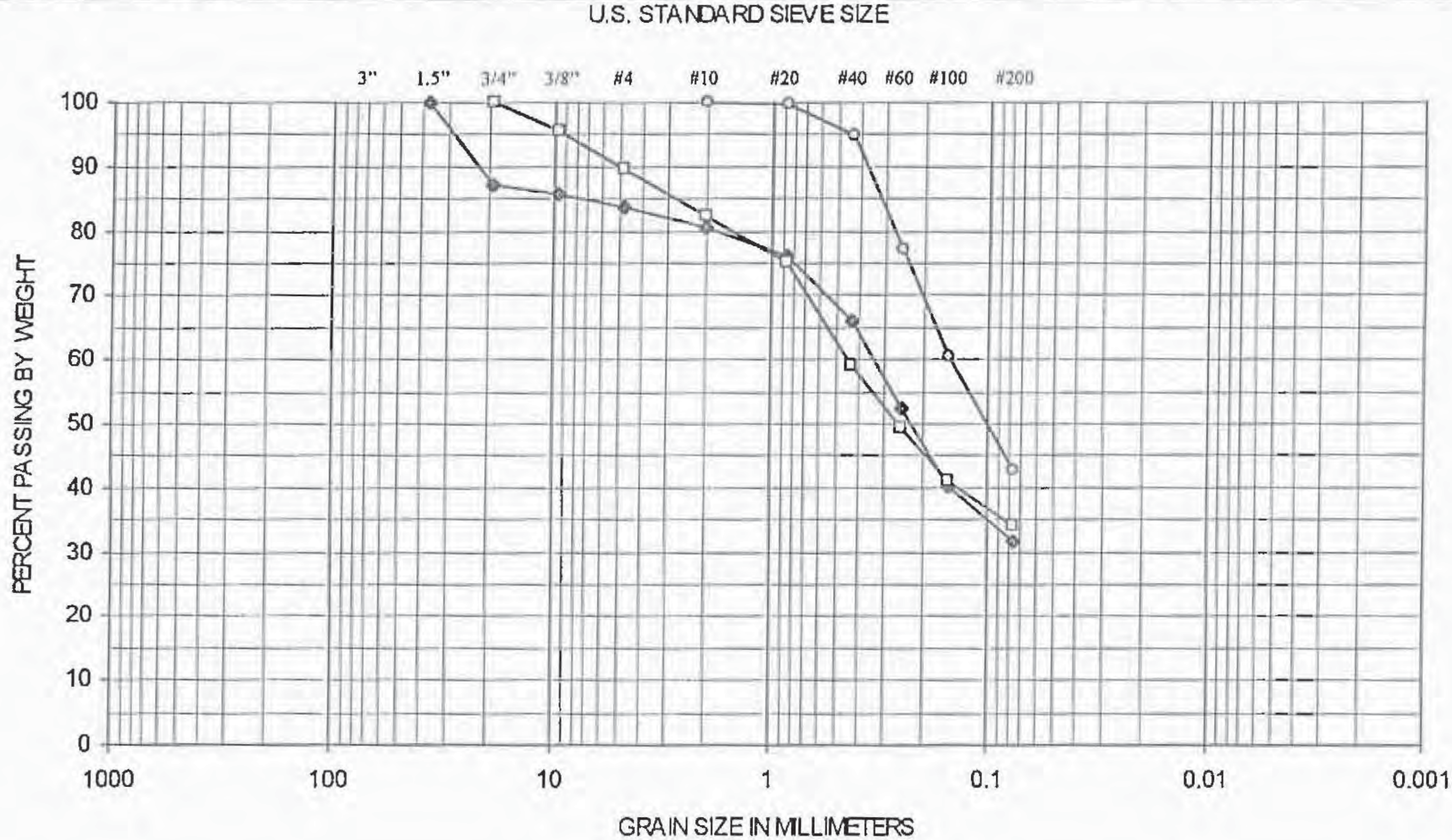
SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◈	P-1	10-11.5	Brown-gray silty fine sand (SM)
□	P-1	25-26.5	Brown fine sandy silt (ML)

Geo Engineers

SIEVE ANALYSIS RESULTS

FIGURE #

0314-035-00 (993-1579.100) JRS:MBB:mbb 9/8/99 (Sieves.ppt)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◈	P-2	15-16.5	Brown silty fine sand with gravel (SM)
□	P-2	30-31.5	Gray silty fine to medium sand (SM)
⊙	P-2	35-36.5	Gray silty fine sand (SM)

GeoEngineers

SIEVE ANALYSIS RESULTS

FIGURE #

JOB NO. 3016	CLIENT GSL Properties	LOCATION Clay & Elliott	BORING NO #1
DRILLING METHOD HSA	DRILLING CONTR. Geoboring	START / FINISH	
SAMPLING METHOD SS	WATER LVL.		
HAMMER WT. 300 / DROP 18"	TIME		SHEET 1 OF 2
DATE 2/26/90	DATE		
BY TSS	ELEVATION		

Core Recovery	Sample Type	Hydrocarbon PPM	Blows	Time	Depth	USCS	SURFACE CONDITIONS: 2½" Asphalt
					0		FILL- Brown clayey silty fine to medium
					1		SAND with (5-10%) ½-1" subround to
					2		round gravel, moist, loose
18"			1				
			2		3		Grey clayey silty fine to medium SAND
			3		4		with (5-10%) ½-1" sub-angular to angular
					5		gravel moist, loose
							piece of glass in sample
					6		
					7		Grey silty clayey fine to coarse SAND
			2		8		with (15-20%) angular gravel, moist
18"			1				loose
			2		9		
					10		
					11		
					12		Tan Silty fine to coarse SAND with (20-25%)
			8		13		angular ¼-½" Gravel moist, loose
18"			15				
			19		14		
					15		
					16		
					17		
6"			20				Tan silty fine to medium SAND with (20-25%)
			20		18		1-2" sub-angular to angular gravel, damp
			22		19		dense
					20		

NOTES:

BORING TERMINATED AT____ BELOW EXISTING GRADE.
GROUNDWATER ENCOUNTERED AT____DURING DRILLING.
WELL AS BUILT:
SCREEN SIZE ________ CASING SIZE ________
SCREEN LOCATION ________
LOCKING CAP YES ☐ NO ☐
BENTONITE SEAL ________
CONCRETE ________
SURFACE CASING ________
BACKFILL ________

SRH GROUP
SRH Environmental Management
12245 N.E. Whitaker Way Portland, Or. 97230

Proj. No. | Date | Pl...

JOB NO. 3016	CLIENT GSL Properties	LOCATION Broad & Elliot	BORING NO
DRILLING METHOD HSA	DRILLING CONTR. Geoboring	START / FINISH	#1
SAMPLING METHOD SS	WATER LVL.		
HAMMER WT. 300 DROP 18"	TIME		SHEET
DATE 2/26/90	DATE		2 OF 2
BY TSS	ELEVATION		

Core Recovery	Sample Type	Hydrocarbon PPM	Blows	Time	Depth	USCS	SURFACE CONDITIONS:
					20		
					21		
					22		Grey silty fine to coarse SAND with inter beds of silty fine to coarse SAND with ½-1" gravel, Saturated, dense
18"			18 14 18		23		groundwater at 22'
					24		
					25		
					26		
					27		End of Boring
					8		
					9		
					0		
					1		
					2		
					3		
					4		
					5		
					6		
					7		
					8		
					9		
					0		

NOTES:

BORING TERMINATED AT 27 BELOW EXISTING GRADE.
GROUNDWATER ENCOUNTERED AT 22 DURING DRILLING.
WELL AS BUILT:
SCREEN SIZE .02" CASING SIZE
SCREEN LOCATION 27-22"
LOCKING CAP YES ☒ NO ☐
BENTONITE SEAL 22' Surface
CONCRETE
SURFACE CASING
BACKFILL

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SRH Environmental Management
12245 N.E. Whitaker Way Portland, Or. 97230

Proj. No. 3016 Date 2/27/90 Plate

JOB NO. 3016	CLIENT GSL Properties	LOCATION Broad & Elliott		BORING NO
DRILLING METHOD HSA		DRILLING CONTR. Geoboring	START / FINISH	#2
SAMPLING METHOD SS		WATER LVL.		
HAMMER WT. 300	DROP 18"	TIME		SHEET
DATE 2/26/90		DATE		1 OF 1
BY TSS		ELEVATION.		

Core Recovery	Sample Type	Hydrocarbon PPM	Blows	Time	Depth	USCS	SURFACE CONDITIONS: 3" Asphalt
					0		FILL- Brown silty fine to medium SAND
					1		with (10-15%) Sub-round to round gravel
					2		damp loose
18"			1 2 1		3 4		
					5		
					6		
					7		Brown silty clayey fine to coarse SAND
18"			1 1 1		8 9		with interbeded lense of decaying organic wood bark, wet loose
					10		Grey silty fine to medium SAND with (5-10%
					11		<½" sub-angular to angular gravel, moist
			12 14 17		12 13		medium dense
					14		Groundwater at 12' Grey fine to coarse sandy GRAVEL (½-1")
					15		saturated, dense
					16		
			18 18 20		17 18		
					19 20		

NOTES:

BORING TERMINATED AT 18 BELOW EXISTING GRADE.
GROUNDWATER ENCOUNTERED AT 12 DURING DRILLING.
WELL AS BUILT:
SCREEN SIZE .02"   CASING SIZE 4"
SCREEN LOCATION 18-8'
LOCKING CAP   YES ☒   NO ☐
BENTONITE SEAL 5-2'
CONCRETE 2'-Surface
SURFACE CASING Minument
BACKFILL

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SRH Environmental Management
12245 N.E. Whitaker Way Portland, Or. 97230

Proj. No. [illegible] | Date [illegible] | Plate

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE 4/18/85 HOLE NO. 1

PROJECT Alaskan Way Seawall GRD. ELEV. 6.0

LOCATION [illegible] 51' W & 18' N. of NE corner of intersection of Clay & Alaskan Way

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
		A	3	3	2	5	medium sandy gravel (to 1") with minor silt	loose	damp	brown	
5											
											▼ (water level)
		B	5	7	5	12	same - gravel to 1" diam.	med. dense	wet	brown	
10											
		C	3	2	1	3	same - slightly siltier - gravel in sampler prevented full recovery only 1" recovered	very loose	sat'd	brown	
15											
		D	13	8	13	21	same - less silt - more gravel but smaller - only to ½" diam	med. dense	sat'd	grey	
20											
		E	3	2	2	4	gravelly, fine grained sandy SILT with glass, wood etc. - old shoreline?	very loose	sat'd	grey	
25											
		F	2	2	3	5	same - old shoreline?				
30											

10644

INSPECTOR

C8 7-241

MATERIALS LABORATORY

LOG OF TEST BORING

DATE 4/18/85 [redacted]

PROJECT Alaskan Way Seawall GRD. ELEV. 6.0

LOCATION 51' W & 18' N of NE corner of intersection of Clay & Alaskan Way

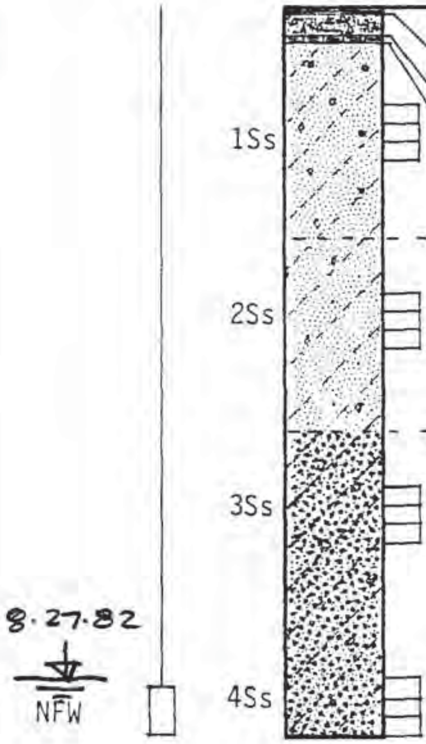
STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
		G	7	9	11	20	3" recovery - mostly wood with some silts, sands & gravel	—	sat'd	gray	
	35										
		H	17	16	12	28	silty sand to sandy silt with some gravel	med. dense	sat'd	gray	
	40										
		I	55/6			100+	silty sandy gravel (glacial till)	very dense	sat'd	gray	
	45										
		J	40	50/5	|	100+	medium sand with some silt and gravel	very dense	sat'd	grey	
	50										
		K	50/6	|	|	100+	1' heave medium sand - minor silt - some gravel	very dense	sat'd	grey	
	55										
		L	49	50/4	|	100+	same - siltier	very dense	sat'd	gray	
	60										

INSPECTOR

40" N. ℄ WALL ST. & 20' W. ℄ ELLIOTT AVE

Location: MH-802

TB-2
8-18-82



0.0'

2" Asphalt — 0.17'

6" Concrete — 0.67'

3" Bricks — 0.92'

(4,7,8)SM Tan, moist, gravelly, silty, fine SAND; becoming dark gray at 3.0'

- - - - - - 6'

(5,7,10)SM Brownish gray, moist, silty, fine SAND with a trace of gravel and medium sand

- - - - - - 11'

(16,32,21)SM Tan, saturated,gravelly, silty, medium to coarse SAND with a trace of fine sand

(31,49,72)SM Same as above, only moist and fine to coarse SAND

— BOH-19.0'

PRELIMINARY

PACIFIC TESTING LABORATORIES 3220 17th AVE. W. SEATTLE, WA. 98119 206-282-0666	TEST BORING LOG for Seattle City Light Proposed Utility Vaults Seattle, Washington	**PROJECT NO.** 8208-3010 **DATE** 8-19-82 **DRAWN** JEM **ENGR./GEOL.** CJJ **APPROVED**

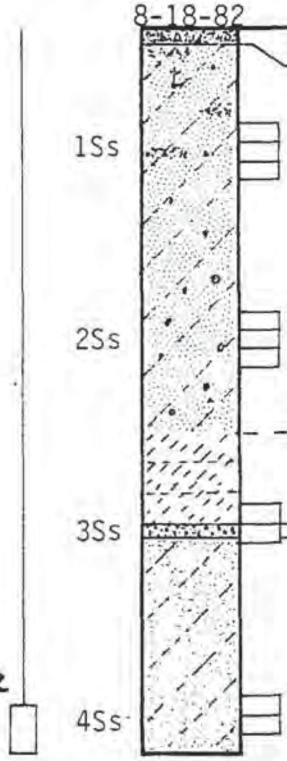
K+E CRYSTALENE® TRACING PAPER

40± N. ℄ VINE ST. & 150± W. ℄ WESTERN AVE.

Location: V-844

TB-3

8-18-82



0.0'

6" concrete 0.5'

1Ss (7,12,24)SM Brownish gray, moist, silty fine SAND with a trace of coarse sand & minor clean sand lenses

2Ss (6,12,14)SM Same as above, with gravel & no sand lenses

Gray, damp, clayey SILT

3Ss (11,50,-)ML 13.0'

SW gray, saturated, clean, fine to coarse SAND 13.3'

Tan, moist, silty, very fine SAND

DRY 8-27-82 NFW

4Ss (20,50/4,-)SM Same as above, only damp

— BOH-19.0'

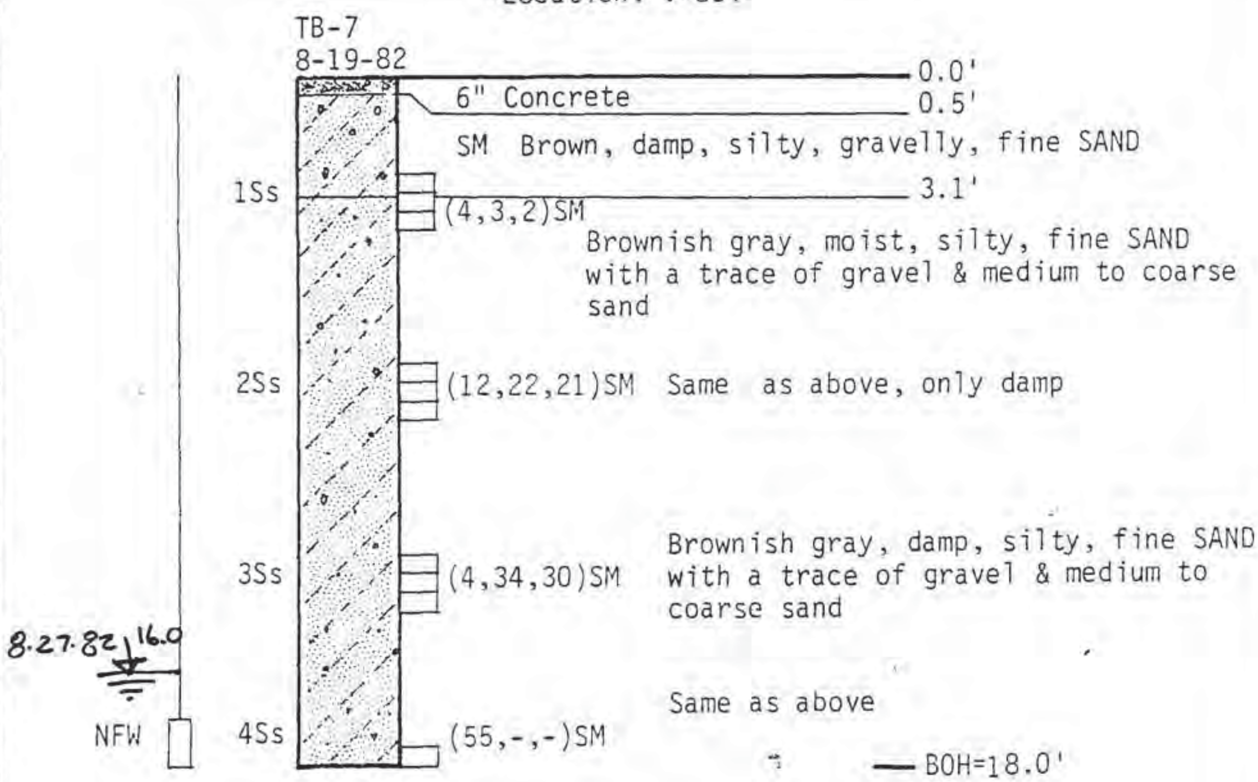
PRELIMINARY

PACIFIC TESTING LABORATORIES 3220 17th AVE. W. SEATTLE, WA. 98119 206-282-0666	TEST BORING LOG for Seattle City Light Proposed Utility Vaults Seattle, Washington	**PROJECT NO.** 8208-3010 **DATE** 8-19-82 **DRAWN** JEM **ENGR./GEOL.** CJJ **APPROVED**

K+E CRYSTALENE® TRACING PAPER

45º N. ℄ WALL ST. & 170º W. ℄ WESTERN AVE

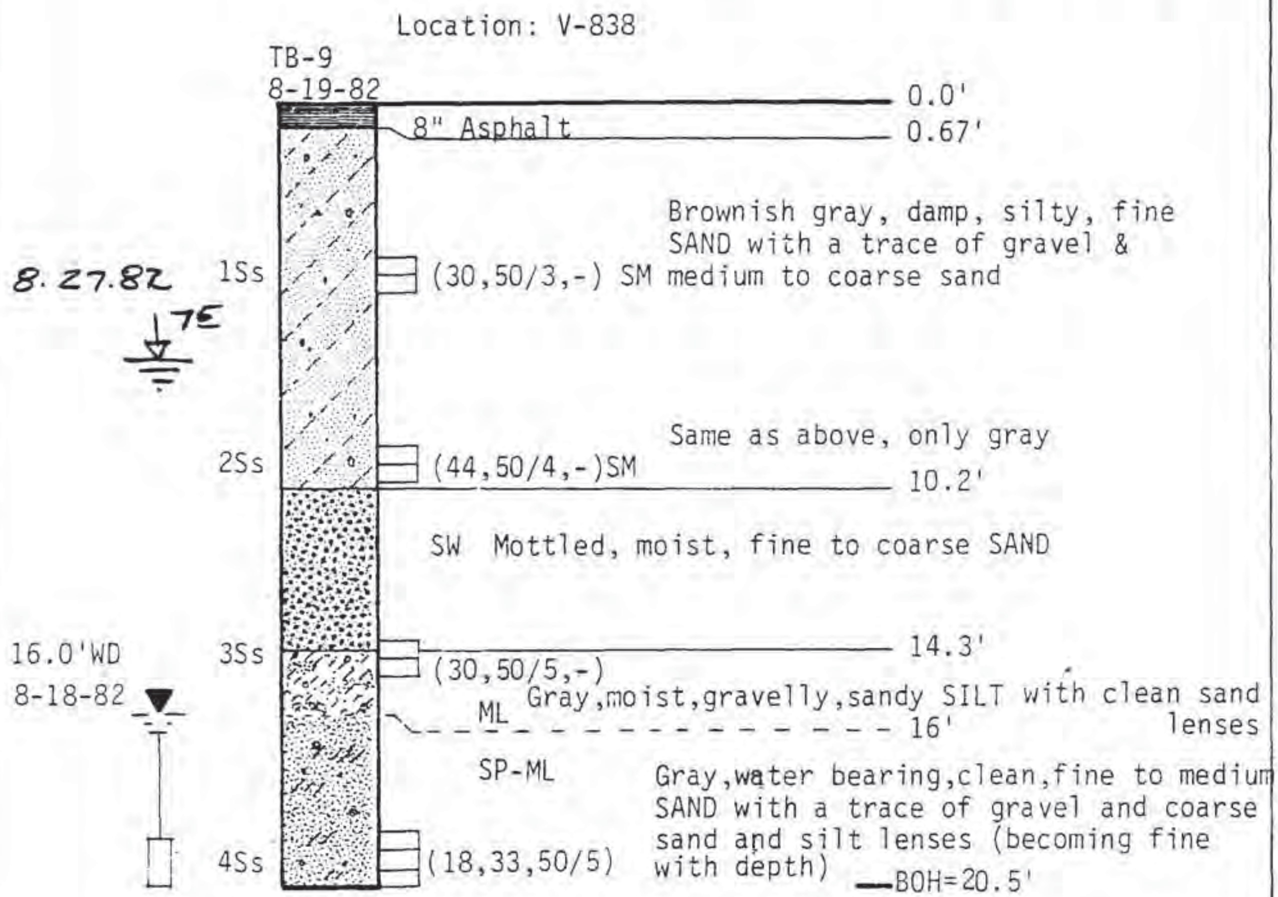
Location: V-854



PRELIMINARY

PACIFIC TESTING LABORATORIES 3220 17th AVE. W. SEATTLE, WA. 98119 206-282-0666	TEST BORING LOG for Seattle City Light Proposed Utility Vaults Seattle, Washington	**PROJECT NO.** 8208-3010 **DATE** 8-19-82 **DRAWN** JEM **ENGR./GEOL.** CJJ **APPROVED**

15º N. ℄ CEDAR ST. & 170º E. ℄ ELLIOTT AVE.



PRELIMINARY

PACIFIC TESTING LABORATORIES 3220 17th AVE. W. SEATTLE, WA 98119 206-282-0666	TEST BORING LOG for Seattle City Light Proposed Utility Vaults Seattle, Washington	**PROJECT NO.** 8208-3010 **DATE** 8-19-82 **DRAWN** JEM **ENGR./GEOL.** CJJ **APPROVED**

K+E CRYSTALENE® TRACING PAPER

PROJECT: Intracorp/Western Ave/WA **RECORD OF BOREHOLE B-4** SHEET 1 OF 2

DATUM: MSL

PROJECT NUMBER: 993 1529.100.200 BORING LOCATION: Western Ave. BORING DATE: 8/26/99

DEPTH FEET	BORING METHOD	DESCRIPTION	USCS	ELEV. / DEPTH	NUMBER	TYPE	BLOWS / 6 IN. (140 lb. hammer, 30 inch drop)	N	REC/ATT
0	4 1/4-inch I.D. HSA	Asphalt							
		Compact, olive gray, nonstratified, moist to wet, silty fine to medium SAND, some angular to subrounded gravel (FILL)	SM						
					1	SS	12-9-17	26	18/18
5		Very dense, gray, nonstratified, damp, silty fine to medium SAND, some subrounded gravel (TILL)	SM		2	SS	19-37-37	74	18/18
					3	SS	29-41-50/5	>91	17/18
10					4	SS	28-50/6	>50	12/18
15					5	SS	16-28-40	68	18/18
		Hard, gray, nonstratified, moist, CLAY, trace sand, trace gravel, some saturated sand lenses, fractured (GLACIOLACUSTRINE)	CL						
20					6	SS	20-36-30	66	18/18
25		Water-bearing fine sand lens			7	SS	14-19-18	37	18/18
30		Log continued on next page							

PENETRATION RESISTANCE BLOWS/FT. ■ (0, 10, 20, 30, 40, 50)

WATER CONTENT, PERCENT Wp W Wl

PIEZOMETER GRAPHIC / WATER LEVEL: Flush Monument; Cement; Bentonite Grout; 2-inch Sch.40 PVC Riser; 10/20 Silica Sand; 2-inch Sch.40 PVC Screen

DRILL RIG: CME 85 LOGGED: JCM

DRILLING CONTRACTOR: Gregory Drilling CHECKED:

DRILLER: Chris DATE: 9/10/99

Golder Associates

PROJECT: Intracorp/Western Ave/WA **RECORD OF BOREHOLE B-4** SHEET 2 OF 2

DATUM: MSL

PROJECT NUMBER: 993 1529.100.200 BORING LOCATION: Western Ave. BORING DATE: 8/26/99

DEPTH FEET	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT	PENETRATION RESISTANCE BLOWS/FT. ■ (0 10 20 30 40 50) / WATER CONTENT PERCENT Wp W Wl	PIEZOMETER GRAPHIC / WATER LEVEL
30	4 1/4-inch I.D. HSA	Hard, gray, nonstratified, moist, CLAY, trace sand, trace gravel, some saturated sand lenses, fractured (GLACIOLACUSTRINE)	CL			8	SS	8-14-20	34	18/18	■	10/20 Silica Sand; 2-inch Sch.40 PVC Screen
		Boring terminated at 31.5 ft bgs										
35												
40												
45												
50												
55												
60												

DRILL RIG: CME 85

DRILLING CONTRACTOR: Gregory Drilling

DRILLER: Chris

LOGGED: JCM

CHECKED:

DATE: 9/10/99

Golder Associates

PROJECT: Intracorp/Western Ave/W[redacted]

SHEET 1 OF 2

DATUM: MSL

PROJECT NUMBER: 993 1529.100.200 BORING LOCATION: Western Ave. BORING DATE: 8/26/99

DEPTH FEET	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT	PENETRATION RESISTANCE BLOWS/FT. ■ 0 10 20 30 40 50 / WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER GRAPHIC / WATER LEVEL
0	4 1/4-inch I.D. HSA	Asphalt										Flush Monument; Cement
		Compact to very dense, olive gray to olive brown, nonstratified, damp to moist, silty fine to medium SAND, trace to some gravel, slight iron staining (FILL)	SM									Bentonite Grout; 2-inch Sch.40 PVC Riser
						1	SS	13-50/5		11/18		
5						2	SS	9-15-15	30	18/18	■ 30	
						3	SS	5-11-18	29	18/18	■ 29	
10						4	SS	5-11-25	36	18/18	■ 36	
15		Very dense, gray, nonstratified, damp, silty fine to medium SAND, little angular to subrounded gravel (TILL)	SM			5	SS	18-50/6		12/18		
20						6	SS	35-50/4		10/18		
25						7	SS	29-50/4		10/18		
												10/20 Silica Sand
30		Log continued on next page										

Log continued on next page

DRILL RIG: CME 85

DRILLING CONTRACTOR: Gregory Drilling

DRILLER: Chris

LOGGED: JCM

CHECKED:

DATE: 9/10/99

Golder Associates

PROJECT: Intracorp/Western Ave/WA[redacted]

SHEET 2 **OF** 2

DATUM: MSL

PROJECT NUMBER: 993 1529.100.200 **BORING LOCATION:** Western Ave. **BORING DATE:** 8/26/99

DEPTH FEET	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 6 IN. 140 lb. hammer 30 inch drop	N	REC/ATT	PENETRATION RESISTANCE BLOWS/FT ■ / WATER CONTENT, PERCENT (Wp, W, Wl)	PIEZOMETER GRAPHIC / WATER LEVEL
30	4 1/4-inch I.D. HSA	Very dense, gray, nonstratified, damp, silty fine to medium SAND, little angular to subrounded gravel (TILL)	SM			8	SS	12-20-31	51	18/18		ATD; 10/20 Silica Sand
		Very dense, gray, nonstratified, we, fine sandy SILT	ML									
35		Very stiff, gray, nonstratified, damp, CLAY, little gravel, bits of organics as wood, trace fine sand (GLACIOLACUSTRINE)	CH			9	SS	4-7-12	19	18/18		2-inch Sch.40 PVC Screen
40						10	SS	7-10-16	26			
45		End of hole at 41.5 ft bgs										
50												
55												
60												

DRILL RIG: CME 85

DRILLING CONTRACTOR: Gregory Drilling

DRILLER: Chris

LOGGED: JCM

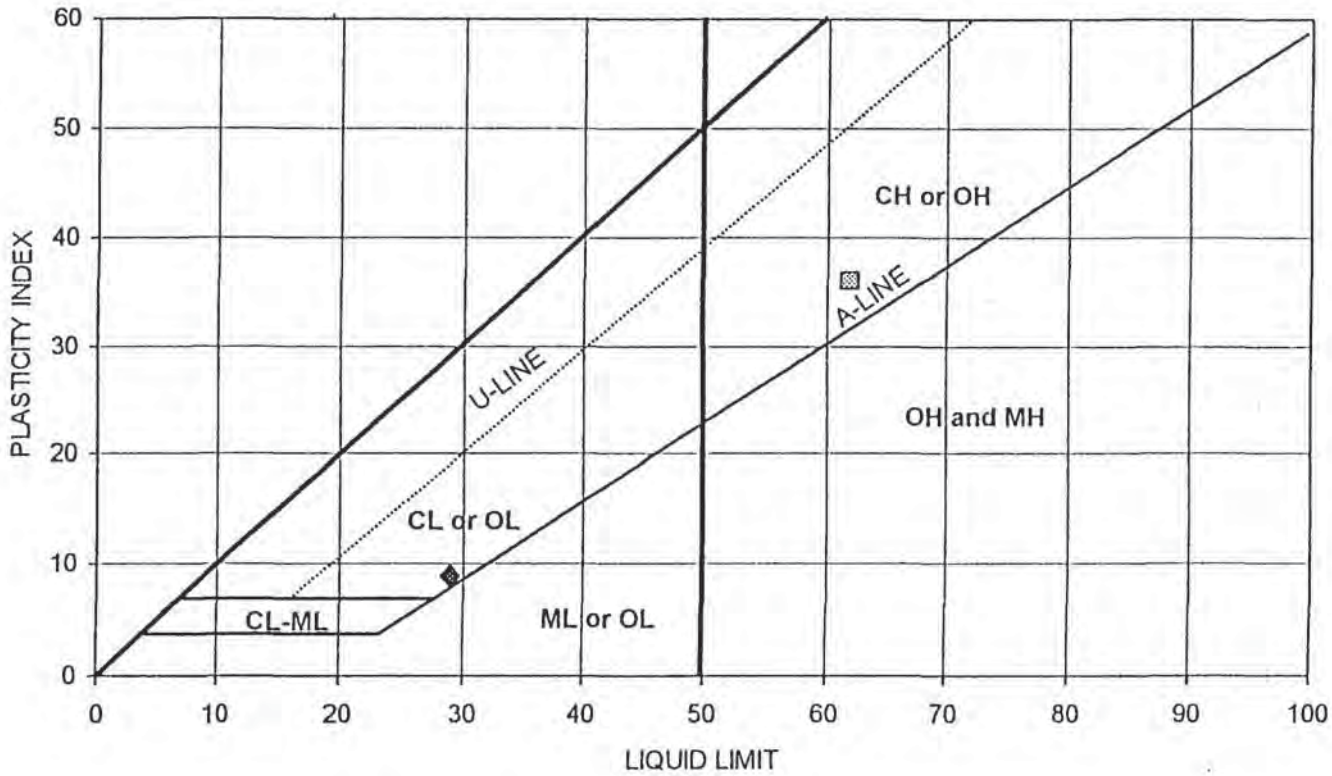
CHECKED:

DATE: 9/10/99

Golder Associates

0314-037-00 JRS:MBB:mbb 9/3/99 (Atterbergs.ppt)

PLASTICITY CHART



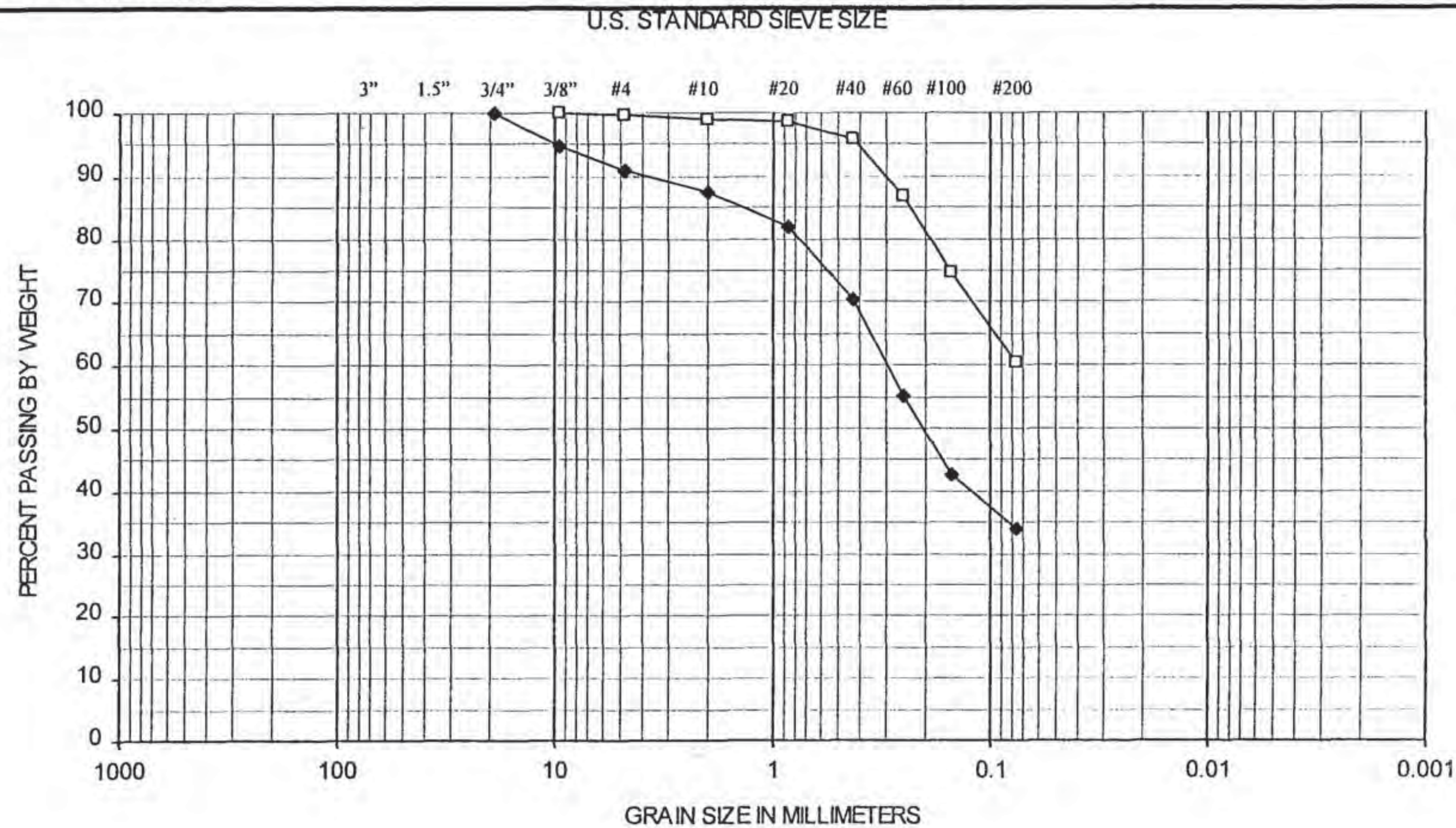
SYMBOL	EXPLORATION NUMBER	SAMPLE DEPTH	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	SOIL DESCRIPTION
◆	B-4	20-21.5'	13.2	29	9	Gray clay (CL)
▩	B-5	35-36.5'	30.5	62	36	Gray fat clay (CH)

GeoEngineers

ATTERBERG LIMITS TEST RESULTS

FIGURE #

0314-037-00 JRS:MBB:mbb 9/3/99 (Sieves.ppt)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

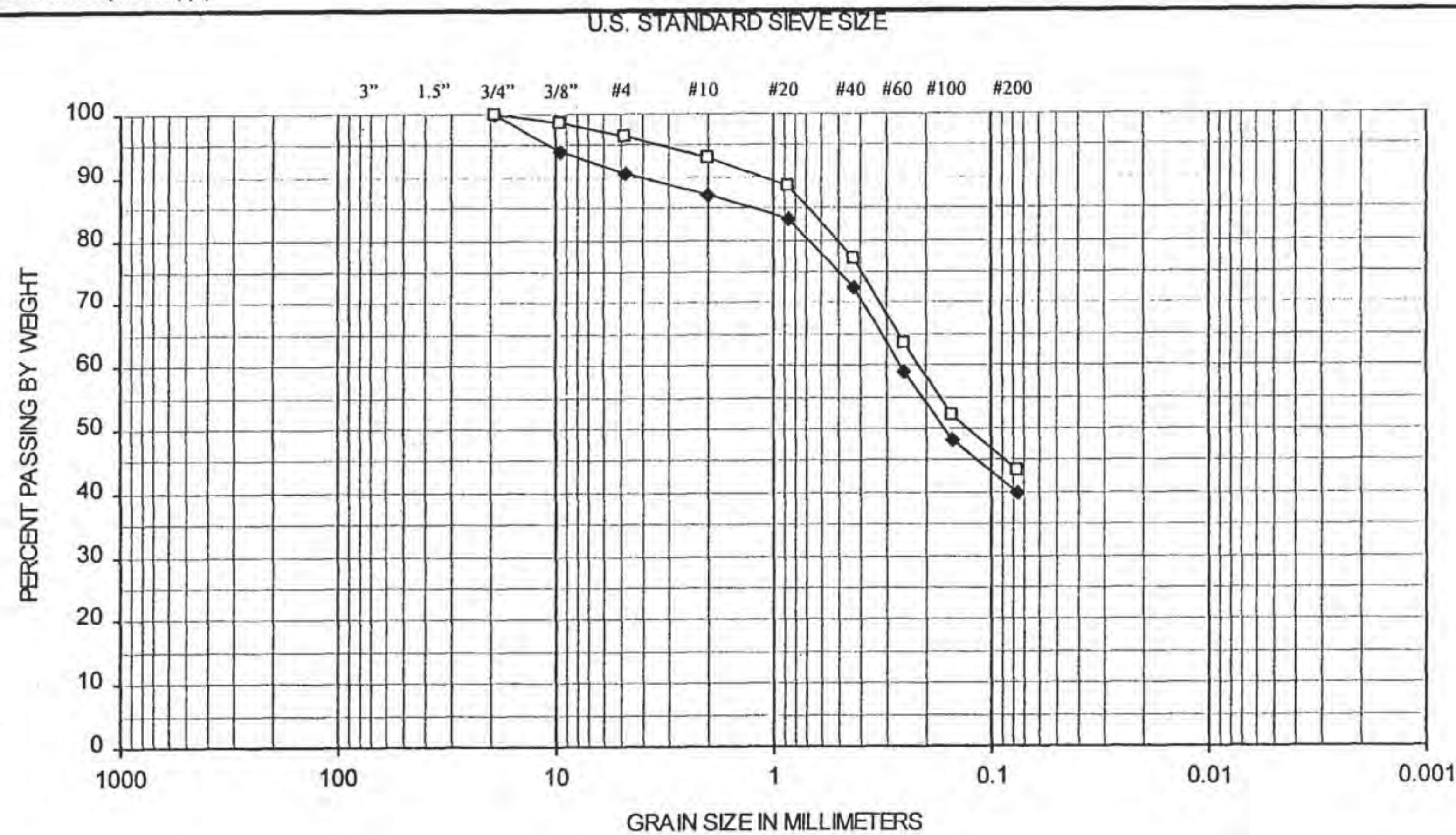
SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◆	B-5	20-21.5	Gray silty fine to medium sand (SM)
□	B-5	30-31.5	Gray fine sandy silt (ML)

Geo Engineers

SIEVE ANALYSIS RESULTS

FIGURE #

0314-037-00 JRS:MBB:mbb 9/3/99 (Sieves.ppt)



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	EXPLORATION NUMBER	DEPTH (ft)	SOIL CLASSIFICATION
◆	B-1	5-6.5	Brown silty fine sand (SM)
□	B-4	7.5-9	Gray silty fine to medium sand (SM)

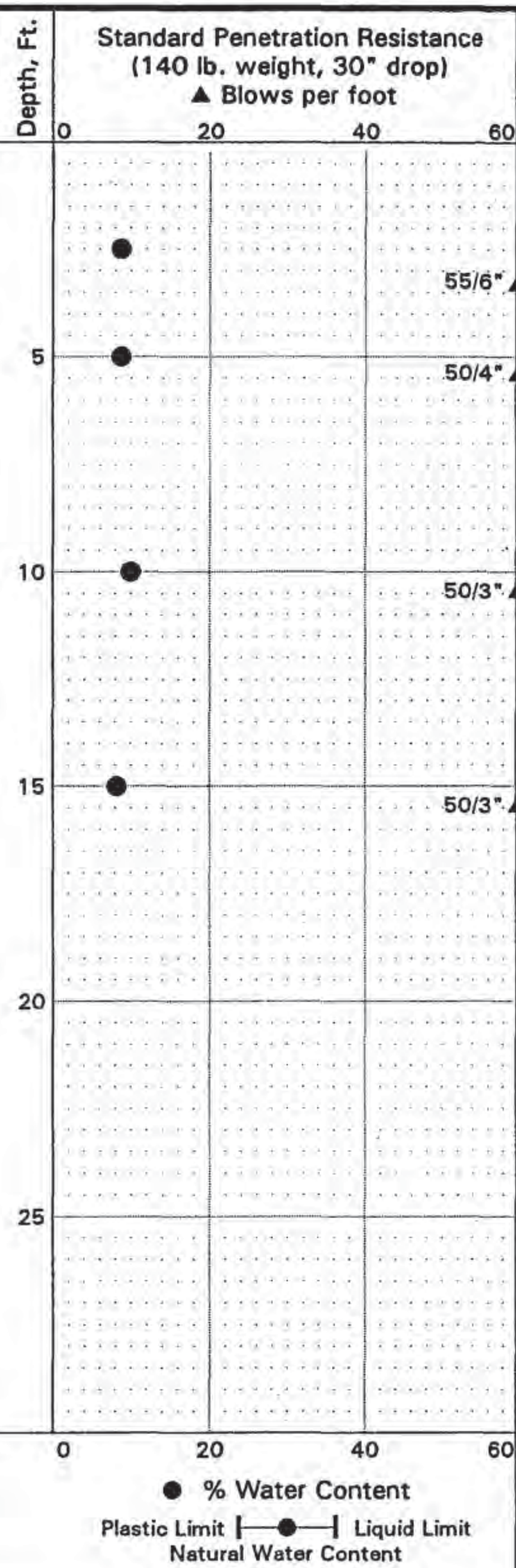
GeoEngineers

SIEVE ANALYSIS RESULTS

FIGURE #

MASTERLG 11/30/98

SOIL DESCRIPTION Surface Elevation: Approx. 36.0 Feet	Depth, Ft.	Geology	Samples	Ground Water
ASPHALT PAVEMENT	0.2			
Very dense, gray-brown, slightly gravelly to gravelly, silty SAND/; moist; SM.			1, 2, 3, 4	None observed during drilling
BOTTOM OF BORING COMPLETED 10/1/98	15.8			



LEGEND

- • Sample Not Recovered
- 2" O.D. Split Spoon Sample
- 3" O.D. Shelby Tube Sample
- Surface Seal
- Annular Sealant
- Piezometer Screen
- Grout
- Water Level
- Low Water Level

NOTES

1. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
2. The discussion in the text of this report is necessary for a proper understanding of the nature of subsurface materials.
3. Water level, if indicated above, is for the date specified and may vary.
4. Refer to KEY for explanation of "Symbols" and definitions.
5. USC letter symbol based on visual classification.

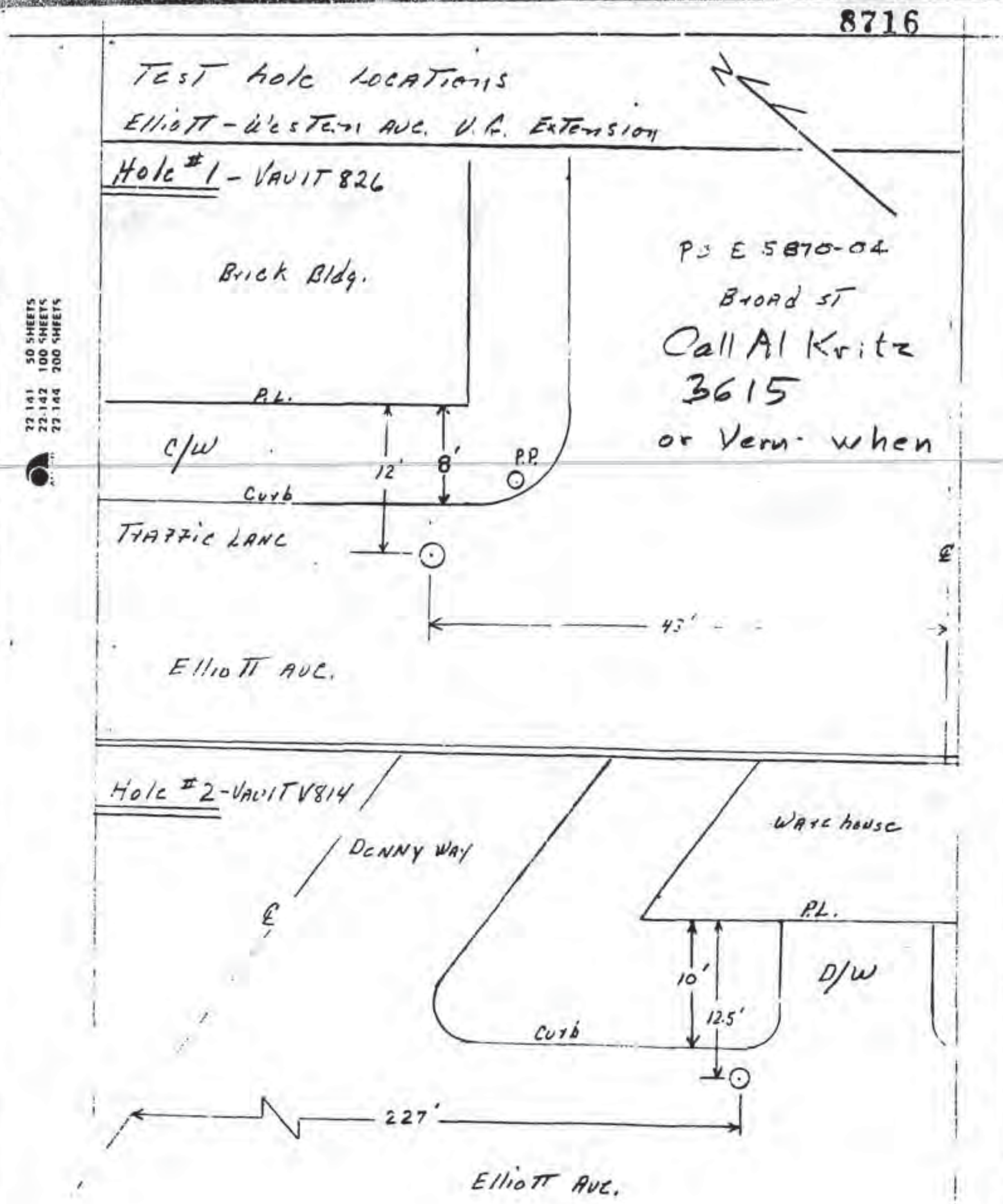
Western/Cedar Building
2715 & 2717 Western Avenue
Seattle, Washington

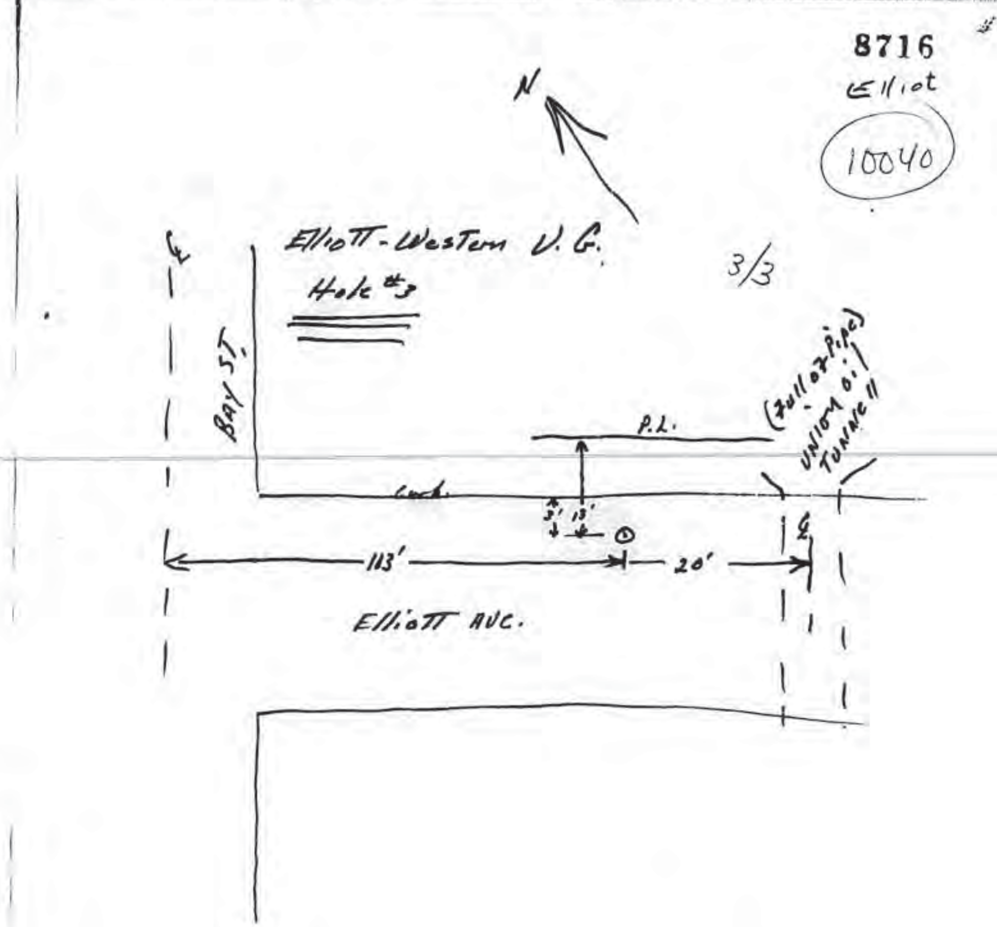
LOG OF BORING B-3

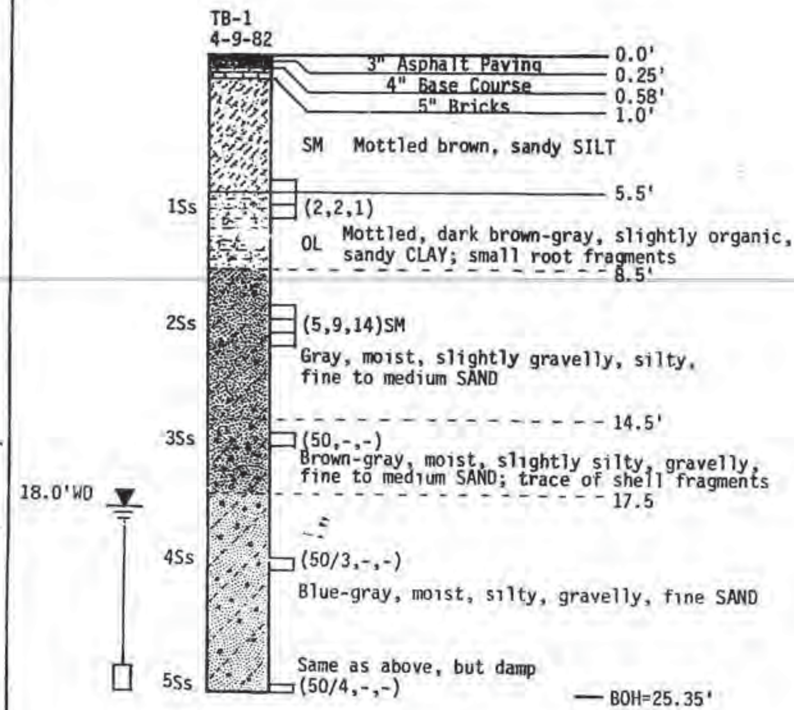
November 1998 W-8491-01

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 7


8716
Test hole locations
Elliott - Western Ave. V.C. Extension
N
Hole #1 - Vault 826
Brick Bldg.
P.L.
C/W
12'
8'
P.P.
Curb
Traffic Lane
43'
Elliott Ave.
PS E 5870-04
Broad St
Call Al Kritz
3615
or Vern when
Hole #2 - Vault V814
Denny Way
Warehouse
P.L.
D/W
10'
12.5'
Curb
227'
Elliott Ave.
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

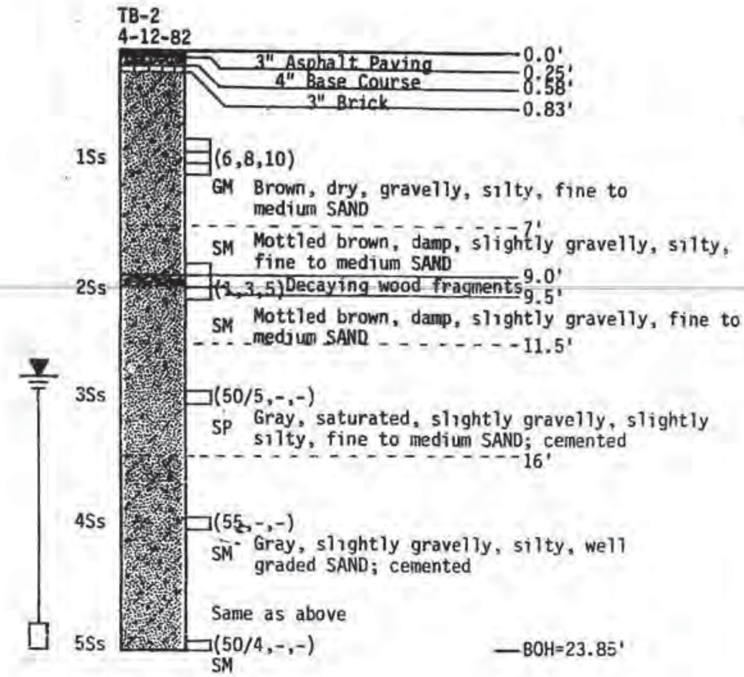

8716
Elliot
10040
N
Elliott - Western V.C.
Hole #3
3/3
Bay St.
P.L.
Curb
3'
13'
113'
20'
(Full of Pipe)
Union Oil
Tunnel
Elliott Ave.



PACIFIC TESTING LABORATORIES
3220 17th AVE. W. SEATTLE, WA. 98119 206-282-0666

TEST BORINGS LOG for
Seattle Engineering Dept.
Site located at corner of
Elliott Ave. & Brood St.
Seattle, Washington

PROJECT NO. 8204-3010
DATE 4-14-82
DRAWN JEM
ENGR./GEOL. MVS
APPROVED [signature]



PACIFIC TESTING LABORATORIES
3220 17th AVE. W. SEATTLE, WA. 98119 206-282-0666

TEST BORING LOG for
Seattle Engineering Dept.
Site located at corner of
Elliott Ave. & Bay St.
Seattle, Washington

PROJECT NO. 8204-3010
DATE 4-14-82
DRAWN JEM
ENGR./GEOL. MVS
APPROVED [signature]

Table A-1
SUMMARY OF PROJECT BORINGS

Boring Name	Date Completed	Total Depth Drilled (feet)	Ground Surface Elevation (feet)	Drilling Company	Drilling Method	Hammer Type
TUNNEL BORINGS						
EB-22	9/19/2002	180.3	107	Geotech	MUD	CAT
EB-23	9/13/2002	180.5	101	Geotech	MUD	CAT
EB-24	9/9/2002	140.5	34	Geotech	MUD	CAT
PUMPING TEST SITES						
TW-1	9/13/2002	139.0	16	Holt	CTL	NA
TW-11	9/12/2002	150.0	16	Holt	H/R	AUTO
TW-12	9/12/2002	33.9	16	Holt	HSA	AUTO
TW-13	9/12/2002	28.0	18	Holt	HSA	AUTO
TW-2	9/19/2002	119.0	15	Holt	CTL	CAT
TW-21	9/11/2002	151.5	15	Holt	H/R	AUTO
TW-22	9/16/2002	29.0	24	Holt	HSA	AUTO
TW-23	9/13/2002	24.0	18	Holt	HSA	AUTO
TW-24	9/13/2002	28.0	19	Holt	HSA	AUTO
TW-25	9/20/2002	123.2	30	Holt	MUD	CAT

NOTES:

1. Elevations were estimated from existing site plans with topography, and should be considered approximate.
2. Drilling methods used include mud rotary (MUD), hollow-stem auger (HSA), or a combination of both (H/R). For the pumping wells (TW-1 and TW-2), cable tool (CTL) methods were used. See the August 2002 Geotechnical Data Report (GDR) for additional discussion of drilling methods.
3. Hammer types used were rope and cathead (CAT), and automatic trip hammer (AUTO). NA = not applicable. See the August 2002 GDR for additional discussion on hammer types.

Table A-2
GEOLOGIC UNITS AND DESCRIPTIONS

Unit Name	Abbrev.	Unit Description
HOLOCENE UNITS		
Fill	Hf	Fill placed by humans, both engineered and nonengineered Various materials, including debris; cobbles and boulders common; commonly dense or stiff if engineered, but very loose to dense or very soft to stiff if nonengineered
Hydraulic Fill	Hhf	Fill placed by dredging from river or bay or sluiced into place from adjacent hills Clay and Silt, very soft to medium stiff (from hills); Silt and fine Sand; scattered shells; very loose to medium dense (not from hills)
Colluvium	Hc	Hillside slope accumulations due to gravity emplacement Disturbed, heterogeneous mixture of several soil types, including organic debris; loose or soft
Landslide Deposits	Hls	Deposits of landslides, normally at and adjacent to the toe of slopes Disturbed, heterogeneous mixture of several soil types; loose or soft, with random dense or hard pockets
Alluvium	Ha	River or creek deposits, normally associated with historic streams, including overbank deposits Sand, silty Sand, gravelly Sand; very loose to very dense
Peat Deposits	Hp	Depression fillings of organic materials Peat, peaty Silt, organic Silt; very soft to medium stiff
Estuarine Deposits	He	Estuary deposits of the ancestral Duwamish River Silty Clay and fine Sand; very soft to very stiff or loose to dense
Beach Deposits	Hb	Deposits along present and former shorelines of Puget Sound and tributary river mouths Silty Sand, sandy Gravel; Sand; scattered fine gravel, organic and shell debris; loose to very dense
Reworked Glacial Deposits	Hrw	Glacially deposited soils that have been reworked by fluvial or wave action Heterogeneous mixture of several soil types; lies on top of glacially overridden soils, loose to dense

(see page 3 for note)

Table A-2
GEOLOGIC UNITS AND DESCRIPTIONS

Unit Name	Abbrev.	Unit Description
VASHON UNITS		
Recessional Outwash	Qvro	Glaciofluvial sediment deposited as glacial ice retreated Clean to silty Sand, gravelly Sand, sandy Gravel; cobbles and boulders common; loose to very dense
Recessional Lacustrine Deposits	Qvrl	Glaciolacustrine sediment deposited as glacial ice retreated Fine Sand, Silt, and Clay; dense to very dense, soft to hard
Till	Qvt	Lodgment till laid down along the base of the glacial ice Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense
Till-like Deposits (diamict)	Qvd	Glacial deposit intermediate between till and outwash, subglacially reworked Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; dense to very dense
Advance Outwash	Qva	Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland Clean to silty Sand, gravelly Sand, sandy Gravel; dense to very dense
Glaciolacustrine Deposits	Qvgl	Fine-grained glacial flour deposited in proglacial lake in Puget Lowland Silty Clay, clayey Silt with interbeds of Silt and fine Sand; locally laminated; scattered organic fragments near base; hard or dense to very dense

(see page 3 for note)

Table A-2
GEOLOGIC UNITS AND DESCRIPTIONS

Unit Name	Abbrev.	Unit Description
PRE-VASHON UNITS		
NONGLACIAL		
Fluvial Deposits	Qpnf	Alluvial deposits of rivers and creeks Clean to silty Sand, gravelly Sand, sandy Gravel, locally slightly clayey to clayey (weathered); scattered organic fragments; very dense
Lacustrine Deposits	Qpnl	Fine-grained lake deposits in depressions, large and small Fine sandy Silt, silty fine Sand, and clayey Silt; scattered to abundant fine organics; dense to very dense or very stiff to hard
Mudflow Deposits	Qpnm	Distal deposits of mass movements such as landslides or lahars Stratified or irregular bodies of a heterogeneous mixture of Gravel, Sand, Silt, and Clay; pumice, obsidian, and ash common; rare organics (charcoal); very stiff to hard or very dense
Peat Deposits	Qpnp	Depression fillings of organic materials Peat, peaty Silt, organic Silt, hard
Paleosol	Qpns	Buried, weathered horizon Clay-rich with various amounts of clastic debris; commonly contains organic material; typically greenish in color; hard or very dense
Landslide Deposits	Qpls	Heterogeneous deposits of landslide debris Chaotically bedded silt, sand, clay, and gravel; may contain wood and other organics; hard or very dense
GLACIAL		
Outwash	Qpgo	Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland Clean to silty Sand, gravelly Sand, sandy Gravel; very dense
Glaciolacustrine Deposits	Qpgl	Fine-grained glacial flour deposited in proglacial lake in Puget Lowland Silty Clay, clayey Silt with interbeds of Silt and fine Sand; very stiff to hard or very dense
Till	Qpgt	Lodgment till laid down along the base of the glacial ice Gravelly silty Sand, silty gravelly Sand ("hardpan"); cobbles and boulders common; very dense
Till-like Deposits (diamict)	Qpgd	Glacial deposit intermediate between till and outwash, subglacially reworked Silty gravelly Sand, silty Sand, sandy Gravel; highly variable over short distances; cobbles and boulders common; very dense
Glaciomarine Deposits	Qpgm	Till-like deposit with clayey matrix deposited in proglacial lake by icebergs, floating ice, and gravity currents Heterogeneous and variable mixture of Clay, Silt, Sand and Gravel; rare shells; cobbles and boulders common; very dense or hard

NOTE: The geologic units are interpretive and based on our opinion of the grouping of complex sediments and soil types into units appropriate for the project. The description of each geologic unit includes only general information regarding the environment of deposition and basic soil characteristics. For example, cobbles and boulders are only included in the description of those units where they are most prominent.

Shannon & Wilson, Inc. (S&W), uses a soil classification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following page. Soil descriptions are based on visual-manual procedures (ASTM D 2488-93) unless otherwise noted.

S&W CLASSIFICATION OF SOIL CONSTITUENTS

- MAJOR constituents compose more than 40 percent, by weight, of the soil. Major consituents are capitalized (i.e., SAND).
- Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).
- Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace of gravel).

MOISTURE CONTENT DEFINITIONS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

ABBREVIATIONS

ATD	At Time of Drilling
Elev.	Elevation
ft	feet
FeO	Iron Oxide
HSA	Hollow Stem Auger
ID	Inside Diameter
in	inches
lbs	pounds
Mon.	Monument cover
N	Blows for last two 6-inch increments
NA	Not applicable or not available
NP	Non plastic
OD	Outside diameter
OVA	Organic vapor analyzer
PID	Photo-ionization detector
ppm	parts per million
PVC	Polyvinyl Chloride
SS	Split spoon sampler
SPT	Standard penetration test
USC	Unified soil classification
WLI	Water level indicator

GRAIN SIZE DEFINITION

DESCRIPTION	SIEVE NUMBER AND/OR SIZE
FINES	< #200 (0.8 mm)
SAND*	
- Fine	#200 to #40 (0.8 to 0.4 mm)
- Medium	#40 to #10 (0.4 to 2 mm)
- Coarse	#10 to #4 (2 to 5 mm)
GRAVEL*	
- Fine	#4 to 3/4 inch (5 to 19 mm)
- Coarse	3/4 to 3 inches (19 to 76 mm)
COBBLES	3 to 12 inches (76 to 305 mm)
BOULDERS	> 12 inches (305 mm)

* Unless otherwise noted, sands and gravels, when present, range from fine to coarse in grain size.

RELATIVE DENSITY / CONSISTENCY

COARSE-GRAINED SOILS		FINE-GRAINED SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
0 - 4	Very loose	Under 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
Over 50	Very dense	15 - 30	Very stiff
		Over 30	Hard

WELL AND OTHER SYMBOLS

Bent. Cement Grout	Surface Cement Seal
Bentonite Grout	Asphalt or Cap
Bentonite Chips	Slough
Silica Sand	Bedrock
PVC Screen	
Vibrating Wire	

Alaskan Way Viaduct and Seawall Project
Seattle, Washington

SOIL CLASSIFICATION AND LOG KEY

June 2002 21-1-09490-816

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 2

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(From ASTM D 2487-98 & 2488-93)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL	TYPICAL DESCRIPTION
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Clean Gravels *(less than 5% fines)*	GW	Well-graded gravels, gravels, gravel/sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines *(more than 12% fines)*	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Clean Sands *(less than 5% fines)*	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines *(more than 12% fines)*	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML	Inorganic silts of low to medium plasticity, rock flour, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		Organic	OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH	Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH	Inorganic clays or medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat, humus, swamp soils with high organic content (see ASTM D 4427)

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.
2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND)* indicate that the soil may fall into one of two possible basic groups.

Alaskan Way Viaduct and Seawall Project
Seattle, Washington

SOIL CLASSIFICATION AND LOG KEY

June 2002 21-1-09490-816

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

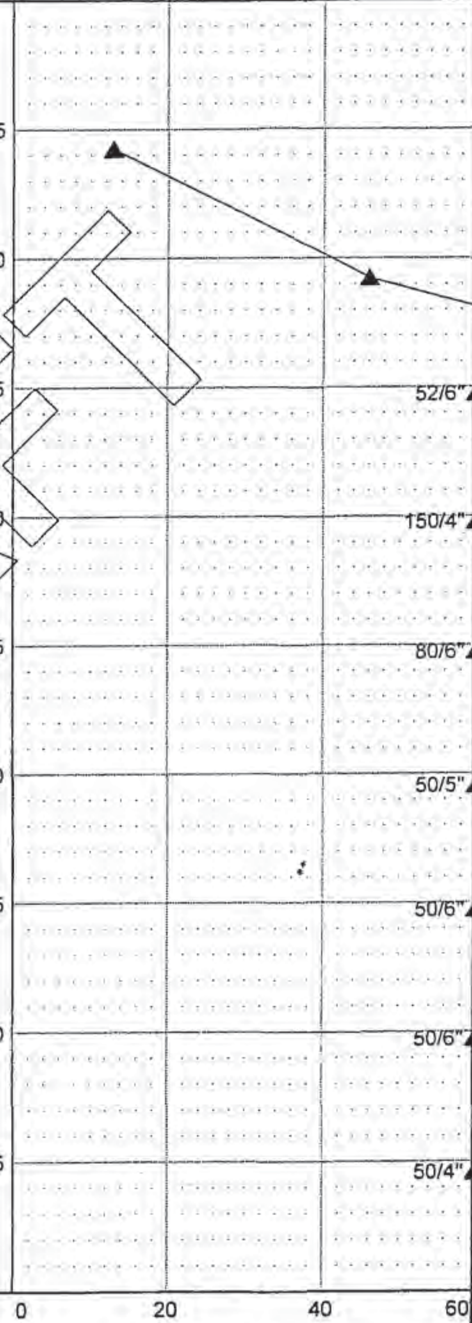
FIG. A-1

SOIL DESCRIPTION Approx. Surface Elev.: 34 Ft. (NAVD-88)	Depth, Ft.	Samples
ASPHALT CONCRETE, CONCRETE, and BRICK.	1.2	
Dense to very dense, yellow-brown, silty, sandy GRAVEL, trace of clay; moist; massive, weathered, abundant iron-oxide staining; (Qpnf/Qpgo) GM.		1*, 2, 3, 4, 5
Interbedded, very dense, gray, slightly silty to silty, fine SAND and slightly fine sandy to fine sandy SILT, trace of clay; moist to wet; massive to laminated, scattered clayey silt seams, abundant organic fragments, scattered partly cohesionless zones; (Qpnl) SM/ML.	27.0	6, 7, 8, 9

Ground Water: 10/31/2002; 10/31/2002

CONTINUED NEXT PAGE

PENETRATION RESISTANCE
▲ Blows per Foot (SPT)
▼ Blows per Foot (non-standard)



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well

● % Water Content
Plastic Limit ├—●—┤ Liquid Limit
Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Alaskan Way Viaduct and Seawall Project
Seattle, Washington

LOG OF BORING EB-24

October 2002 21-1-09490-816

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 1 of 3

WSDOT Agreement No. Y-7888

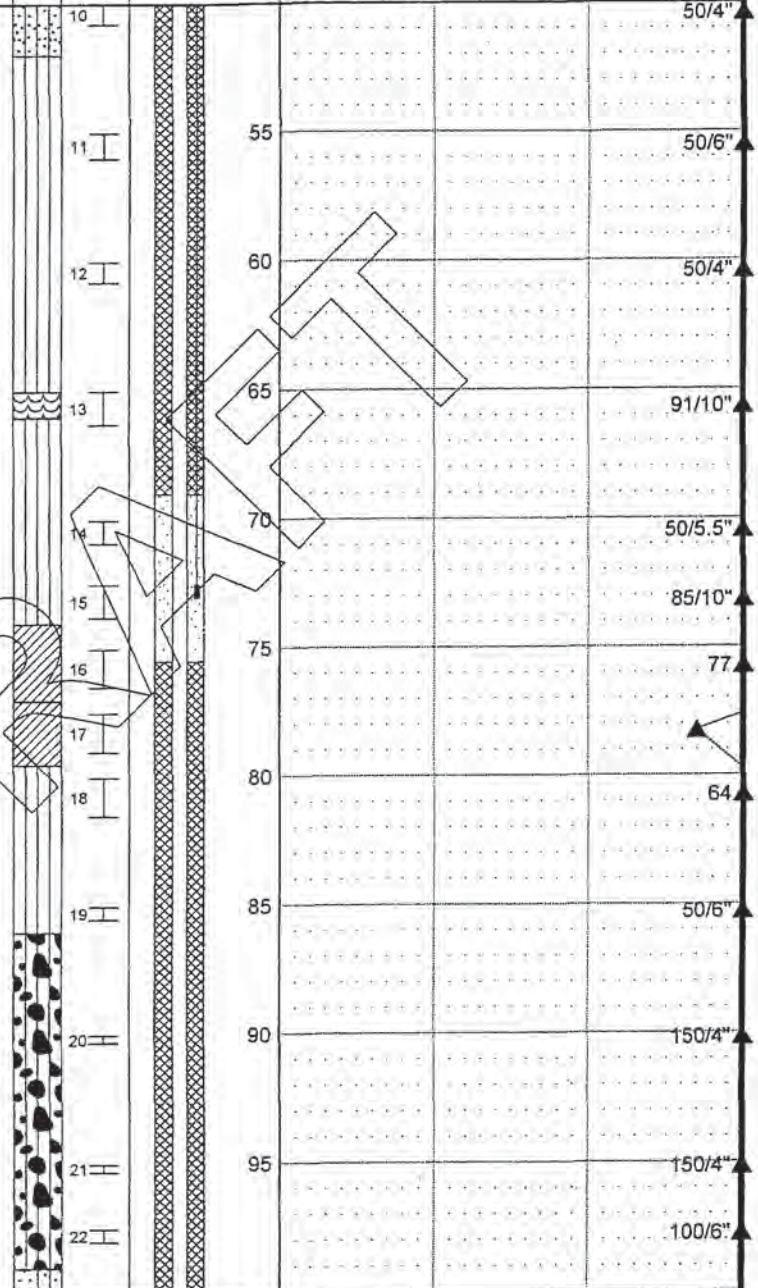
REV 2

MASTER LOG2 21-09490.GPJ SHAN WIL.GDT 10/31/02 Log: AJC Rev: WDN Typ: LKD

SOIL DESCRIPTION Approx. Surface Elev.: 34 Ft. (NAVD-88)	Depth, Ft.
Interbedded, hard, gray, clayey SILT, slightly clayey SILT, trace of fine sand, and dark brown, clayey, organic SILT; wet; bedded to laminated; (Qpnl/Qpnp) ML.	52.0
Hard, dark brown PEAT; moist; bedded; (Qpnp) PT.	65.0
Intermixed, hard, gray, slightly clayey and clayey SILT, slightly silty fine SAND, and silty CLAY: moist; bedded, abundant organics, scattered high-angle slickensided seams; (Qpnl) ML.	66.0
Hard, dark brown, slightly sandy, silty CLAY, trace of gravel to green, clayey SILT; moist; massive, abundant volcaniclastics, abundant charcoal; (Qpnm) CL/CH. - Contact with green, clayey silt (ash) at 75.8 feet.	74.0
Hard, olive-gray and blue-gray mottled, silty CLAY, trace of fine sand; moist; massive; (Qpnl) CH.	77.0
Hard, blue-gray (oxidizes to olive-green), slightly clayey to clayey SILT, trace of fine sand; moist; scattered sand stringers; (Qpnl) ML.	79.5
Very dense, yellow-brown, slightly silty to silty, sandy GRAVEL to silty, gravelly SAND; moist; massive, locally trace of clay, weathered abundant iron-oxide staining; (Qpnf/Qpgo) GM/SM.	86.0
	99.0

CONTINUED NEXT PAGE

Sample	Penetration Resistance (Blows per Foot, SPT)
10	50/4"
11	50/6"
12	50/4"
13	91/10"
14	50/5.5"
15	85/10"
16	77
17	
18	64
19	50/6"
20	150/4"
21	150/4"
22	100/6"



● % Water Content

Plastic Limit ├──●──┤ Liquid Limit
Natural Water Content

LEGEND

- * Sample Not Recovered
- ⊥ Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- ▼ Ground Water Level in Well

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Alaskan Way Viaduct and Seawall Project
Seattle, Washington

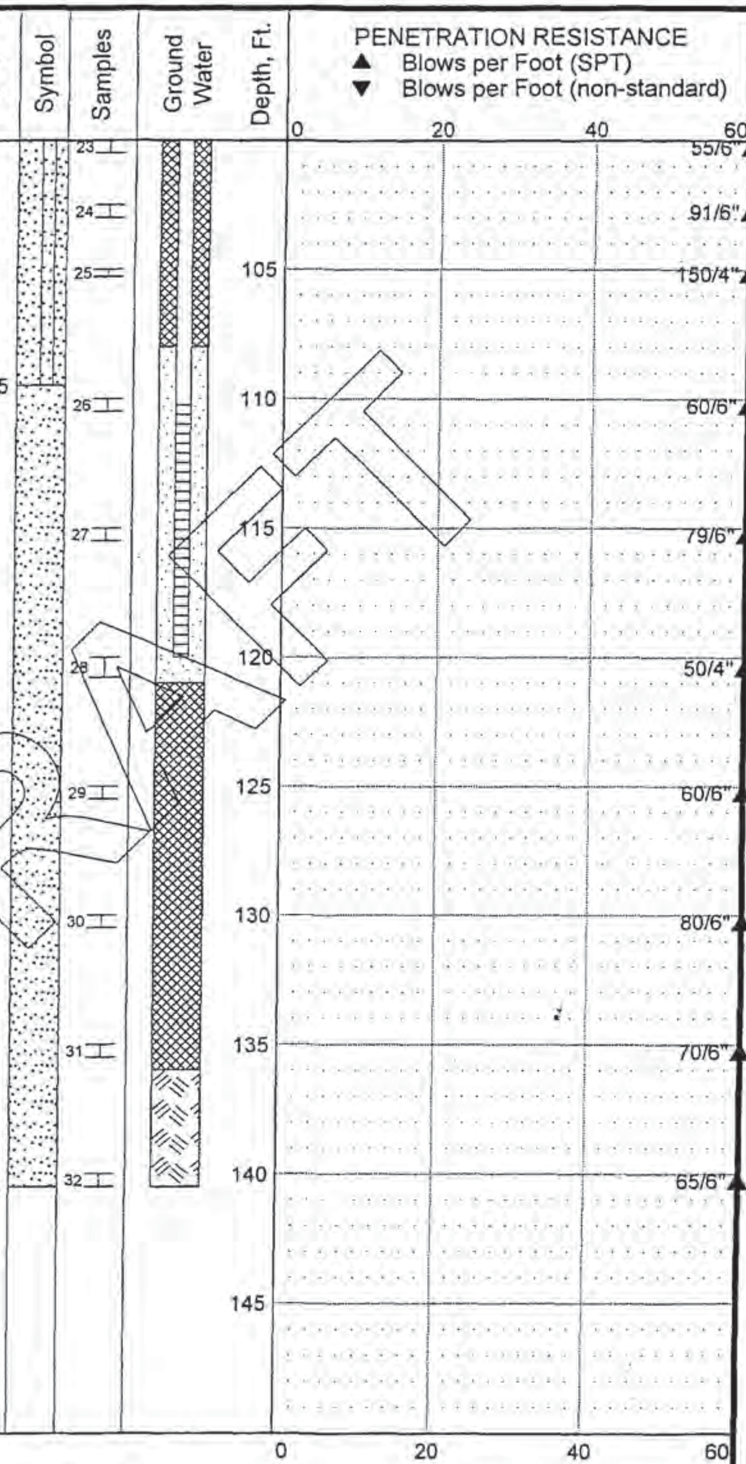
LOG OF BORING EB-24

October 2002 | 21-1-09490-816

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 2 of 3

SOIL DESCRIPTION Approx. Surface Elev.: 34 Ft. (NAVD-88)	Depth, Ft.
Very dense, gray-brown, slightly silty SAND, trace of gravel; moist to wet; locally gravelly, scattered iron-oxide staining; (Qpnf/Qpgo) SP-SM.	
Very dense, gray, fine to medium SAND, trace of silt and gravel; wet; massive; (Qpnf/Qpgo) SP/SP-SM. - Seam of green-gray, silty sand at 123.0 feet.	109.5
BOTTOM OF BORING COMPLETED 9/9/2002	140.5



LEGEND

- * Sample Not Recovered
- Standard Penetration Test
- Piezometer Screen and Sand Filter
- Bentonite-Cement Grout
- Bentonite Chips/Pellets
- Bentonite Grout
- Ground Water Level in Well

● % Water Content

Plastic Limit ├──●──┤ Liquid Limit

Natural Water Content

NOTES

1. The boring was performed using Mud Rotary drilling methods.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. Refer to KEY for explanation of symbols, codes and definitions.
6. USCS designation is based on visual-manual classification and selected lab testing.

Alaskan Way Viaduct and Seawall Project
Seattle, Washington

LOG OF BORING EB-24

October 2002 21-1-09490-816

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-4
Sheet 3 of 3

WSDOT Agreement No. Y-7888

REV 2

MASTER_LOG2 21-09490.GPJ SHAN_WIL.GDT 10/31/02 Log: AJC Rev: WDN Typ: LKD

Boring No. B-1

Logged by: MS

Date: 12/28/99

Approximate Elev.

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)	
Brown silty SAND with gravel, moist. (Fill) (SM)	Loose				10	
Black silty SAND to SAND with silt, trace gravel, moist. (Fill) (SM-SP)				6		
Saturated at 3 feet.	Loose	▼			54	
				5		
Shell fragments at 5 feet.		5				
Wood debris at 6.25 feet.					32	
Gray silty fine to medium SAND with gravel, wet. (SM)	Loose to Medium Dense			8		
1 inch of wood debris (fill) at 8.4 feet.					46	
Gray fine to medium SAND with silt, trace gravel, wet. (SM) (Weathered glacial drift)	Medium Dense to Very Dense			19		
		10				
				67/8"	7	
Gray silty sandy GRAVEL, moist. (GM) Brown mottling at 11.2 feet. Large gravel in sampler at 12.5 feet.	Very Dense					
Light gray fine sandy SILT with clay, damp. (ML) (Glacial drift)	Hard			50/3.5"	13	

Boring terminated at 12.75 feet due to refusal.
Saturated at 3 feet.

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BORING LOG
SKYWAY BUILDING
SEATTLE, WASHINGTON

Proj. No. T-4570 | Date JAN 2000 | Figure A-2

Boring No. B-2

Logged by: MS

Date: 12/28/99

Approximate Elev.

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)	
Brown (light and dark mottled)silty SAND with gravel, moist. (SM) (Fill)	Medium Dense	▼		21	11	
Gray fine to medium SAND with silt, moist. (SM) (Glacial drift)	Very Dense			50/4"	12	
Gray fine sandy SILT, damp. (ML-SM)	Hard					
Gray silty sandy GRAVEL, damp. (GM)	Very Dense					
Gray lenses of silty SAND and sandy SILT, damp. (SM-ML)	Very Dense	5		50/6"	17	
Gray fine sandy SILT, damp. (ML)	Hard			50/4.5"	29	
		10		50/6"	32	
Gray very fine silty SAND, wet. (SM)	Very Dense			50/4"	26	
		15		50/5"	35	

Boring terminated at 15.5 feet.
Groundwater elevation difficult to determine during drilling. (Water added during drilling activities)
Groundwater measured at 1 foot on 12/29/99.

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BORING LOG
SKYWAY BUILDING
SEATTLE, WASHINGTON

Proj. No. T-4570	Date JAN 2000	Figure A-3

Boring No. B-3

Logged by: MS

Date: 12/29/99

Approximate Elev.

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)
Dark brown silty SAND to SAND with silt, saturated, trace shell fragments. (SM) (Fill)	Very Loose		I	1/18"	27
Black SAND with silt to silty SAND, saturated, wood debris. (SP-SM) (Fill) Scattered gravel at 2.5 feet.	Loose		I	10	35
2 inches of wood debris at 5 feet.		5			
Dark gray fine to medium SAND with silt to silty SAND, wet. (SM) (Weathered glacial drift)	Loose		I	9	29
			I	50/4"	8
Gray silty sandy GRAVEL, moist. (GM) (Glacial drift)	Very Dense	10	I	50/5"	11

Boring terminated at 11 feet due to refusal.
Groundwater seepage at surface.

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BORING LOG
SKYWAY BUILDING
SEATTLE, WASHINGTON

Proj. No. T-4570 | Date JAN 2000 | Figure A-4

Boring No. B-4

Logged by: MS

Date: 12/29/99

Approximate Elev.

Soil Description	Consistency/ Relative Density	Depth (ft.)	Sample	(N) Blows/ ft.	Moisture Content (%)	
Brown SAND with silt, gravel, brick debris, wet. (SP) (FILL)	Very Loose	▼		2	25	
Gray SAND with silt, layers of silty sand, sandy silt, and wood debris. (SM-SP) (Fill)	Loose	5		5	21	
Gray silty fine sandy GRAVEL, damp. (GM) (Glacial drift)	Very Dense			50/5"	9	
Gravel in shoe.				50/1"	0.7	

Boring terminated at 9.6 feet due to refusal
Groundwater seepage encountered at 1 foot.

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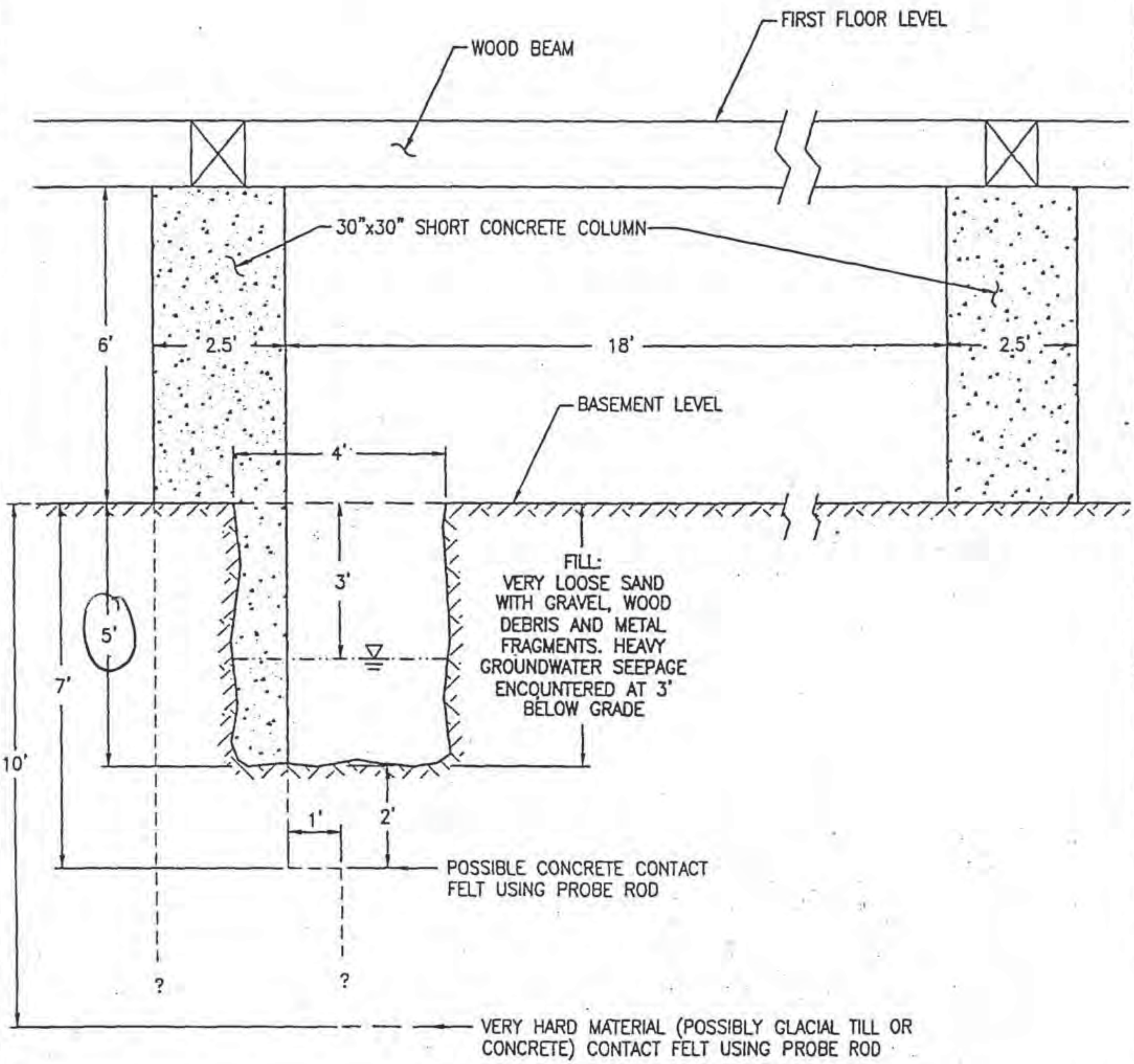
BORING LOG
SKYWAY BUILDING
SEATTLE, WASHINGTON

Proj. No. T-4570	Date JAN 2000	Figure A-5

TEST PIT TP-1



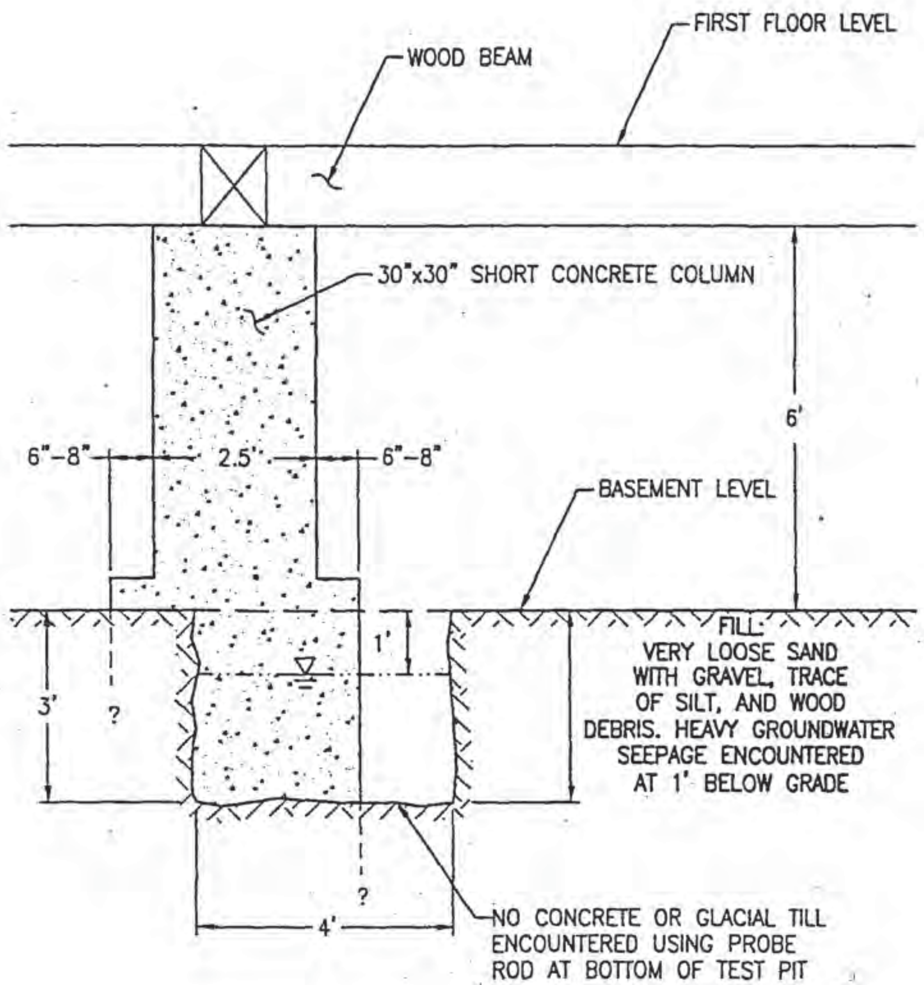
NOT TO SCALE

TERRA ASSOCIATES
Geotechnical Consultants

TEST PIT LOG
SKYWAY BUILDING
SEATTLE, WASHINGTON

Proj.No. 4570	Date JAN. 2000	Figure A-6

TEST PIT TP-2



NOT TO SCALE

TERRA ASSOCIATES
Geotechnical Consultants

TEST PIT LOG
SKYWAY BUILDING
SEATTLE, WASHINGTON

Proj.No. 4570	Date JAN. 2000	Figure A–7

Appendix B

NPDES Basin 69 Vine Calibration and CV Technical Memorandum

September 11, 2018

To: Alex Mockos – Seattle Public Utilities

From: Andrew Henson - Aqualyze
Marshall Kosaka – Aqualyze

Cc: Brent Robinson – Seattle Public Utilities
Justin Twenter – Seattle Public Utilities
Rizwan Hamid - Aqualyze

Subject: WA08 - Central Waterfront Basin 69 Calibration and Control Volume Modeling Technical Memorandum

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1. Introduction

The Central Waterfront (CWF) basin in downtown Seattle features a combined sewer (CS) collection system owned and operated by Seattle Public Utilities (SPU). This system collects sanitary and stormwater runoff flow from an urban area and conveys it to the King County Wastewater Treatment Division (KCWTD) CS system for treatment. The SPU system can become capacity constrained during wet weather periods which can cause CS overflows (CSOs) into Puget Sound via an overflow weir via National Pollutant Discharge Elimination System (NPDES) 69 outfall. SPU is required under its Consent Decree to bring this basin, CWF Basin 69 into compliance by reducing overflows to once per year, on a 20-year rolling average. The control volume (CV) of this basin has been estimated to be approximately 130,000 gallons as part of the Long-Term Control Plan (CH2MHILL 2015).

A hydraulic and hydrologic (H/H) model of the project area was recently refined by Aqualyze under the Wastewater System Analysis (WWSA) project (SPU Contract C16-110S) using the United States Environmental Protection Agency's (EPA) Stormwater Management Model Version 5.1.012 (SWMM5). This model will be used as the basis for the modeling activities under this project.

2. Purpose

The purpose of this TM is to document the modeling procedures, results, and assumptions associated with the Modeling On-Call Contract (C13-031) Work Assignment 8 (WA08) project. The results contained herein will provide the documentation that will inform SPU's future options analysis to identify a CSO control solution for CWF Basin 69.

2.1. Project Goals and Objectives

The goal of this H/H modeling project is to determine the CV and potential high-level solutions to meet the compliance requirement of less than once CSO per year. The following objectives will be completed to achieve the goal:

- Update the H/H model to reflect current SPU modeling standards
- Calibrate the model using 2017-2018 flow monitoring data
- Validate the model against reported CSO frequency and volumes
- Complete the Uncertainty Analysis (UA) procedure to determine percent non-exceedance curves
- Document selected CV
- Identify two high-level flow transfer projects that will bring the basin into compliance.

2.2. Study Boundaries

The CWF Basin 69, shown in Figure 2-1, covers approximately 170 acres in the CWF area of downtown Seattle. It is bordered by Bay Street and Denny Way to the north, Virginia Street to the south, 5th Avenue to the East, and Puget Sound to the West.

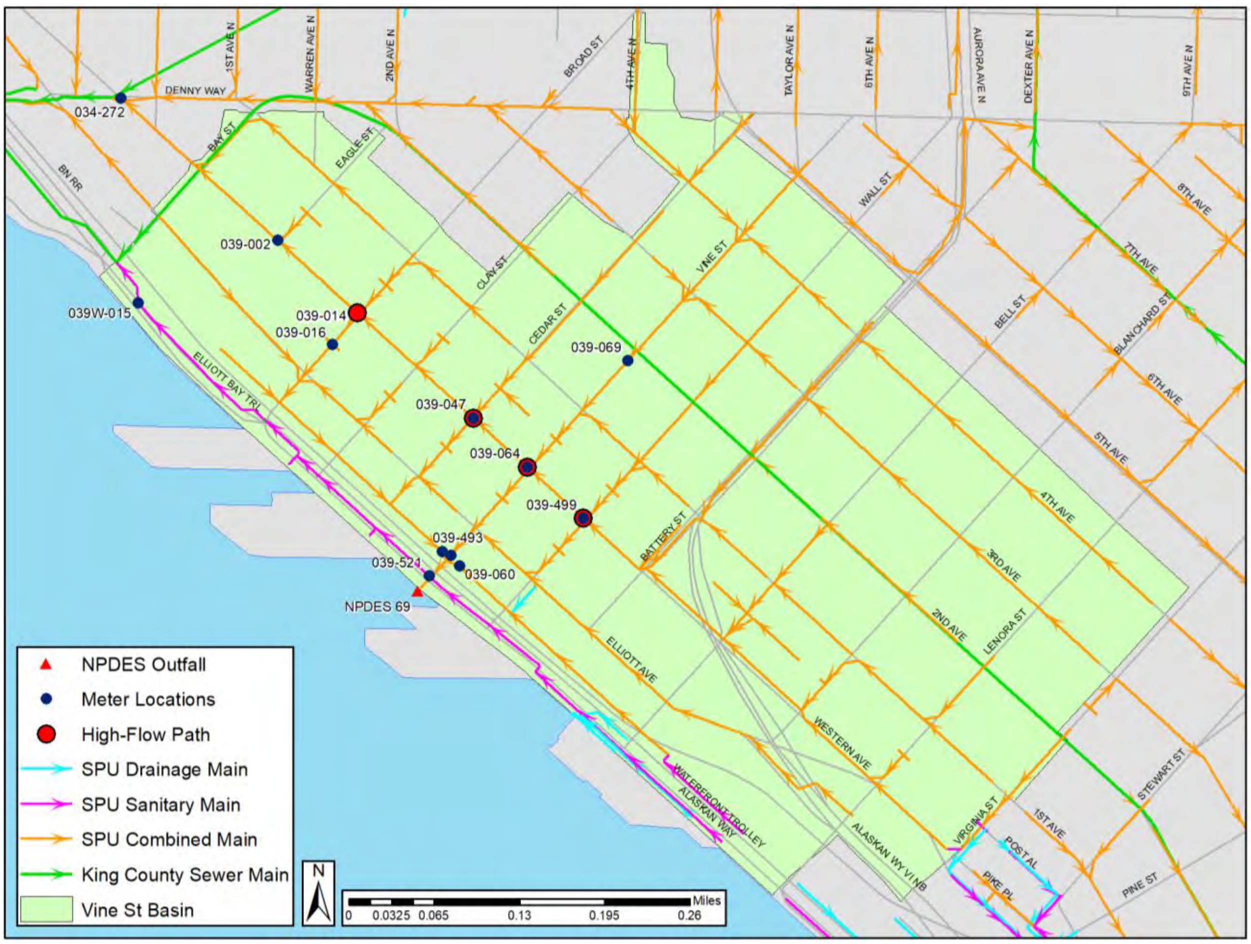

Figure 2-1: Project Study Area

3. Basin Characterization

3.1. Overview

The CWF Basin 69 is characterized primarily by heavily developed urban commercial areas except for the Olympic sculpture park in the north part of the basin, which is parkland. Flow in the CWF Basin 69 generally travels north and west through SPU's CS system and enters KCWTD Elliot Bay Interceptor (EBI). High flows through the Vine Street CSO structure can be diverted to the CSO outfall during high flows which discharges into the Puget Sound on the western boundary of the basin. Table 3-1 provides summary statistics for the basin.

Table 3-1: Vine Street NPDES 69 Basin Summary

Basin Features	Count
Basin area, acres	169.9
Number of Monitoring Locations (Dates)	12 (10/01/2017 – 03/31/2018)
Number of Diversions	6
Number of CSO structures/outfalls	1
Associated SPU Rain gage	RG11

3.1.1. Conveyance System

The conveyance system in the CWF Basin 69 is primarily a combined system except for a relatively small drainage system in the southwest corner (outfalls into Puget Sound). The combined system collects and conveys flow to the KCWTD CS system at two locations:

- The EBI via the Vine Street CSO structure and conveyance along Alaskan Way
- The Denny Way/Lake Union Tunnel just upstream of the Denny Local Regulator via conveyance along Western Avenue.

There are four high-flow paths located along Western Avenue. Three high-flow paths are pipes at MH's MH039-499, MH039-064, and MH039-014. The fourth high-flow path is a weir at MH 039-047. These are shown in Figure 2-1. Figure 3-1 shows a schematic of MH039-499, which is representative of the other MH containing high-flow paths (measurements vary).

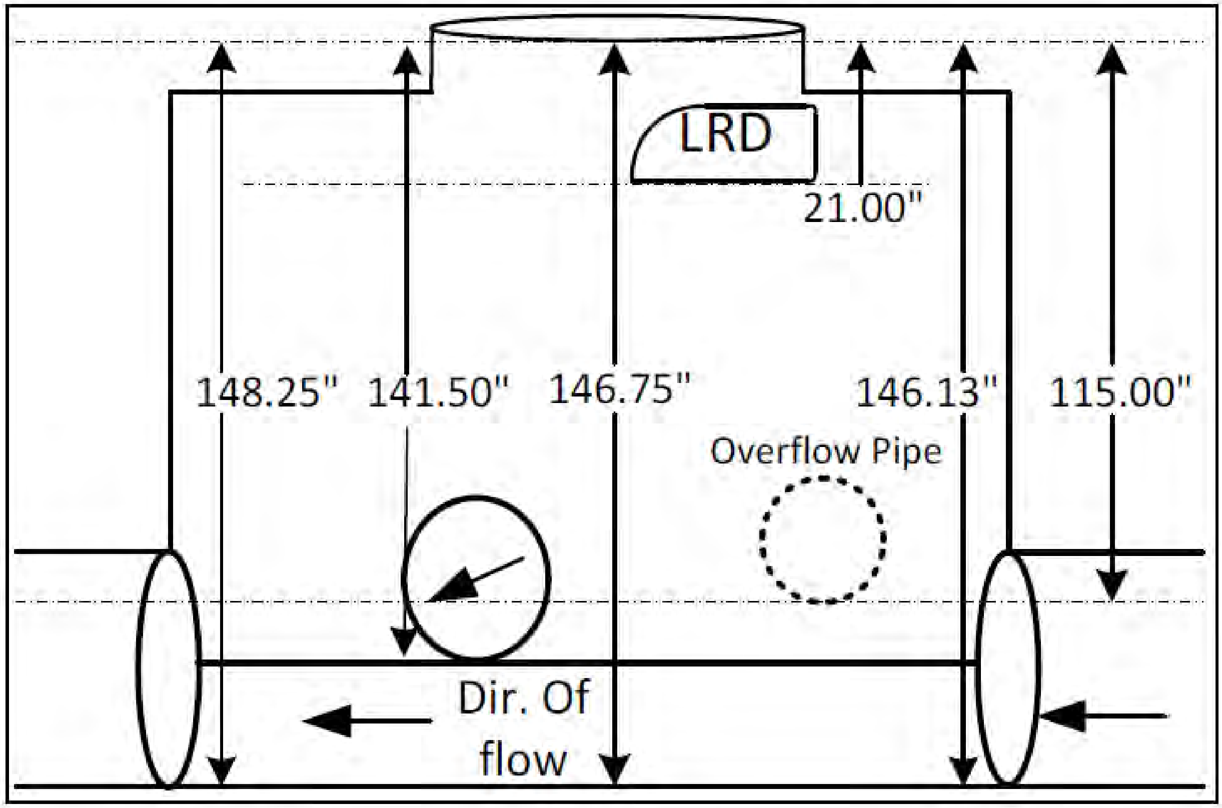

Figure 3-1: MH039-499 Schematic

3.1.2. Land Use

The land use in the CWF Basin 69 is primarily heavily developed urban commercial area except for the Olympic Sculpture Park, which is parkland.

3.1.3. Soils

The underlying soil in the CWF Basin 69 is comprised of primarily of Modified Land which is characterized as silt, sand, debris, or slag. A small portion of the basin is comprised of Clay Loam which is characterized as till or hardpan.

4. Data Collection

4.1. System Data

4.1.1. Pipes and Maintenance Holes (MH)

Data for pipes and MHs was gathered primarily from GIS data provided SPU and supplemented with survey data and flow monitoring site sheets (from ADS, the flow monitoring contractor).

4.1.2. Special Structures

Data for the Vine Street CSO structure was gathered from surveys available from the Alaskan Way

Viaduct and Seawall Replacement (AWVSRP) Project (GHD 2012), the SPU Records Vault, and site sheets from ADS.

4.1.3. Datum Adjustments

The horizontal datum for the project is North American Datum of 1983 (NAD83) High Accuracy Reference Network (HARN) Washington State Lambert Grid Coordinate System North Zone.

The vertical datum is North American Vertical Datum of 1988 (NAVD88). Data provided in the old SPU vertical datum were adjusted by plus (+) 9.7 feet to convert to NAVD88, unless otherwise noted. Data provided in the Metro datum (the datum often used for King County facilities) were adjusted by minus (-) 96.42 ft to convert to NAVD88, unless otherwise noted.

4.2. Surface Data

Surface data for the CWF Basin 69 was gathered from the “stype.shp” shapefile provided by SPU. This data was used to compute percent imperviousness of model subcatchments.

4.3. Rainfall and Flow Meter Data

Flow meter data was collected by ADS and downloaded from their website for use in model calibration. ADS and SPU performed flow meter data QA/QC prior to model calibration. All flow data used for calibration were considered final and that the data was acceptable for use in model calibration. The period of record for each meter site was generally between 10/01/2017 and 04/01/2018. A list of meters used in calibration is provided in Table 4-1. The meter locations are shown on the map in Figure 2-1.

Table 4-1: Vine Street Meter List

Meter	Measurement
Vine069_034272_X1	Depth, Flow, Velocity
Vine069_039060_X1	Depth, Flow, Velocity
Vine069_039069_X1	Depth, Flow, Velocity
Vine069_039493_X1	Depth, Flow, Velocity
Vine069_039016_X1	Depth, Flow, Velocity
Vine069_039521_Y1	Depth, Flow, Velocity
Vine069_039002_X1	Depth, Flow, Velocity
Vine069_039059_X1	Depth, Flow, Velocity
Vine069_039064_Z1	Depth
Vine069_039W015_Z1	Depth
Vine069_039499_Z1	Depth
Vine069_039047_Z1	Depth

SPU provided rain gauge data. It was assumed that the rain gauge data were of sufficient quality for model calibration. Rain gauges were assigned to subcatchments based on Thiessen polygons between rain gauges.

5. Model Development

The H/H model refined under the WWSA project was used as the baseline for the CWF Basin 69 model. The model hydraulics were updated based on SPU GIS data, survey data, and ADS measurements at meter locations. The model subcatchment boundaries were delineated at a finer resolution than previous modelling efforts and subcatchment parameters were recomputed based on the revised delineation.

5.1. Modeling Platform

EPA SWMM5 version 5.1.012 modeling engine was used for calibration and control volume computation carried out in this work assignment. The PCSWMM software package, that utilizes the SWMM5 modeling engine, was used on this project.

5.2. Hydraulic Model Development

5.2.1. Maintenance Holes

All MHs providing connectivity in the project area were included in the model. Each MH was assumed to be a standard 48-inch diameter structure (area of 12.57 sq. ft.) unless otherwise noted. Structures with larger square footage were represented as storage nodes. Each MH was provided a typical ponded area of 5,000 ft^2, unless it was sealed, in which case a surcharge depth of 999 feet was included in lieu of the ponded area. MHs on the Vine Street CSO Puget Sound outfall line were assumed to be sealed to prevent model instabilities due to tidal intrusion.

GIS data, survey data, and ADS site sheets were the primary source data for updates to existing manholes. Survey data, from AWVSRP, and site sheets were preferentially used where present (GHD 2012). For three high flow paths, located at MH039-499, MH039-064, and MH039-047, a combination of measure downs from ADS site sheets and rim elevation from SPU's mainline endpoints GIS layer were used to define pipe inverts.

5.2.2. Pipes and Open Channels

All SPU-owned pipes 8 inches in diameter or greater were included in the model. Best engineering judgment and accepted engineering practice were used to fill any data gaps (i.e., if a pipe invert were missing, adjacent MH inverts may have been used to interpolate missing inverts). Assumptions are documented in the model file under the description field. All pipes were assumed to have a Manning's roughness coefficient of 0.013.

5.2.3. Special Structures

Special structures are defined as those that are hydraulically more complex than typical pipes and MHs. As such, they often require more detailed information to properly represent the structure in the model. The CWF Basin 69 contains orifices, storages, weirs, and a CSO diversion structure. The CSO diversion structure contains a circular bottom orifice, a storage node, and a CSO weir. GIS data, survey data, and as-builts were used to characterize these structures.

Three of the four high flow paths along Western Avenue are pipes connecting to a MH at an offset elevation compared to the normal flow path. Figure 5-1 shows the layout of the high-flow paths and Figure **3**-**1** shows a section of MH039-499, which is representative of the others. An orifice was used in the model to connect the pipe to the MH at the three high flow paths at MH039-499, MH039-064, and MH039-014. These elements were used to aid in the calibration process. A weir is located at the high flow path at MH039-047 and was modeled as such.

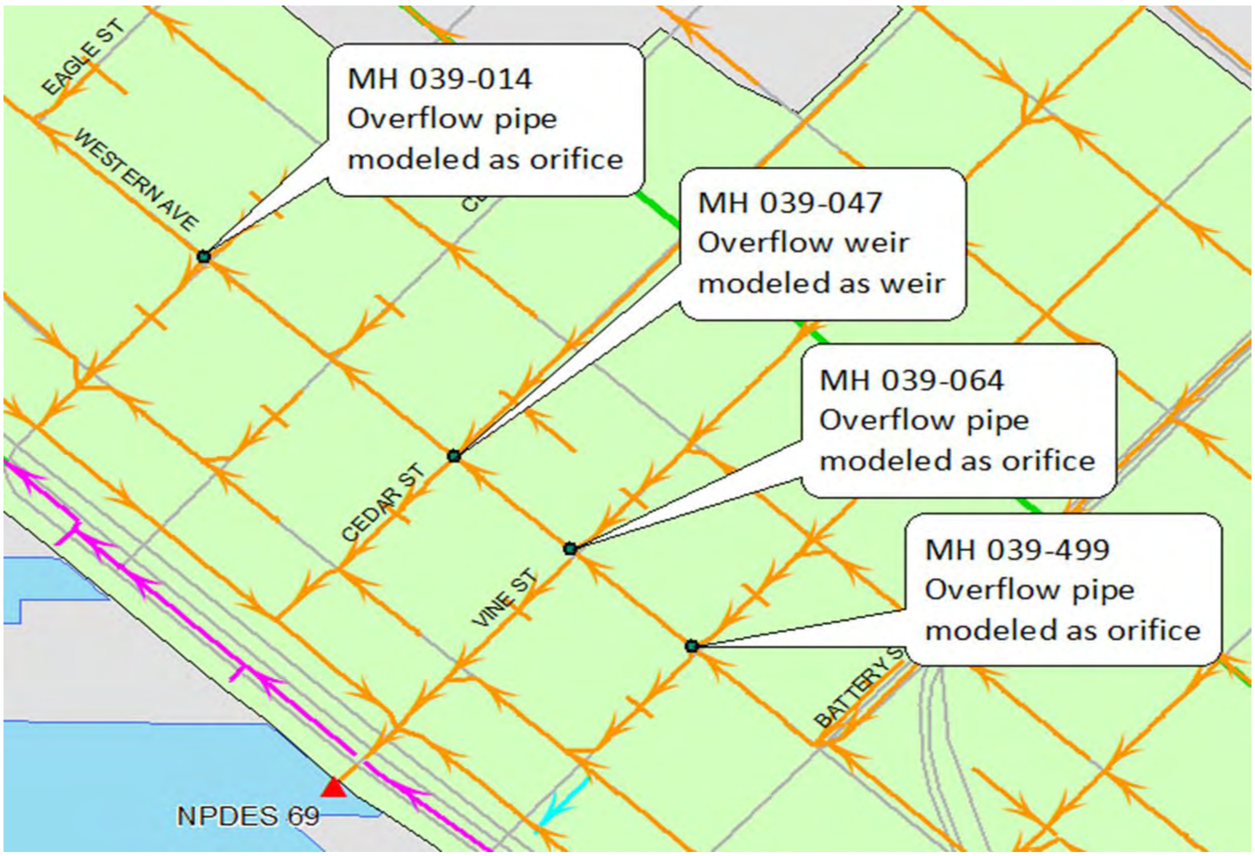

Figure 5-1: Western Avenue High-Flow Paths

5.2.4. Outfalls

The CWF Basin 69 model contains three outfalls, two at the northern end where the SPU system joins the KCWTD CS system and one on the western boundary where the CSO structure overflow path discharges to the Puget Sound.

5.3. Hydrologic Model Construction

5.3.1. Subcatchment Delineation

The base model was inherited with subcatchments delineated using contour-based surface flow patterns in conjunction with catch basin locations. These inherited subcatchments were delineated at a resolution of roughly two to four city-blocks each. The subcatchment delineation was revised to a finer resolution of roughly ½ to 1 block each based on lateral connections and surface contours under this project. Each subcatchment was also separated into three types: catchments (denoted with a "C" prefix in the model), buildings (denoted with a "BLD" prefix in the model), and right-of-way (ROW, denoted with a "ROW" prefix in the model) to allow for greater accuracy in routing flow. This approach allowed for a calibration approach that does not rely on impervious area as a calibration parameter. The separation of "C", "ROW" and "BLD" allows for more a more accurate representation of conductivity, time of concentration, and flow routing than a single catchment to represent an area. In addition, it also offers more flexibility to implement these as calibration parameters.

Hydrologic parameters were also revised to better characterize the building and ROW areas separated from the refined subcatchments. GIS overlay routines utilizing the "Surface Type" layer, ROW layer and the buildings polygon layer were used to determine areas of each subcatchment that were buildings and ROW and the imperviousness of the ROW and remaining catchment area. Buildings were assumed to have a slope of 40% (estimated roof slope) and an imperviousness of 85%. Non-building subcatchments had imperviousness capped at 85 percent per discussions with SPU. In highly impervious areas such as CWF Basin 69, there is often not enough pervious area to route flow to that would make a meaningful difference in calibration. Therefore, to use subarea routing as a calibration parameter, imperviousness was capped. Aqualyze found that 85% was the highest threshold at which the model was sensitive to changes in sub-area routing. Subcatchments were assigned nominal Green-Ampt infiltration parameters which were adjusted as calibration parameters.

5.3.2. Dry-Weather Flow Conditions

Dry-weather flow (DWF) analysis was conducted to determine the wastewater production at each meter site from its metershed. The methodology and protocols used to establish DWF for each site are summarized below.

1) Programmatically run the following criteria in Aqualyze's QP Manager software:
    a) Compute average daily flow rate for each day of the monitoring period
    b) Filter out wet days with greater than 0.1 inches of rainfall
    c) Filter out any days that fall outside of two standard deviations of the data set from 1 (b). This typically gets rid of days with antecedent rainfall.
    d) Generate average 24-hour DWF curve from 1 (c)
    e) Compare individual days with the computed average DWF in 1 (d) and manually unselect days with missing data, unexplained data spikes, or suspected influence from preceding rain
2) Using the revised data set from 1 (e), establish the average DWF for the site

3) Generate 24-hour time patterns for weekday and weekend (unit hydrograph)
4) Conduct flow mass balance at sites with upstream meter locations and ensure that the net difference is not less than zero
5) Use average DWF and time patterns from 2 and 3 in the model.

A flow mass balance was conducted for the CWF Basin 69. The meter layout is shown in Figure 5-2 and the results are tabulated below in Table 5-1. Depth meters are not included. DWF flow patterns and average values are taken from the next flow meter downstream.

DWF values and patterns were distributed evenly at each node contributing to a given flow meter. DWF was not computed for junctions contributing to the meter located at 039-016 because the meter is in an overflow path that only sees flow during large storm events. The downstream value and pattern for 039-493 was applied to these junctions.

Vine069_039W015_Z1 is a depth meter located at the downstream end of the western branch of the CWF Basin 69. Junctions tributary to this meter have been assigned the DWF value and pattern from a representative meter, Vine069_039493_X1. These junctions are not considered in area and flow balance calculations presented below.

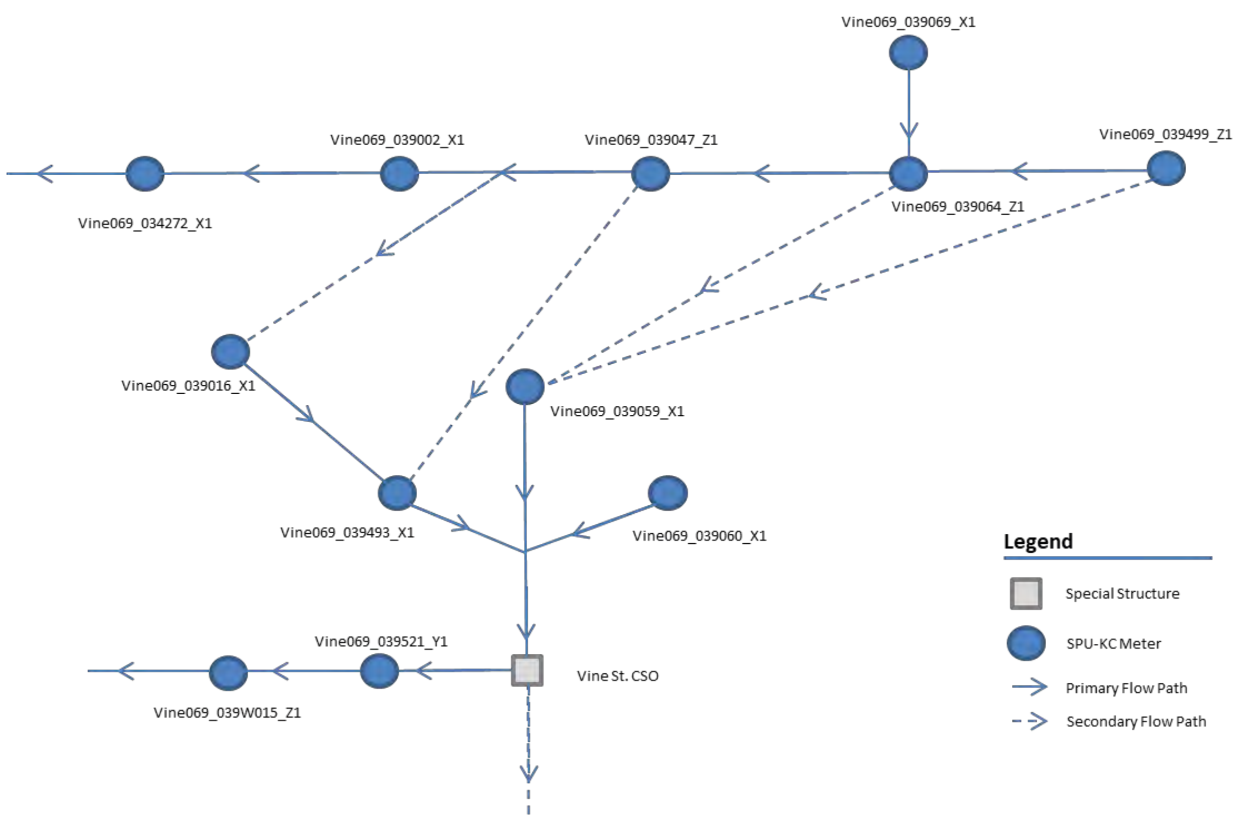

Figure 5-2: CWF Basin 69 Meter Layout

Table 5-1: Vine Street NPDES 69 Basin Summary

Meter	Dry-Weather Flow (MGD)		Tributary Area (ac)		Net DWF/Net Area (gal/ac/d)
	Gross	Net	Gross	Net	
Vine069_039521_Y1	0.241	0.027	48.56	7.77	3,474
Vine069_039060_X1	0.054	0.054	6.96	6.95	7,761
Vine069_039059_X1	0.087	0.087	13.94	13.9	6,241
Vine069_039493_X1	0.073	0.073	19.89	19.8	3,670
Vine069_039016_X1[1]	-	-	-	-	-
Vine069_034272_X1	0.884	0.031	132.26	10.0	3,093
Vine069_039002_X1	0.853	0.643	122.24	104.	6,174
Vine069_039069_X1	0.209	0.209	18.08	18.0	11,559

5.4. Boundary Conditions

A water surface elevation timeseries, provided by SPU/KCWTD, was used to account for the downstream water level in the EBI. A free outfall was used at the connection at the Denny Way/Lake Union Tunnel (MH 034-272) as the invert at MH 034-272 is approximately 25 feet higher than the invert of the Denny Way/Lake Union Tunnel and is not thought to be influenced by downstream water levels.

A tidal boundary condition was used at the Vine Street CSO outfall to account for the tide in the Puget Sound. Tidal data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service's (NOS's) gauge station (Sta.) 9447130 (NOAA 2018). A saltwater correction was applied to the tidal boundary condition.

6. Model Calibration and Validation

6.1. Calibration Process

Calibration was performed in two steps. First, the parameters controlling the impervious response of the basin were calibrated. These parameters control the quick response and peak flows of the basin, in addition to controlling the amount of water that infiltrates into the ground. These parameters include hydraulic conductivity, depression storage, and sub-area routing options. Sub-area routing allows water to flow from the impervious section of a subcatchment to the pervious section, before flowing into the outlet. By calibrating these parameters first, the volume of water available for use in the SWMM5 groundwater module model is held relatively constant allowing the groundwater parameters to be calibrated in a more straightforward manner. The groundwater parameters include aquifer bottom elevation, lower groundwater loss rate, and GW Flow Coefficient (A1) and GW Flow Exponent (B1).

New aquifers were created for each of the meter basins except for Vine069_039016_X1 as there are no

[1] Vine069_039016_X1 is in an overflow path which only sees flow during large storm events.

subcatchments directly tributary to this meter. The new aquifers were developed using the following methodology:

- The average tributary MH depth in each metershed was added to the meter location invert elevation to calculate the average metershed surface elevation.
- The meter elevation was used for the threshold elevation of the contributing subcatchments.
- Groundwater variables such as GW Flow Coefficient (A1) and GW Flow Exponent (B1) were calibration parameters.

6.2. Calibration Events

For each meter, a set of large storm events (relative to the meter) were selected as calibration events on which to focus during calibration. A period before and after the storm event was included to assess the antecedent and recession conditions and to check the impact of seasonality on individual calibration events. Table 6-1 lists the events used during calibration.

Table 6-1: Calibration Events

Event Date	Duration (hr)	Peak Rainfall (in/hr)	Total Rainfall (in)	Recurrence Interval (yr)[2]
10/18/2017	93.25	0.48	2.51	1
11/19/2017	100.58	1.08	2.92	2
12/18/2017	30.42	0.60	1.71	1.25
12/28/2017	33.17	0.24	1.32	< 0.5
1/17/2018	32.25	0.72	1.27	1
1/29/2018	13.50	0.36	0.91	1

6.3. Target Calibration Criteria

Calibration targets were derived from Chapter 7 of SPU's Drainage Standards and Guidelines (Seattle Public Utilities 2017). The following is a summary of the criteria used:

- Simulated time of peak flow should be within one hour of peak flow
- Simulated peak flow should be within -15% and +25% of observed peak flow for a given event
- Simulated flow volume should be within -10% and +20% of the observed flow volume for a given event

In addition to percent difference between ([modeled – observed] / observed) between observed and simulated flow and total volume for various storms, each meter was also evaluated for goodness-of-fit (GOF) statistics. GOF was computed by averaging, at each meter, the ratio of simulated peak flow to observed peak flow for each event in the set of calibration events. Standard deviation was also

[2] Recurrence interval is based on SPU Rain Gage 11 and its corresponding IDF curve.

calculated to indicate the spread. A GOF value of 1.00 for an event would indicate a perfect match between simulated flow and observed flow and a standard deviation of zero would indicate no variance between storms.

6.4. Calibration Locations

The model was calibrated at 12-meter locations as listed in Table 4-1. Meters with available flow data were calibrated to flow and the remaining meters were calibrated to depth.

6.5. Calibration Results

A good calibration of the basin was achieved with 6 of 8 flow meters meeting the Chapter 7 guidelines for calibration. The first meter that did not meet the Chapter 7 guidelines, Vine069_039016_X1, was in an overflow pipe that only saw flow during large storm events. SPU indicated there were data reliability issues with this meter and the data should be used to determine whether the high-flow path was active during an event as opposed to the peak flow and total flow during an event. The second meter that did not meet the Chapter 7 guidelines, Vine069_039002_X1, was difficult to calibrate as it was the first flow meter downstream of the high-flow paths. This was an area of complex hydraulics and it was difficult to simulate the correct split of flow at the high-flow paths resulting in an acceptable calibration in terms of peak flow but under-simulated volume for the calibration events. There was also a mass balance issue with meter Vine069_034272_X1 where some storms produced high peak values at the upstream meter (Vine069_039002_X1) as well as some instances of higher DWF values at the upstream meter. Based on guidance from SPU and ADS (Mitchell 2018), it was determined that Vine069_034272_X1 was more reliable based on the opinion of ADS engineers.

Calibration plots for four meters are presented here:

- Vine069_039069_X1 is the furthest upstream flow meter in the basin and demonstrates the calibration of areas upstream of the high flow paths and the Vine Street CSO structure.
- Vine069_039499_Z1 is a depth meter located at the first high-flow path along Western Avenue. This meter is somewhat representative of the other depth meter calibrations at the high-flow paths.
- Vine069_039059_X1 is a flow meter downstream of the high-flow paths but upstream of the Vine Street CSO structure. This meter demonstrates the calibration of the area between complex hydraulic structures.
- Vine069_039521_Y1 is a flow meter just downstream of the Vine Street CSO structure. This meter demonstrates the calibration and performance of the CSO structure.

Calibration plots and statistics for the remaining meters can be found in Appendix A.

6.5.1. Vine069_039069_X1

The meter Vine069_039069_X1 lies in the eastern portion of the basin and is the furthest upstream flow meter. A good calibration was achieved at this location with five events meeting the target calibration criteria. Table 6-2 provides calibration statistics for Vine069_039069_X1 and Figure 6-1 shows the simulated and observed flow for the 11/19/2017event at this meter.

Table 6-2: Calibration Statistics for Calibrated Events at Meter Vine069_039069_X1

	Peak Flow			Total Flow			Rainfall	
Event Date	**Obs.**	**Pred.**	**Peak % Diff.**	**Obs.**	**Pred.**	**Vol. % Diff.**	**Peak Int. (in/hr)**	**Total Depth (in)**
10/18/2017	3.54	3.75	5.9%	1.82	1.75	-3.7%	0.48	2.51
11/19/2017	3.25	4.05	24.5	2.17	2.00	-8.1%	1.08	2.92
12/18/2017	2.85	2.66	-6.8%	0.97	0.93	-3.3%	0.60	1.71
01/17/2018	3.94	4.50	14.1	0.86	0.78	-9.8%	0.72	1.27
01/29/2018	2.25	2.64	17.2	0.52	0.49	-5.1%	0.36	0.91
Average			**11.0**			**-6.0%**		

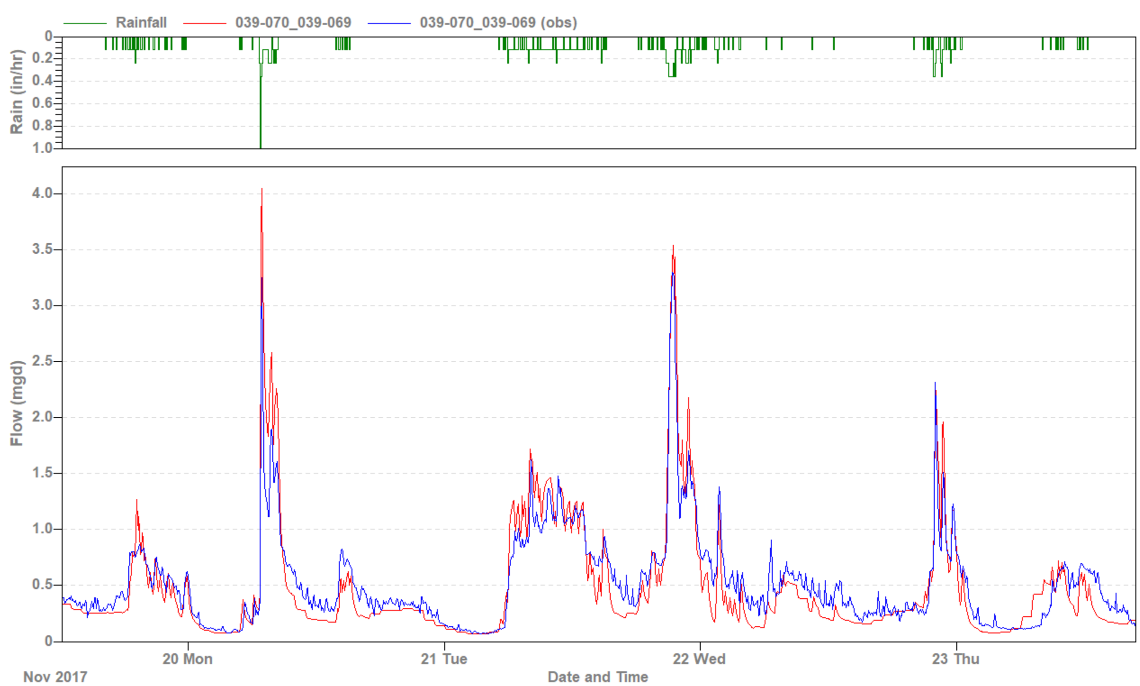

Figure 6-1: Observed and Predicted Flow at Meter Vine069_039069_X1: 11/19/2017 Event

6.5.2. Vine069_039499_Z1

The meter Vine069_039499_Z1 is located at a high-flow path along Western Avenue. The primary flow path continues north along Western Avenue while the high-flow path runs west toward the Vine Street CSO structure. It is the most upstream depth meter in the basin and was challenging to calibrate due to the relatively large tributary area and uncertain hydraulics for the high-flow path. An orifice was used to control flow along the high flow path and the orifice coefficient was used as a calibration parameter.

Table 6-3 provides calibration statistics for Vine069_039499_Z1 and Figure 6-2 shows the simulated and observed flow for the 11/19/2017 event at this meter.

Table 6-3: Calibration Statistics for Calibrated Events at Meter Vine069_039499_Z1

Event Date	Peak Depth (ft) Obs.	Peak Depth (ft) Pred.	Relative Peak Diff. (ft)	Rainfall Peak Int. (in/hr)	Rainfall Total Depth (in)
10/18/2017	2.66	2.23	-0.43	0.48	2.51
11/19/2017	2.75	2.77	0.02	1.08	2.92
12/18/2017	1.30	0.97	-0.33	0.60	1.71
01/17/2018	3.23	3.34	0.11	0.72	1.27
01/29/2018	1.81	1.03	-0.78	0.36	0.91
Average			**-0.28**		

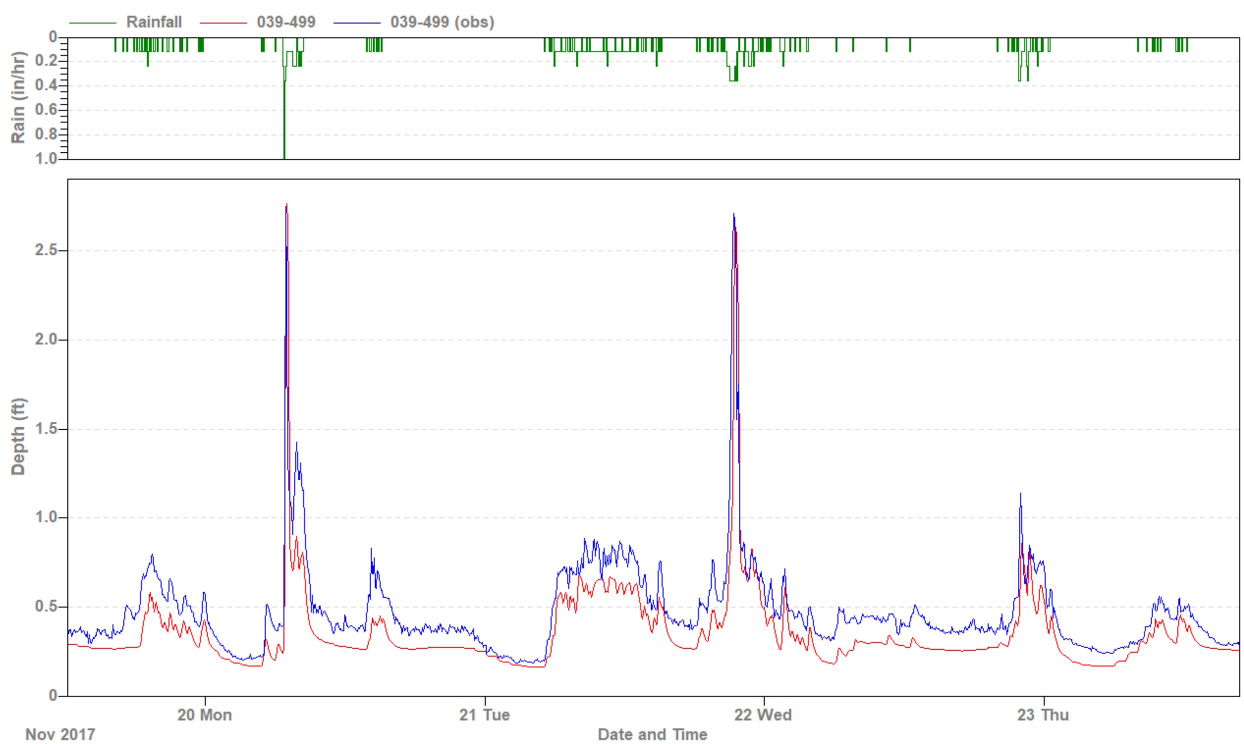

Figure 6-2: Observed and Predicted Depth at Meter Vine069_039499_Z1: 11/19/2017 Event

6.5.3. Vine069_039059_X1

The meter Vine069_039059_X1 lies downstream of the high-flow paths along Western Avenue and upstream of the Vine Street CSO structure. This meter was a challenge to calibrate due to the uncertain hydraulics at high-flow paths upstream and the relatively small net area of the metershed. However, a good calibration was achieved with five events meeting the target calibration criteria. Table 6-4 provides calibration statistics for Vine069_039059_X1 and Figure 6-3 shows the simulated and observed flow for the 11/19/2017 event at this meter.

Table 6-4: Calibration Statistics for Calibrated Events at Meter Vine069_039059_X1

	Peak Flow			Total Flow			Rainfall	
Event Date	Obs.	Pred.	Peak % Diff.	Obs.	Pred.	Vol. % Diff.	Peak Int. (in/hr)	Total Depth (in)
10/18/2017	3.36	2.94	-12.7%	0.90	0.87	-3.6%	0.48	2.5
11/19/2017	3.63	4.50	23.9%	1.13	1.08	-4.1%	1.08	2.9
12/18/2017	1.45	1.65	14.3%	0.52	0.50	-5.1%	0.60	1.7
01/17/2018	5.24	6.09	16.2%	0.44	0.45	2.2%	0.72	1.2
01/29/2018	1.70	1.60	-6.0%	0.29	0.26	-9.6%	0.36	0.9
Average			**7.1%**			**-4.1%**		

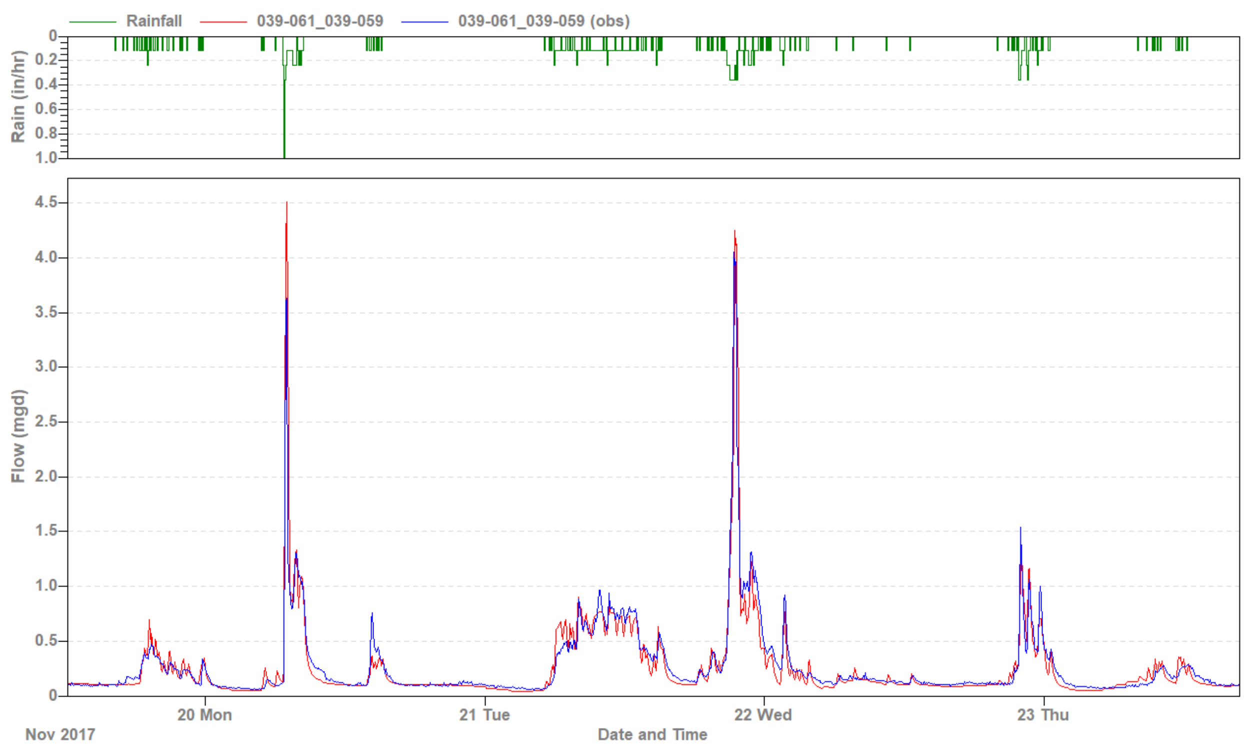

Figure 6-3: Observed and Predicted Flow at Meter Vine069_039059_X1: 11/19/2017 Event

6.5.4. Vine069_039521_Y1

The meter Vine069_039521_Y1 is located at the downstream end of the Vine Street CSO structure. Flow travelling north along Alaskan Way and flow through the drop orifice in the CSO structure contribute to this meter. A good calibration was achieved at this location with five events meeting the target calibration criteria. Table 6-5 provides calibration statistics for Vine069_039521_Y1 and Figure 6-4 shows the simulated and observed flow for the 11/19/2017 event at this meter.

Table 6-5: Calibration Statistics for Calibrated Events at Meter Vine069_039521_Y1

	Peak Flow (mgd)			Total Flow (mgal)			Rainfall	
Event Date	Obs.	Pred.	Peak % Diff.	Obs.	Pred.	Vol. % Diff.	Peak Int. (in/hr)	Total Depth (in)
10/18/2017	6.26	5.74	-8.3%	2.55	2.35	-7.7%	0.48	2.51
11/19/2017	8.70	8.17	-6.1%	3.52	3.36	-4.8%	1.08	2.92
12/18/2017	3.86	4.20	8.9%	1.51	1.56	3.3%	0.60	1.71
01/17/2018	7.19	8.44	17.4%	1.47	1.38	-6.0%	0.72	1.27
01/29/2018	5.04	4.73	-6.1%	0.87	0.83	-4.9%	0.36	0.91
Average			**1.2%**			**-4.0%**		

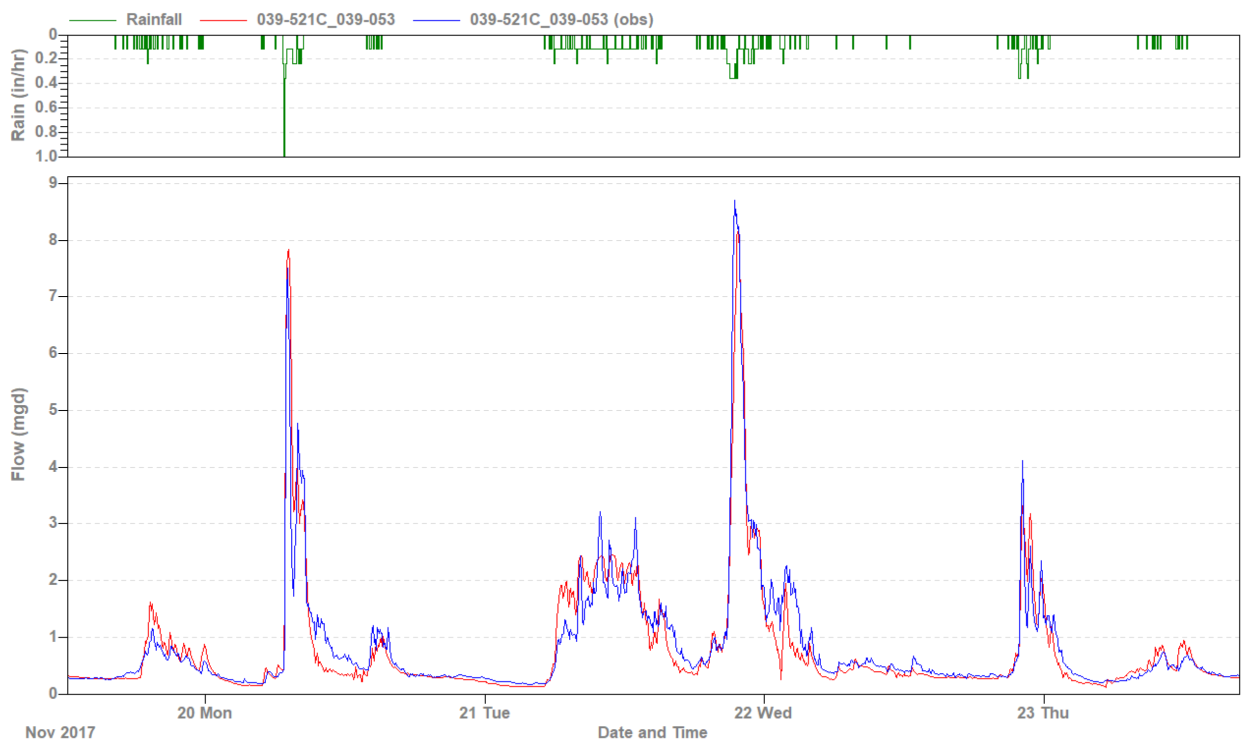

Figure 6-4: Observed and Predicted Flow at Meter Vine069_039521_Y1: 11/19/2017 Event

6.5.5. Vine069_034272_X1

The meter Vine069_034272_X1 is located at the downstream end of the basin on the primary flow path along Western Avenue. A good calibration was achieved at this location with five events meeting the target calibration criteria. Table 6-6 provides calibration statistics for Vine069_034272_X1 and Figure 6-5 shows the simulated and observed flow for the 11/19/2017 event at this meter.

Table 6-6: Calibration Statistics for Calibrated Events at Meter Vine069_034272_X1

	Peak Flow (mgd)			Total Flow (mgal)			Rainfall	
Event Date	Obs.	Pred.	Peak % Diff.	Obs.	Pred.	Vol. % Diff.	Peak Int. (in/hr)	Total Depth (in)
10/18/2017	12.41	13.52	9.0%	8.11	7.76	-4.4%	0.48	2.51
11/19/2017	12.01	14.09	17.3%	9.50	8.81	-7.2%	1.08	2.92
12/18/2017	11.31	11.82	4.5%	4.52	4.14	-8.5%	0.60	1.71
01/17/2018	12.51	14.43	15.4%	3.61	3.48	-3.6%	0.72	1.27
01/29/2018	11.52	12.49	8.4%	2.42	2.18	-9.7%	0.36	0.91
Average			**10.9%**			**-6.7%**		

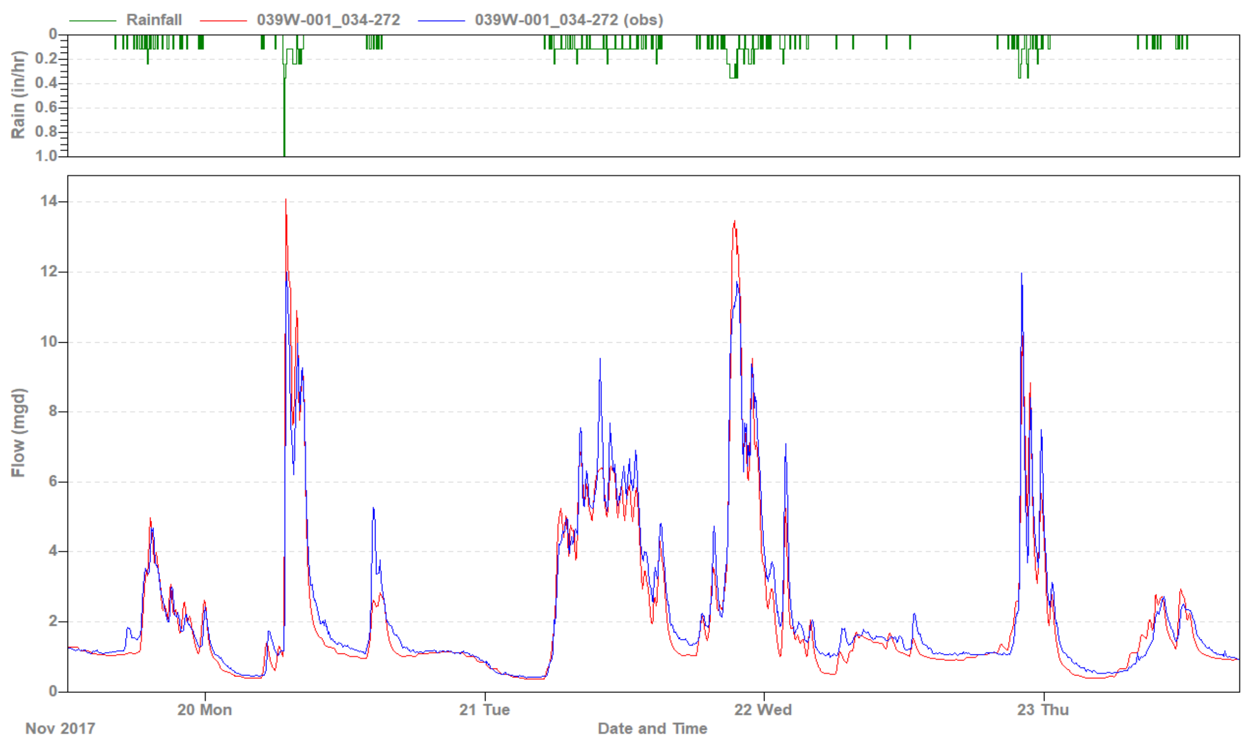

Figure 6-5: Observed and Predicted Flow at Meter Vine069_034272_X1: 11/19/2017 Event

6.5.6. Remaining Meters

Plots for remaining meters can be found in Appendix A. No events met the calibration standards at Vine069_039016_X1 as it is in an overflow pipe and has data quality issues. For meter Vine069_039002_X1, a good calibration of peak flow was achieved for five events while the calibration of volume met the standards for no events. This was due to unreliable data. A good depth calibration was achieved at Vine069_039064_Z1 for two events. This was due to difficulty simulating the proper split of flow between the primary flow path and the high flow path at this location. Vine069_039047_Z1 presented similar challenges to Vine069_039064_Z1 and a good depth calibration was achieved for two events due to difficulty simulating the proper split of flow between the primary flow path and the high flow path at this location. SPU approved the calibration for all meters given the above challenges.

7. Existing System Performance

7.1. Capacity Limitations and Surface Flooding in the System

No surface flooding was simulated in the existing conditions model for the calibration period. However, there are capacity limitations in the basin due to the proximity to the EBI. Flow through the Vine Street CSO structure and along Alaskan Way is heavily influenced by the water level in the EBI. Figure 7-1 shows a plot of the water level in the EBI, the head at 039W-015 which is the most downstream flow monitoring location on Alaskan Way (one link upstream of the connection point to the EBI), and the head in the Vine Street CSO structure. For all but the periods of highest intensity rainfall, the head just upstream of the connection to the EBI mirrors that of the head in the EBI. The Vine Street CSO structure is also influenced by the water level in EBI during periods of moderate rainfall, however, the head continues to rise in the structure during very intense rainfall.

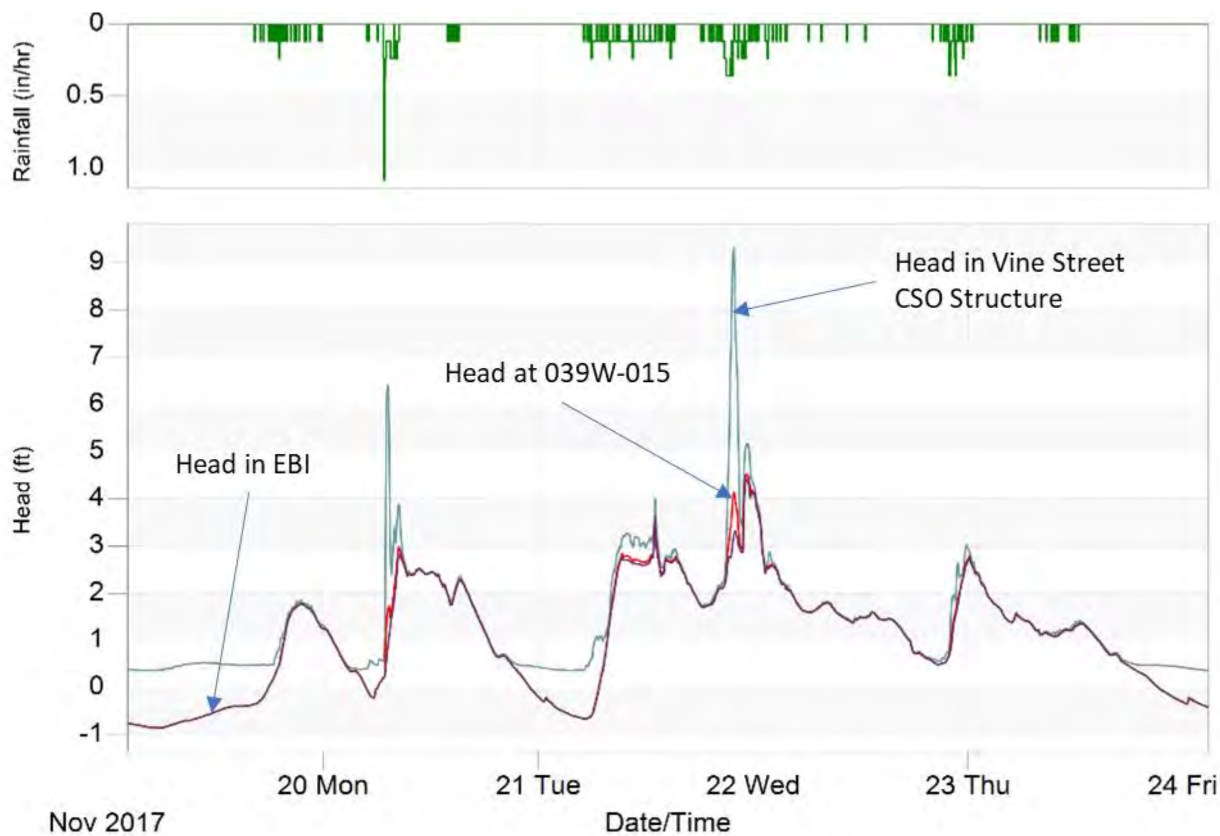

Figure 7-1: Head at 039W-015 (red), Head in the EBI Near the Denny Lake Union Regulator (blue), and Head in the Vine Street CSO Structure (turquoise)

7.2. Characteristics of Combined Sewer Overflows

A comparison of observed and simulated CSO volumes for the past eight years (corresponding to the available CSO reports) was performed to validate the model. The model did a good job of simulating frequency of CSO events. However, the model did a poor job simulating the duration of CSO events, predominantly simulating a longer duration for a given event. As a result, the model simulated much higher CSO volumes than observed. Table 7-1 shows simulated and observed CSO count and frequency from January 2010 through March 2018. Table 7-2 shows a comparison of observed and simulated CSO volumes from 2010 through 2017.

Table 7-1: Observed and Simulated CSO Count and Frequency for August 2010 to Present

	Observed	Simulated
Count	21	22
Frequency	2.6	2.8

Table 7-2: Observed and Simulated CSO Events 2010 - 2017

Start Date	Observed Vol. (gal)	Simulated Vol. (gal)	Difference (gal)	Difference (%)	Observed Duration (hr)	Simulated Duration (hr)	Difference (hr)
9/17/2010	214,775	181,900	-32,875	-15.3%	26.87	27.00	0.13
12/11/2010	-	21,850	-	-	-	0.42	-
3/9/2011	9,893	-	-	-	0.13	-	-
5/21/2011	48,047	11,220	-36,827	-76.6%	0.33	0.25	-0.08
5/21/2012	44,198	84,350	40,152	90.8%	0.23	0.42	0.19
11/19/2012	232,895	364,000	131,105	56.3%	10.47	3.08	-7.39
8/29/2013	17,744	51,090	33,346	187.9%	0.15	0.33	0.18
9/5/2013	357,052	905,600	548,548	153.6%	1.70	2.5	0.80
9/28/2013	64,217	70,350	6,133	9.6%	0.33	0.33	0.00
1/2/2014	-	20,440	-	-	0.16	-	-
1/11/2014	15,895	-	-	-	-	-	-
3/5/2014	53,587	249,000	195,413	364.7%	0.44	0.81	0.37
9/2/2014	136,756	513,700	376,944	275.6%	0.42	1.19	0.77
1/18/2015	169,490	427,400	257,910	152.2%	0.55	1.01	0.46
3/15/2015	152,295	267,600	115,305	75.7%	1.35	1.22	-0.13
8/14/2015	69,385	358,900	289,515	417.3%	0.27	0.88	0.61
9/5/2015	44,045	404,000	359,955	817.2%	0.22	0.95	0.73
10/10/2015	-	2,600	-	-	-	0.06	-
2/12/2016	1,182	-	-	-	0.12	-	-
5/19/2016	30,470	-	-	-	0.32	-	-
10/14/2016	-	30,430	-	-	-	0.34	-
10/15/2016	-	12,280	-	-	-	0.11	-

Start Date	Observed Vol. (gal)	Simulated Vol. (gal)	Difference (gal)	Difference (%)	Observed Duration (hr)	Simulated Duration (hr)	Difference (hr)
11/15/2016	5,057	80,830	75,773	1498.4%	0.18	0.30	0.12
2/9/2017	135,902	136,500	598	0.4%	1.20	0.75	-0.45
4/26/2017	-	223,600	-	-	-	0.57	-
5/4/2017	10,459	8,509	(1,950)	-18.6%	0.11	0.11	0.00

A long-term simulation was run from 1/3/1978 to 3/30/2018. Table 7-3 shows simulated CSO count and frequency for the most recent and worst 20-year period during this period. Worst here is defined in terms of volume of the 21st largest storm.

Table 7-3: Simulated CSO Count and Frequency for the Most Recent and Worst 20-Year Period

	1998 – 2017 (Most Recent)	1996 – 2015 (Worst)
Count	39	38
Frequency	1.95	1.9
21st Largest Storm Volume (gal)	99,350	181,900

CSO count and frequency were simulated well; 28 events simulated over 10 years versus 27 observed over the same 10-year period. However, the model did a poor job simulating volumes, generally simulating longer durations and thus higher volumes than observed. The over-simulation in duration and volume for large CSO events is likely due to a combination of lack of storms of similar size during the calibration period and more efficient simulated collection system as compared to the physical system.

8. Uncertainty Analysis

SPU uses an Uncertainty Analysis (UA) process to facilitate the CV decision making process. UA utilizes the ACU-SWMM software package developed by MGS Consultants and Aqualyze to consider three areas of uncertainty:

1. Uncertainties in historic precipitation (stationary climate) - How representative is the historic rainfall record for use in prediction of future flows?
2. Uncertainties in predictions from watershed modeling - Values determined from quality of model calibration in terms of flow prediction.
3. Residual uncertainties – “catch-all” for uncertainties not captured in the other three categories.

Additionally, the UA accounts for climate change through a set of perturbed rainfall timeseries that represent three different climate epochs:

1. 2015 or Current Climate - the same as the historic rainfall record
2. 2035 Climate - perturbed rainfall representative of what the climate might resemble in the year 2035

3. 2100 Climate - perturbed rainfall representative of what the climate might resemble in the year 2100

The use of ACU-SWWM for this project required input from uncertainties in the list above. These are shown in Table 8-1. The SWMM5 model uncertainty indicates that the overall calibrated model is slightly under-predicting volume with a Global GOF for volume equal to 0.966 (Note: This value is subtracted from 2 to yield 1.034 for ACU-SWMM input, which specifies that the uncertainty distribution is adjusted upward to compensate for the under-prediction). The global standard deviation of 0.1164 indicates that there is some variability in the calibration. The residual uncertainty mean and standard deviation are selected from the ACU-SWMM literature and indicate that there is a moderate to high level of residual uncertainty.

Table 8-1: Uncertainty Inputs to ACU-SWMM

Uncertainty	Mean	Standard Deviation
Precipitation	1.000	0.0460
Model	1.034 (2-0.966)	0.1164
Residual	1.000	0.0860

These were input into the program which then generates a set of 11 scaling factors which when applied to rainfall timeseries, represents the full range of volumes within which the CV lies. The mean of SWMM model uncertainty determined the average of all scaling factors, and the standard deviations of all uncertainty sources determine the spread of the factors. Table 8-2 shows the scaling factors.

Table 8-2: ACU-SWMM Scaling Factors

Scaling Factor #	Scaling Factor
1	0.835655
2	0.895564
3	0.943292
4	0.945008
5	0.959978
6	0.999425
7	1.034907
8	1.084488
9	1.185747
10	1.242553
11	1.247385

The three rainfall timeseries were then scaled by each scaling factor and model simulations conducted for a total of 33 model simulations. The results of each model simulation, which in this case is the CV (the 21st largest CSO event in the most frequent CSO 20-year period), was then entered into ACU-SWMM to generate a set of uncertainty bound curves for each climate scenario. See the MGS report

(MGS 2009) for more discussion of the ACU-SWMM program and the statistical methods contained therein. The curves for each climate scenario are then plotted on the same graph to support the decision-making process. The results of this process are shown in Table 8-3 and Figure 8-1. Negative values indicate the basin would be in compliance for a given uncertainty percentile.

Table 8-3: Control Volume Results for Current and Future Climate Scenarios

Uncertainty Percentile	Control Volume (MG)		
	Existing Climate	**2035 Climate**	**2100 Climate**
5%	-0.0254	-0.0185	0.0876
10%	0.0158	0.0269	0.1232
16%	0.0518	0.0269	0.1621
25%	0.0956	0.1148	0.2094
50%	0.2016	0.2313	0.3239
75%	0.3273	0.3697	0.4597
84%	0.3944	0.4435	0.5321
90%	0.4588	0.5144	0.6017
95%	0.5463	0.6108	0.6963

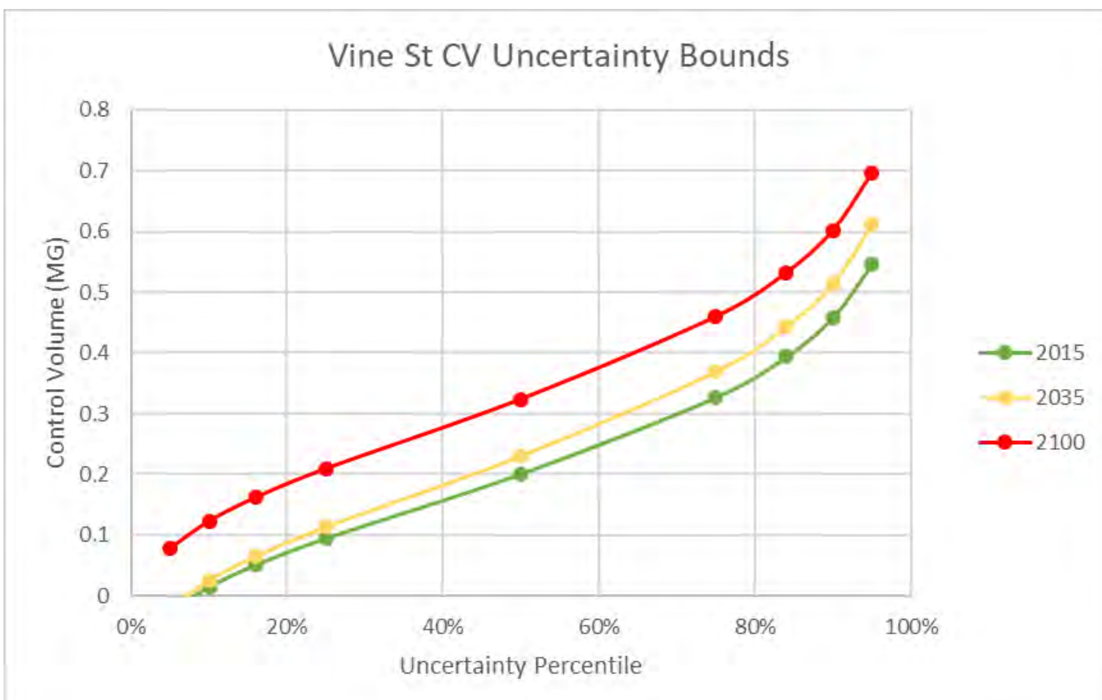

Figure 8-1: Vine Street Control Volume Uncertainty Bounds

This plot compares CV with confidence interval. SPU reviewed the curves in conjunction with the model validation results to select a CV of 182,000 gallons, which corresponds to a 40 percent confidence interval for the 2035 climate epoch and a scaling factor of 0.985. For the flow transfer options (Section 9), SPU selected the 50th percent confidence interval for the 2035 climate epoch which is a CV of 230,000 gallons and scale factor of 1.0145

9. Flow Transfer Options

The goal of the flow transfer options is to bring the CWF Basin 69 into compliance by transferring flow to KCWTD rather than an in-basin solution (i.e. storage). Two options were evaluated using rainfall scaled by a factor of 1.0145 which corresponds to CV of approximately 230,000 gallons. A more conservative CV is used in this exercise because the increase in cost is relatively minor between this CV and the selected CV of 182,000 gallons.

Each option was simulated for a 40-year period. The options were evaluated for CSO frequency and count as well as peak flows entering the KC system for storms of various return periods. The options were optimized to have the smallest increase in peak flows to KC while still bringing the basin into compliance. The options could likely be further optimized as this was a high-level exercise for the purposes of this project.

9.1. Flow Transfer Option A

Flow transfer Option A, shown in Figure 9-1, focuses on increasing the flow through the Vine Street CSO structure and along Alaskan Way thus decreasing flow over the CSO weir. To accomplish this, the bottom orifice in the CSO structure is enlarged to a diameter of 2 feet. The stretch of pipes along Alaskan Way between the structure and the EBI is upsized to a diameter of 3 feet. At the connection to the EBI a 2.5 ft diameter orifice is added to moderate the flow entering the KC system. Table 9-1 provides a comparison of simulated CSO frequency and count for the existing conditions and Flow Transfer Option A for the period of record, 1978 to 2017, and the worst 20 years, 1998-2017 for existing conditions and 1996-2015 for Option A.

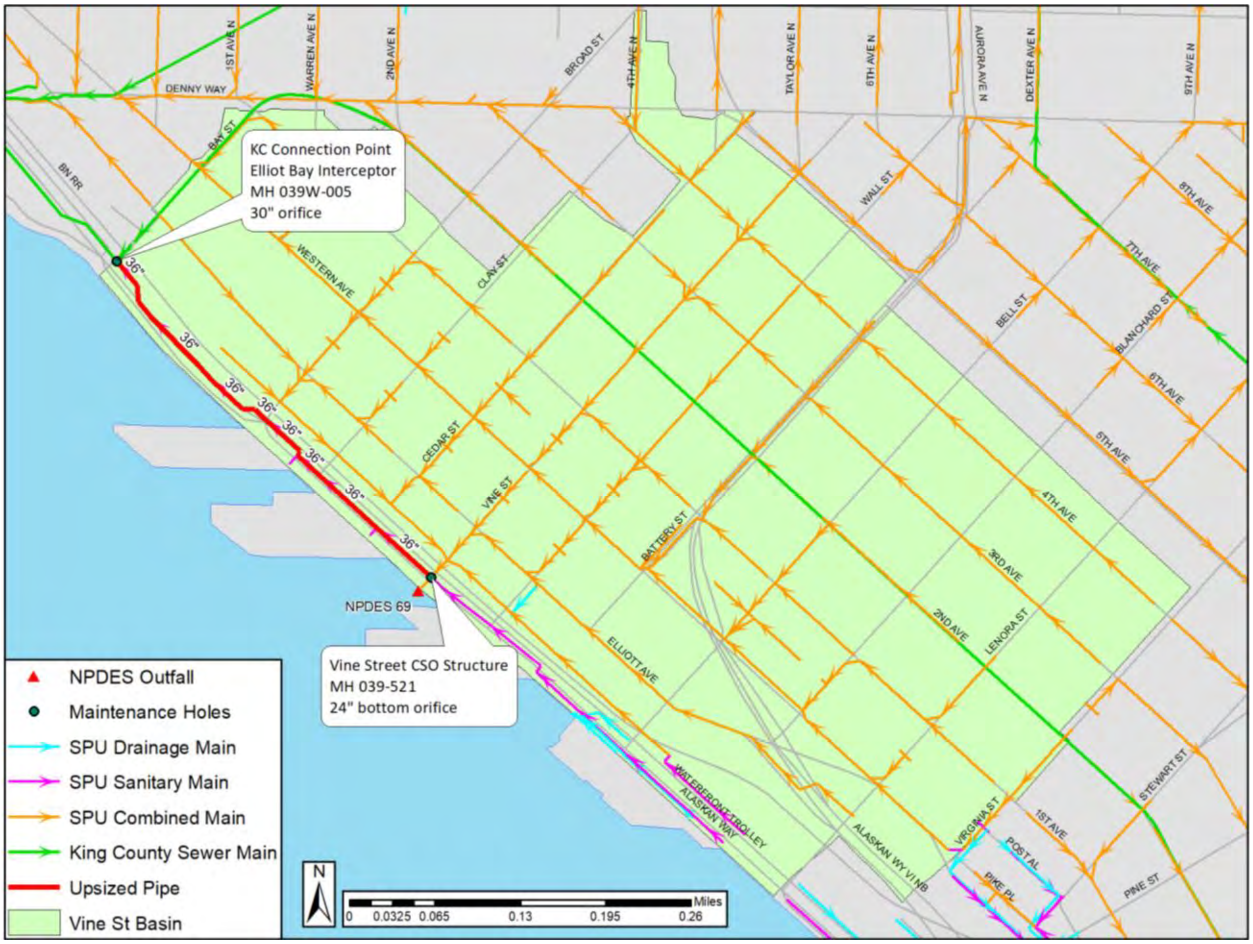

Figure 9-1: Flow Transfer Option A

Table 9-1: Simulated CSO Count and Frequency (Option A)

	Existing Conditions		Flow Transfer Option A	
	1978 - 2017	1998 - 2017	1978 - 2017	1996 - 2015
Count	70	45	28	20
Frequency	1.75	2.25	0.7	1

9.2. Flow Transfer Option B

Flow transfer Option B show in Figure 9-2, focuses on preventing flow during large events from travelling over the high-flow paths on Western Avenue and instead, travelling along the primary flow path to the EBI. To accomplish this, all high-flow paths were removed and the stretch of pipes along Western Avenue between Battery Street and Broad Street were upsized to three feet in diameter. No orifice was used here in an effort to prevent flooding – because the high-flow paths along Western Avenue, which provide flood protection, were removed for this option. Table 9-2 provides a comparison of simulated CSO frequency and count for the existing conditions and Flow Transfer Option B for the period of record, 1978 to 2017, and the worst 20 years, 1998-2017 for existing conditions and 1996-

2015 for Option B.

Figure 9-2: Flow Transfer Option B

Table 9-2: Simulated CSO Count and Frequency (Option B)

	Existing Conditions		Flow Transfer Option B	
	1978 - 2017	1998 - 2017	1978 - 2017	1996 - 2015
Count	70	45	18	12
Frequency	1.75	2.25	0.45	0.6

9.3. Peak Flows to King County

To evaluate peak flows to KC, peak flows for baseline, Option A, and Option B at both Alaskan Way and Western Avenue were plotted versus return interval for various storm events. Figure 9-3 shows a plot of peak flow to KC via Alaskan Way versus recurrence interval for each option and existing conditions, and Figure 9-4 shows a plot of peak flow to KC via Western Avenue versus recurrence interval for each option and existing conditions. The baseline curve on the Western Avenue plot is obscured by Option A because peak flows along Western Avenue are unaffected by changes along Alaskan Way.

Option A produces a significantly smaller increase in peak flows along Alaskan Way and unchanged peak flows along Western Avenue. Both scenarios indicate an increase in peak flows for higher return periods sent to KC and would require negotiations with that agency.

Flow to KC via Alaskan Way and Western Avenue for a 1-year flow event under baseline conditions, Option A, and Option B are shown in Figure 9-5 and Figure 9-6, respectively. Again, for flow to KC via Western Avenue, the baseline curve obscures Option A because flows along Western Avenue are unaffected by changes along Alaskan Way. Note that the same storm event does not necessarily cause the 1-year flow in the three scenarios so the peak values might vary slightly from those shown in Figure 9-3 and Figure 9-4.

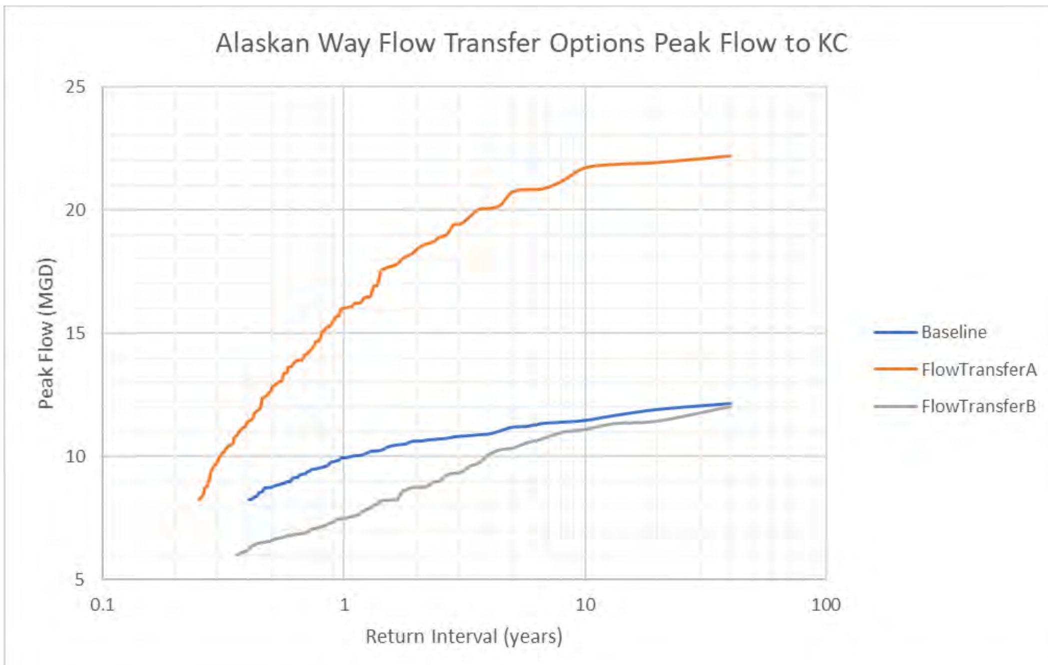

Figure 9-3: Peak Flow to KC via Alaskan Way for Existing Conditions and Options A and B

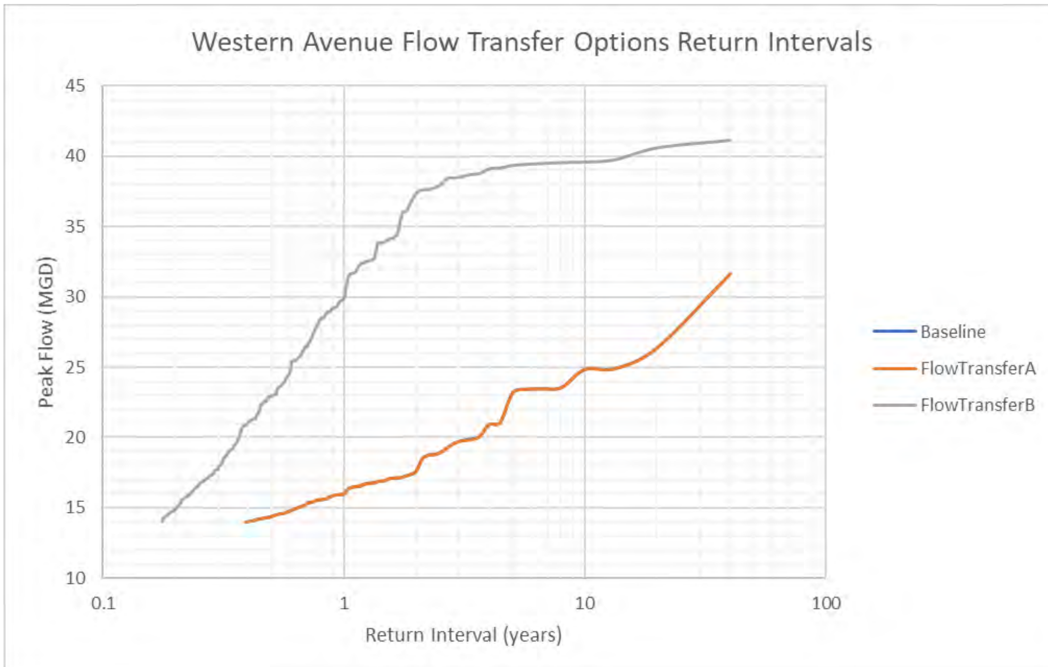

Figure 9-4: Peak Flow to KC via Western Avenue for Existing Conditions and Options A and B

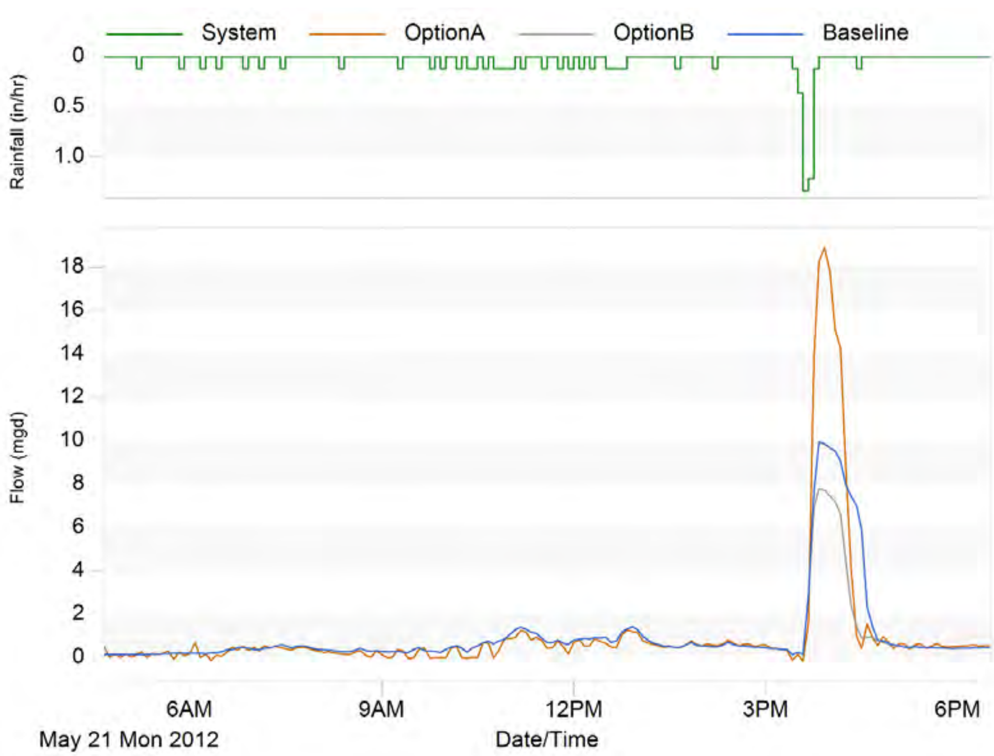

Figure 9-5: Flow to KC via Alaskan Way for Existing Conditions (gray), Option A (orange), and Option B (blue) – 05/21/2012, 1-year event

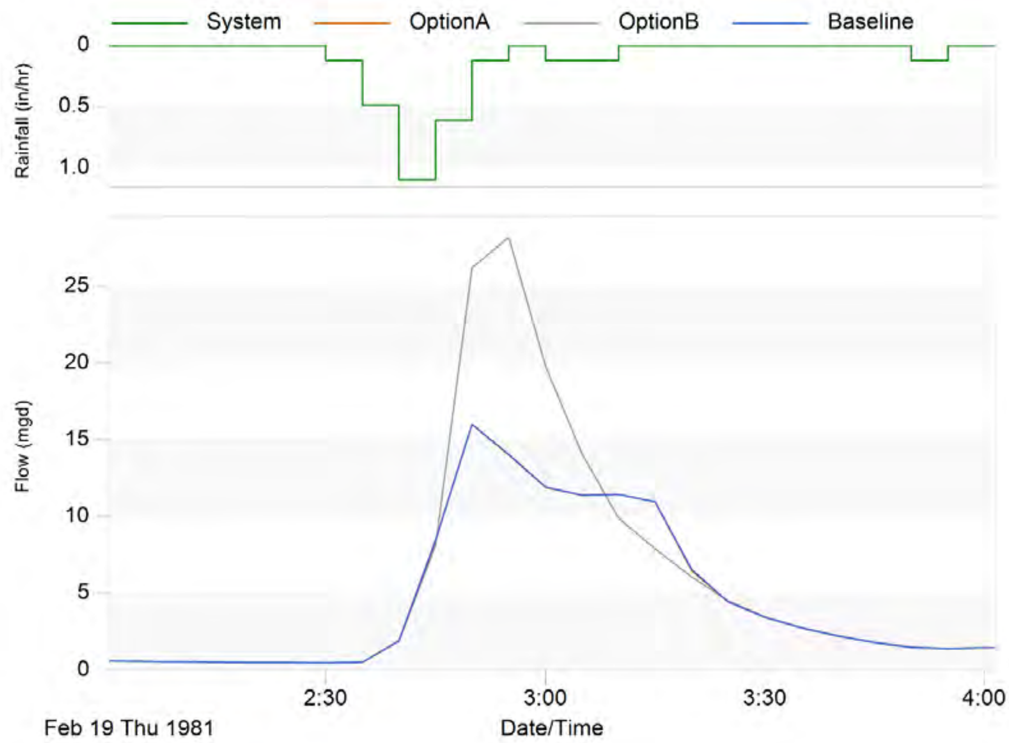

Figure 9-6: Flow to KC via Western Avenue for Existing Conditions (gray), Option A (orange), and Option B (blue) – 02/19/1981, 1-year flow event

10. QA/QC Review Process

10.1. Model Refinement

The base model was put through an internal QC process before submittal to SPU. SPU reviewed the base model and provided suggestions for further refinement. Refinements from the internal QC process and SPU's review were incorporated in the baseline prior to calibration.

10.2. Calibration

The calibrated model was put through an internal QC process prior to submittal to SPU. SPU reviewed the calibration and provided suggestions to improve the calibration. Refinements from the internal QC process and SPU's review were incorporated in the calibrated model prior to performing CV estimates and flow transfer options.

11. Summary and Conclusions

The CWF Basin 69 SWMM5 H/H model inherited from WWSA was updated based on GIS and survey data provided by SPU. The subcatchment delineation was refined on a smaller scale and areas of complex or uncertain hydraulics were updated based on new ADS measurements, GIS data and engineering judgment. New DWF patterns and average values were computed based on monitoring data for the

2017-2018 wet season. The model was calibrated to 2017-2018 wet season and was validated using observed CSO data at the Vine Street CSO structure.

A good overall calibration was achieved for the basin with 6 of the 8 flow meters meeting the Chapter 7 guidelines for calibration. One limitation of the model is the simulated depth at three depth meters along Western Avenue. The model did a reasonable job simulating depth at these locations given the complex and uncertain hydraulics. CSO count and frequency were simulated well; 28 events simulated over 10 years versus 27 observed over the same 10-year period. However, the model did a poor job simulating volumes, generally simulating longer durations and thus higher volumes than observed. The over-simulation in duration and volume for large CSO events is likely due to a combination of lack of storms of similar size during the calibration period and more efficient simulated collection system as compared to the physical system.

The calibrated model and UA were used to provide SPU with CV curves for present, 2035 and 2100 climate scenarios to assist the CV decision making. SPU selected a confidence interval of 40% for the 2035 climate scenario which corresponds to a CV of 182,000 gallons.

A more conservative 50% confidence interval for the 2035 climate scenario was used in assessing two flow transfer options to bring the basin into compliance. Flow transfer Option A consisted of increasing the bottom orifice in the Vine Street CSO structure, upsizing the pipes along Western Ave between the CSO structure and the EBI, and adding an orifice, to control flow entering the EBI. Option B consisted of removing all high flow paths along Western Ave and upsizing the pipes along Western Avenue between Battery Street and Broad Street Both options brought the basin into compliance, however, Option A is preferable as it generates a much smaller increase in peak flows to KC system.

12. Uncertainties and Limitations

Model calibration and validation completed under this project relied on flow monitoring data and overflow reports provided by others. It was assumed that the data was sufficient for use in the context it was provided.

Modeling completed under this project included representation of complex hydraulic structures. Every effort was made to ensure complete information was used to represent those structures using the SWMM5 engine. Actual performance may differ from those represented in the model.

High level flow transfer solutions were determined without specific information on flow transfer limits from the vantage point of KC. Construction feasibility outside of ensuring common pipe sizes and current alignments was outside of the scope of this project (i.e. utility conflicts or other construction challenges were not investigated). The layouts and results discussed in this TM could likely be further refined.

13. References

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14. Appendices

Appendix A – Additional Calibration Plots for CWF Basin 069

Appendix C

Basin 69 Hydraulic Modeling Technical Memorandum

August 21, 2019

To: Shailee Sztern – Seattle Public Utilities (SPU)

From: Andrew Henson - Aqualyze
Marshall Kosaka – Aqualyze

Cc: Nichole Kruse – Murraysmith
Rizwan Hamid - Aqualyze

Subject: Basin 69 Modeling Technical Memorandum

1. Introduction

The Central Waterfront Basin 69 (Basin 69) is located at the north end of the Seattle's downtown waterfront, adjacent to Elliott Bay. The Basin is highly developed and densely populated. Sanitary flows and stormwater runoff are collected in a combined sewer system that discharges to King County infrastructure, to be treated at the King County West Point Wastewater Treatment Plant (WWTP). During heavy precipitation events, stormwater runoff can overwhelm the sewer system within the Basin and trigger a combined sewer overflow (CSO), discharging excess flows into Elliott Bay at Outfall 69.

In 2013, the City of Seattle entered into a Consent Decree requiring the City to control each combined sewer outfall to the State CSO performance standard. Per the Consent Decree and SPU's wastewater NPDES permit, control is defined as one CSO per year, based on a 20 year moving average. During the period 1999-2018, Basin 69 averaged 1.8 CSOs per year.

A hydraulic and hydrologic (H/H) model of the Basin was recently refined by Aqualyze under the Modeling On-Call Contract (C13-031) Work Assignment 8 (WA08) using the United States Environmental Protection Agency's (EPA) Stormwater Management Model Version 5.1.012 (SWMM5). This model was used as the basis for the modeling activities under this project. SPU's Uncertainty Analysis (UA) process was also performed as a part of WA08 to determine the control volume (CV) for Basin 69. The UA process considers three areas of uncertainty:

1. Uncertainties in historic precipitation (stationary climate) - How representative is the historic rainfall record for use in prediction of future flows?
2. Uncertainties in predictions from watershed modeling - Values determined from quality of model calibration in terms of flow prediction.
3. Residual uncertainties – "catch-all" for uncertainties not captured in the other three categories.

Additionally, the UA accounts for climate change through a set of perturbed rainfall timeseries that represent three different climate epochs:

1. 2015 or Current Climate - the same as the historic rainfall record

2. 2035 Climate - perturbed rainfall representative of what the climate could resemble in the year 2035
3. 2100 Climate - perturbed rainfall representative of what the climate could resemble in the year 2100

Two CVs were ultimately selected for use in evaluating different options. A CV of 233,000 gallons, equating to a 50 percent confidence interval with rainfall representative of the expected 2035 climate, is used for flow transfer options (a confidence interval of 50 percent means that there is a 50 percent chance that the basin will be in compliance in the year 2035 if the CV is controlled). Storage options use a CV of 182,000 gallons, equating to a 40 percent confidence interval with rainfall representative of the expected 2035 climate (Aqualyze Inc 2018). Note that the simulated overflow volumes generally over-predicted CSO volumes as compared to observed events, therefore SPU was comfortable selecting a CV with a confidence interval less than 50 percent. The alternatives identified and documented in this technical memorandum were developed with the intent of planning system improvements to achieve control of Basin 69.

2. Purpose

The purpose of this TM is to document the modeling procedures, results, and assumptions associated with the Phased Consultant Services for the Vine Basin CSO Control Project Contract (SU0-18-007-S). The results presented herein document alternatives development and modeling that is intended to help inform SPU's selection of a preferred CSO control solution for Basin 69.

2.1. Project Goals and Objectives

The following project objectives were used to guide the efforts of this project towards achieve the project goal of evaluating the anticipated efficacy of various alternatives to achieve CSO control within Basin 69:

- Identify and develop CSO control alternatives
- Develop framework to gauge efficacy of stormwater control alternatives
- Test efficacy of the CSO control alternatives using short term H/H modeling
- Perform long-term H/H modeling simulations for alternatives
- Document results to support the Option Analysis process

2.2. Study Boundaries

Basin 69, shown in **Figure 2-1**, covers approximately 150 acres in the Central Waterfront area of downtown Seattle. It is bordered by Bay Street and Denny Way to the north, Virginia Street to the south, 5th Avenue to the east, and Elliott Bay to the west.

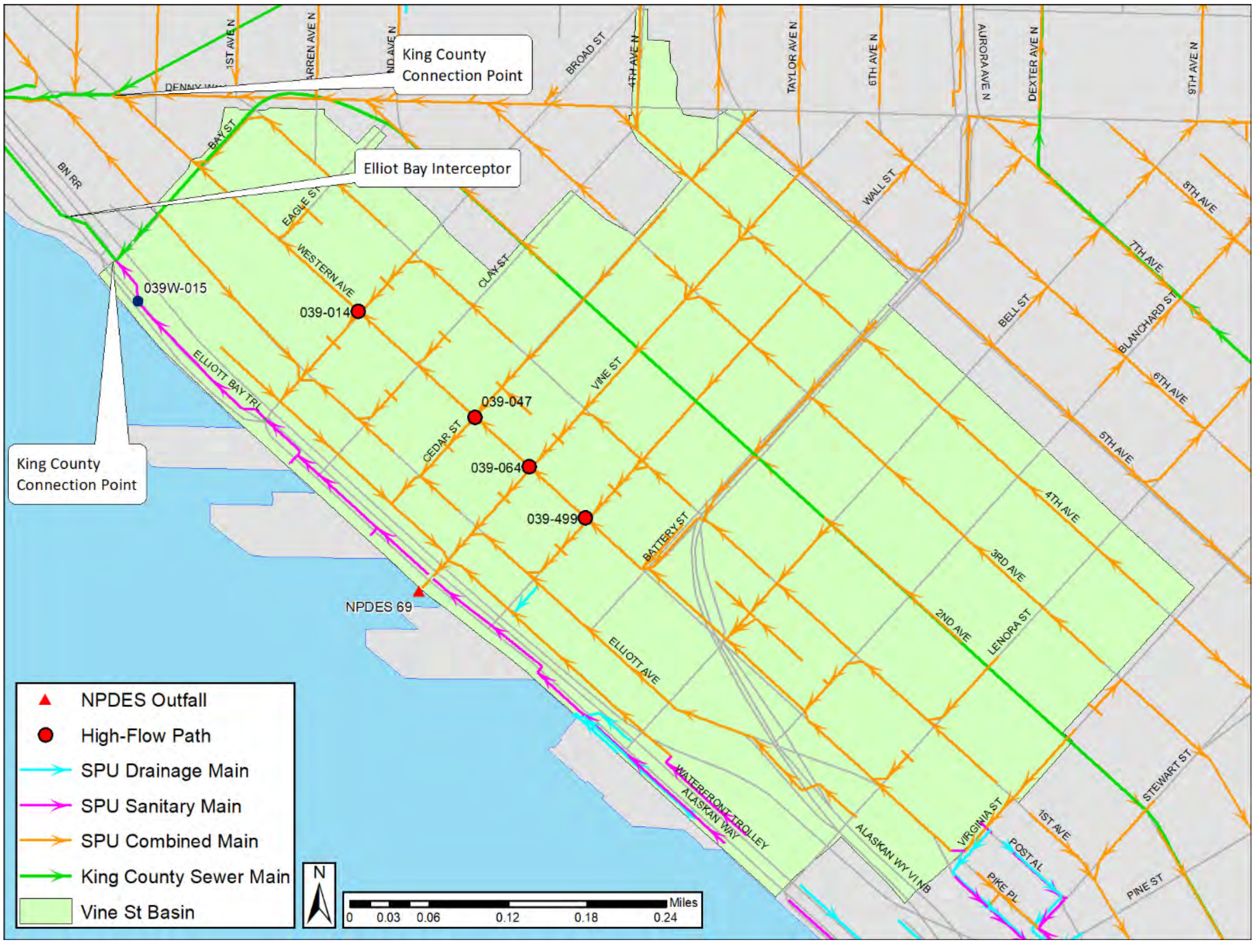

Figure 2-1: Map of Basin 69 Model Area

3. Basin Characterization

Sanitary flows and stormwater runoff are collected in a combined sewer system that discharges to the King County (KC) Denny Way Interceptor and KC Elliott Bay Interceptor (EBI). Both interceptors convey flows to the KC Denny Regulator. The KC Denny Regulator pumps flows to the KC West Point Wastewater Treatment Plant (WWTP) for treatment. During heavy precipitation events, stormwater runoff can overwhelm the sewer system within the Basin and trigger a CSO event at the CSO Control Structure, located within the intersection of Alaskan Way and Vine Street. The Basin 69 CSO Outfall (Outfall 69) discharges overflows through the seawall into Elliott Bay, just west of the Alaskan Way and Vine Street intersection. **Table 3-1** provides a summary information for the Basin.

Table 3-1: Basin 69 Summary

Basin Features	Count
Basin Area, acres	150
Number of Diversions	6
Number of CSO structures/outfalls	1
Associated SPU Rain gage	RG11

3.1. Conveyance System

The sewer system in Basin 69 is primarily a combined system except for a relatively small drainage system in the southwest corner (outfalls into Elliott Bay). During dry weather flows, Basin 69 is divided into two separate sub-basins: the "Lower Basin" located to the west of Western Avenue and the "Upper Basin" located to the east of Western Avenue as shown in **Figure 3-1**. Dry weather flows collected in the "Upper Basin" are collected in a 24 inch/30 inch combined sewer within Western Avenue that conveys flows north and discharges to the KC Denny Way Interceptor at the intersection of Western Avenue and Denny Way. The KC Denny Way Interceptor conveys flows to the KC Denny Regulator. The "Lower Basin" collects dry weather flows from the "Lower Basin" and conveys them through a 48 inch diameter sewer that crosses beneath the BNSF Railroad Tracks along Alaskan Way. Flows then pass through the CSO Control Structure to the combined sewer in Alaskan Way, which flows north and ultimately discharges to the KC Elliott Bay Interceptor. The KC Elliott Bay Interceptor also conveys flows to the KC Denny Regulator. The KC Denny Regulator pumps flows to the KC West Point Wastewater Treatment Plant (WWTP).

During wet weather events, the sewer levels in Western Avenue rise. As the sewer levels rise, four high flow paths along the Western Avenue allow excess flow to pass from the "Upper Basin" into sewer infrastructure in the "Lower Basin." The four high flow paths are located at the intersections of Western Avenue and Bell Street, Vine Street, Cedar Street, and Broad Street. Three high-flow paths are pipes at maintenance holes (MH) MH 039-499, MH 039-064, and MH 039-014. The fourth high-flow path is a weir at MH 039-047. The locations are shown in **Figure 2-1** and **Figure 3-1**.

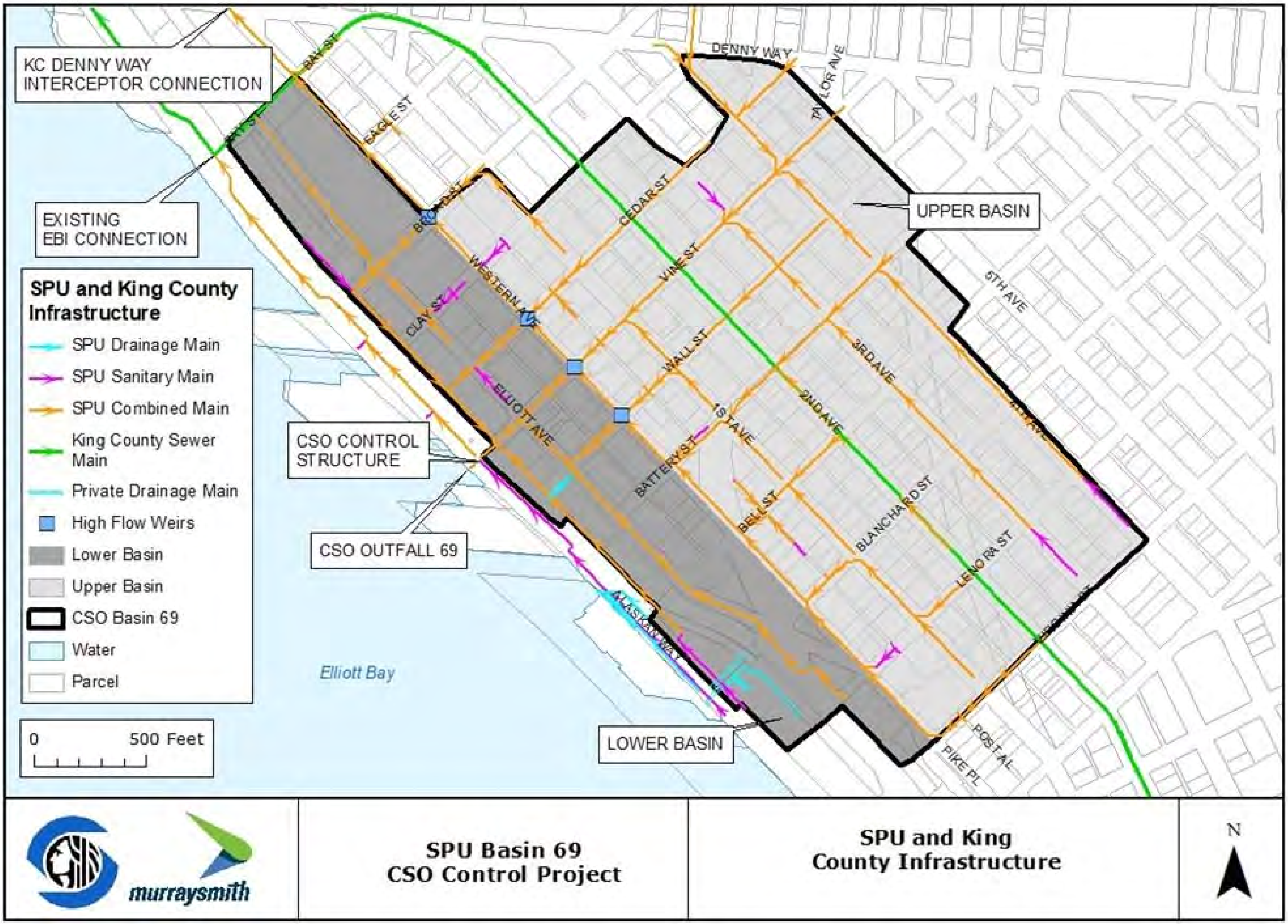

Figure 3-1: SPU and King County Basin Infrastructure

As the sewer level in the Alaskan Way sewer rises, the level within the CSO Control Structure also rises. If the level rises above the elevation of the CSO weir located in the CSO Control Structure, a CSO event is triggered and flows discharge to Elliott Bay via CSO Outfall 69.

The CSO Control Structure is a below-grade concrete vault with a bottom orifice that conveys flow to the sewer to the north within Alaskan Way to the KC Elliott Bay Interceptor. Excess flows are conveyed over a weir in the CSO Control Structure and discharge to Elliott Bay through CSO Outfall 69. A plan view of the CSO Control Structure is provided in **Figure 3-12**.

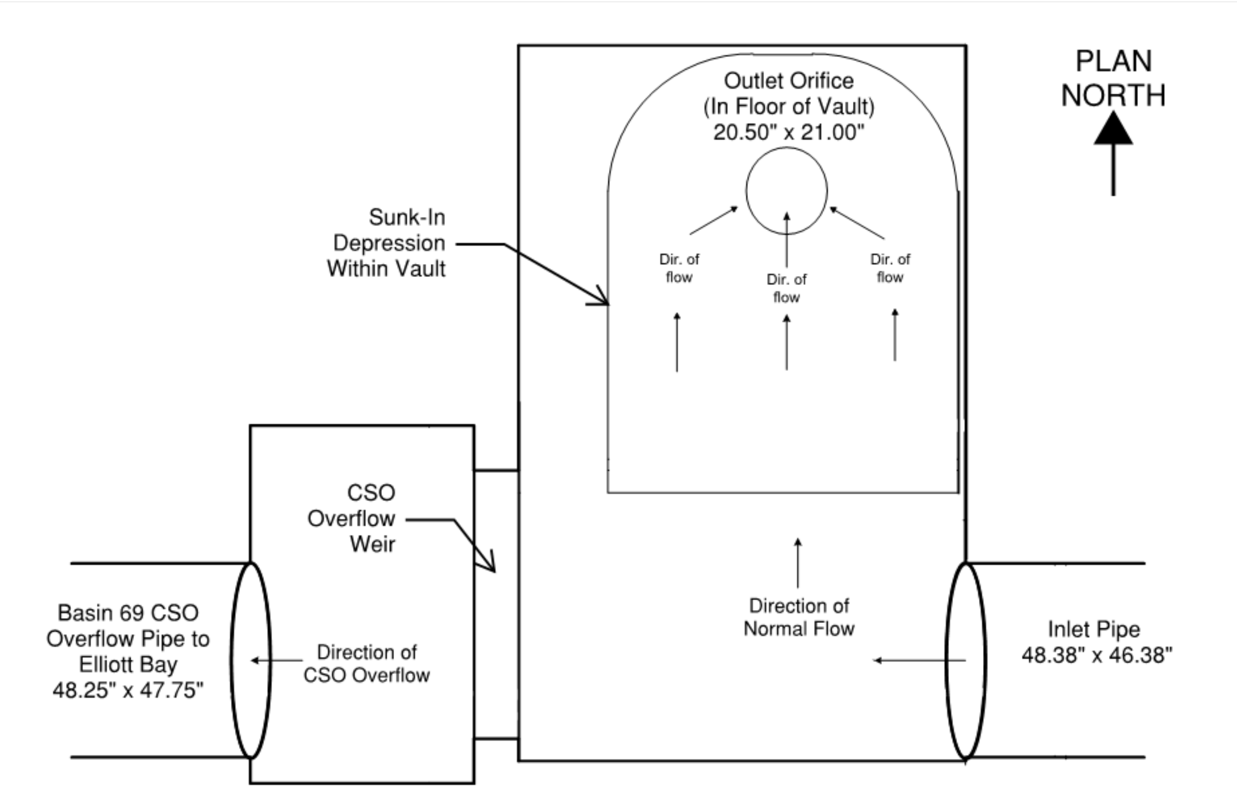

Figure 3-2: Basin 69 CSO Control Structure - Plan View

Significant transportation and infrastructure improvement projects are planned or in progress in Basin 69 that could impact the conveyance system configuration in portions of the Basin. Modeling and options analysis reflect the state of the conveyance system at the time of this project. No planned development or planned changes to stormwater code were incorporated in the alternatives analysis as limited information was available. It is recommended that any planned conveyance changes in the Basin be reviewed as the project progresses to design.

3.2. Land Use

The land use in Basin 69 is primarily heavily developed urban residential and commercial area except for Olympic Sculpture Park, which is parkland. Estimates from the Puget Sound Regional Council show that the population in the Basin could increase in the coming decades, however expected population increases were not included in modeling for this project as the fraction of the wet weather flow that would be affected by population change is relatively low (approximately two percent increase). It is recommended that this assumption is reviewed, and future population and land use be considered prior to the design of a selected alternative.

Impacts to basin flows due to future land use changes was evaluated using the methodology employed in SPU's Wastewater System Analysis project (Aqualyze Inc. 2019). Increased flows due to increased impervious area associated with development are expected to be mitigated as a as a result of implementing the City's current Stormwater Code applied to redevelopment within the Basin (i.e. lower peak stormwater runoff flows are required as area is redeveloped by the current Stormwater Code).

4. H/H Model

The H/H model used for this project was developed under WA08. The model hydraulics were updated based on SPU GIS data, survey data, and flow/level measurements (collected by ADS) at meter locations. The model sub-catchment boundaries were delineated at an approximate block scale and sub-catchment parameters were computed through GIS routines. The model was then calibrated to 12 meter locations following SPU's modeling guidelines (Seattle Public Utilities 2017). For this project, no updates or revisions were made to the baseline model. The modeling and analysis presented in this document utilizes the NAVD88 datum. For more details on model development and updates refer to the WA08 modeling TM (Aqualyze Inc 2018).

4.1. Modeling Platform

EPA SWMM5 version 5.1.012 modeling engine was used to test effectiveness of various options, run long-term simulations and compute control volumes for this work assignment. The PCSWMM software package, that utilizes the SWMM5 modeling engine, was used on this project.

4.2. Boundary Conditions

A water surface elevation timeseries, provided by SPU/KCWTD, was used to account for the downstream water level in the EBI. A free outfall was used at the connection at the Denny Way/Lake Union Tunnel (MH 034-272) as the invert at MH 034-272 is approximately 25 feet higher than the invert of the Denny Way/Lake Union Tunnel and is not thought to be influenced by downstream water levels.

A tidal boundary condition was used at the CSO Outfall 69 to account for the tide in Elliott Bay. Tidal data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Ocean Service's (NOS's) gauge station (Sta.) 9447130 (NOAA 2018). A saltwater correction was applied to the tidal boundary condition.

4.3. Rainfall and Evapotranspiration

Basin 69 falls entirely within the Thiessen polygon of Rain Gage (RG) 11. SPU provided two rainfall timeseries for this modeling effort: historical observed rainfall at RG11 and a perturbed RG11 timeseries representative of the 2035 climate. The rainfall time series starts on 9/1/1976 and ends on 5/19/2018. The 2035 rainfall, scaled to correspond to the selected CV per the UA process, was used to analyze the options. The rainfall was scaled by 1.014 for flow transfer options and 0.985 for storage and GSI options. A more conservative CV is used for flow transfer options because the increase in cost associated with increased flow transfer capacity is anticipated to be relatively minor between this CV and the selected CV of 182,000 gallons used for storage options (Aqualyze Inc 2018).

Evapotranspiration data was also utilized in the model simulations. Evapotranspiration data is collected by Washington State University (WSU) at the Puyallup, WA campus. SPU provided original timeseries data which was supplemented with data from the Washington Agricultural Weather Network Version 2.0 downloaded from the WSU website.

5. Existing System Performance

5.1. Capacity Limitations and Surface Flooding in the System

Minor surface flooding was simulated in the existing conditions model for the period from 1978 through 2017 at various points in the system. However, there are capacity limitations in the Basin due to site hydraulics. Flow through the CSO Control Structure and along Alaskan Way is heavily influenced by the HGL in the KC Elliott Bay Interceptor (EBI). **Figure 5-1** shows a plot of the HGL in the EBI, the head at 039W-015 (the last SPU-owned MH near the EBI connection, shown in **Figure 2-1**), and the head in the CSO Control Structure. For all but the periods of highest intensity rainfall, the head just upstream of the connection to the EBI mirrors that of the head in the EBI. The CSO Control Structure is also influenced by the water level in EBI during periods of moderate rainfall, however, the head continues to rise in the structure during very intense rainfall or periods of elevated flow. This indicates that the SPU system between the CSO Control Structure and the EBI connection point has limited capacity during intense rainfall events.

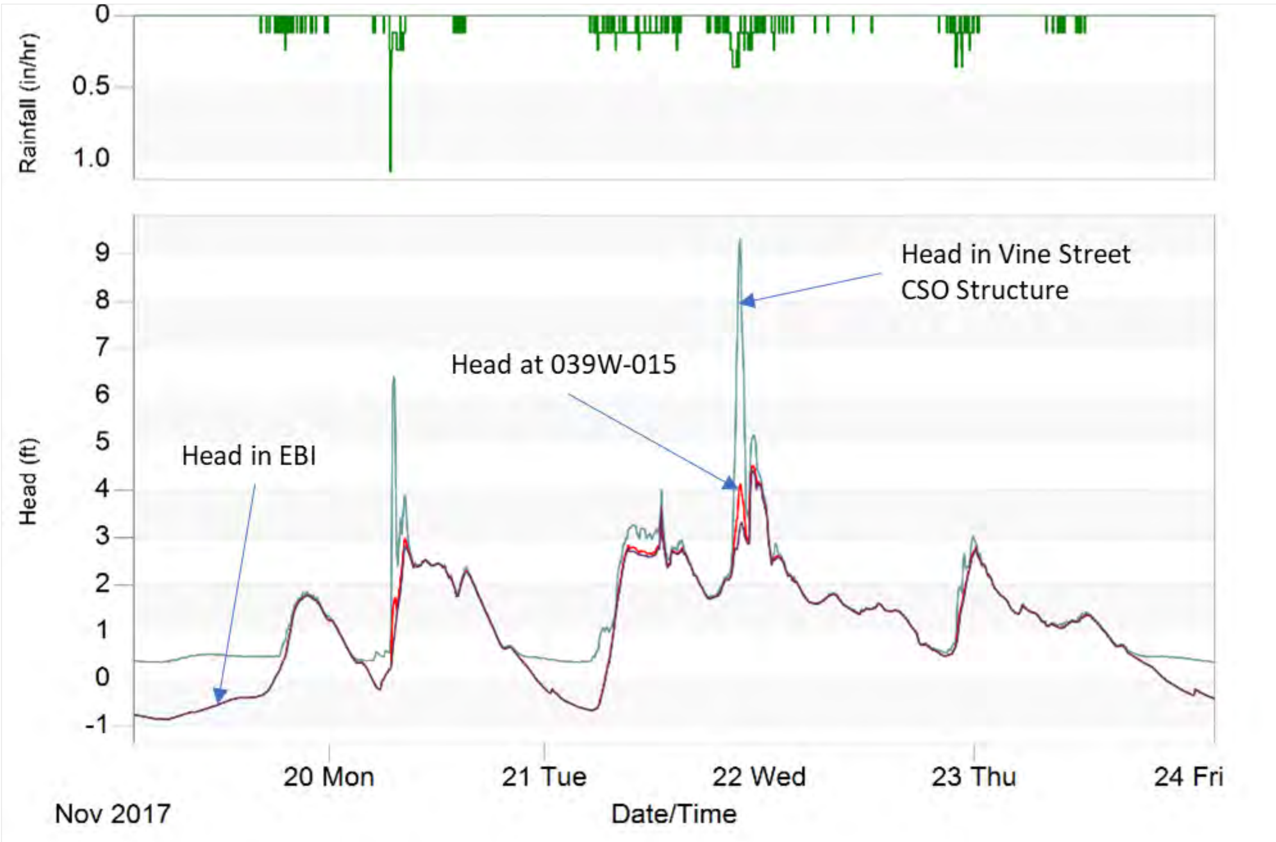

Figure 5-1: Head at 039W-015 (red), Head in the EBI Near the Denny Lake Union Regulator (blue), and Head in the CSO Control Structure (turquoise)

5.2. Characteristics of Combined Sewer Overflows

SPU conducts flow monitoring at their CSO Outfalls throughout Seattle. Recorded flows for Outfall 69 are available as annual CSO counts from 2006 through 2009. Starting in 2010, SPU has published an annual report on the Combined Sewer Overflow Reduction Program which provides detailed information on each CSO event like date, duration, and volume.

A long-term simulation was performed to evaluate CSO events and the Basin CV under existing conditions. The long-term simulation utilized historical rainfall from 1978 through 2017 and the boundary conditions described in **Section 4**. **Table 5-1** shows simulated and observed counts of CSO events and frequency in events per year from 2006 through 2017.

Table 5-2 provides simulated CSO count and frequency for the most recent (1998-2017) and worst 20 year period (1996-2015) during the 40 year period of record. Worst here is defined in terms of volume of the 21st largest storm.

Table 5-1: Observed and Simulated CSO Count and Frequency for 2006 through 2017

CSO Metric	Observed	Simulated
Count	31	30
Frequency	2.6	2.5

Table 5-2: Simulated CSO Count and Frequency for the Most Recent and Worst 20 Year Period

CSO Metric	1998 – 2017 (Most Recent)	1996 – 2015 (Worst)
Count	39	38
Frequency	2.0	1.9
21st Largest Storm Volume (gal)[1]	99,350	181,900

[1]These values are derived from simulations using historic, unscaled rainfall and therefore are not indicative of the CV for Basin 69.

6. Alternatives Analysis

A series of alternatives were developed for analysis using H/H modeling. The alternatives considered as part of this project fall into three categories:

- **Transfer:** These alternatives identified ways of conveying excess flows to KC for conveyance to the treatment plant to prevent CSO events. This type of alternative requires either larger or additional connections to KC's existing infrastructure, as well as coordination and approval from KC to receive, convey and treat the additional flows.
- **Storage:** These alternatives identified ways of capturing and storing excess flows within the Basin to prevent CSO events. This type of alternative included inline storage, offline storage and storage tank configurations, with a preference for inline storage if it is hydraulically feasible due to fewer equipment requirements and lower operation and maintenance requirements. Potential storage locations were identified based on sewer slopes, topography, City-owned property locations and planning level utility information.
- **Stormwater Infrastructure and Program Improvements:** These alternatives identified ways for reducing or removing stormwater inflow from the combined sewer system. Green stormwater infrastructure (GSI) best management practices (BMPs) such as cisterns and roadway bioretention were considered in additional to programmatic changes to the City's Stormwater Code for capacity constrained basins, and incentive programs that encourage private property owners and developers to reduce peak stormwater discharge rates into the combined sewer system.

Several alternatives were evaluated at a high level for initial screening including two flow transfer configurations and storage at various locations in the Basin. Four final options were carried through for more detailed H/H modeling analysis which are detailed herein.

6.1. Flow Transfer Options

The goal of the flow transfer options is to meet the performance standard of no more than one CSO event per year on a 20 year moving average by transferring excess flow to KCWTD. Two alternatives were evaluated using perturbed rainfall representative of the 2035 climate scaled by a factor of 1.014 which corresponds to CV of approximately 233,000 gallons. Each alternative was simulated for a 40 year period. The alternatives were evaluated based on CSO frequency, count, as well as peak flows entering the KC system for precipitation events of various return periods. The alternatives were optimized to have the smallest increase in peak flows to KC while still meeting the performance standard.

6.1.1. Alternative 1 – Alaskan Way Parallel Flow Transfer

The Alaskan Way Parallel Flow Transfer Alternative, shown in **Figure 6-1**, conveys excess flow to KCWTD via a 24 inch diameter parallel sewer that flows from the CSO Control Structure to a new connection to the KC EBI where flows are discharged for further conveyance and treatment. A diversion weir, 5 feet tall by 5 feet long, is proposed just upstream of the CSO Control Structure at an inlet elevation of 9.5 feet (NAVD88). This is higher than the existing inlet downstream at 4.13 feet but lower than the CSO weir inlet elevation of 12.05 feet (NAVD88). The weir inlet elevation was optimized to limit the increase in peak flows to KCWTD while still meeting the performance standard. This configuration also features a 5 foot tall by 5 foot long weir at Broad Street which allows flow to travel from the existing line to the parallel line when the existing pipe is surcharged. Flow from the proposed parallel sewer discharges to the EBI at a connection point near Bay Street via a 2 foot diameter orifice. **Figure 6-2** shows the operation of the Alaskan Way Parallel Flow Transfer Alternative for the 6/3/2008 CSO event. This event has the 21st largest CSO volume for the baseline configuration in the worst 20 year period.

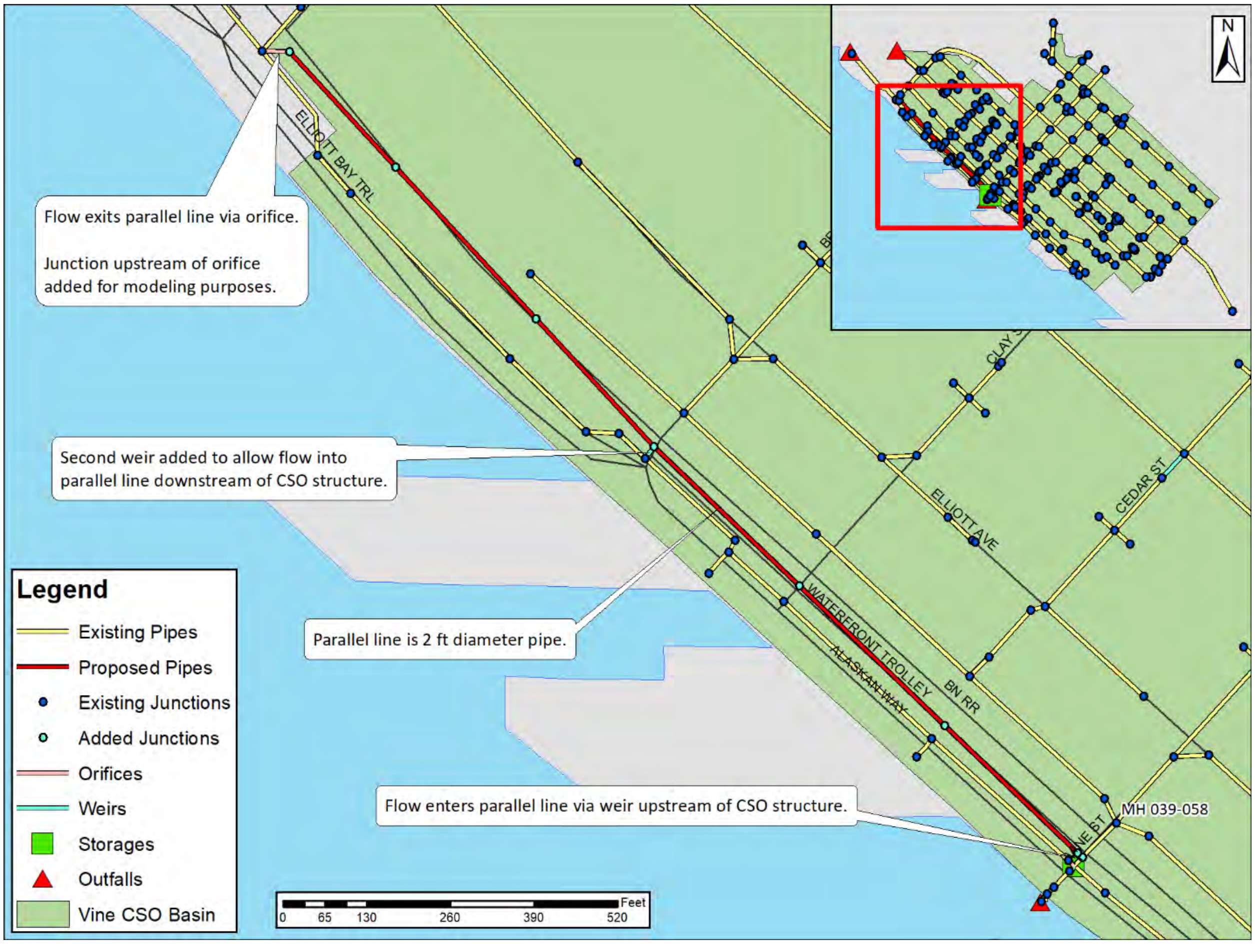

Figure 6-1: Alaskan Way Parallel Flow Transfer Alternative Configuration

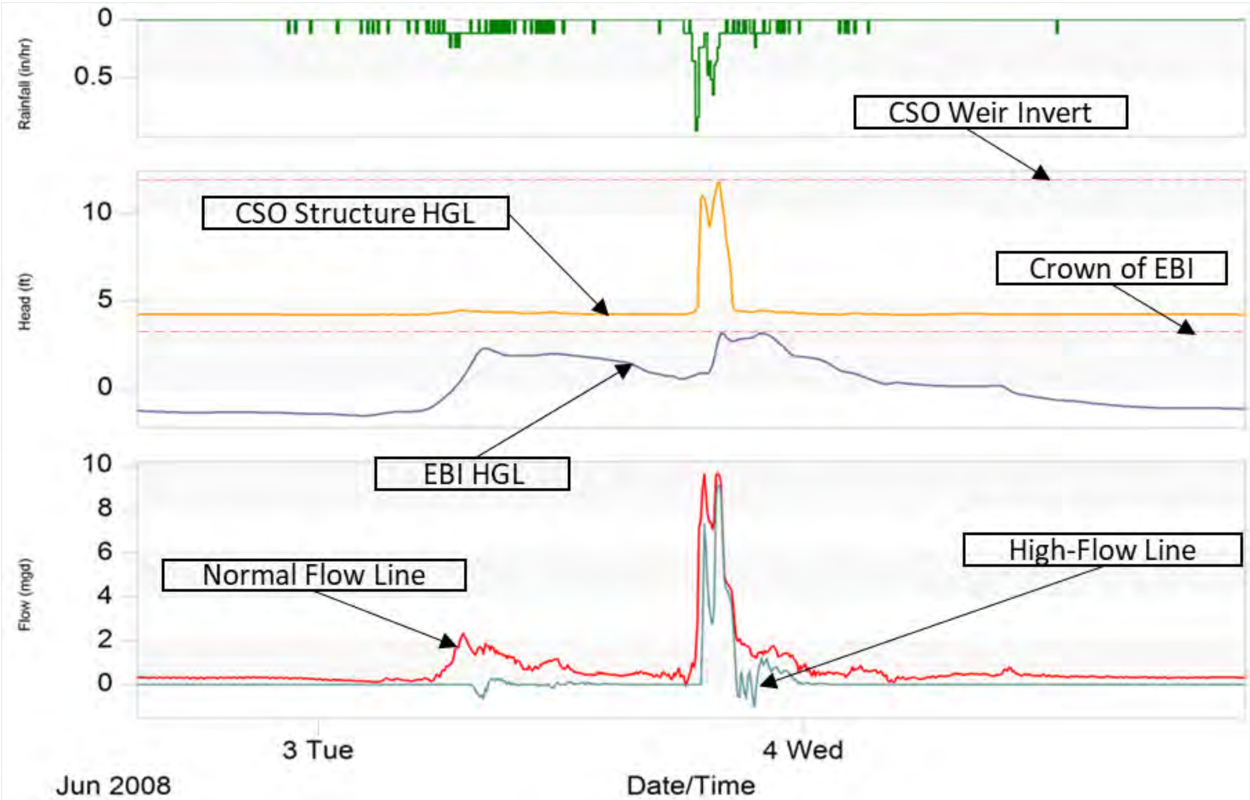

Figure 6-2: Alaskan Way Parallel Flow Transfer Alternative Operation – 6/3/2008 CSO Event

A long-term simulation was performed for this configuration to assess the performance of this alternative and characterize the expected reduction in CSO events and CV. The simulation was run using 2035 climate perturbed rainfall for a period from January 1, 1978 to January 1, 2018 scaled by a factor of 1.014. Boundary conditions as described in **Section 4** were used to simulate downstream water surface elevations. **Table 6-1** provides a summary of long-term simulation results for this alternative. The increased conveyance in combination with diversion of flow upstream of the CSO Control Structure reduces the HGL between the EBI and the CSO Control Structure resulting in the Basin meeting the performance standard.

Table 6-1: Summary of Long-Term Simulation Results - Alaskan Way Parallel Flow Transfer

Period of Record (years)	CSO Frequency		Alaskan Way Parallel Flow Transfer		
	Total # of CSO Events	Average Annual	Total Volume of CSOs (MG)	CV (MG)	CV Event Date
20 worst	20	1	5.61	0	N/A
40	29	0.7	8.28	0	N/A

A comparison of flows to the KCWTD EBI for the baseline configuration and the Alaskan Way Parallel Flow Transfer configuration is provided in **Table 6-2**. Average peak and annual flows for Alaskan Way reflect the sum of flow through the existing line and flow through the proposed parallel line.

Table 6-2: Alaskan Way Parallel Flow Transfer Downstream Impact Comparison

Scenario	Average Annual Peak Flow Rate (MGD)			Average Annual Flow Volume (MG)	
	Alaskan Way Existing	Alaskan Way Proposed	Western Avenue	Alaskan Way	Western Avenue
Baseline	10.06	N/A	18.13	127.2	371.1
Option 1	9.63	7.86	18.13	127.6	371.1

In addition to meeting the performance standard, alternative options should not significantly increase the HGL such that basement backups or sewer overflows (SSO) might occur. To asses this, the maximum head was evaluated at MH 039-058 (labeled in **Figure 6-1**), the first MH upstream of the proposed flow diversion. Heads with recurrence intervals from approximately 0.5 years to approximately 67 years at MH 039-058were plotted against their respective recurrence intervals for the baseline and the Alaskan Way Parallel Flow Transfer configurations. This plot is shown in **Figure 6-3**. For all return intervals plotted, the head in the baseline configuration is greater than that of the flow transfer configuration.

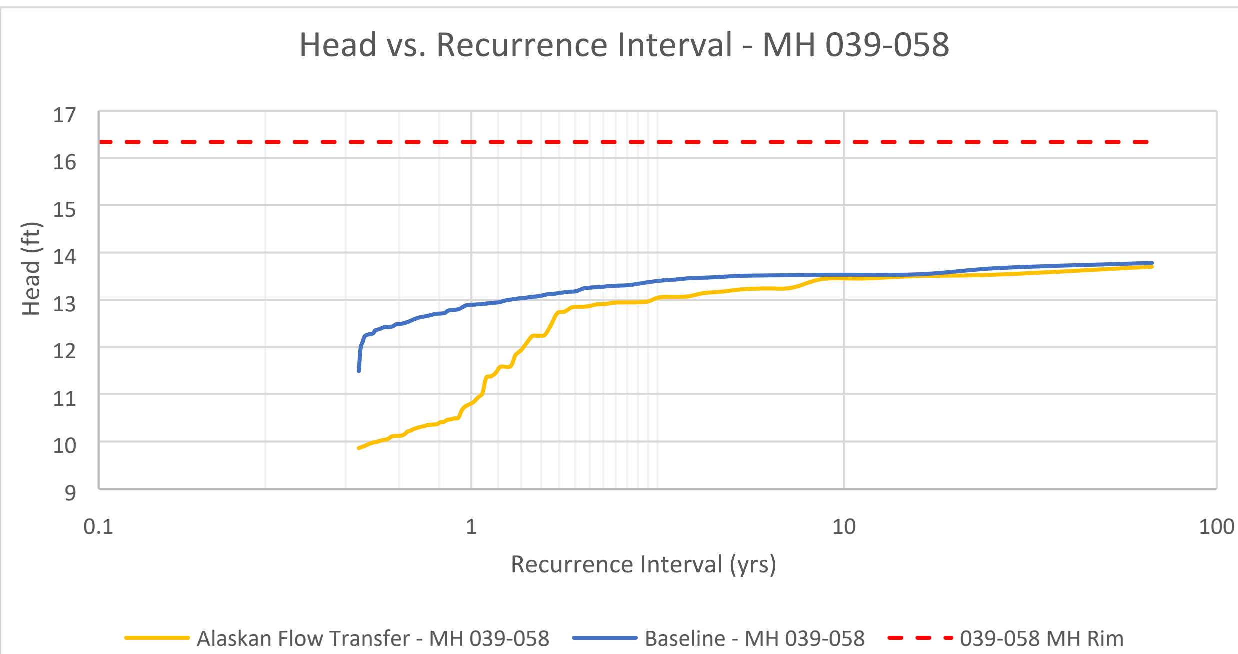

Figure 6-3: Maximum Head versus Recurrence Interval at MH 039-058 for the Baseline and Alaskan Way Parallel Flow Transfer Configurations

6.1.2. Alternative 2 – Elliott Avenue New Flow Transfer

The Elliott Avenue New Flow Transfer Alternative, shown in **Figure 6-4**, conveys flow to KCWTD via diversion at the intersection of Elliott Avenue and Vine Street and a proposed 24 inch diameter sewer in

Elliott Avenue. For this alternative, the proposed sewer in Elliott Avenue becomes the primary flow path with an invert elevation of 14.2 feet at the diversion. High flows on Vine Street are conveyed to the existing CSO Control Structure over a 2 feet tall by 3.5 feet long weir with an invert elevation of 18 feet. The configuration of the diversion and high-flow weir were optimized to meet the performance standard while minimizing peak flows to KCWTD.

Flows are conveyed to the north along Elliott Avenue and discharged to the KC EBI via a 2 foot diameter orifice at the intersection of Bay Street and Elliott Avenue. This alternative is relatively unaffected by downstream water levels; however, the proposed diversion can impact levels in the existing sewer along Elliott Avenue to the south of Vine Street. The diversion was configured such that levels in the existing sewer south of Vine Street do not cause SSO upstream of the structure. **Figure 6-5** shows the Elliott Avenue New Flow Transfer Alternative operations for the 6/3/2008 CSO event.

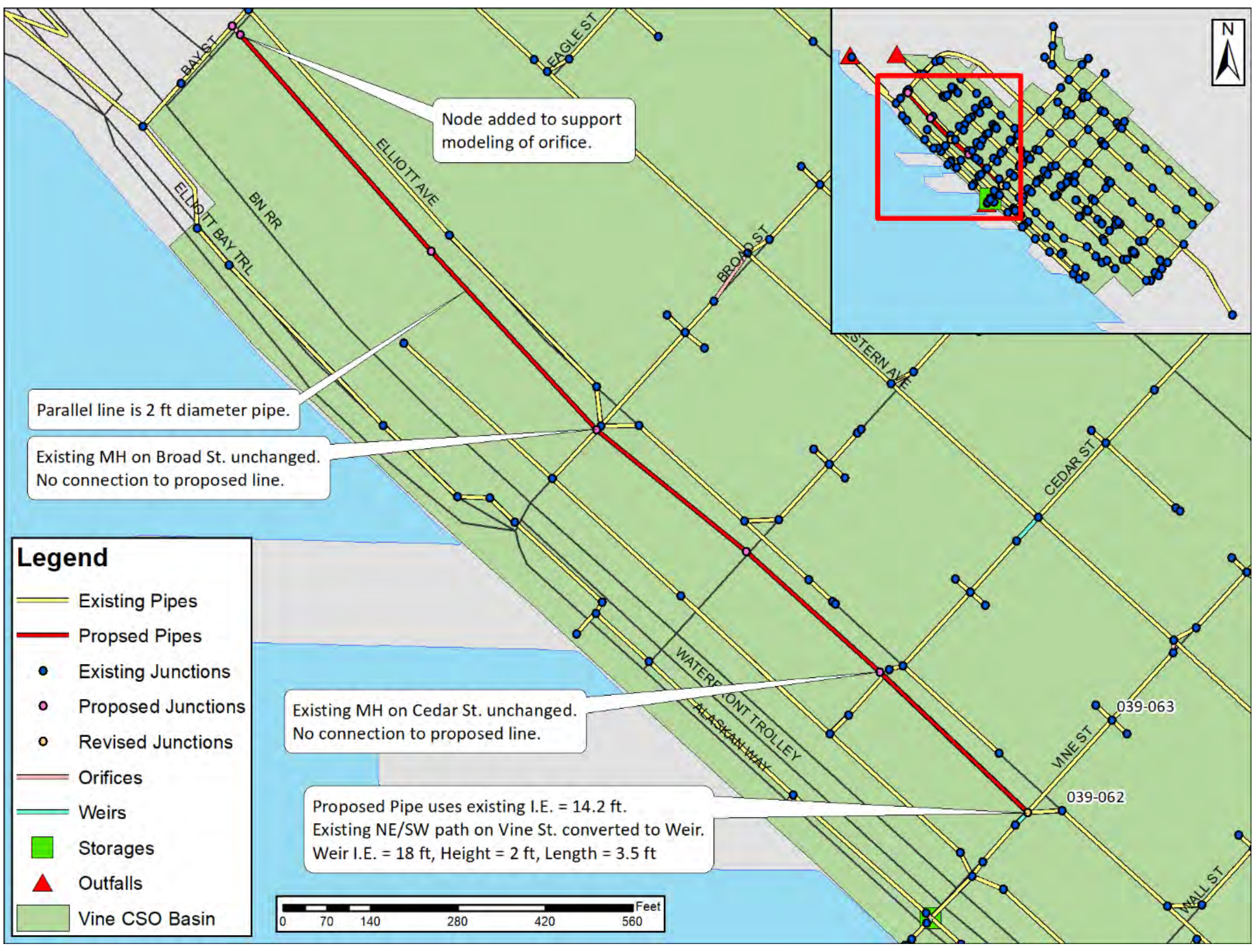

Figure 6-4: Elliott Avenue New Flow Transfer Alternative Configuration

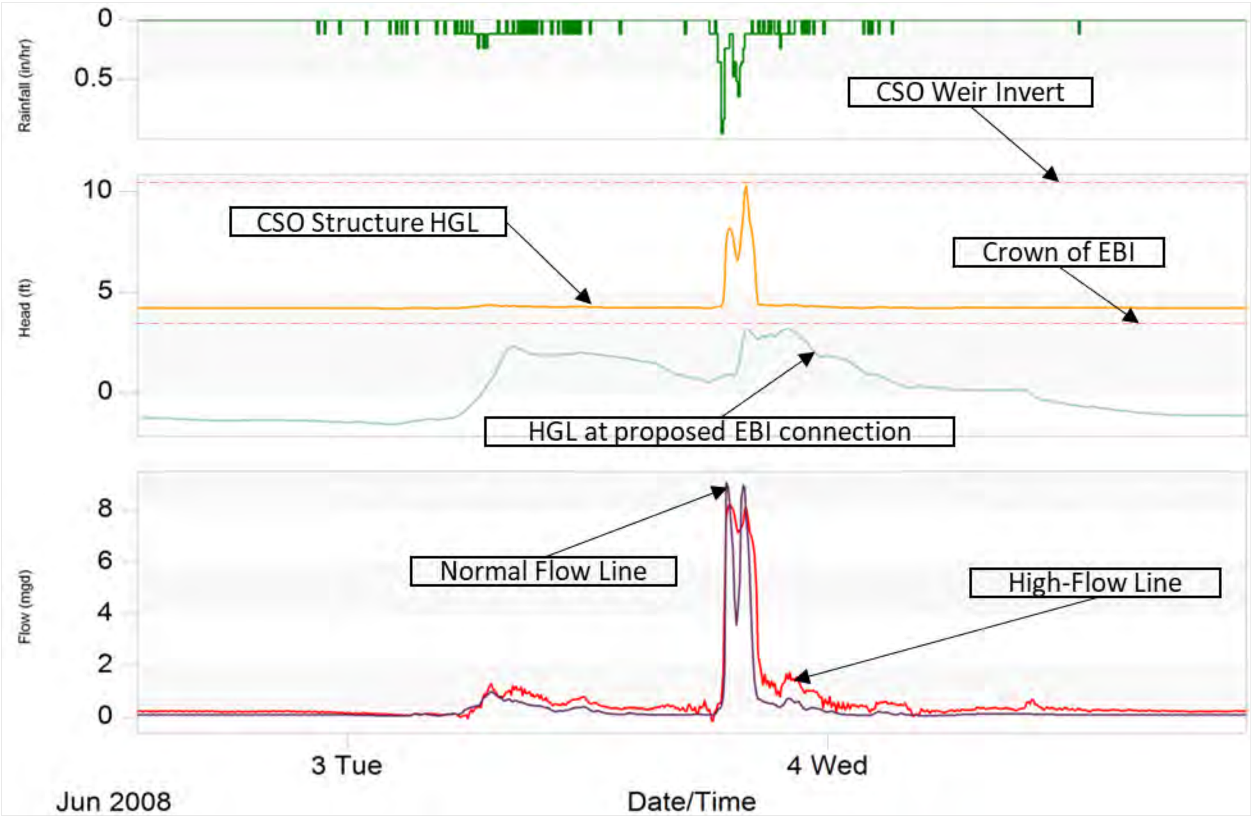

Figure 6-5: Elliott Avenue New Flow Transfer Alternative Operation – 6/3/2008 CSO Event

A long-term simulation using rainfall as described in **Section 6** and boundary conditions as described in **Section 4** was performed to assess the performance of this configuration. **Table 6-3** provides a summary of long-term simulation results for this alternative.

Table 6-3: Summary of Long-Term Simulation Results – Elliott Avenue New Flow Transfer

Period of Record (years)	CSO Frequency		Elliott Avenue New Flow Transfer Alternative		
	Total # of CSO Events	Average Annual	Total Volume of CSOs (MG)	CV (MG)	CV Event Date
20 worst	20	1.0	3.64	0	N/A
40	27	0.7	5.15	0	N/A

A comparison of flows to KCWTD system for the baseline configuration and the Elliott Avenue New Flow Transfer configuration is provided in **Table 6-4**.

Table 6-4: Elliott Avenue New Flow Transfer Downstream Impact Comparison

Scenario	Average Annual Peak Flow Rate (MGD)			Average Annual Flow Volume (MG)		
	Alaskan Way	Elliott Avenue	Western Avenue	Alaskan Way	Elliott Avenue	Western Avenue
Baseline	10.06	N/A	18.13	127.2	N/A	371.1
Alternative 2	8.76	8.12	18.13	89.0	38.5	371.1

To assess the effect of the Elliott Avenue New Flow Transfer configuration on HGLs in the Basin, the maximum head was evaluated at MH 039-062 and MH 039-063 (labeled in **Figure 6-4**), the first upstream MHs of the proposed flow diversion. Heads with recurrence intervals from approximately 0.5 years to approximately 67 years at MH 039-062 and MH 039-063were plotted against their respective recurrence intervals for the baseline and the Elliott Avenue New Flow Transfer configurations. These plots are shown in **Figure 6-6** and **Figure 6-7**. For all return intervals plotted, the head in the baseline configuration is greater than that of the flow transfer configuration for both MHs.

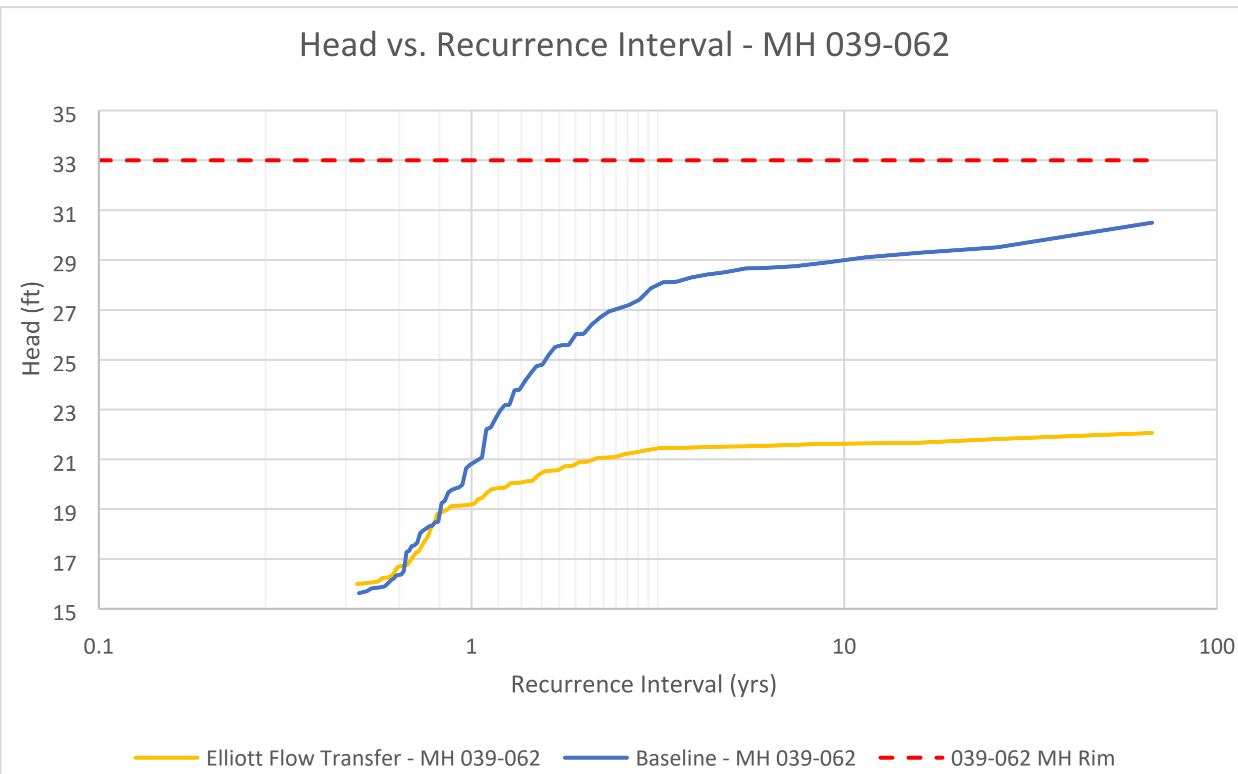

Figure 6-6: Maximum Head at MH 039-062 versus Recurrence Interval for the Baseline and Elliott Avenue New Flow Transfer Configurations

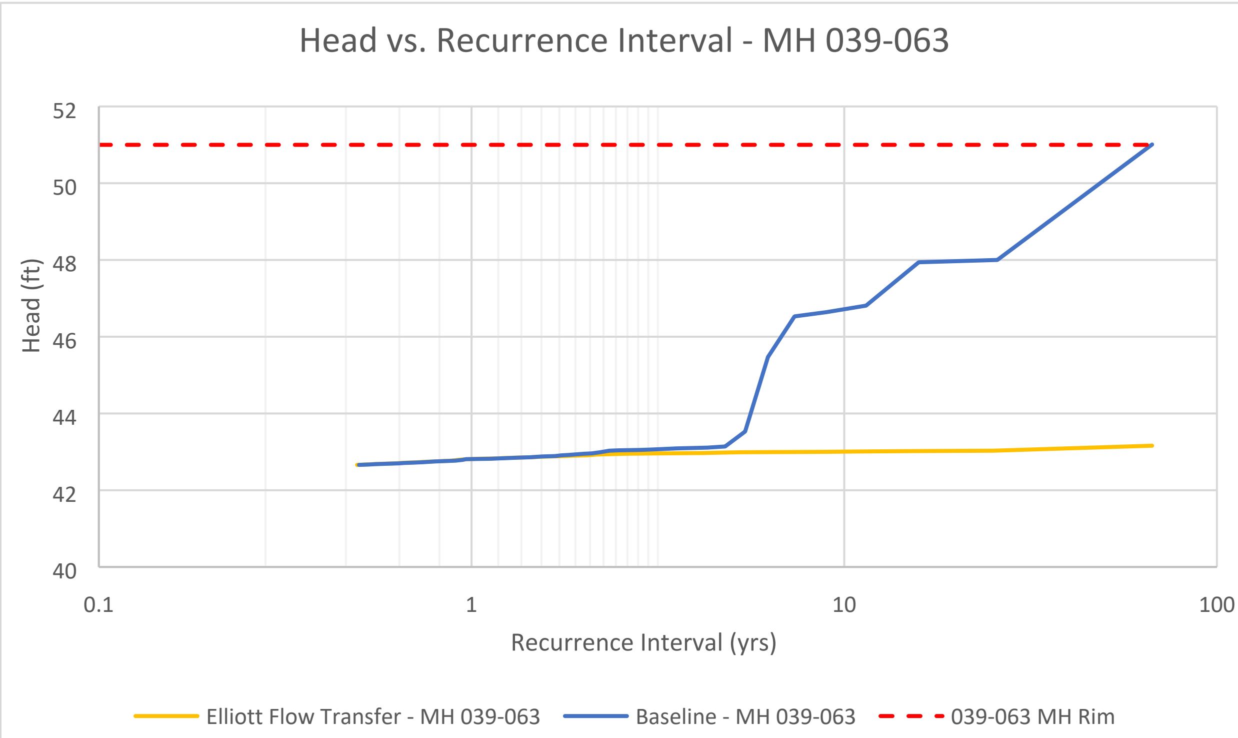

Figure 6-7: Maximum Head at MH 039-063 versus Recurrence Interval for the Baseline and Elliott Avenue New Flow Transfer Configurations

6.2. Storage Options

Only one storage alternative was selected for detailed analysis (Alternative 3) which features inline storage in Alaskan Way. The goal of the storage option is to meet the performance standard of no more than one CSO event per year on a 20 year moving average by storing excess flow when the system is at capacity. In the existing configuration, flow passes through the CSO Control Structure into the Alaskan Way sewer and is conveyed north to the KC EBI connection. The proposed storage pipe is located downstream of the CSO Control Structure (to the north of the CSO Control Structure) and releases flow as water levels between the proposed storage and EBI recede.

This alternative was evaluated using perturbed rainfall representative of the 2035 climate scaled by a factor of 0.985 which corresponds to CV of approximately 182,000 gallons. The storage option was simulated for a 40 year period and was evaluated based on CSO frequency, count, as well as peak flows entering the KCWTD system for precipitation events of various return periods. The alternative was optimized to not significantly increase peak flows to KC while still meeting the performance standard.

Alternative 3 consists of approximately 263,000 gallons of inline storage located directly downstream of the CSO Control Structure. The bottom orifice in the CSO Control Structure is upsized to 2.25 feet in diameter and the pipe between the CSO Control Structure and the proposed storage is upsized to 3 feet in diameter. Flow exits the inline storage via two orifices, each 2 feet in diameter; the first is located at the bottom of the storage with an invert elevation of -0.8 feet and the second located at invert elevation of 2 feet. The storage also features a high flow weir 10 feet in length and 2 feet tall located at the top of the storage at an invert elevation of 7.2 feet. The Alaskan Way Inline Storage Alternative configuration is shown in **Figure 6-8**.

This alternative relies on storing flows downstream of CSO Control Structure to control CSO events in Basin 69. The upsized orifice and conveyance downstream of the CSO Control Structure allows more flow to pass through the CSO Control Structure and on to the inline storage. This reduces the HGL in the CSO Control Structure thereby reducing CSOs, allowing the Basin to meet the performance standard.

The inline storage pipe is sized larger than the CV because it is located downstream of the CSO Control Structure. This is due to the impact of the levels in the EBI on the proposed storage; the proposed storage must store the CV as well as mitigate the effect of downstream water levels. Additionally, the configuration was optimized to not significantly increase peak flows to KCWTD along Alaskan Way. This was accomplished with the use of multiple orifices. The first and lower of the two orifices is surcharged for most large events. The second, higher, orifice allows for higher flows to exit the storage. During the peak of large events this orifice is often surcharged and the level in the storage can build until it reaches the high-flow weir. This weir serves as an outlet to allow the storage to drain before it becomes full and floods. **Figure 6-9** shows the Alaskan Way Inline Storage Alternative operations for the 11/18/2003 CSO event. This event has the 21st largest CSO volume for the baseline configuration in the worst 20 year period.

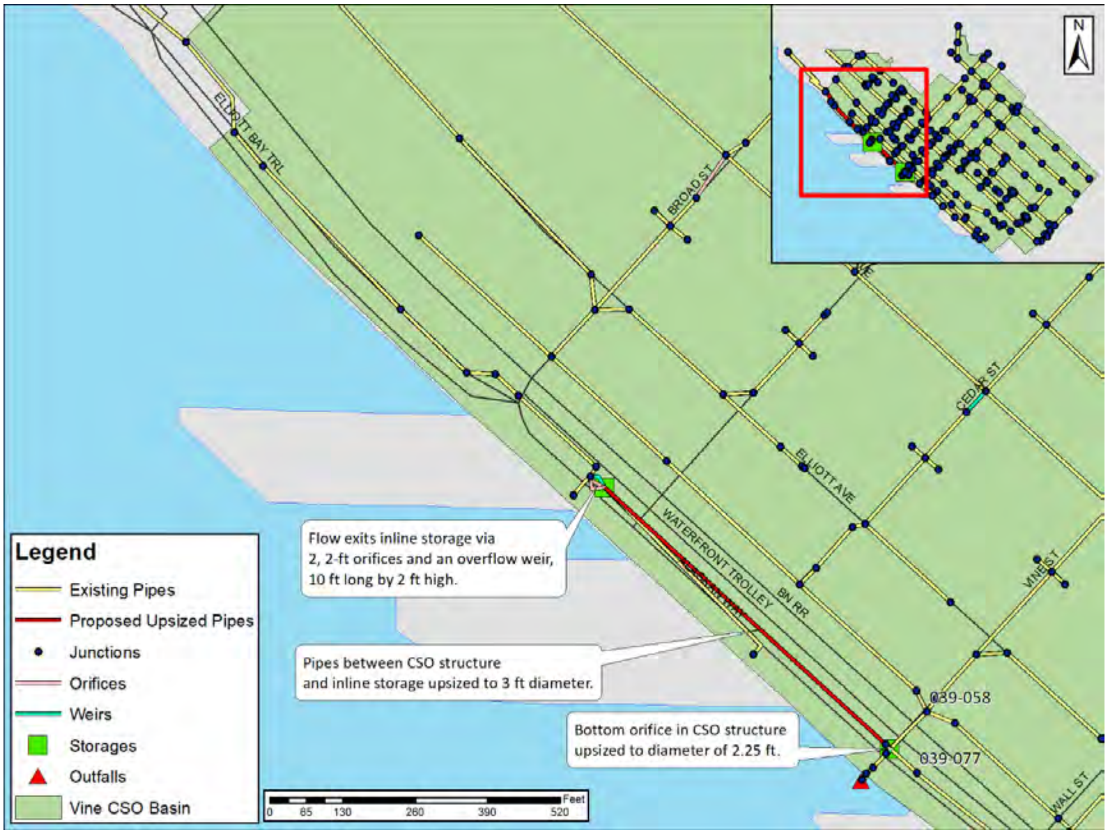

Figure 6-8: Alaskan Way Inline Storage Alternative Configuration

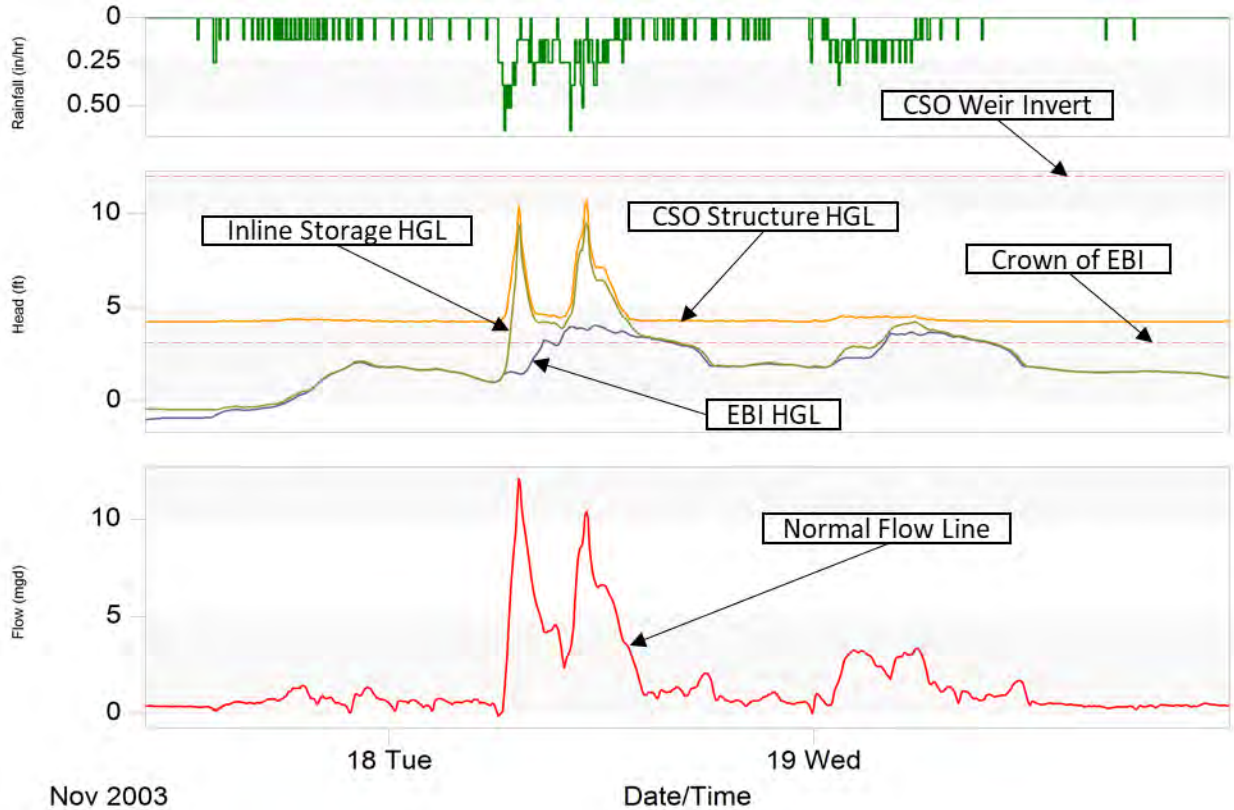

Figure 6-9: Alaskan Way Inline Storage Operation – 11/18/2003 CSO Event

A long-term simulation using rainfall and boundary conditions as described in **Section 4** was performed to assess the performance of this configuration. **Table 6-5** provides a summary of long-term simulation results for this alternative.

Table 6-5: Summary of Long-Term Simulation Results – Alaskan Way Inline Storage

Period of Record (years)	CSO Frequency		Elliott Ave Flow Transfer Option		
	Total # of CSO Events	Average Annual	Total Volume of CSOs (MG)	CV (MG)	CV Event Date
20	20	1.0	5.79	0	N/A
40	31	0.8	8.19	0	N/A

A comparison of flows to KCWTD CS system for the baseline configuration and the Elliott Avenue New Flow Transfer configuration is provided in **Table 6-6**.

Table 6-6: Alaskan Way Inline Storage Downstream Impact Comparison

Scenario	Average Annual Peak Flow Rate (MGD)		Average Annual Flow Volume (MG)	
	Alaskan Way	Western Avenue	Alaskan Way	Western Avenue
Baseline	10.06	18.13	127.2	371.1
Alternative 3	10.59	18.13	128.6	371.1

To assess the effect of the Alaskan Way Inline Storage configuration on HGLs in the Basin, the maximum head was evaluated at MH 039-058 and MH 039-077 (labeled in **Figure 6-8**), the first upstream MHs of the proposed storage and CSO Control Structure. Heads with recurrence intervals from approximately 0.5 years to approximately 67 years at MH 039-058 and MH 039-077were plotted against their respective recurrence intervals for the baseline and the Elliott Avenue New Flow Transfer configurations. These plots are shown in **Figure 6-10** and **Figure 6-11**. For all return intervals up to approximately 40 years, the head in the baseline configuration is greater than that of the storage configuration for both MHs. Above the 40 year recurrence interval the head at MH 039-077 does increase for the Alaskan storage configuration. However, this is beyond the level of service for this option. Further optimization could mitigate increases in head at higher recurrence intervals.

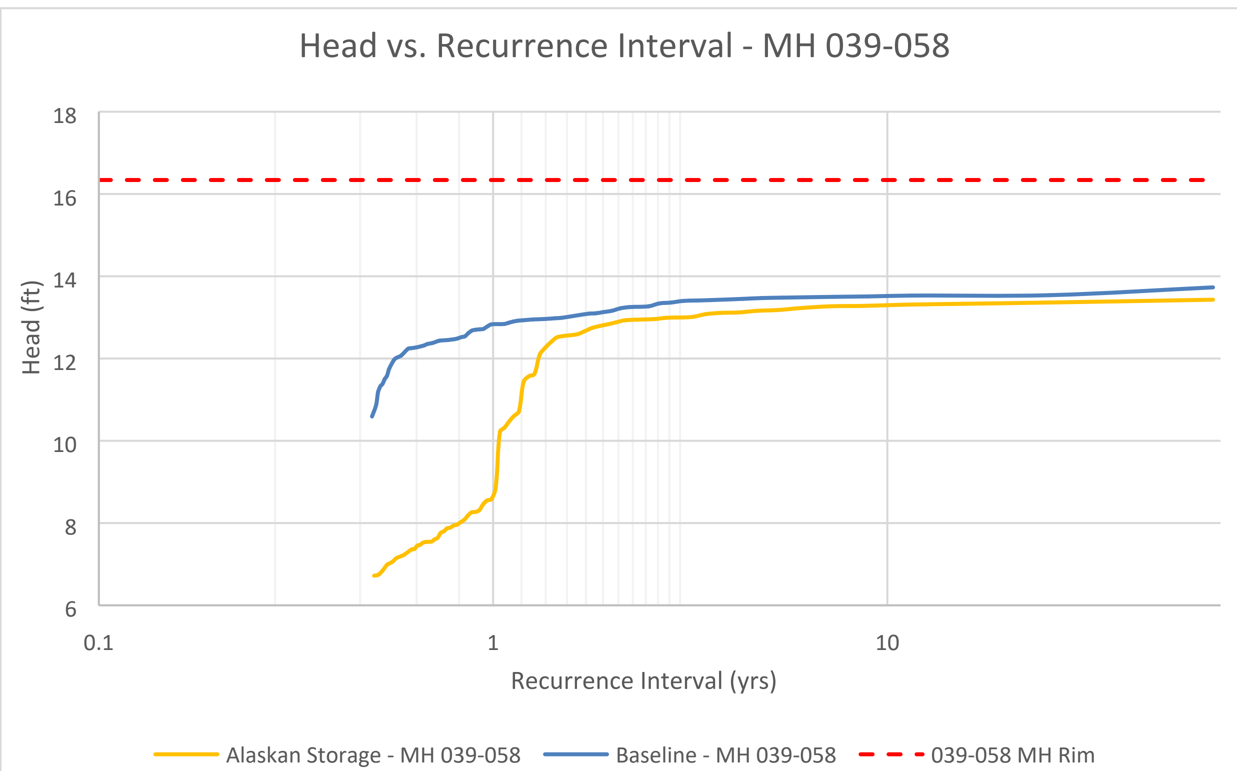

Figure 6-10: Maximum Head versus Recurrence Interval for the Baseline and Alaskan Way Inline

Storage Configurations

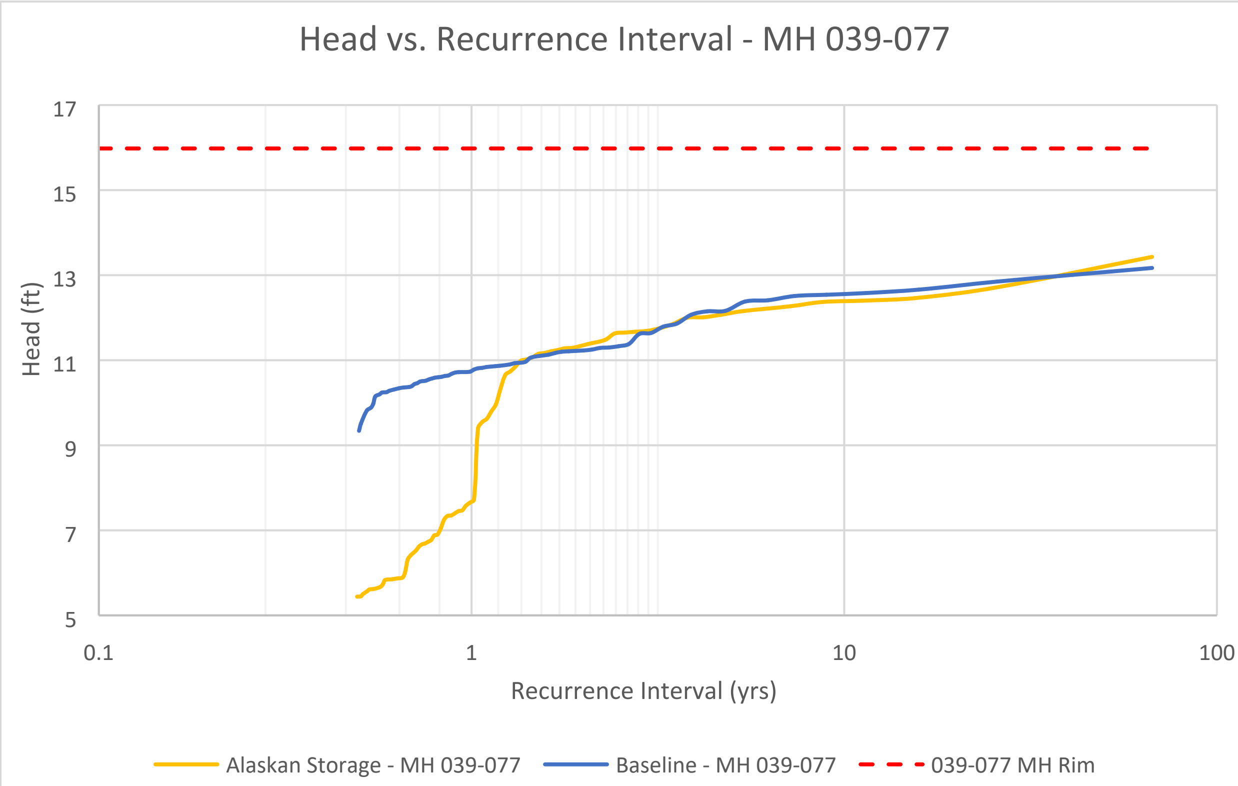

Figure 6-11: Maximum Head at MH 039-077 versus Recurrence Interval for the Baseline and Alaskan Way Inline Storage Configurations

6.3. Green Options

The goal of the green options is to meet the performance standard of no more than one CSO event per year on a 20 year moving average by implementing stormwater control methods including green stormwater infrastructure (GSI) such as bioretention and stormwater storage in alleys (green alleys) to reduce peak flows to the CSO Control Structure. GSI located throughout the Basin will collect and store stormwater runoff from impervious areas but are assumed to not infiltrate any of the runoff collected. Therefore, the GSI function primarily as small storage, delaying the timing of peak flows to the CSO Control Structure. One green option will also be supplemented with standard grey storage similar to the inline storage described in **Section 6.3.2**.

Two options were evaluated using perturbed rainfall representative of the 2035 climate scaled by a factor of 0.985 which corresponds to CV of approximately 182,000 gallons. This scaling factor was selected for consistency with the inline storage option as one green option will include a grey inline storage as part of the option.

6.3.1. Bioretention/Green Alley Performance

To assess the performance of bioretention cells and green alleys in the Basin prior to running long-term simulations, a relationship was developed between impervious area captured by bioretention cells and green alleys and the reduction in CSO volume for the Basin. Execution of this task was based upon two important assumptions: first, the bioretention cells and green alleys store the 1 year storm. Second, the bioretention cells and green alley have no infiltrative capacity.

Using these assumptions, the performance of these elements was estimated by removing runoff from impervious area from the system in the SWMM5 model. Two scenarios were constructed by removing impervious area from sub-catchments above and below Western Avenue. Due to the presence of high-flow paths along Western Avenue, runoff from areas above Western Avenue has a different impact to CSO volumes than runoff below Western Avenue. For each scenario, varying amounts of impervious area were removed, and a CV was computed based on the 11/18/2003 CSO event. This event has the 21st largest CSO volume for the baseline configuration in the worst 20 year period. These model runs used 2035 rainfall scaled by a factor of 0.985 and used boundary conditions as described in **Section 1**. Impervious area removed and peak runoff reduction for each scenario and the corresponding CV reduction are provided in **Table 6-7**. These results were used to develop CV reduction curves, shown in **Figure 6-12**.

Table 6-7: Basin 69 Impervious Area Removed and CV Reduction

Scenario		1	2	3	4	5	6
Above Western (Upper Basin)	Impervious Area Removed (ac)	0.15	0.55	0.94	4.89	38.91	87.65
	Peak Runoff Reduction (MGD)	0.05	0.21	0.37	1.63	12.57	43.93
	CV Reduction (MG)	0.0058	0.0088	0.0104	0.0449	0.1755	0.1755
Below Western (Lower Basin)	Impervious Area Removed (ac)	0.14	0.62	1.12	5.05	12.34	27.93
	Peak Runoff Reduction (MGD)	0.05	0.21	0.93	1.93	4.33	14.84
	CV Reduction (MG)	0.0040	0.0093	0.0132	0.0398	0.0801	0.1640

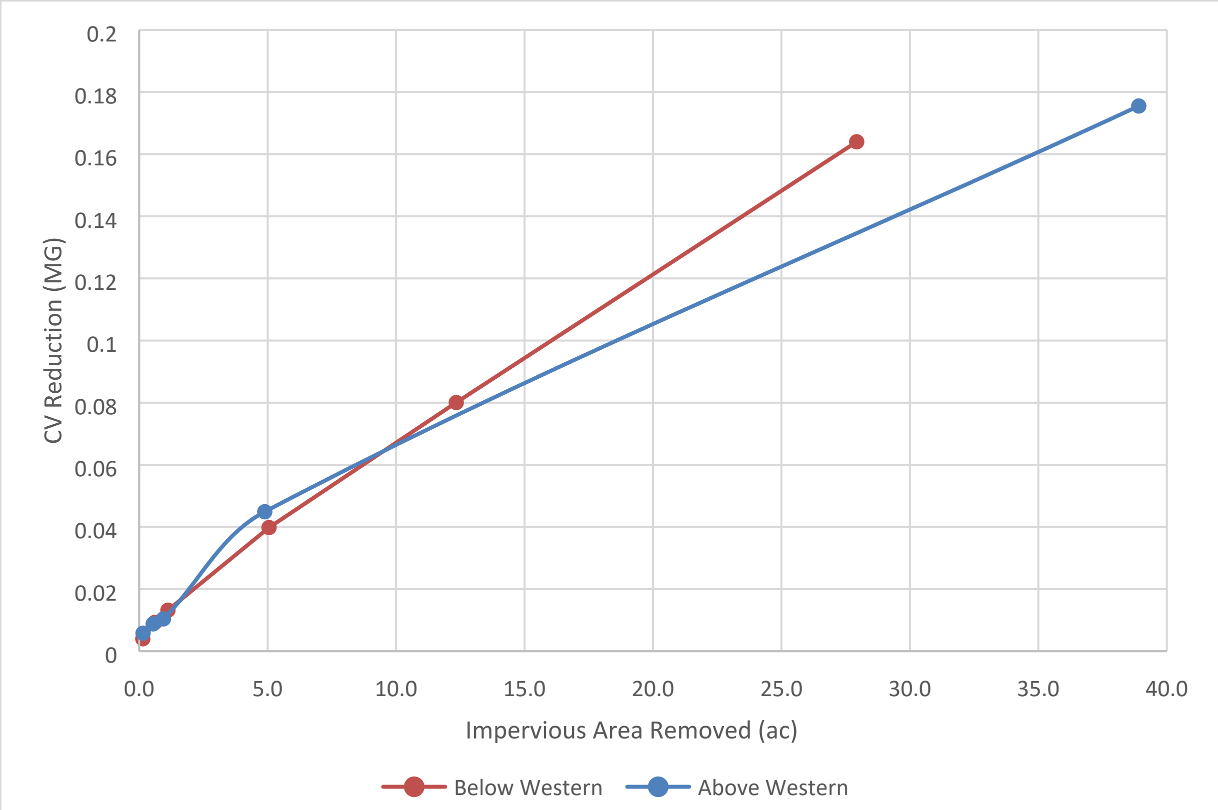

Figure 6-12: CV Reduction Versus Impervious Area Removed Above and Below Western

MGS Flood modeling was performed by Robin Kirschbaum, Inc. (RKI) to establish the anticipated performance of "typical" bioretention cells and green alleys under a 1 year storm. This analysis determined bioretention cells and green alleys were unable to completely store a 1 year storm due to the assumed passive orifice design controlling discharge to the sewer system (design of the green option configurations are detailed in **Section 6.3.2**). Therefore, the CV reduction versus impervious area removed could not be used to estimate the CV performance of the green options. Instead, a relationship between peak flow reduction and CV reduction was developed using MGS Flood and SWMM5 modeling results. **Table 6-8** provides the peak flow reduction for the bioretention and green alleys based on MGS Flood modeling by RKI (Robin Kirschbaum, Inc. 2019). Impervious area removed in SWMM5 modeling versus peak runoff reduction is shown in **Figure 6-13**.

Table 6-8: MGS Flood Peak Flow Reduction Results

	Impervious Area Captured (ac)	Peak Flow Reduction (CFS)	Peak Flow Reduction (MGD)	Peak Flow Reduction per Impervious Acre (MGD/ac)
Bioretention	0.5	0.0620	0.0401	0.0801
Green Alley	0.5	0.0810	0.0524	0.1047

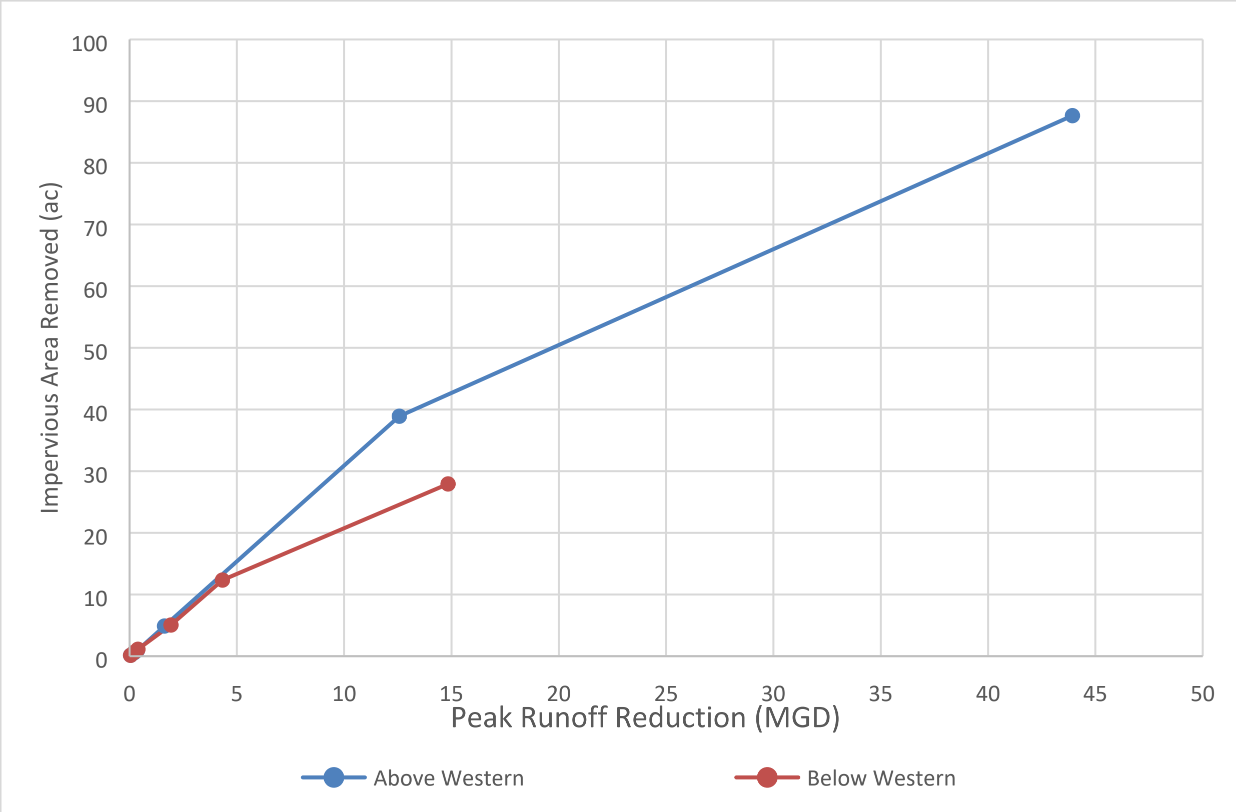

Figure 6-13: Impervious Area Removed Versus Peak Runoff Reduction Above and Below Western

For a given amount of impervious area captured, one can determine the expected CV reduction by first computing peak flow reduction based on the peak flow reduction per impervious acre rate determined by the RKI analysis and summarized in **Table 6-8**. Using trendlines developed from the curves in **Figure 6-13** and the peak runoff reduction computed above, the impervious area removed was computed. Using the calculated impervious area removed and the trendlines developed from the curves in **Figure 6-12**, the expected CV reduction for the Basin was determined. Using these curves and the MGS Flood modeling results, SPU selected two green options to model with long term simulations. The configurations and results of these simulations are discussed in the following sections.

6.3.2. Alternative 4A – Green/Grey Option

Alternative 4A consists of GSI, in the form of green alleys and roadside bioretention, as well as inline combined sewer storage in Alaskan Way to delay the peak flow to the CSO Control Structure and store flow downstream of the CSO Control Structure. The configuration of Alternative 4A is shown in **Figure 6-14**.

Two green alleys were implemented for this option; the first located above Western Avenue between Wall Street, 1st Avenue, Battery Street, and Western Avenue, collects and stores runoff from approximately 0.5 acres of impervious area adjacent to the alley and discharges to the combined sewer.

The second green alley, located below Western Avenue between Vine Street, Elliott Avenue, Wall Street, and Alaskan Way, collects and stores runoff from approximately 1 acre of impervious area adjacent to the alley and discharges to the combined sewer. Both green alleys discharge to the combined sewer via a 0.5 inch diameter orifice located at the bottom of the green alley and feature a 1 foot tall by 5 feet long high flow orifice to prevent flow from overtopping the alley surface.

A total of 16 bioretention cells are proposed along Vine Street; eight are located above Western Avenue (within the "upper basin") and 8 are located below Western Avenue (within the "lower basin"). Each set of 8 bioretention cells were modeled as one storage node. A set of 8 bioretention cells collects runoff from a total of approximately 1 acre of impervious right-of-way (ROW) area adjacent to the cells. Each bioretention cell drains via a 0.5 inch diameter orifice located at the bottom of the cells and feature a 0.5 feet tall by 5 feet long high flow weir located 1 foot from the top of the cell to maintain 1 foot freeboard in each cell.

The drain orifices for both the bioretention and the green alleys were modeled as 3 inch diameter pipes with flow limits based on the MGS Flood modeling. MGS Flood analysis, performed by RKI, determined the peak flow from the bioretention cells was 0.0155 MGD; peak flow from the alley capturing 0.5 acres of impervious area was 0.00388 MGD and 0.0084 MGD from the green alleys which collected 1 acre of impervious area (Robin Kirschbaum, Inc. 2019). These flow rates were applied as flow limits in the PCSWMM modeling.

This alternative also utilizes approximately 92,000 gallons of inline storage located just downstream of the CSO Control Structure. The pipe between the CSO Control Structure and the proposed storage is upsized to 3 feet in diameter. Flow exits the inline storage via two orifices, the first, 2 feet in diameter, is located at the bottom of the storage with an invert elevation of -0.2 feet. The second orifice is 0.65 feet in diameter with an invert elevation of 1.75 feet. The storage also features a high flow weir 0.5 feet long and 2 feet tall with an invert elevation of 12.2 feet.

Neither the green alleys nor the bioretention cells can infiltrate flow which effectively makes them small storages which delay peak flow to the CSO Control Structure. The addition of inline storage downstream of the CSO Control Structure, in conjunction with the GSI assets, slightly reduces the level in the CSO Control Structure and thus provides some reduction in CSO events. However, the combination of GSI and inline storage does not delay the timing of peak flows enough or provide enough HGL reduction in the CSO Control Structure for the Basin to meet the performance standard. **Figure 6-15** shows Alternative 4A operations for the 11/18/2003 CSO event.

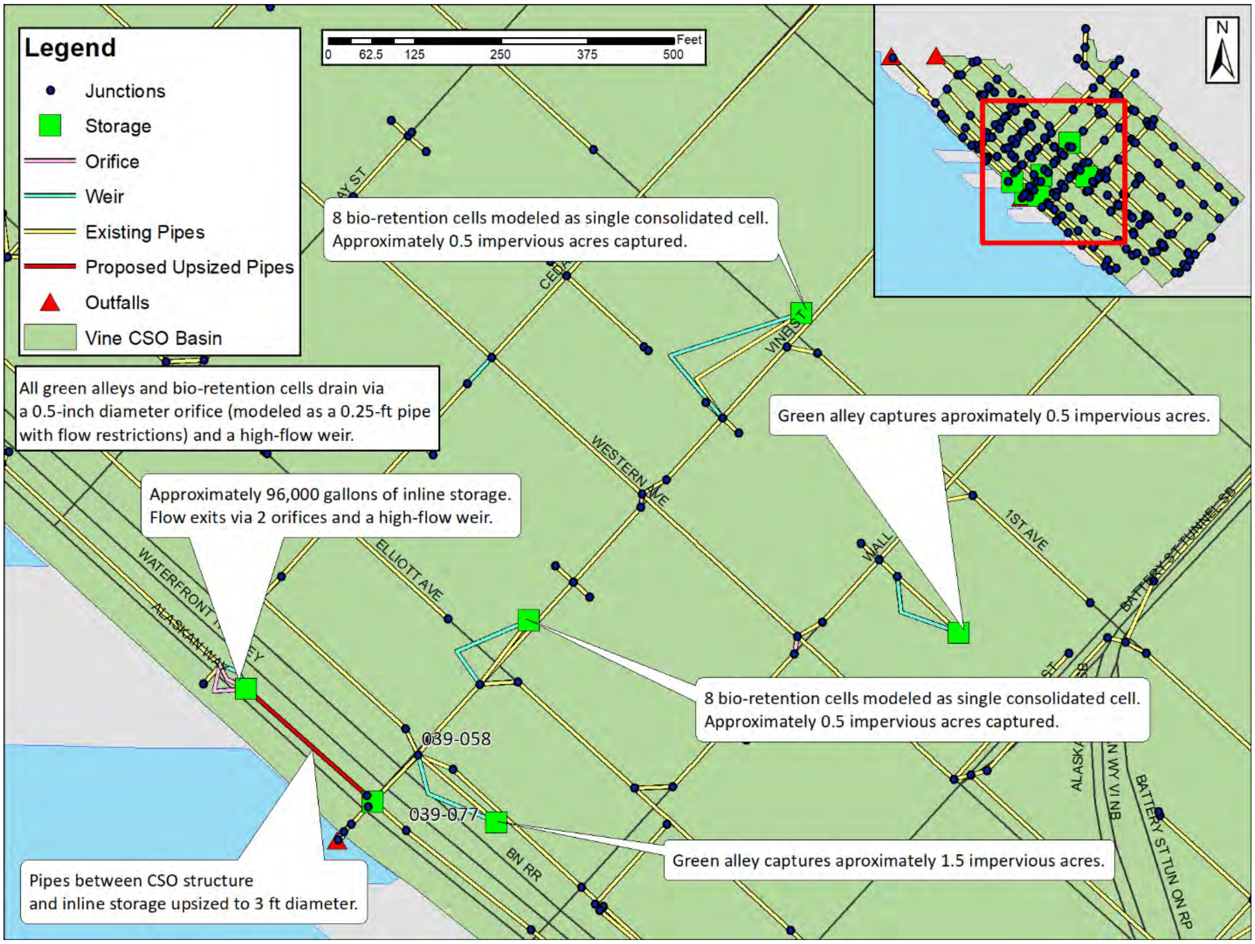

Figure 6-14: Alternative 4A – Green Option

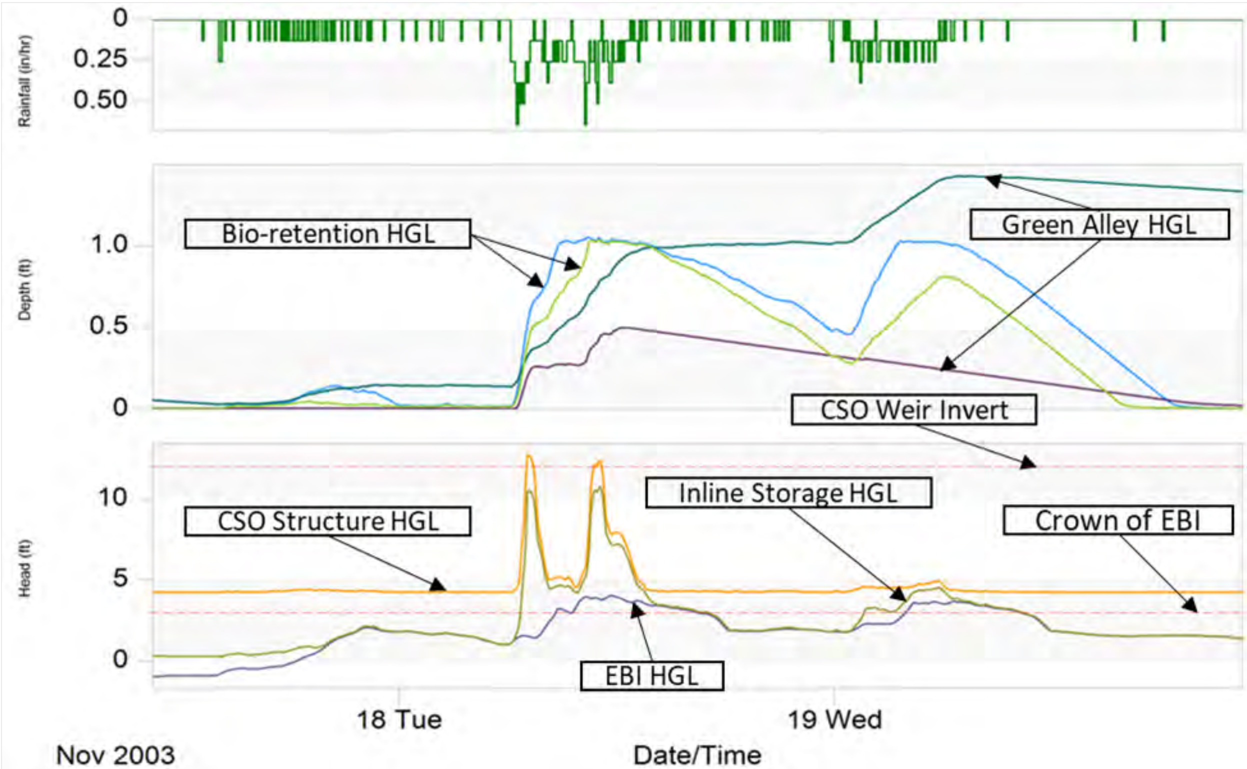

Figure 6-15: Alternative 4A Operations – 11/18/2003 CSO Event

A long-term simulation using rainfall as described in **Section 6.3** and boundary conditions as described in **Section 4** was performed to assess the performance of this configuration. **Table 6-9** provides a summary of long-term simulation results for this alternative.

Table 6-9: Summary of Long-Term Simulation Results – Alternative 4A

Period of Record (years)	CSO Frequency		Alternative 4A		
	Total # of CSO Events	Average Annual	Total Volume of CSOs (MG)	CV (MG)*	CV Event Date
20	30	1.5	11.39	0.092	11/18/2003
40	45	1.1	15.88	0.092	11/18/2003

*The CV volume represents the remaining volume to be mitigated by Stormwater Code revisions.

A comparison of flows to KCWTD CS system for the baseline configuration and the configuration of Alternative 4A is provided in **Table 6-10**. The project scope did not allow for optimization of this alternative for the Basin to meet the performance standard.

Table 6-10: Alternative 4A Downstream Impact Comparison

Scenario	Average Annual Peak Flow Rate (MGD)		Average Annual Flow Volume (MG)	
	Alaskan Way	Western Avenue	Alaskan Way	Western Avenue
Baseline	10.06	18.13	127.2	371.1
Alternative 4A	9.37	17.73	126.4	369.7

To assess the effect of Alternative 4A on HGLs in the Basin, the maximum head was evaluated at MH 039-058 and MH 039-077(labeled in **Figure 6-14**), the first upstream MHs of the proposed storage and CSO Control Structure. The green alley located between Western Avenue and Alaskan Way also discharges to 039-058. Heads with recurrence intervals from approximately 0.5 years to approximately 67 years at MH 039-058 and MH 039-077 were plotted against their respective recurrence intervals for the baseline and the Alternative 4A configurations. These plots are shown in **Figure 6-16** and **Figure 6-17**. For all return intervals up to approximately 40 years, the head in the baseline configuration is greater than that of the Alternative 4A configuration for both MHs. Above the 40 year recurrence interval the head at 039-077 does increase for Alternative 4A. However, this is beyond the level of service for this alternative. Further optimization could mitigate increases in head at higher recurrence intervals.

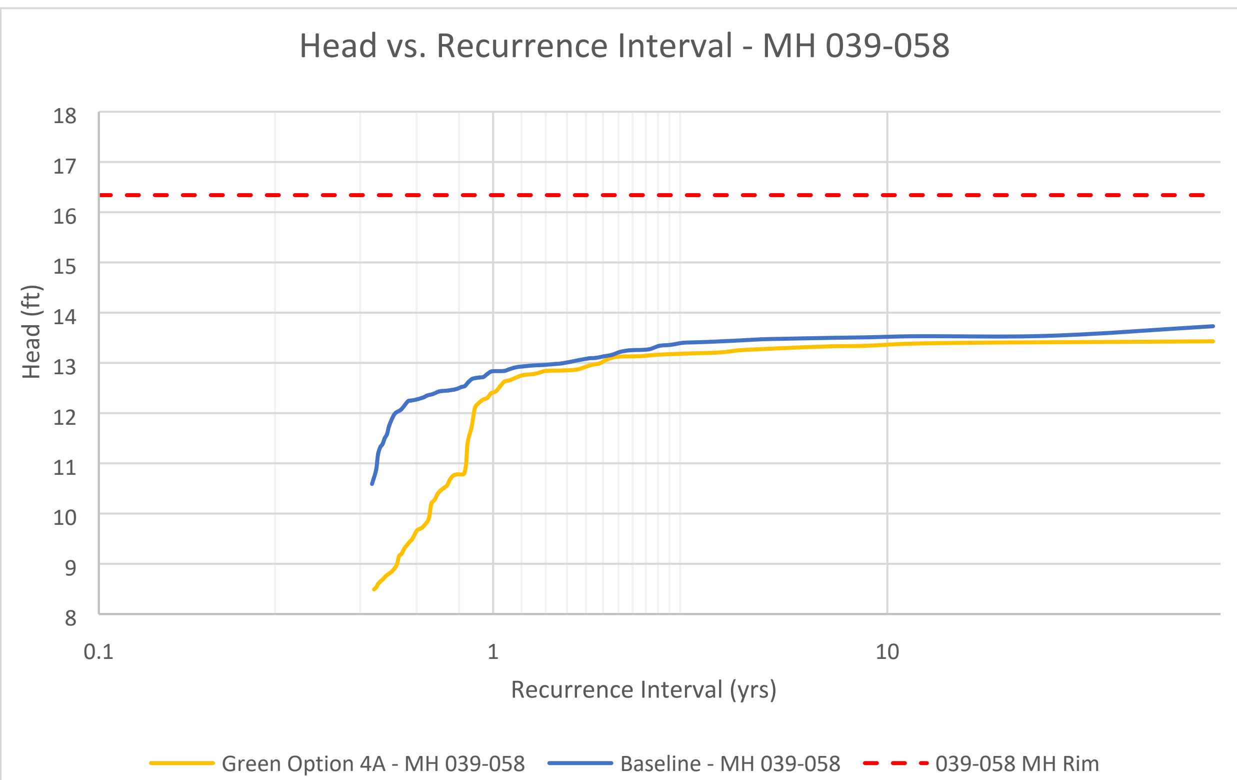

Figure 6-16: Maximum Head versus Recurrence Interval at MH 039-058 for Baseline Condition and Alternative 4A

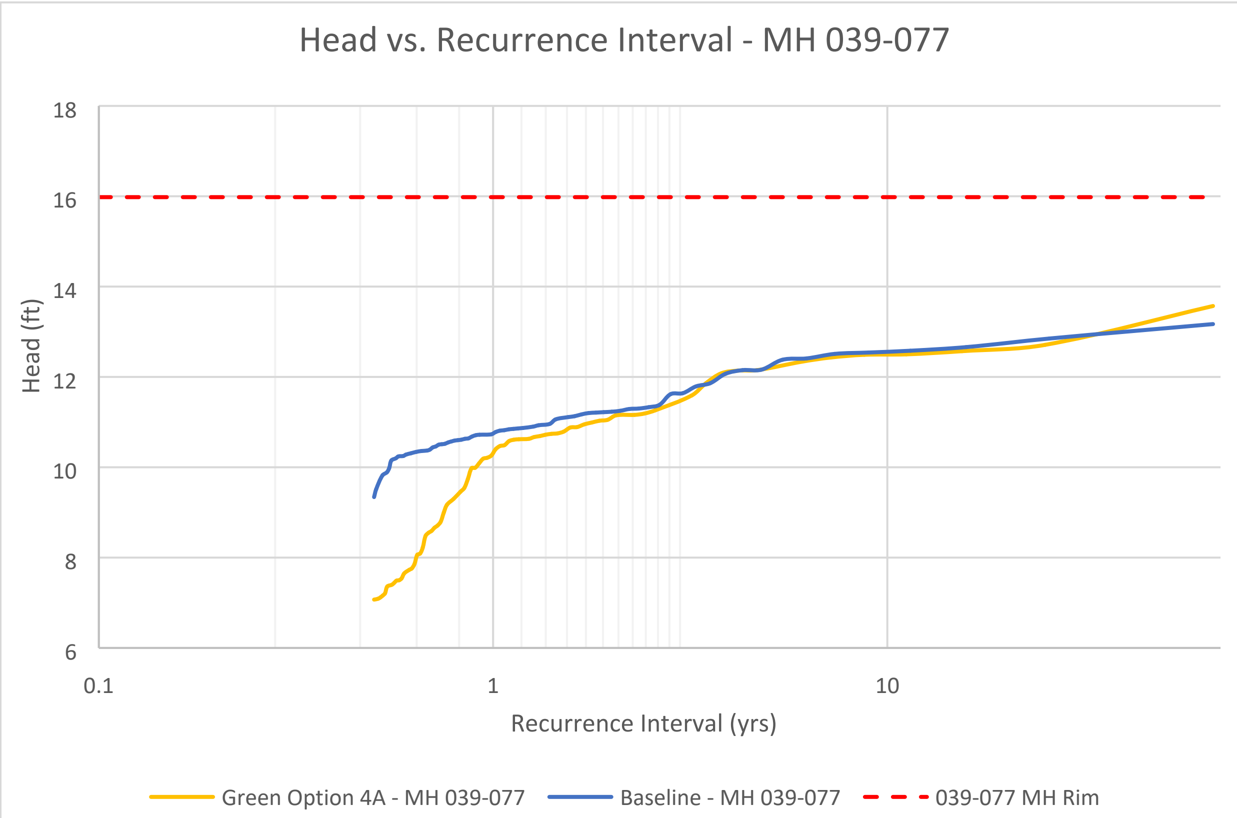

Figure 6-17: Maximum Head versus Recurrence Interval at MH 039-077 for the Baseline Condition and Alternative 4A

6.3.3. Alternative 4B – Green Option

This alternative uses GSI, in the form of green alleys and roadside bioretention cells, to delay peak flows to the CSO Control Structure. This alternative is identical to Alternative 4A except for the lack of inline storage on Alaskan Way. Bioretention cells and green alleys are located and configured as in Alternative 4A and have no infiltration capacity. The configuration of Alternative 4B is shown in **Figure 6-18**. Like Alternative 4A, this configuration slightly reduces the HGL in the CSO Control Structure resulting in a small reduction of CSO events, however, it does not meet the performance standard. **Figure 6-19** shows Alternative 4B operations for the 11/18/2003 CSO Event.

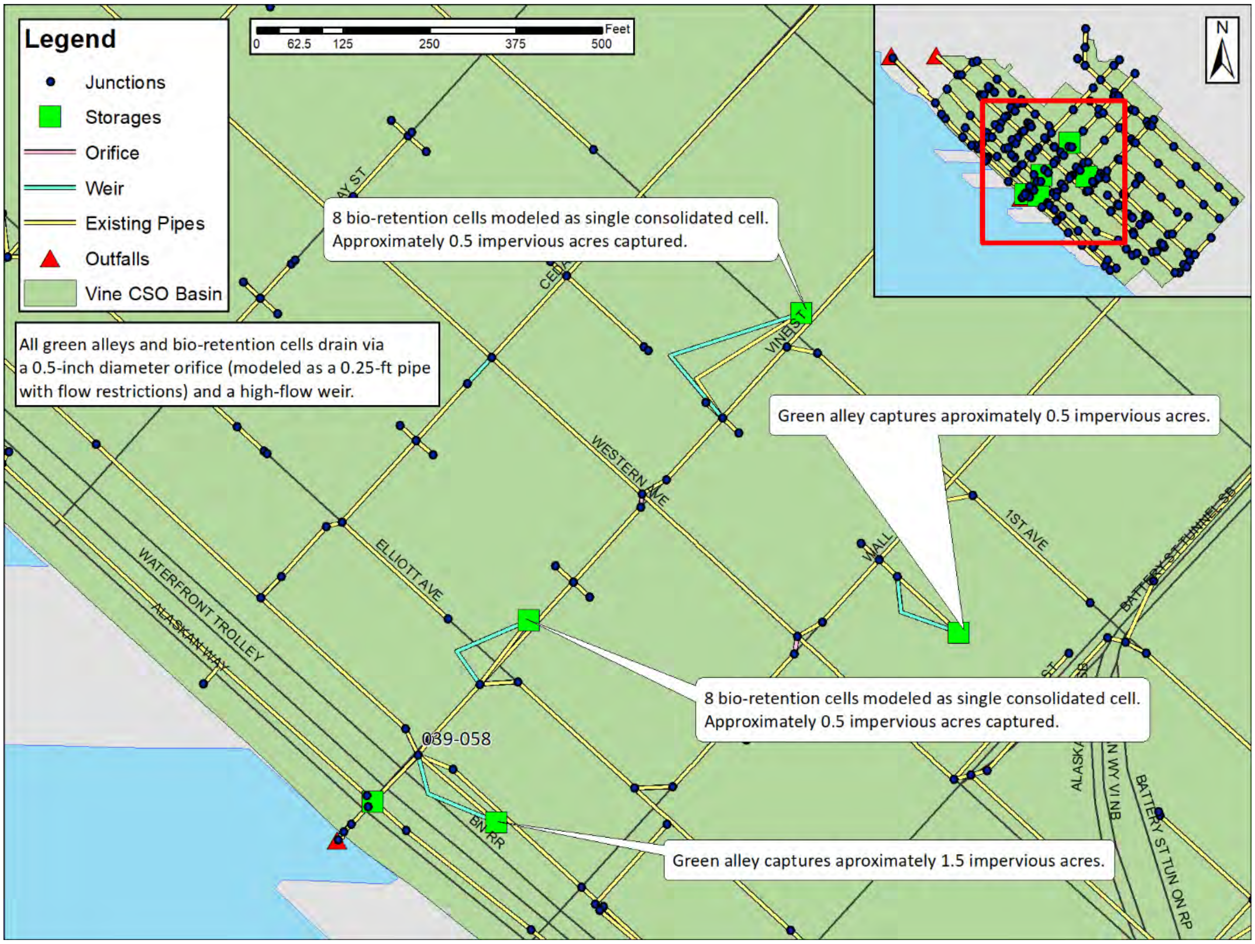

Figure 6-18: Alternative 4B – Green Option

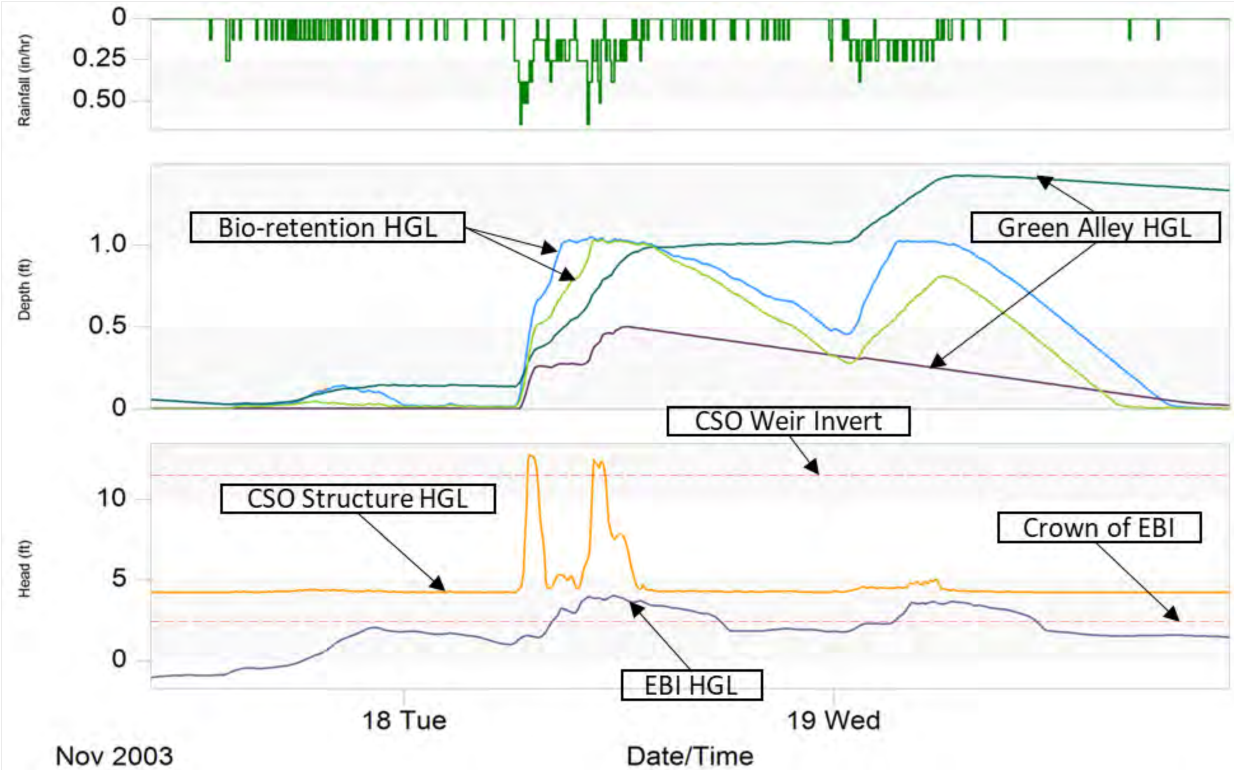

Figure 6-19: Alternative 4B Operations – 11/18/2003 CSO Event

A long-term simulation using rainfall as described in **Section 8** and boundary conditions as described in **Section 4.2** was performed to assess the performance of this configuration. **Table 6-11** provides a summary of long-term simulation results for this alternative.

Table 6-11: Summary of Long-Term Simulation Results – Alternative 4B

Period of Record (years)	CSO Frequency		Alternative 4B		
	Total # of CSO Events	Average Annual	Total Volume of CSOs (MG)	CV (MG)*	CV Event Date
20	40	2.0	12.90	0.150	11/18/2003
40	65	1.6	18.08	0.150	11/18/2003

*The CV volume represents the remaining volume to be mitigated by Stormwater Code revisions

A comparison of flows to KCWTD for the baseline configuration and Alternative 4B is provided **Table 6-12**.

Table 6-12: Alternative 4B Downstream Impact Comparison

Scenario	Average Annual Peak Flow Rate (MGD)		Average Annual Flow Volume (MG)	
	Alaskan Way	Western Avenue	Alaskan Way	Western Avenue
Baseline	10.06	18.13	127.2	371.1
Alternative 4B	9.80	17.74	126.5	369.8

To assess the effect of Alternative 4B on HGLs in the Basin, the maximum head was evaluated at MH 039-058 (labeled in **Figure 6-18**). This MH is the discharge point for the green alley, which is located between Western Avenue and Alaskan Way, and is expected to be most impacted by the green alleys and bioretention cells. Heads with recurrence intervals from approximately 0.5 years to approximately 67 years at MH 039-058 were plotted against their respective recurrence intervals for the baseline and Alternative 4B configurations. This plot is shown in **Figure 6-20**. For all return intervals, the head in the baseline configuration is greater than that of Alternative 4B.

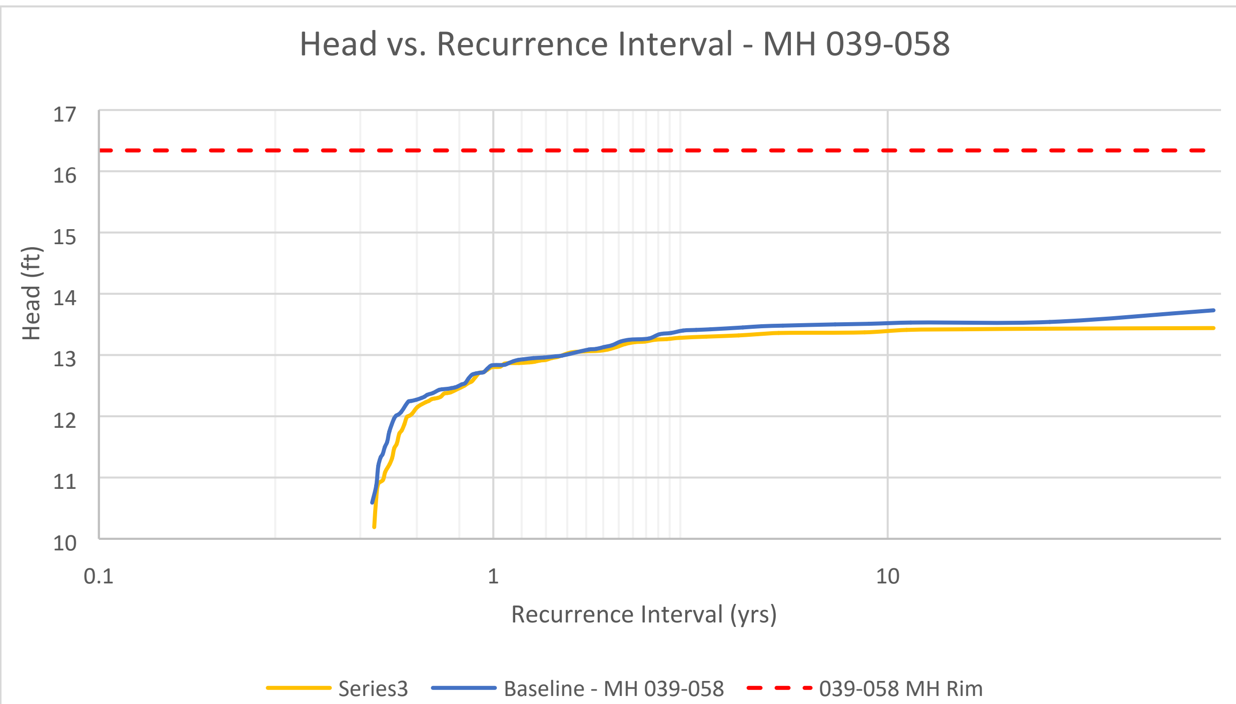

Figure 6-20: Maximum Head versus Recurrence Interval at MH 039-058 for the Baseline and Alternative 4B Configurations

7. Conclusion

The Vine Basin CSO Control Project options analysis effort has produced flow transfer, storage, stormwater control alternatives to achieve CSO control in Basin 69. These alternatives were simulated for short periods of time, generally single CSO events, to test effectiveness and refine the configuration.

The refined alternatives were then run through a long-term simulation to determine their CSO performance over the 40 year rainfall period of record.

These alternatives have varying levels of effectiveness with flow transfer alternatives being most effective, followed by the storage, with the stormwater control alternatives being least effective. The storage and flow transfer alternatives could meet the performance standard of no more than one CSO event per year on a 20 year moving average, while the stormwater control alternative could not meet this performance standard.

The most effective alternative, the Elliott Avenue New Flow Transfer, proposes a diversion at Vine Street and Elliott Avenue and conveys flow via a proposed line along Elliott Avenue discharging to the EBI via a proposed connection at Elliott Avenue and Bay Street. This option converts the primary flow path in the Basin to the proposed line along Elliott Avenue, allowing it to collect most of the flow in the Basin and transfer it to KCWTD, circumventing the CSO Control Structure and significantly reducing the occurrence of CSO events.

8. Limitations and Uncertainties

The analysis performed during this project utilizes models and CVs developed in recent projects. No further calibration or CV analysis was completed as part of this project.

The GSI options relied on assumptions and modeling by others to determine CSO efficacy. It was outside of the Aqualyze scope to perform QA/QC on modeling analysis provided by RKI and it was assumed that that information was suitable for use in this analysis. These options also relied on best-fit trendlines developed from multiple model simulations and some variability in results could be expected if these options were developed further. It is not recommended that those trendlines be used for other projects without first determining applicability. Note that the GSI options were not optimized such that the Basin meets the performance standard.

The analysis relies on boundary conditions provided by KCWTD, and it was assumed that this information was suitable for use. These conditions should be reviewed for applicability as a selected option moves into design.

Care was taken to review impacts to HGL in the portions of the system adjacent to proposed options to ensure no unintended SSOs. It was outside of the scope of this project to review impacts to adjacent basement (if any) elevations. This should be considered as the project moves into more mature option definition, design, and construction.

As stated in previous sections, no consideration was made for population changes or changes to the basin conveyance system that are proposed or are being designed by others outside of this project. It is recommended that those areas be revisited prior to modeling in support of design.

9. References

Aqualyze Inc. 2018. "Central Waterfront Basin 69 Calibration and Control Volume Modeling Technical Memorandum."

Aqualyze Inc. 2019. "Wastewater System Analysis Project Report."

NOAA. 2018. "Tides and Currents: Seattle, WA - Station ID:9447130."

Robin Kirschbaum, Inc. 2019. "SPU Vine Basin CSO Control MGS Flood Summary DRAFT 20190408.xlsx." doi:eeee.

Seattle Public Utilities. 2017. "Drainage Standards and Guidlines." Seattle.

Appendix D
SEPA Checklist

SEATTLE PUBLIC UTILITIES
SEPA ENVIRONMENTAL CHECKLIST

This State Environmental Policy Act (SEPA) environmental review of Seattle Public Utilities' (SPU's) Central Waterfront (Basin 69) Combined Sewer Overflow (CSO) Control Project has been conducted in accordance with the Washington SEPA (RCW 43.21C), state SEPA regulations (Washington Administrative Code [WAC] Chapter 197-11), and the City of Seattle (City) SEPA ordinance (Seattle Municipal Code [SMC] Chapter 25.05).

A. BACKGROUND

1. **Name of proposed project**:

   Central Waterfront Basin (Basin 69) CSO Control Project

2. **Name of applicant**:

   Seattle Public Utilities

3. **Address and phone number of applicant and contact person:**

   Shailee Sztern, PE, Project Manager
   Seattle Public Utilities
   Project Delivery and Engineering Branch
   Seattle Municipal Tower, Suite 4900
   P.O. Box 34018
   Seattle, WA 98124-4018
   (206) 233-1532
   Shailee.Sztern@seattle.gov

4. **Date checklist prepared:**

   August 23, 2019

5. **Agency requesting checklist:**

   Seattle Public Utilities

6. **Proposed timing or schedule (including phasing, if applicable):**

   Construction of the CSO control improvements in Basin 69 (the Project) is anticipated to require approximately 12 to 16 months, with a tentative start date of July 2022. Construction is required to be completed no later than December 31, 2025. Project construction would progress block-by-block to minimize traffic impacts and impacts to the downtown urban environment and community.

7. **Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain.**

   The Project is part of a larger City-wide effort by SPU, as mandated through Consent Decree, to complete certain CSO-control related activities. Several CSO-reduction projects are being actively pursued throughout the City, including the Ship Canal Water Quality Project, East Montlake Project, Portage Bay Project, and Magnolia Basin 60 Pump Station Upgrades. Cumulatively, these projects contribute to CSO reduction throughout the City; however, this proposed Project is subject to its own environmental review and permit processes. No additional expansions or additions related to this proposal are currently planned.

8. List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal.

- Central Waterfront Basin (Basin 69) CSO Control Project Draft Engineering Report (June 2019), which describes the project need, existing conditions, the alternatives that were evaluated, and the selected alternative to achieve Consent Decree CSO performance standard. The Engineering Report will be approved by the Washington State Department of Ecology (Ecology) prior to construction. Submittal to Ecology will occur no later than December 31, 2019.
- On March 14, 2013, Seattle Department of Transportation (SDOT) issued a SEPA Final Environmental Impact Statement (FEIS) for the Elliott Bay Seawall Project, which has a project area that overlaps with a majority of the Project corridor (defined as the extent of proposed area of disturbance within the public right of way of Elliott Avenue) for the proposed Project. On December 16, 2013, SDOT issued a Final Supplemental Environmental Impact Statement (FSEIS) that analyzed impacts related to design refinements and adjustments to the construction sequencing and approach. These documents are on file with the City.

  The proposed Project lies largely within the area analyzed by the FEIS and FSEIS. Because the environments of the projects overlap, the Elliott Bay Seawall Project FEIS and FSEIS and all their supporting Discipline Reports, in their entireties and as corrected and amended, are incorporated by reference into this SEPA environmental review for SPU's proposed Project (per WAC 197-11-635 and 754).

9. Do you know whether applications are pending for governmental approvals of other proposals directly affecting the property covered by your proposal? If yes, explain.

According to the City of Seattle Land Use and Building Permit Maps, there are one active land use application and four building permit applications awaiting government approval adjacent to the Project area. However, these projects are located on private parcels, outside the Right-of-Way (ROW) where the majority of construction for this proposed Project would occur.

According to the SDOT Project and Construction Coordination Map, there are currently no planned ROW projects within the Project corridor that would be under construction during the Project's anticipated 2022–2025 construction window.

10. List any government approvals or permits that will be needed for your proposal, if known.

The following permits or approvals will be required before Project construction can commence:

- Ecology approval of Central Waterfront Basin (Basin 69) CSO Control Project Final Engineering Report
- SPU SEPA Review
- SDOT Street Improvement Permit
- SDOT Construction Street Use Permit
- Seattle Department of Construction and Inspections (SDCI) Noise Variance *(potential based on construction plan and equipment)*

- SDCI/King County Permit for Temporary Dewatering
- Ecology National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit (CSGP) *(potential based on approach to stormwater management)*
- Seattle Parks & Recreation Revocable Use Permit *(potential based on selected construction staging area)*

11. Give a brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page.

Project Background

The proposed Project has been initiated to fulfill requirements from the City's Wastewater Consent Decree (Civil Action No. 2:13-cv-678, entered in U.S. District Court on July 3, 2013). SPU operates and maintains combined sewer systems within the City. During large storm events, the combined systems can overflow, resulting in CSOs. The Consent Decree requires the City to control CSO events to no more than one untreated discharge per year, assessed on a 20-year moving average, for each CSO outfall. The purpose of this Project is to construct system improvements to achieve that performance standard within Basin 69. The Project is needed because during the period of 1999 to 2018, Basin 69 averaged 1.8 CSOs per year.

The Consent Decree mandated the preparation of a Long-Term Control Plan (LTCP). Central Waterfront Basin 69 is identified in the LTCP for control by 2025. The LTCP set the following milestones to achieve CSO control in Basin 69:

- Submit Draft Engineering Report to Ecology by June 30, 2019.
- Submit Final Engineering Report to Ecology by December 31, 2019.
- Complete Draft Plans and Specifications by June 30, 2021.
- Complete Final Plans and Specifications by December 31, 2021.
- Begin Construction by July 1, 2022.
- Complete Construction by September 30, 2025.
- Achieve Controlled Status by September 30, 2026.

This proposed Project, as outlined in these discrete steps, will achieve the goal of CSO control within Basin 69, as required by the Consent Decree and applicable environmental regulations.

This SEPA checklist analyzes the potential Project-specific environmental impacts that could result from construction and operation of the recommended alternative.

Project Description

The proposed Project would control the frequency of Basin 69 CSOs by increasing combined sewer system conveyance capacity upstream of an existing CSO Control Structure. It would also establish a new discharge connection to King County's Elliott Bay Interceptor. The Project would increase peak flows and total discharged flows to King County's Elliott Bay Interceptor, which would reduce the flow managed by the existing CSO Control Structure. The combined sewer system currently experiences a CSO event when the hydraulic grade line in the existing Alaskan Way sewer and CSO Control Structure are elevated above the CSO overflow weir elevation. The Project would provide additional conveyance capacity by adding a new sewer in Elliott Avenue and diversion structure upstream of the CSO Control Structure to divert flows away from the existing CSO Control Structure. This delays the hydraulic grade line from rising above the CSO weir elevation, resulting in a reduction in CSO event frequency.

Proposed Project Elements:

- Installation of approximately 1,800 linear feet of new 24-inch-diameter gravity sewer pipe and other appurtenances, such as maintenance holes, within Elliott Avenue, from Vine Street to Bay Street
- Installation of a new connection to King County's existing Elliott Bay Interceptor
- Construction of a new sewer diversion vault and weir at the crossing of the existing sewer line at the intersection of Vine Street and Elliott Avenue
- Improvements to existing curb ramps within the Project corridor, consistent with Americans with Disabilities Act (ADA) specifications

The following Project elements are also assumed and would be coordinated with other City agencies throughout design and implementation:

- Green Stormwater Infrastructure (such as bioretention facilities within existing planter strips in the ROW)
- Installation of flexible porous surface treatment within existing tree pits along the Project corridor
- Potential improvements to street lighting and pedestrian crossings

Project Construction

Project construction would be completed entirely within the ROW of Elliott Avenue through open trench construction. Work would occur in one-block increments to minimize traffic and community impacts; once installation of the proposed CSO control improvements is complete for a respective block, the pavement would be temporarily restored, and parking spaces/drive lanes would be restriped. Once construction of all CSO control improvements is complete, the pavement would be resurfaced/striped within the entire Project corridor and additional improvements (ADA curb ramps, bioretention facilities, tree pit covers, and lighting/pedestrian crossing improvements, as applicable) would be installed. Construction is anticipated to last approximately 12 to 16 months.

SPU or SPU's Contractor may lease space within proximity to the Project area to support construction staging and laydown. Properties that do not have a current active use or existing vertical structures are most likely to be used in this capacity. The lease for a staging area would be negotiated between SPU and the property owner and would require that the site be restored to preconstruction conditions or better following completion of the Project.

Project Operation

Operations and maintenance (O&M) of the completed Project is anticipated to be consistent with SPU's existing gravity sewer infrastructure, which requires annual maintenance, and inspection every 10 years with a closed-circuit television (CCTV) to further evaluate conditions. No sewer solids handling is anticipated to be required, as solids would be conveyed to the West Point Wastewater Treatment Plant with the sewer flows. If solids do build-up, they would be removed using a Vactor Truck and disposed of at an approved location.

12. Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any, and section, township, and range, if known. If a proposal would occur over a range of area, provide the range or boundaries of the site(s). Provide a legal description, site plan, vicinity map, and topographic map, if reasonably available. While you should submit any plans required by the agency, you are not required to duplicate maps or detailed plans submitted with any permit applications related to this checklist.

The Project is within the ROW of Elliott Avenue, from its intersection with Bay Street to its intersection with Vine Street. The Project corridor is located within the NE quarter of Section 36, Township 25N, Range 3E; and NW quarter of Section 31, Township 25N, Range 4E of the Willamette Meridian. There is no street address available for the Project corridor. The following attachments provide additional detail:

Attachment A – Vicinity Map
Attachment B – Site Plan

B. ENVIRONMENTAL ELEMENTS

1. Earth

a. General description of the site: *[Check the applicable boxes]*

☒ Flat ☐ Rolling ☐ Hilly ☐ Steep Slopes ☐ Mountainous
☐ Other: (identify)

The Project corridor is approximately 1,800 linear feet in length and is composed entirely of developed ROW. According to the SDCI GIS Mapping Application, topography within the Project corridor is generally flat, with little to no discernable slope.

Additional information on geology and soils is found in the Geology and Soils Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

b. What is the steepest slope on the site (approximate percent slope)?

The Project corridor is flat, with little to no discernable slope.

c. What general types of soils are found on the site (for example, clay, sand, gravel, peat, muck)? If you know the classification of agricultural soils, specify them and note any agricultural land of long-term commercial significance and whether the proposal results in removing any of these soils.

Over the last century, urban development in the Project area has resulted in a predominance of disturbed native soils/sediments, cut slopes, and large placements of fill material. The entire Project area has been developed and disturbed in this way. Due to the developed conditions of the Project area, there are no existing soils suitable for agriculture and no agricultural lands. Additional information on geology and soils is found in the Geology and Soils Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

d. Are there surface indications or history of unstable soils in the immediate vicinity? If so, describe:

According to the SDCI GIS Mapping Application, a portion of the Project corridor is located within a liquefaction-prone area. Additional information on seismic issues and slope stability is found in the Geology and Soils Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

e. Describe the purpose, type, total area, and approximate quantities and total affected area of any filling, excavation, and grading proposed. Indicate the source of fill.

Construction of the proposed Project would require excavation of approximately 7,000 cubic yards of material as part of the proposed open trench construction. Excavated areas would be backfilled with stockpiled material once the new sewer pipe and other improvements have been installed. Approximately 2,500 cubic yards of pipe bedding, aggregate, and other fill material would also be imported to provide adequate base for this infrastructure.

Material that requires export would be disposed of at a City-approved upland location or used as fill material (if determined suitable) at sites approved for filling and grading. Imported fill material would be clean and obtained from an approved local supplier.

f. Could erosion occur as a result of clearing, construction, or use? If so, generally describe:

Given the construction approach and the urban setting, no significant erosion is anticipated during or as a result of SPU's proposed work. To minimize the potential for erosion, the contractor will implement erosion and sediment control best management practices (BMPs) contained within a Project-specific Construction Stormwater and Erosion Control (CSEC) Plan and a Tree, Vegetation, and Soil Protection (TVSP) Plan.

The completed Project would not increase the potential for erosion because the type of surface and use of the Project area would not change. Once Project construction is complete, disturbed areas would be restored to preconstruction conditions or better.

g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?

The Project corridor is almost entirely covered with impervious asphalt or concrete surfaces (exception being the limited street tree pits and planter strips along Elliott Avenue). Surfaces disturbed by Project construction would be replaced with impervious asphalt or concrete surfaces. No discernable change in impervious surface area would occur as a result of the completed Project.

h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any:

To reduce and control erosion during construction, the contractor will be required to implement BMPs identified within a Project-specific Stormwater Pollution Prevention Plan (SWPPP), CSEC Plan, and TVSP Plan. In addition, if the contractor elects to treat and discharge stormwater to Elliott Bay during construction, the contractor will be responsible for complying with Ecology's NPDES CSGP. No other earth impacts are anticipated to result from construction or operation of the proposed Project.

2. Air

a. What types of emissions to the air would result from the proposal [*e.g.*, dust, automobile, odors, industrial wood smoke, greenhouse gases (GHG)] during construction, operation, and maintenance when the project is completed? If any, generally describe and give approximate quantities if known.

Mobile and stationary equipment would be used for project construction, thus generating emissions due to the combustion of gasoline and diesel fuels (such as oxides of nitrogen, carbon monoxide, particulate matter and smoke, uncombusted hydrocarbons, hydrogen sulfide, carbon dioxide, and water vapor). Emissions during construction could also include dust from grading activities and exhaust (carbon monoxide, sulfur, and particulates) from construction equipment; these emissions are expected to be minimal, localized, and temporary.

The proposed project would produce greenhouse gases (GHGs) in three ways: embodied in the proposed gravel aggregate, paving and concrete work; through construction activity (as described above); and during regular operation, maintenance, and monitoring activities. Total GHG emissions for the proposed project are estimated to be approximately 5,084.71 metric tons of carbon dioxide emission ($MTCO_2e$); however, approximately 93.5 percent of this total would be generated by GHG's embodied in the proposed gravel aggregate, paving and concrete. GHG emissions embodied in the gravel aggregate, paving and concrete would be spread out over the 100-year design life of the constructed project. The GHG emission calculations are shown in Attachment C and described in the table below. One metric ton is equal to approximately 2,205 pounds. Also, the embodied energy in other materials (such as ductile iron pipe) used in this project has not been estimated for purposes of this SEPA environmental review due to the difficulty and inaccuracy of calculating those estimates.

The proposed project would also generate GHG emissions during operation, maintenance, and monitoring. The estimated emissions are based on the assumed emissions that would be generated annually. The estimated average GHG emissions generated from operations, maintenance, and monitoring over the 100-year design life of the constructed project is 158.06 $MTCO_2e$.

Summary of Greenhouse Gas Emissions

Activity/Emission Type	GHG Emissions (pounds of CO_2e)[1]	GHS Emissions (metric tons of CO_2e)[1]
Paving and Concrete	10,480,668	4,754.1
Construction Activities (Diesel)	310,423	140.81
Construction Activities (Gasoline)	69,984	31.74
Long-term Maintenance (Diesel)	N/A	N/A
Long-term Maintenance (Gasoline)	348,462	158.06
Total GHG Emissions	11,209,751.7	5,084.71

[1] Note: 1 metric ton = 2,204.62 pounds of CO_2e. 1,000 pounds = 0.45 metric tons of CO_2e

b. Are there any off-site sources of emissions or odor that may affect your proposal? If so, generally describe.

There are no known off-site sources of emissions or odors that could negatively affect the proposed Project.

c. Proposed measures to reduce or control emissions or other impacts to air, if any:

During construction, impacts to air quality would be reduced and controlled through implementation of standard federal, state, and local emission control criteria and City construction practices. These would include requiring the contractor to use the best available control technologies, proper vehicle maintenance, and minimizing vehicle and equipment idling. In addition, the contractor will implement dust control measures during earthwork, including but not limited to street sweeping, water application to exposed soil surfaces, and covering of soil stockpiles to minimize fugitive dust.

3. Water

a. Surface:

(1) Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal streams, saltwater, lakes, ponds, wetlands)? If so, describe type and provide names. If appropriate, state what stream or river it flows into.

The Project area is paved. There are no surface waterbodies within the Project corridor. The nearest surface waterbody is Elliott Bay, located approximately 300 feet to the southwest of the Project corridor.

(**2) Will the project require any work over, in, or adjacent to (within 200 feet) the described waters? If so, please describe, and attach available plans.**

The proposed Project would not require work within 200 feet of Elliott Bay, which is the nearest surface waterbody to the Project corridor.

(3) Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands, and indicate the area of the site that would be affected. Indicate the source of fill material.

The proposed Project would not require filling or excavation of any surface water.

(4) Will the proposal require surface water withdrawals or diversions? If so, give general description, purpose, and approximate quantities if known.

The proposed Project would not require surface water withdrawals or diversions.

(5) Does the proposal lie within a 100-year floodplain? If so, note location on the site plan.

The Project corridor does not lie within a designated 100-year floodplain.

(6) Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.

The proposed Project would not create a new discharge point of waste materials to surface waters. However, the Project purpose is to reduce the frequency of CSO events that currently occur within Basin 69. CSOs are a source of water pollution that can result in temporary increases in bacterial counts, odors, aesthetic degradation of shorelines, adverse effects on sediment quality, and increased public health concerns in areas where there is potential for public contact. The proposed Project would reduce the number and volume of those CSOs and thereby improve water quality of the nearby surface water.

b. Ground:

(1) Will groundwater be withdrawn from a well for drinking water or other purposes? If so, give a general description of the well, proposed uses and approximate quantities withdrawn from the well. Will water be discharged to groundwater? Give general description, purpose, and approximate quantities if known.

During Project construction, groundwater is expected to be withdrawn from the open trenches given the anticipated excavation depths of up to 16 feet and the anticipated elevation of the groundwater table. Collected groundwater is expected to be treated and discharged to the King County sewer system, following receipt of a King County Industrial Wastewater Discharge Permit. Groundwater would be treated before discharge. The contractor may also elect to treat and discharge water to Elliott Bay, in accordance with a CSGP. The volumes, quality, and ultimate disposition of collected groundwater are not known at this time.

The completed Project would not require the use of groundwater.

(2) Describe waste material that will be discharged into the ground from septic tanks or other sources, if any (for example: domestic sewage; industrial, containing the following chemicals…; agricultural, *etc.*). Describe the general size of the system, the number of such systems, the number of houses to be served (if applicable), or the number of animals or humans the system(s) are expected to serve.

The proposed Project would not require discharge of any waste material to groundwater.

c. Water Runoff (including storm water):

(1) Describe the source of runoff (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.

Stormwater runoff within Basin 69 is generated from upstream streets, sidewalks, driveways, and impervious areas from privately and publicly owned improvements. Stormwater is collected by inlets and catch basins throughout Basin 69. Basin 69 is divided into two separate sub-basins: the “lower basin” located west of Western Avenue and the “upper basin” located east of Western Avenue. Dry weather flows in the “upper basin” are collected in a combined sewer within Western Avenue that conveys flows north and discharges to the King County Denny Way Interceptor, which conveys flows to the King County Denny Regulator. The “lower basin” collects dry weather flows and conveys them through a 48-inch diameter sewer that crosses beneath the BNSF Railroad

Tracks along Alaskan Way. Flows then pass through a CSO Control Structure to the combined sewer in Alaskan Way, which flows north and ultimately discharges to the King County Elliott Bay Interceptor. The King County Elliott Bay Interceptor also conveys flows to the King County Denny Regulator. The King County Denny Regulator pumps flows to the King County's West Point Wastewater Treatment Plant (WWTP).

During wet weather events, the combined sewage levels in the pipes within Western Avenue rise. As the sewage levels rise, four high-flow paths along Western Avenue allow excess flow to pass from the "upper basin" into sewer infrastructure in the "lower basin." The four high-flow paths are located at the intersections of Western Avenue and Bell Street, Vine Street, Cedar Street, and Broad Street. These high flows paths are elevated sewer connections or weirs. As the combined sewage level in the Alaskan Way sewer rises, the level within the CSO Control Structure also rises. If the level rises above the elevation of the CSO weir located in the CSO Control Structure, a CSO event is triggered and flows discharge to Elliott Bay via CSO Outfall 69.

The proposed Project would change how flows from the "upper basin" and portions of the "lower basin" are conveyed to the King County Elliott Bay Interceptor. Dry weather flows in the Vine Street sewer (flowing from the east to the west) would be directed into the proposed sewer line in Elliott Avenue. Additionally, sewer flows in Elliott Avenue to the south of Vine Street would also be directed into the proposed sewer line within Elliott Avenue. A diversion vault would be constructed at the intersection of Vine Street and Elliott Avenue and would redirect the two existing sewers into the proposed Elliott Avenue sewer line. During a wet weather event, a weir in the proposed diversion vault would allow high flows to continue down the Vine Street sewer into the CSO Control Structure and Alaskan Way sewer, matching the current flow path. The rest of Basin 69 would continue to operate as before. These improvements would reduce the frequency and volume of CSO discharges to Elliott Bay. Additional details are provided in the *Central Waterfront Basin (Basin 69) Combined Sewer Overflow Control Project Draft Engineering Report* (June 2019).

Stormwater runoff may need to be managed during construction of the proposed Project to prevent sediment from entering and leaving the construction site. Any precipitation falling on the construction site would be contained on-site and either allowed to infiltrate or collected and then treated before being discharged to a combined sewer or surface water.

(2) Could waste materials enter ground or surface waters? If so, generally describe.

The potential for waste materials to enter ground or surface waters would be low, given that all construction work is expected to take place within the ROW. However, the contractor will be required to implement BMPs identified in a Project-specific SWPPP or CSEC Plan to avoid or minimize this risk. Additionally, groundwater and stormwater in the Project area would be collected and treated during Project construction, prior to discharge.

(3) Does the proposal alter or otherwise affect drainage patterns in the vicinity of the site? If so, describe.

The proposed Project would be constructed within the ROW of Elliott Avenue. Existing concrete and pavement would be restored consistent with original conditions where construction has occurred. The Project would not increase the amount of impervious surfaces currently present within the Project corridor. Therefore, drainage patterns in the vicinity of the Project corridor would remain the same as the existing conditions.

The flow paths for stormwater in the combined sewer conveyance system within Basin 69 would be altered by the completed Project, consistent with the description provided in Section B.3.c.1 above. The purpose of these modifications is to achieve the aforementioned CSO performance standard within Basin 69.

d. Proposed measures to reduce or control surface, ground, runoff water, and drainage impacts, if any:

A fundamental goal of the proposed Project is to reduce the frequency and volume of CSOs in Basin 69. The proposed Project would reduce the frequency and volume of CSO events and improve water quality of the nearby surface water (Elliott Bay). Typical open trenching construction methods are anticipated, and no adverse impacts to surface waters or groundwater are expected. The contractor will be required to comply with BMPs identified in a Project-specific SWPPP or CSEC Plan and, if applicable, the Ecology NPDES CSGP.

4. Plants

a. Types of vegetation found on the site: *[check the applicable boxes]*

☒ Deciduous trees:	☐ Alder	☐ Maple	☐ Aspen	☐ Other: (identify)
☒ Evergreen trees:	☐ Fir	☒ Cedar	☐ Pine	☐ Other: (identify)
☒ Shrubs				
☒ Grass				
☐ Pasture				
☐ Crop or grain				
☐ Orchards, vineyards, or other permanent crops				
☐ Wet soil plants:	☐ Cattail	☐ Buttercup	☐ Bulrush	☐ Skunk cabbage
☐ Other: (identify)				
☐ Water plants:	☐ water lily	☐ eelgrass	☐ milfoil	☐ Other: (identify)
☐ Other types of vegetation: (identify)				

Vegetation found within and near the Project corridor is consistent with vegetation common of an urban setting. Vegetation is generally limited to landscaped trees, shrubs, and grasses located within planter strips or tree pits within the Elliott Avenue ROW.

b. What kind and amount of vegetation will be removed or altered?

There are no plans to remove existing vegetation within the Project corridor.

c. List threatened or endangered species known to be on or near the site.

No federally listed endangered or threatened plant species or state-listed sensitive plant species are known to occur within the urban environment of downtown Seattle and the Project area.

d. Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any:

Bioretention cells would be constructed within the Project corridor, in existing planter strips. Native plants would be used for these facilities. Existing vegetation within the Project corridor will be protected during construction by the contractor, through adherence to a TVSP Plan.

e. List all noxious weeds and invasive species known to be on or near the site.

Construction would occur within the paved ROW, which is not suitable habitat for noxious weeds or invasive species. In addition, vegetated areas within the Project corridor are landscaped and maintained to eliminate/control the growth of noxious weeds or invasive species.

5. Animals

a. List any birds and other animals that have been observed on or near the site or are known to be on or near the site: *[check the applicable boxes]*

Birds:	☒ Hawk	☐ Heron	☒ Eagle	☒ Songbirds
☒ Other: pigeon, crow, seagull				
Mammals:	☐ Deer	☐ Bear	☐ Elk	☐ Beaver
☒ Other: possum, rat				
Fish:	☐ Bass ☐ Salmon	☐ Trout	☐ Herring	
☐ Shellfish	☐ Other:			

Fauna within the Project corridor are those adapted to urban environs.

b. List any threatened or endangered species known to be on or near the site:

The proposed Project is more than 300 feet east of Elliott Bay. There are several Endangered Species Act-listed species within the Elliott Bay. While these species occur within the general vicinity of the Project corridor, Project construction and operation would not occur within the regulatory buffer for Elliott Bay, and therefore, no adverse impacts are expected as a result of the proposed Project.

c. Is the site part of a migration route? If so, explain.

The Puget Sound region is known to be an important migratory route for many animal species. Portions of the Seattle downtown waterfront area may be part of migratory corridors for bald eagles and other bird species traveling to and from foraging areas in Puget Sound or Lake Washington. Bull trout; steelhead; and chinook, chum, pink, and coho salmon use the Puget Sound nearshore. The Puget Sound region is also within the Pacific Flyway—a flight corridor for migrating waterfowl, migratory songbirds, and other birds. The Pacific Flyway extends from Alaska to Mexico and South America.

d. Proposed measures to preserve or enhance wildlife, if any:

The proposed Project would not result in adverse impacts to wildlife or their environs; therefore, measures to preserve or enhance wildlife are not included.

e. List any invasive animal species known to be on or near the site.

Many invasive animal species are found within the City. However, the Project corridor is entirely paved and does not support habitat for noxious or invasive animal species.

6. Energy and Natural Resources

a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs? Describe whether it will be used for heating, manufacturing, *etc.*

The completed CSO control improvements would not require any supplementary energy to operate because they would rely on gravity-driven flow. However, SPU currently uses minor amounts of electricity to monitor flows in this part of its existing combined sewer system and would continue to do so for the completed Project. If it is determined through coordination with SDOT that pedestrian lighting/crossing improvements are warranted, the Project would require limited use of electricity to power these improvements. The improvements to pedestrian lighting/crossing throughout the Project area would be typical of an urban environment.

b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe.

Most of the completed Project would be buried, with few components constructed above ground surface. Portions of the Project that would be constructed above ground surface (lighting/crossing improvements, bioswales, curb ramps, etc.) would not interfere with adjacent properties' usage of solar energy due to their low or narrow profiles.

c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any:

The proposed Project would not result in adverse energy or natural resource impacts; therefore, measures to reduce or control energy impacts are not included in the Project design.

7. Environmental Health

a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste, that could occur as a result of this proposal? If so, describe:

During construction of SPU's proposed Project, small amounts of materials present may include gasoline and diesel fuels, hydraulic fluids, oils, lubricants, solvents, paints, and other chemical products. A spill of one of these chemicals could potentially occur during construction as a result of either equipment failure or worker error. Also, contaminated soils, sediments, or groundwater could be exposed during excavation. If disturbed, contaminated substances could expose construction workers and potentially other individuals in the vicinity through blowing dust, stormwater runoff, or vapors.

SPU's completed Project would convey combined sewage and stormwater flows as part of an existing conveyance system. The completed Project would not create any new exposure to environmental health hazards and would reduce the number and volume of CSO discharges.

(1) Describe any known or possible contamination at the site from present or past uses.

Existing environmental data indicate that, in general, soil and groundwater contamination is present throughout the urban waterfront area of downtown Seattle. Historical and current land uses in the Project area include industrial, commercial, and residential activity. Previous industrial uses in this area include metal works, foundries and plating operations, machine shops, warehouses, and fueling facilities. In the downtown area, commonly encountered contaminants include metals, solvents, and petroleum products. A high-level review of geotechnical reports from other projects determined that more than 50 percent of the boreholes/monitoring wells along Elliott Avenue indicated the presence of hydrocarbons. However, contamination found in the area is generally less than levels of concern for soil and groundwater. Additional information on historical land uses and contaminated materials is found in the Contaminated Materials Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

(2) Describe existing hazardous chemicals/conditions that might affect project development and design. This includes underground hazardous liquid and gas transmission pipelines located within the project area and in the vicinity.

Elliott Avenue contains natural gas lines, which would be a consideration during construction. Ground disturbance would occur in proximity to the natural gas utility corridor. Hazardous conditions could occur in the event that Project construction unexpectedly encounters these utilities.

No known hazardous chemicals/conditions could affect Project development and design.

(3) Describe any toxic or hazardous chemicals that might be stored, used, or produced during the project's development or construction, or at any time during the operating life of the project.

Construction of the proposed Project would require use and storage of relatively small amounts of materials such as gasoline and diesel fuels, hydraulic fluids, oils, lubricants, solvents, paints, and other chemical products. No toxic or hazardous chemicals would be stored, used, or produced at any time during the operating life of the Project.

(4) Describe special emergency services that might be required.

Fire and medical response services may be required in the event of an emergency during construction or operation/maintenance of the proposed Project. However, the completed Project would not result in higher levels of special emergency services than already exist at the Project location.

(5) Proposed measures to reduce or control environmental health hazards, if any:

A Phase 1 site assessment would be completed prior to construction to evaluate the presence and possible sources of contaminated soil or groundwater. If contaminated materials are encountered during construction, these materials would be segregated and removed from the site for proper disposal at a Subtitle D-permitted landfill. The removal and disposal of contaminated material encountered during construction would result in beneficial effects related to soil and groundwater quality in the Project area.

The contractor will be required to comply with City-approved CSEC Plan and a Fugitive Dust Control Plan; potentially obtain coverage under and comply with the NPDES CSGP; develop and implement a City-approved Spill Prevention, Control, and Countermeasures Plan that addresses handling and disposal of known and unanticipated contamination of soil and groundwater; and develop and comply with a City-approved Hazardous Materials Spill Prevention and Management Plan during construction. Any soils contaminated by spills during construction would be excavated and disposed of in a manner consistent with the level and type of contamination, in accordance with federal, state, and local regulations.

As required by the Washington Department of Labor and Industries (WAC 296-843), the contractor will be required to prepare a City-approved Health and Safety Plan prior to work commencing. The plan would address proper employee training, use of protective equipment, contingency planning, and secondary containment of hazardous materials. In work areas with known contamination in soil, sediment, and groundwater, workers would be required to be Hazardous Waste Operation and Emergency Response-certified (40-hour HAZWOPER Certification [29 CFR and WAC 296-843]), which is required for individuals involved in cleanup of uncontrolled hazardous waste sites.

b. Noise

(1) What types of noise exist in the area which may affect your project (for example: traffic, equipment, operation, other)?

There are no existing sources of noise that would affect the proposed Project.

(2) What types and levels of noise would be created by or associated with the project on a short-term or a long-term basis (for example: traffic, construction, operation, other)? Indicate what hours noise would come from the site.

Project construction would result in a short-term increase of noise levels within the Project area. This temporary increase in noise levels would result from construction equipment and practices within the Project corridor. Short-term noise from construction equipment would largely be within the allowable maximum levels of the City's Noise Control Ordinance (SMC Chapter 25.08); noise monitoring would occur to ensure compliance with the maximum permissible noise levels. Within the allowable maximum levels, SMC 25.08 permits noise from construction equipment between the hours of 7 a.m. and 7 p.m. weekdays, and 9 a.m. and 7 p.m. weekends and legal holidays. Some construction activities, such as saw cutting, may temporarily exceed the maximum permissible noise levels. In these discrete cases, which may amount to 40 days over the course of construction, a noise variance would be acquired for the proposed work.

Long-term, the completed Project would not produce noise discernable over the existing background noise of the Project's urban setting.

(3) Proposed measures to reduce or control noise impacts, if any:

Construction equipment would be muffled in accordance with the applicable laws. Noise monitoring would be implemented to ensure that Project construction remains in compliance with the maximum permissible noise limitations prescribed in SMC Chapter 25.08. A noise variance would be acquired in the discrete cases when prescriptive noise limitations are expected to be exceeded.

8. Land and Shoreline Use

a. What is the current use of the site and adjacent properties? Will the proposal affect current land uses on nearby or adjacent properties? If so, describe.

The Project corridor is composed of the right of way of Elliott Avenue. Adjacent land uses include park, multi-family residential, office, retail/service, and other uses. More information on land uses of the adjacent properties is found in the Land Use, Shorelines, and Parks and Recreation Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS. The proposed Project would not affect current land uses on nearby or adjacent properties.

b. Has the project site been used as working farmlands or working forest lands? If so, describe. How much agricultural or forest land of long-term commercial significance will be converted to other uses as a result of the proposal, if any? If resource lands have not been designated, how many acres in farmland or forest land tax status will be converted to nonfarm or nonforest use?

There are no working farms or forest lands on or near the Project corridor.

(1) Will the proposal affect or be affected by surrounding working farm or forest land normal business operations, such as oversize equipment access, the application of pesticides, tilling, and harvesting? If so, how?

The proposed Project would not be affected by normal business operations of working farms or forest lands as there are no designated agricultural or forest lands in the City.

c. Describe any structures on the site.

The Project corridor is composed of Elliott Avenue right of way. Structures within the Project corridor are limited to traffic signals, wayfinding, below-grade maintenance holes, below-grade vaults and pedestrian amenities (lighting/crossing, etc.). Adjacent properties contain a wide array of structures consistent with the urban development of downtown Seattle.

d. Will any structures be demolished? If so, what?

The proposed Project would require pavement/concrete cutting to access the underlying utility corridor and to modify existing curb ramps within Elliott Avenue. Existing utilities are not expected to require relocation or removal. No other demolition/alteration of existing structures would occur.

e. What is the current zoning classification of the site?

Per SMC 23.30.020 zoning boundaries extend to the center line of public rights of way. Therefore, the Project corridor contains a mixture of downtown mixed-use zones such as downtown mixed commercial, residential, and harbor front.

f. What is the current comprehensive plan designation of the site?

The Project corridor is located within the downtown comprehensive plan designation, largely within the "downtown mixed residential/commercial." More information on current comprehensive plan designations is found in the Land Use, Shorelines, and Parks and Recreation Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

g. If applicable, what is the current shoreline master program designation of the site?

The Project corridor is located more than 200 feet from the nearest regulated water body and does not lie within City shoreline master program jurisdiction.

h. Has any part of the site been classified as an "environmentally critical" area? If so, specify.

A majority of the Project corridor would be located directly adjacent to a liquefaction prone delineated area, an environmentally critical area as identified and mapped by SDCI's GIS Mapping Application. However, approximately 650 feet of the westernmost portion of the Project corridor is mapped within the liquefaction prone area.

i. Approximately how many people would reside or work in the completed project?

The proposed Project is a utility improvement project; no people would reside or work within the completed Project.

j. Approximately how many people would the completed project displace?

No people would be displaced by the proposed Project.

k. Proposed measures to avoid or reduce displacement impacts, if any:

The proposed Project would not result in displacement impacts; therefore, no avoidance or reduction measures are proposed.

l. Proposed measures to ensure the proposal is compatible with existing and projected land uses and plans, if any:

The proposed Project is a utility improvement project. No land use compatibility impacts would occur; therefore, no additional measures other than obtaining pertinent permit approval to conduct the proposed work would occur.

m. Proposed measures to reduce or control impacts to agricultural and forest lands of long-term commercial significance, if any:

The Project would have no effect on agriculture or forest lands; therefore, no impact control or reduction measures are proposed.

9. Housing

a. Approximately how many units would be provided, if any? Indicate whether high, middle, or low-income housing.

The proposed Project does not include the construction of housing units.

b. Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing.

The proposed Project would not eliminate existing housing units.

c. Proposed measures to reduce or control housing impacts, if any:

No housing impacts would occur; therefore, the proposed Project does not include housing impact reduction or control measures.

10. Aesthetics

a. What is the tallest height of any proposed structure(s), not including antennas? What is the principal exterior building material(s) proposed?

The proposed CSO control improvements would occur within the subsurface of Elliott Avenue; however, the proposed Project includes lighting/pedestrian crossing improvements. Lighting/pedestrian crossing improvements would be mounted on metal poles along the Project corridor. Exact locations/configurations for these improvements have yet to be determined.

b. What views in the immediate vicinity would be altered or obstructed?

The viewshed within the Project corridor would be temporarily altered during Project construction. However, these impacts would be limited to the duration of construction. Long-term, the viewshed would be slightly improved through the installation of bioretention cells within existing planter strips.

c. Proposed measures to reduce or control aesthetic impacts, if any:

Project construction would occur in one-block phases. This allows for temporary pavement/concrete restoration and restriping to occur before work progresses further along the Project corridor. Once all CSO control improvements are installed, the Project corridor would be permanently resurfaced and restriped. No other aesthetic reduction or control measures are proposed as only short-term construction impacts would occur.

11. Light and Glare

a. What type of light or glare will the proposal produce? What time of day would it mainly occur?

Most of the Project construction would occur during daylight hours. Work conducted in low light conditions would require artificial lighting to ensure worker safety. To minimize potential spillover from this lighting, the lights would be downcast and focused on the construction zone. Construction lighting may increase ambient light conditions within the immediate Project area but impacts to sensitive receivers are not anticipated.

Long-term light and glare impacts are not anticipated. Interagency coordination with SDOT may result in the addition of lighting/pedestrian crossing improvements throughout the Project corridor; however, these improvements would be consistent with typical conditions throughout the downtown urban environment and would not result in an adverse impact.

b. Could light or glare from the finished project be a safety hazard or interfere with views?

The proposed CSO control improvements would not result in the production of light or glare. If minor lighting/pedestrian crossing improvements are included in the scope of work, these improvements would not result in light or glare impacts; rather, these improvements would increase pedestrian safety along the Project corridor.

c. What existing off-site sources of light or glare may affect your proposal?

The proposed Project consists of subsurface utility improvements, curb ramp modifications, installation of bioretention cells, pedestrian lighting/crossing improvements, and the addition of flexible porous pavement within existing tree wells. These Project components would not be affected by existing sources of light or glare.

d. Proposed measures to reduce or control light and glare impacts, if any:

No adverse light or glare impacts would result from the completed Project; therefore, no reduction or control measures are proposed.

12. Recreation

a. What designated and informal recreational opportunities are in the immediate vicinity?

The proposed Project would be constructed adjacent to the Olympic Sculpture Park and near the Belltown Cottage Park. The Project area is also located in the vicinity of the Elliott Bay Trail, multiple piers extending into Elliott Bay, and Puget Sound, all of which provide recreation opportunities. More information on those resources is found in the Land Use, Shorelines, and Parks and Recreation Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

b. Would the proposed project displace any existing recreational uses? If so, describe.

The proposed Project would temporarily disrupt pedestrian use and access to bike lanes one block at a time. Additionally, SPU might reach an agreement with Seattle Parks and Recreation to temporarily utilize portions of the Olympic Sculpture Park as a construction staging/laydown area during Project construction, if other staging options are not considered viable. If SPU were to utilize this park land, temporary recreational impacts would occur, as a portion of the Olympic Sculpture Park would be inaccessible to park users.

Post-construction, recreational opportunities would be consistent with existing conditions as the Elliott Avenue right of way and Olympic Sculpture Park (if used for staging/laydown) would be restored to original conditions or better once Project construction is complete.

c. Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any:

Construction of the proposed Project would require temporary lane closures and establishment of detours. Such closures and detours would comply with relevant policies administered by SDOT as part of its Street Use permitting process. There are numerous route alternatives for pedestrians, joggers, and bicyclists in the neighborhood. Portions of Elliott Avenue disturbed by Project construction, and if applicable, any staging areas established within park space, would also be restored to original conditions or better. Permanent displacement of existing recreational resources would not occur.

13. Historic and Cultural Preservation

a. Are there any buildings, structures, or sites, located on or near the site that are over 45 years old listed in or eligible for listing in national, state, or local preservation registers? If so, specifically describe.

According to the Washington State Department of Archaeology & Historic Preservation Washington Information System for Architectural and Archaeological Records Data (WISAARD), there is one resource within the immediate vicinity of the Project corridor that is determined eligible for listing (Ainsworth & Dunn Warehouse). Other resources that are in the general Project area, approximately 250 feet from the Project corridor, have yet to receive an eligibility determination. More information regarding historic and cultural resources in the Project area can be found in the Cultural Resources Assessment Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

b. Are there any landmarks, features, or other evidence of Indian or historic use or occupation? This may include human burials or old cemeteries. Are there any material evidence, artifacts, or areas of cultural importance on or near the site? Please list any professional studies conducted at the site to identify such resources.

As stated above, the Ainsworth & Dunn Warehouse (determined eligible for listing) is located adjacent to the Project corridor. However, according to the Seattle Department of Neighborhoods Landmarks Map, there are no designated landmarks within the Project corridor. The nearest landmarks are the William Tell Hotel and Bell Building, located more than 1,000 feet from the Project corridor on Battery Street.

Based on the historical and cultural setting of the Project area, if excavation extended into native soils, pre-contact Native American and historical period artifacts or sites could be encountered. However, it is unlikely that native soils would be encountered during construction. According to the Cultural Resources Assessment Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS, the average fill depth in the Project area from Broad Street south to Vine Street is approximately 23.8 feet below ground surface; Project construction is not anticipated to extend below 16 feet below ground surface. More information can be found in the Cultural Resources Assessment Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

c. Describe the methods used to assess the potential impacts to cultural and historic resources on or near the project site. Examples include consultation with tribes and the Department of Archaeology and Historic Preservation, archaeological surveys, historic maps, GIS data, *etc.*

SDOT issued a SEPA FEIS on March 14, 2013 for the Elliott Bay Seawall Project. The FEIS was supported by a Cultural Resource Assessment prepared by SWCA Consultants and Mimi Sheridan. This document was previously incorporated by reference into this Environmental Checklist (see Section A.8).

d. Proposed measures to avoid, minimize, or compensate for loss, changes to, and disturbance to resources. Please include plans for the above and any permits that may be required.

The proposed Project would not affect buildings or known cultural resources. Only soils beneath Elliott Avenue within the Project corridor would be affected by construction.

There are no documented historic or cultural resources beneath this portion of Elliott Avenue.

The proposed Project is located on previously disturbed and filled upland areas of the City. The Project's location on previously disturbed and filled ground reduces the likelihood of encountering contextually significant archaeological resources. It is anticipated that excavations could reach depths of approximately 16 feet deep; at this depth, it is not anticipated that native soils would be encountered. However, the contractor will implement measures from a Project-specific Inadvertent Discovery Plan to protect unknown resources during construction. Should evidence of cultural artifacts or human remains, either historic or prehistoric, be encountered during excavation, work in that immediate area would be suspended and the find would be examined and documented by a professional archaeologist. Decisions regarding appropriate mitigation and further action would be made at that time.

14. Transportation

a. Identify public streets and highways serving the site or affected geographic area, and describe proposed access to the existing street system. Show on site plans, if any.

The proposed Project is located within the public ROW of Elliott Avenue and its intersection with Bay, Broad, Clay, Cedar, and Vine Streets. To accommodate construction, one traffic lane on Elliott Avenue would be open at all times. Where construction work overlaps with the intersections mentioned above, detours would be provided to mitigate for temporary accessibility impacts.

b. Is the site or affected geographic area currently served by public transit? If so, generally describe. If not, what is the approximate distance to the nearest transit stop?

Downtown Seattle is served by numerous Metro public transit routes, although no route currently uses the portion of Elliott Avenue that comprises the Project corridor. The nearest transit stops are located near the intersection of Denny Way and 1st Avenue, approximately 600 feet to the north of the Project corridor.

c. How many additional parking spaces would the completed project or nonproject proposal have? How many would the project or proposal eliminate?

The completed Project would not create any new parking spaces; no existing parking spaces would be permanently displaced. Construction would temporarily eliminate on-street parking spaces; however, the one-block construction phasing would limit temporary on-street parking impacts to approximately 3 months per block. Specific timing and duration of parking and lane closures are not known at this time, but such closures would comply with relevant policies administered by SDOT as part of its Street Use permitting process.

d. Will the proposal require any new or improvements to existing roads, streets, pedestrian, bicycle or state transportation facilities, not including driveways? If so, generally describe (indicate whether public or private).

The proposed Project includes restoration of the portion of Elliott Avenue impacted by construction, to pre-construction conditions or better. Minor improvements to the public right of way would also occur. These include ADA improvements to existing curb ramps, installation of bioretention facilities, placement of porous pavement within existing tree wells, and potentially minor lighting/pedestrian crossing improvements (to be determined through coordination with SDOT).

e. Will the project or proposal use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.

The proposed Project is located near the Seattle Waterfront at Elliott Bay, which is used by ferries, cruise ships, and commercial vessels. In addition, BNSF owns and operates a railway approximately 160 feet to the southwest of the Project corridor. The proposed Project would not require use of, or interfere with, these transportation resources.

f. How many vehicular trips per day would be generated by the completed project or proposal? If known, indicate when peak volumes would occur and what percentage of the volume would be trucks (such as commercial and nonpassenger vehicles). What data or transportation models were used to make these estimates?

The completed Project would produce minimal vehicle trips. Vehicle trips would be produced only during monitoring/maintenance of completed Project. This would result in approximately one annual roundtrip to the Project corridor (anticipated to be an existing SPU maintenance vehicle used for these purposes). Every 10 years, SPU crews would inspect the pipes with a closed-circuit television to evaluate conditions by way of video surveillance. This could require a total of two additional roundtrips for that year. These trips would likely occur during business hours (between 7 a.m. and 6 p.m.) on weekdays. Monitoring and maintenance would occur over the constructed Project's 100-year lifespan.

g. Will the proposal interfere with, affect or be affected by the movement of agricultural and forest products on roads or streets in the area? If so, generally describe.

Neither the proposed Project nor its construction would interfere with, affect, or be affected by the movement of agricultural and forest products on roads or streets.

h. Proposed measures to reduce or control transportation impacts, if any:

The construction-related transportation impacts of the proposed Project would be controlled through implementation of the following:

- The contractor will adhere to a City-approved, Project-specific Traffic Control Plan, prepared in accordance with SDOT's Traffic Control Manual.
- Project construction would occur in one-block phases. Pavement restoration/ restriping would occur after installation of the proposed CSO control improvements is complete per each one-block phase. This would ensure that conditions could be restored to the greatest extent practicable for blocks where construction is complete.
- The proposed right of way work would be reviewed and approved by SDOT prior to commencement of Project construction to ensure that impacts to the transportation network are within appropriate limits.

- Construction would be implemented in a way that avoids full closure of any block so through traffic could be maintained. Where work would occur within an intersection, a detour would be provided.

15. Public Services

a. Would the project result in an increased need for public services (for example: fire protection, police protection, public transit, health care, schools, other)? If so, generally describe.

The proposed Project is not expected to create an increased need for public services. Project construction would always be required to accommodate emergency access for buildings accessed via the Project corridor. Emergency access would comply with relevant policies administered by SDOT as part of its Street Use permitting process.

b. Proposed measures to reduce or control direct impacts on public services, if any.

During construction, the Project would always be required to accommodate emergency access for structures accessed via the Project corridor. Otherwise, reduction or control measures are not included as no adverse impacts on public services would result from the proposed Project.

16. Utilities

a. Check utilities available at the site, if any: *[check the applicable boxes]*

☐ None
☒ Electricity ☒ Natural gas ☒ Water ☒ Refuse service
☒ Telephone ☒ Sanitary sewer ☐ Septic system
☐ Other:

An extensive network of utilities is located within the Project corridor. More information on public utilities is found in the Public Services and Utilities Discipline Report for the Elliott Bay Seawall Project FEIS and FSEIS.

b. Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.

The proposed Project is a CSO control improvement project led by SPU that would reduce CSO events in Basin 69. The proposed CSO control improvements would consist of the following:

- Installation of approximately 1,800 linear feet of 24-inch-diameter gravity sewer pipe and other appurtenances, such as maintenance holes, within Elliott Avenue, from Vine Street to Bay Street
- Establishment of a new connection to King County's existing Elliott Bay Interceptor
- Construction of a new sewer diversion vault and weir at the crossing of the existing sewer at the intersection of Vine Street and Elliott Avenue

Construction of the proposed CSO control improvements would be completed through open trench construction. While relocation of existing utilities is not currently planned, if it is anticipated that vertical or horizontal spacing conflicts occur with existing utilities, relocation of these utilities may be required. This would be determined during detailed design of the proposed Project, and during construction, if necessary.

C. SIGNATURE

The above answers are true and complete to the best of my knowledge. I understand that the lead agency is relying on them to make its decision.

Signature: ______________________ Date: 8/22/2019
Shailee Sztern, PE, Project Manager

Attachment A – Vicinity Map
Attachment B – Site Plan
Attachment C – Greenhouse Gas Emissions Worksheet

Attachment A – Vicinity Map

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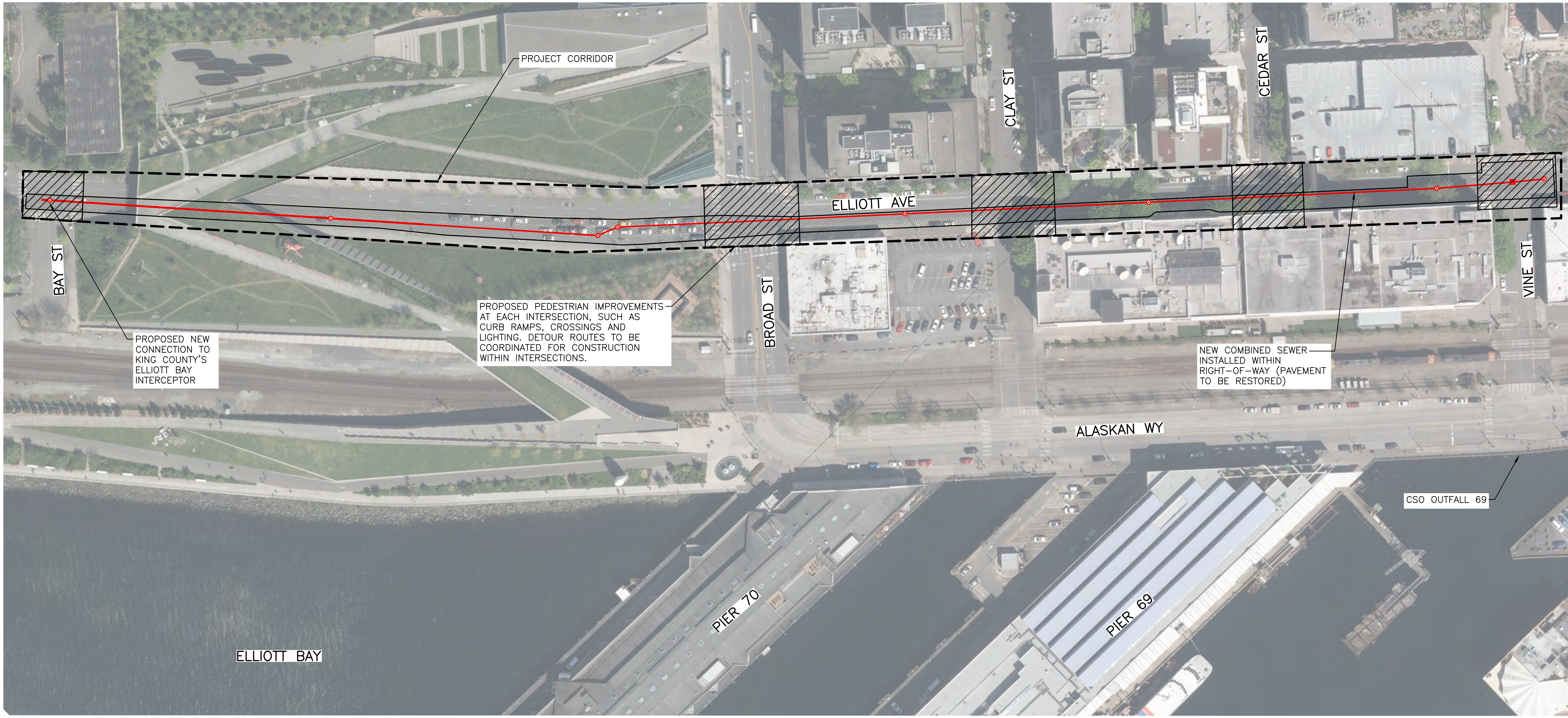
SPU Vine Basin Combined Sewer Overflow Control Project
Seattle, Washington

Vicinity Map

I:\GIS\Projects\MS-SPU Vine\MXD\CSO Control Project\Vicinity Map.mxd
7/23/2019

Attachment B – Site Plan



SITE PLAN

60 30 0 60 120

SCALE IN FEET

LEGEND

(red line)	PROPOSED COMBINED SEWER ALIGNMENT
(dashed line)	PROJECT CORRIDOR
(hatched)	PEDESTRIAN IMPROVEMENTS AT INTERSECTIONS
(stippled)	ANTICIPATED PAVEMENT RESTORATION AREA

Seattle Public Utilities

AUGUST 2019

CENTRAL WATERFRONT BASIN (BASIN 69) COMBINED SEWER OVERFLOW CONTROL PROJECT

PROJECT AREA SITE PLAN

murraysmith
520 PIKE STREET, SUITE 1350
SEATTLE, WA 98101
P 206.462.7030

Attachemnt B - Site Plan

H:\EVT_Projects\18\2252 – SPU Vine Basin CSO Control Project\CAD\Figures\18-2252-WA-ELLIOT TRANSFER fig.dwg
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Attachment C – Greenhouse Gas Emissions Worksheet

Section I: Buildings						
			Emissions Per Unit or Per Thousand Square Feet ($MTCO_2e$)			
Type (Residential) or Principal Activity (Commercial)	# Units	Square Feet (in thousands of square feet)	Embodied	Energy	Transportation	Lifespan Emissions ($MTCO_2e$)
Single-Family Home	0		98	672	792	0
Multi-Family Unit in Large Building	0		33	357	766	0
Multi-Family Unit in Small Building	0		54	681	766	0
Mobile Home	0		41	475	709	0
Education		0.0	39	646	361	0
Food Sales		0.0	39	1,541	282	0
Food Service		0.0	39	1,994	561	0
Health Care Inpatient		0.0	39	1,938	582	0
Health Care Outpatient		0.0	39	737	571	0
Lodging		0.0	39	777	117	0
Retail (Other than Mall)		0.0	39	577	247	0
Office		0.0	39	723	588	0
Public Assembly		0.0	39	733	150	0
Public Order and Safety		0.0	39	899	374	0
Religious Worship		0.0	39	339	129	0
Service		0.0	39	599	266	0
Warehouse and Storage		0.0	39	352	181	0
Other		0.0	39	1,278	257	0
Vacant		0.0	39	162	47	0
					TOTAL Section I Buildings	**0**

Section II: Pavement						
						Emissions ($MTCO_2e$)
Pavement (street, sidewalk, asphalt patch) or concrete pad, in thousands of square feet (50 $MTCO_2e$ per 1,000 square feet of pavement)		94,500				4,725
Gravel aggregate, in cubic yards (import volume of material is converted to tons and multiplied by an emissions conversion factor of 0.0034 MTCO2e per metric ton of material; see note 1)		6,111				29.1
					TOTAL Section II Pavement	**4,754.1**

Section III: Construction	
(See detailed calculations below)	Emissions ($MTCO_2e$)
TOTAL Section III Construction	**172.55**

Section IV: Operations and Maintenance	
(See detailed calculations below)	Emissions ($MTCO_2e$)
TOTAL Section IV Operations and Maintenance	**158.06**

TOTAL GREENHOUSE GAS (GHG) EMISSIONS FOR PROJECT ($MTCO_2e$)	**5,084.71**

Attachment C – Greenhouse Gas Emissions Worksheet, continued

Section III Construction Details		
Construction: Diesel		
Equipment	**Diesel (gallons)**	**Assumptions**
Trackhoe	1,048	523.8 hours X 2 gallons per hour
Dump Truck	9,993	49,968 miles / 5 mpg
Concrete Truck	231	1,155 miles / 5 mpg
Road Roller	420	120 hours X 3.5 gallons per hour
Subtotal Diesel Gallons	11,692	
GHG Emissions in lbs CO_2e	310,423	26.55 lbs CO_2e per gallon of diesel
GHG Emissions in metric tons CO_2e	140.81	1,000 lbs = 0.45359237 metric tons

Construction: Gasoline		
Equipment	**Gasoline (gallons)**	**Assumptions**
Pick-up Trucks or Crew Vans	2,880	57,600 miles / 20 mpg (assumed Ford F-150)
Subtotal Gasoline Gallons	2,880	
GHG Emissions in lbs CO_2e	69,984	24.3 lbs CO_2e per gallon of gasoline
GHG Emissions in metric tons CO_2e	31.74	1,000 lbs = 0.45359237 metric tons

Construction Summary		
Activity	**CO_2e in pounds**	**CO_2e in metric tons**
Diesel	310,423	140.81
Gasoline	69,984	31.74
Total for Construction	380,407	**172.55**

Section IV Long-Term Operations and Maintenance Details		
Operations and Maintenance: Diesel		
Equipment	**Diesel (gallons)**	**Assumptions**
Emergency Operation	N/A	
Maintenance Operation	N/A	
Subtotal Diesel Gallons		
GHG Emissions in lbs CO_2e		26.55 lbs CO_2e per gallon of diesel
GHG Emissions in metric tons CO_2e		1,000 lbs = 0.45359237 metric tons

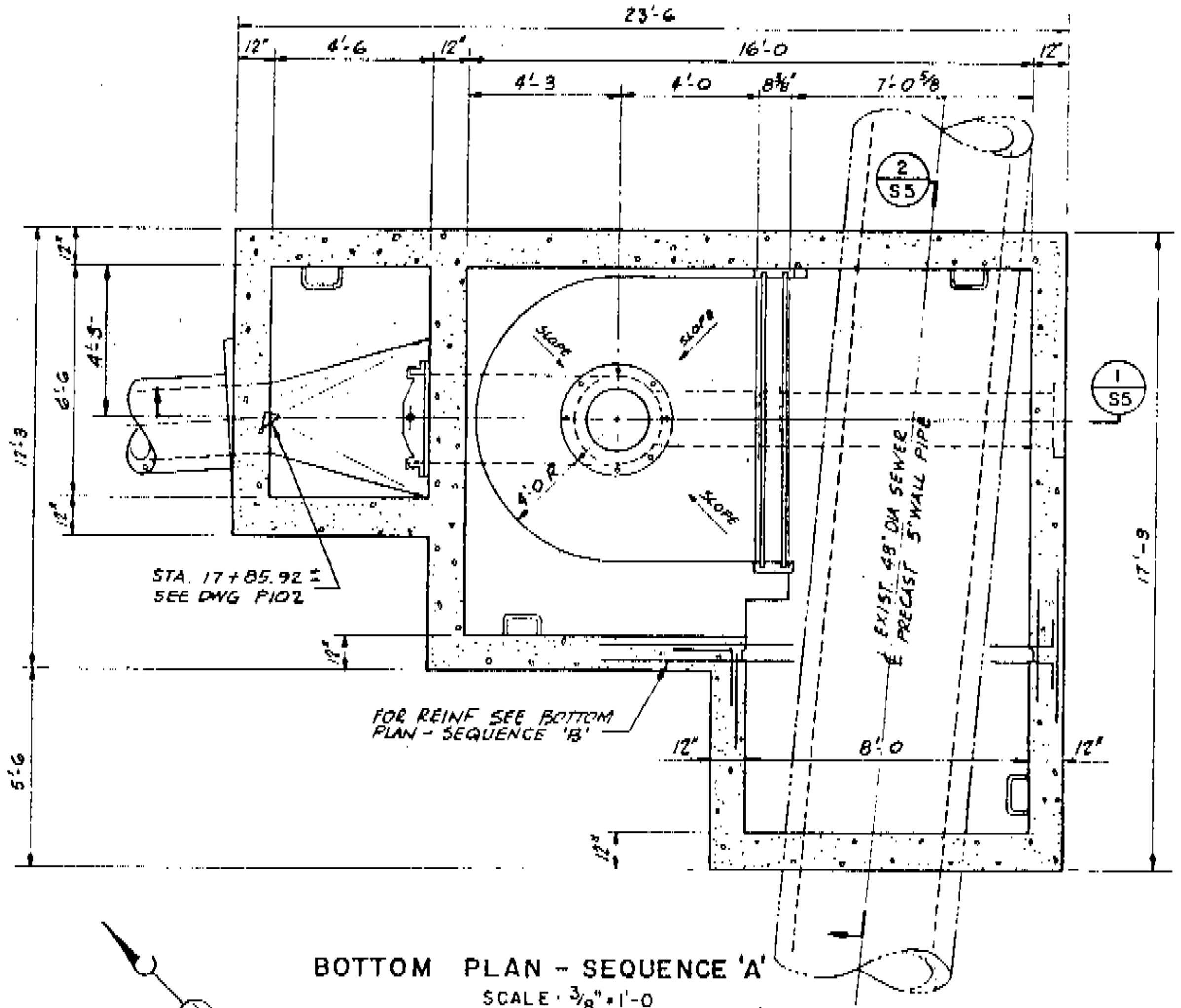
Operations and Maintenance: Gasoline		
Equipment	**Gasoline (gallons)**	**Assumptions**
O&M truck (CCTV)	40	2 days of O&M every 10 years, 30 miles/ day, 15 mpg, 100 years
WetVac Truck	14,300	3 days/year to complete O&M, 27 total hours X 5 gallons per hour + 7.5 gallons for trips to and from site (30 miles roundtrip / 12 mpg X 3 trips), 100 years
Subtotal Gasoline Gallons		
GHG Emissions in lbs CO_2e	348,462	24.3 lbs CO_2e per gallon of gasoline
GHG Emissions in metric tons CO_2e	158.06	1,000 lbs = 0.45359237 metric tons

Operations and Maintenance Summary		
Activity	**CO_2e in pounds**	**CO_2e in metric tons**
Diesel		
Gasoline	348,462	158.06
Total Operations and Maintenance	348,462	**158.06**

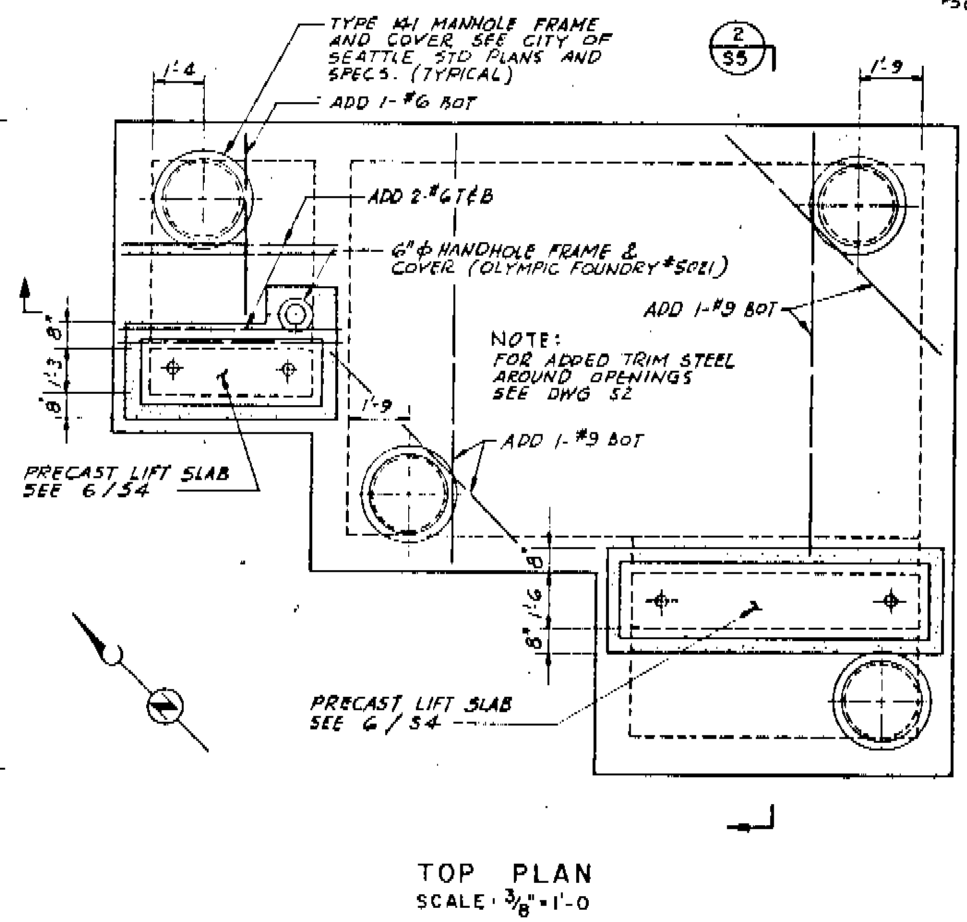
1. For purposes of estimating greenhouse gas emissions, the volume of gravel aggregate was converted to tonnage with a conversion factor of 1.4 metric tons (MT) per cubic yard. The tonnage was multiplied by the USEPA's estimated emissions rate, 0.0034 MTCO2e per MT of gravel/sand/clay production, as presented in the EPA's Spreadsheets for Environmental Footprint Analysis. Emissions associated with construction equipment used to construct the access road are presented in Section III.

Appendix E

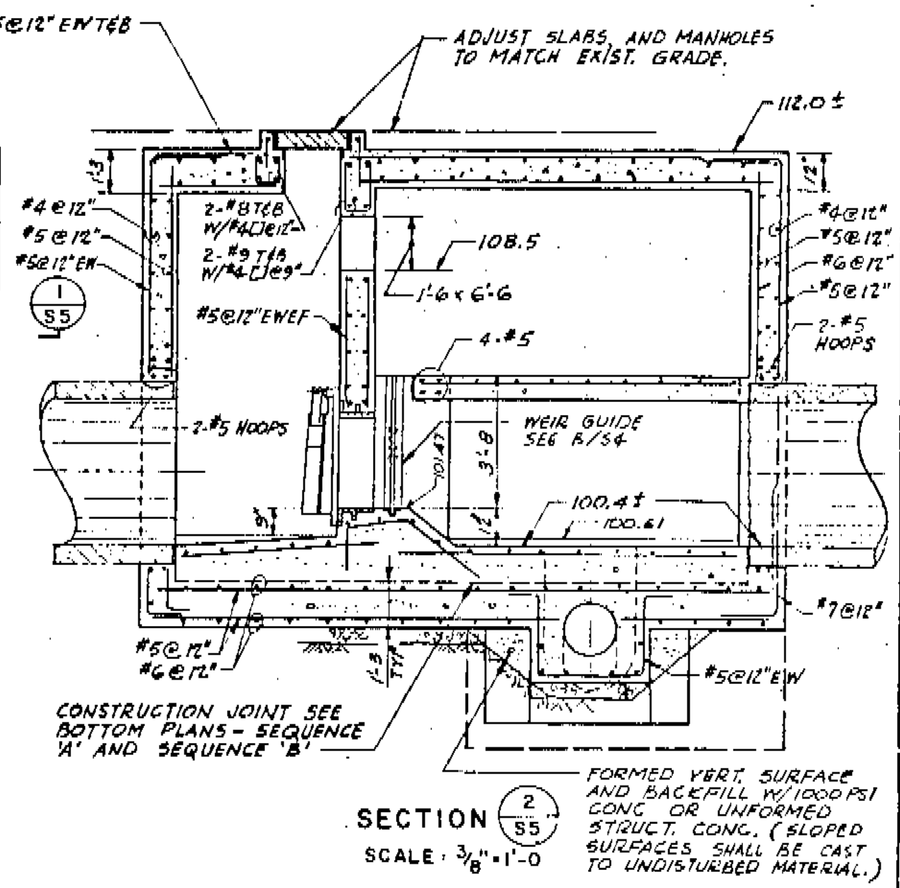
Basin 69 CSO Control Structure Record Drawing



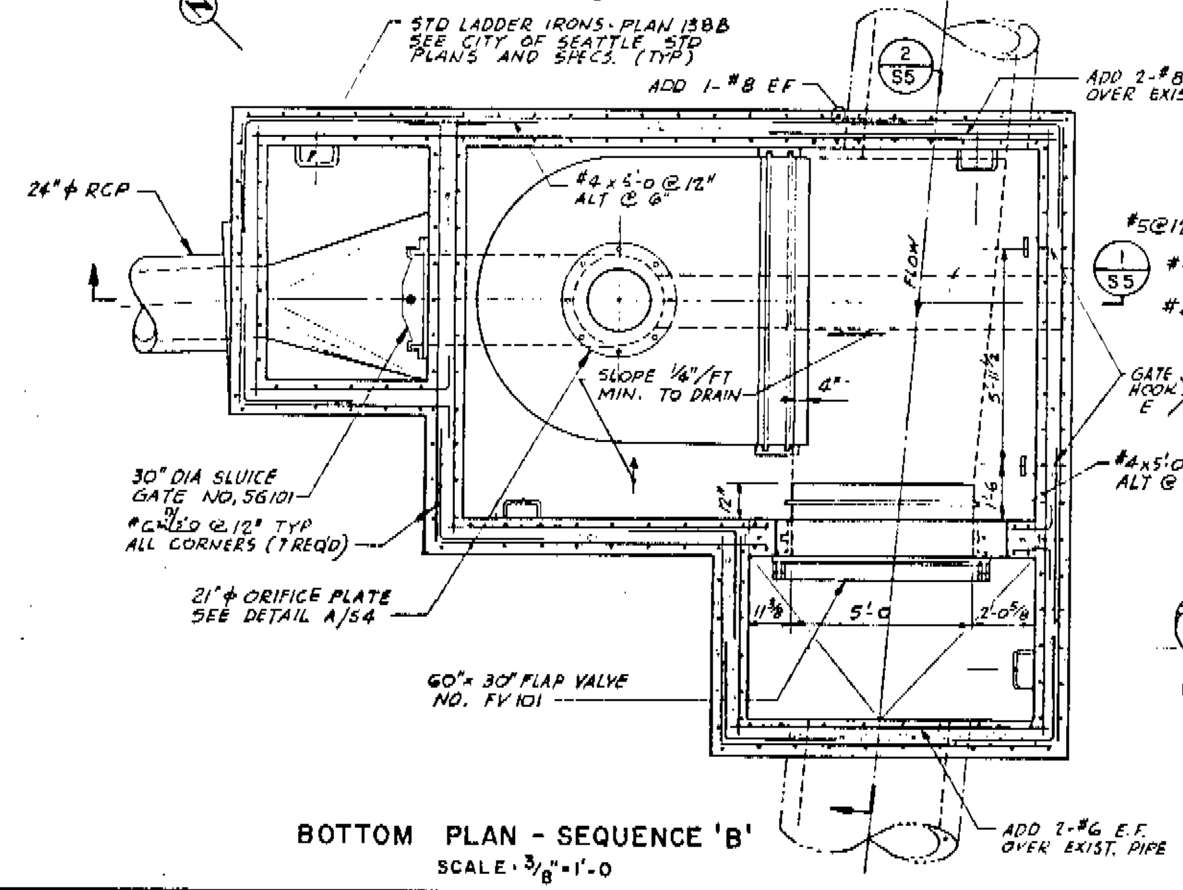
BOTTOM PLAN - SEQUENCE 'A'
SCALE: 3/8" = 1'-0



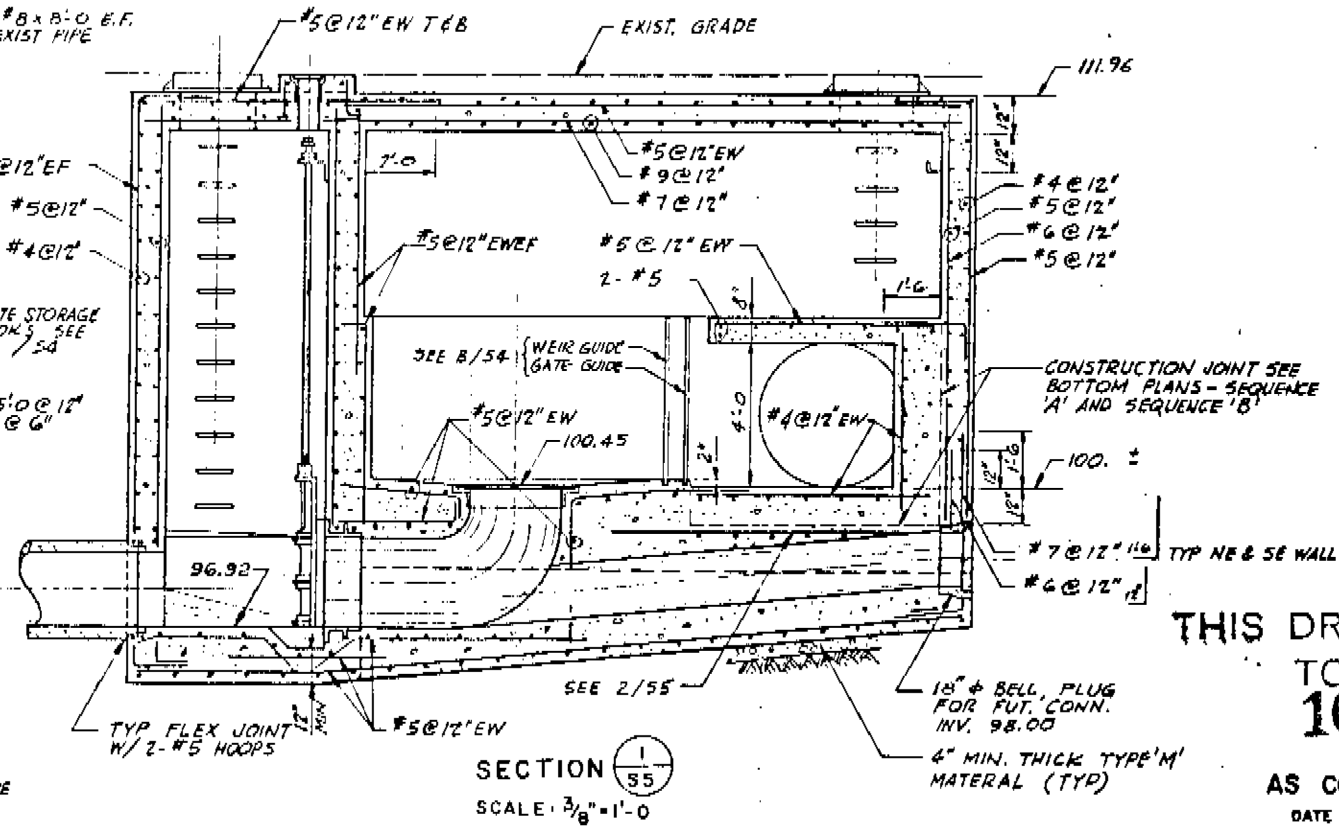
TOP PLAN
SCALE: 3/8" = 1'-0



SECTION 2/S5
SCALE: 3/8" = 1'-0



BOTTOM PLAN - SEQUENCE 'B'
SCALE: 3/8" = 1'-0



SECTION 1/S5
SCALE: 3/8" = 1'-0

"THE MUNICIPALITY OF METROPOLITAN SEATTLE DOES NOT WARRANT OR GUARANTEE THE ACCURACY OR COMPLETENESS OF THE ...

GENERAL NOTES

1. SEE SPECIAL CONSTRUCTION NOTES DRAWING G2 FOR TIMING AND BYPASSING PROVISION.
2. EXISTING SEWER SHALL BE SUPPORTED DURING CONSTRUCTION.
3. CLEAN AND ROUGHEN ALL EXISTING SURFACES PRIOR TO PLACING CONCRETE.
4. LINE DRILL AND REMOVE EXISTING SEWER AS SHOWN.
5. BACKFILL AROUND THE STRUCTURE SHALL NOT BE PLACED UNTIL ALL INTERIOR WALLS AND TOP SLAB ARE PLACED.

THIS DRAWING REDUCED TO HALF SIZE

104833

AS CONSTRUCTED
DATE MARCH 1970

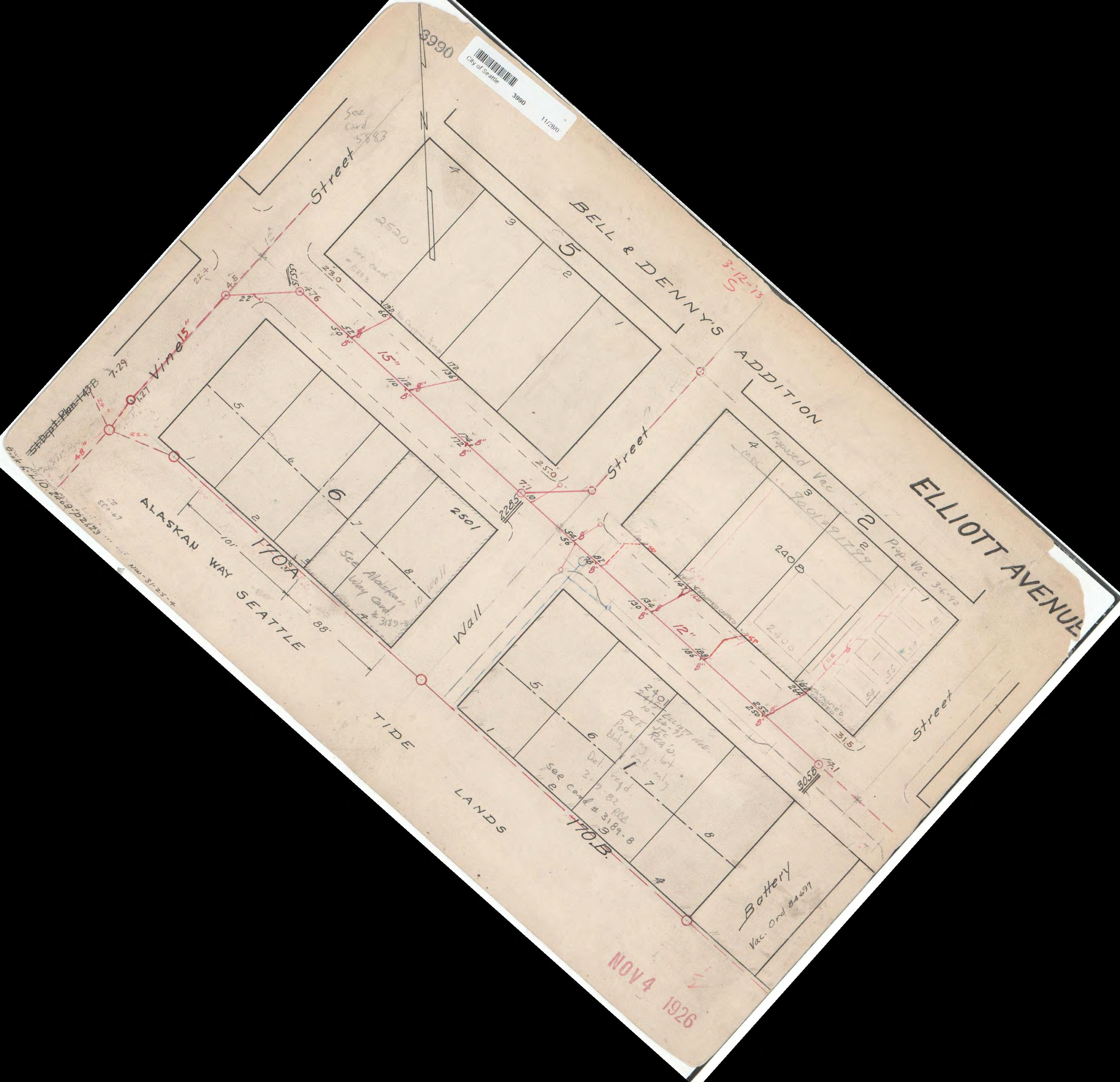
MARTIN C. DIRKS — REGISTERED PROFESSIONAL ENGINEER
ROGER F. WILCOX — REGISTERED PROFESSIONAL ENGINEER

DESIGNED WJ / DRAWN WG / CHECKED MCD	METROPOLITAN ENGINEERS — BROWN AND CALDWELL, CAREY AND KRAMER, HILL AND INGMAN, R.W. BECK AND ASSOCIATES	MUNICIPALITY OF METROPOLITAN SEATTLE — SCALE AS NOTED; FILE W210P; DATE DEC. 1968	WEST POINT SYSTEM	ALASKAN WAY INTERCEPTOR — VINE STREET DIVERSION STRUCTURE PLANS AND SECTIONS — DRAWING NUMBER S5; SHEET NUMBER 9 of 30

Appendix F

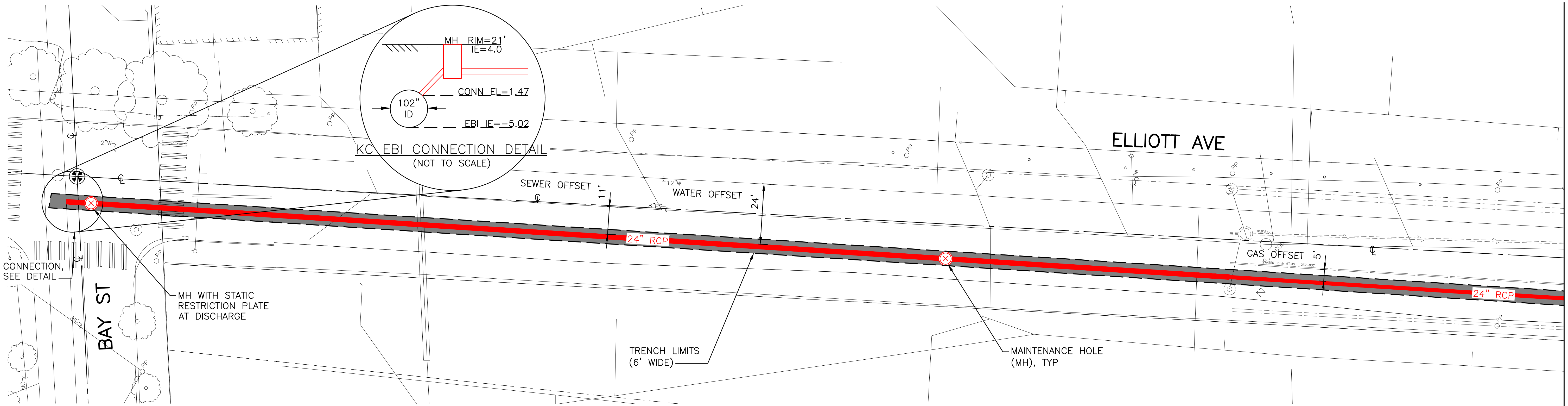
Elliott Avenue Side Sewer Cards

City of Seattle
5883
12/27/01
VINE ST.
BELL & DENNYS ADD.
S 3-12-93
Ave.
Western
Elliott
ALASKAN WAY
12" P.
20" Pipe
15"
24"
DEC 1 1926
5883
169 C
170-A
2601-3-5
See Elliott Ave. Card
Capped
Parking lot
Vol. 11 P-225
Book 6-LID2469-P22


3990
City of Seattle 3990 11/29/0
See Card 5883
BELL & DENNY'S ADDITION
ELLIOTT AVENUE
Vine Street
Wall Street
Battery Street
Vac. Ord 84697
ALASKAN WAY SEATTLE
TIDE LANDS
5
6
2
1
2520
2501
2408
2401
170.A
170.B.
15"
12"
8"
3-12-13
See Alaskan Way Card # 3189-8
Proposed Vac
Prop. Vac 3-6-92
See Card # 3189-8
NOV 4 1926

Appendix G

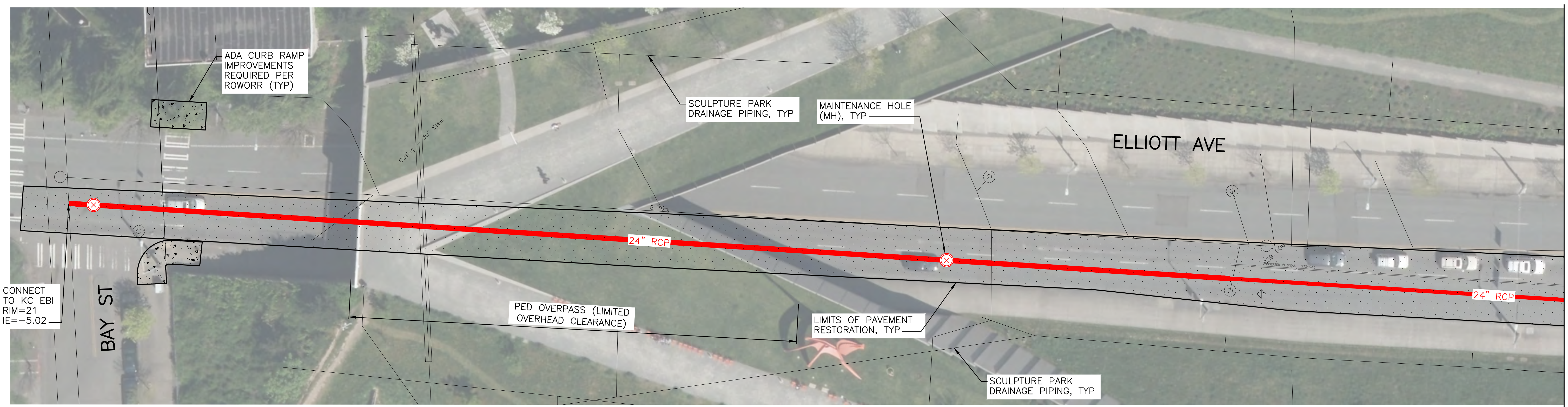
Preliminary Layout Drawings of Elliott Avenue Flow Transfer



Note:
All utility information shown is based on the SPU provided PERC map. No survey data was available or used to produce these layouts.

UTILITY PLAN
(SEE BELOW FOR AERIAL PLAN)

20 10 0 20 40
SCALE IN FEET



Note:
All utility information shown is based on the SPU provided PERC map. No survey data was available or used to produce these layouts.

AERIAL PLAN
(SEE ABOVE FOR UTILITY PLAN)

PRELIMINARY (APPROX 10% DESIGN) - NOT FOR CONSTRUCTION

TRANSFER – ELLIOTT – 24" SEWER AND NEW EBI CONNECTION

murraysmith
520 PIKE STREET, SUITE 1350
SEATTLE, WA 98101
P 206.462.7030

APPROVED FOR ADVERTISING
LIZ ALZEER
DEPARTMENT OF FINANCE & ADMINISTRATIVE SERVICES
SEATTLE, WASHINGTON . . . . 20 . .
BY: . . . .
CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

INITIALS AND DATE		INITIALS AND DATE	
DESIGNED	DSN	REVIEWED:	
CHECKED	CHK	DES.	CONST.
		SDOT	PROJ. MGR.
DRAWN	HCM	RECEIVED	
CHECKED	DAK	REVISED AS BUILT	

ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS AND OTHER DOCUMENTS CALLED FOR IN SECTION 0-02.3 OF THE PROJECT MANUAL.

PRELIMINARY (10% COMPLETE)

Seattle Public Utilities
ORDINANCE NO. ORD
PW NO. PW
MISC
SCALE: 1"=20'

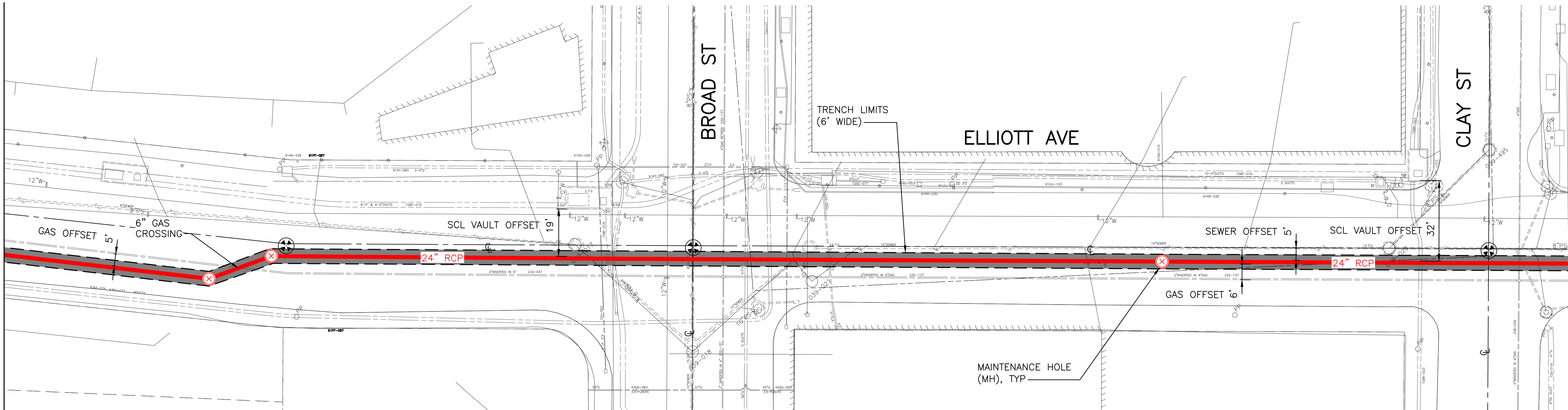
SPU VINE BASIN CSO CONTROL PROJECT
TRANSFER – ELLIOTT – 24" SEWER AND NEW EBI CONNECTION

JOB PC PO
CO CO
VPI #
TR-E-1
SHEET 1 OF 3

VAULT SERIAL #	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

H:\EVT_Projects\18\2252 – SPU Vine Basin CSO Control Project\CAD\Sheets\18-2252-WA-C-ELLIOT TRANSFER.dwg
Nick.McFaddin Feb-15-19 11:40am

SDOT ######, ######



Note:
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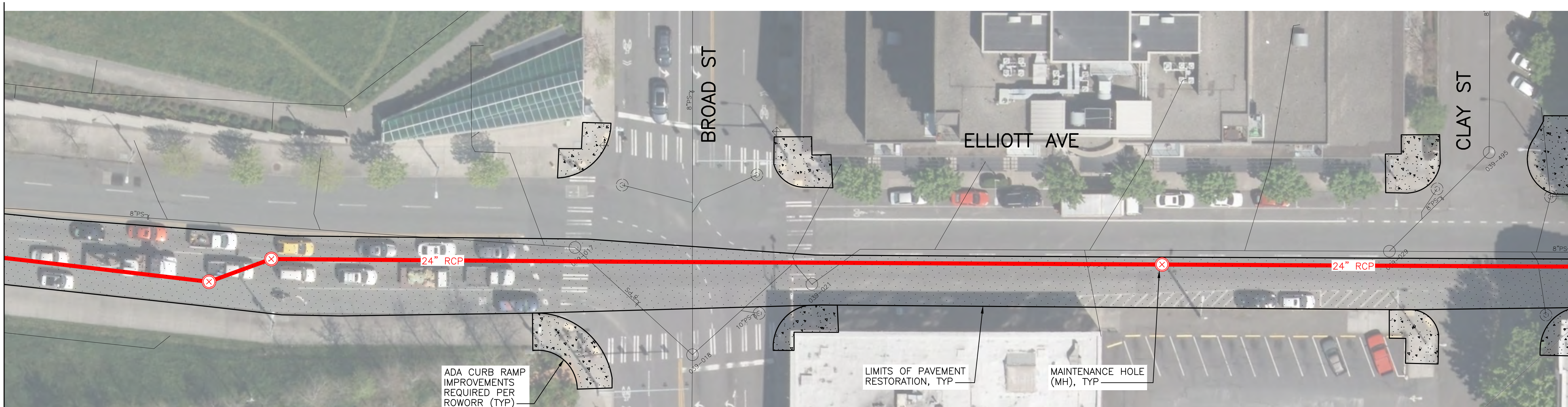
UTILITY PLAN
(SEE BELOW FOR AERIAL PLAN)

20 10 0 20 40
SCALE IN FEET



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(SEE ABOVE FOR UTILITY PLAN)

PRELIMINARY (APPROX 10% DESIGN) - NOT FOR CONSTRUCTION

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INITIALS AND DATE		INITIALS AND DATE	
DESIGNED	DSN	REVIEWED:	
CHECKED	CHK	DES.	CONST.
		SDOT	PROJ. MGR.
DRAWN	HCM	RECEIVED	
CHECKED	DAK	REVISED AS BUILT	

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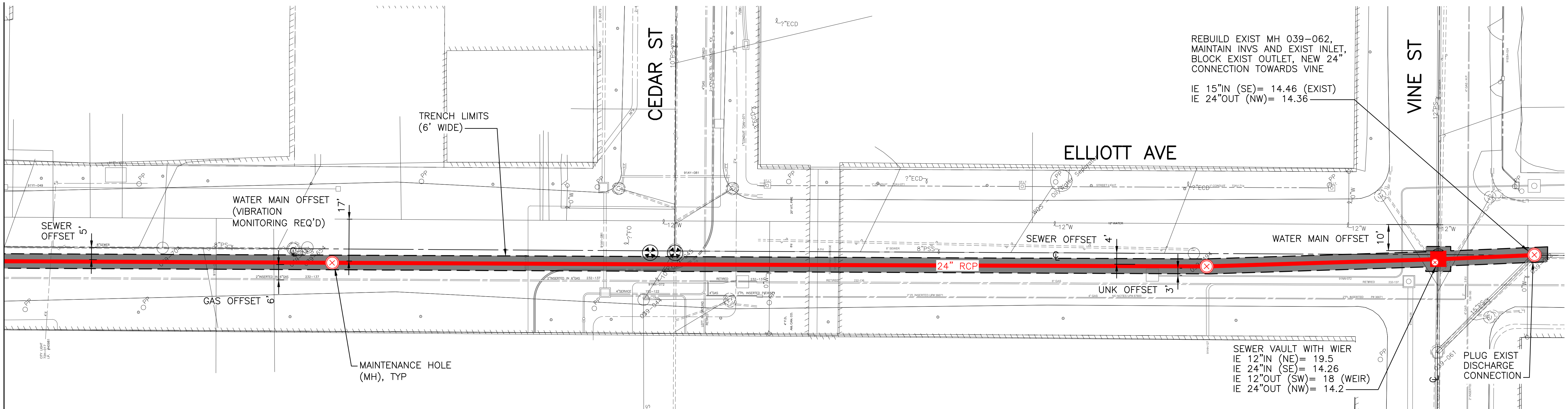
PRELIMINARY (10% COMPLETE)

Seattle Public Utilities
ORDINANCE NO. ORD   PW NO. PW
MISC
SCALE: 1"=20'

SPU VINE BASIN CSO CONTROL PROJECT
TRANSFER – ELLIOTT – 24" SEWER AND NEW EBI CONNECTION

JOB PC PO / CO CO
VPI #
TR-E-2
SHEET 2 OF 3

H:\EVT_Projects\18\2252 – SPU Vine Basin CSO Control Project\CAD\Sheets\18-2252-WA-C-ELLIOT TRANSFER.dwg
Nick.McFaddin Feb-15-19 11:40am



Note:
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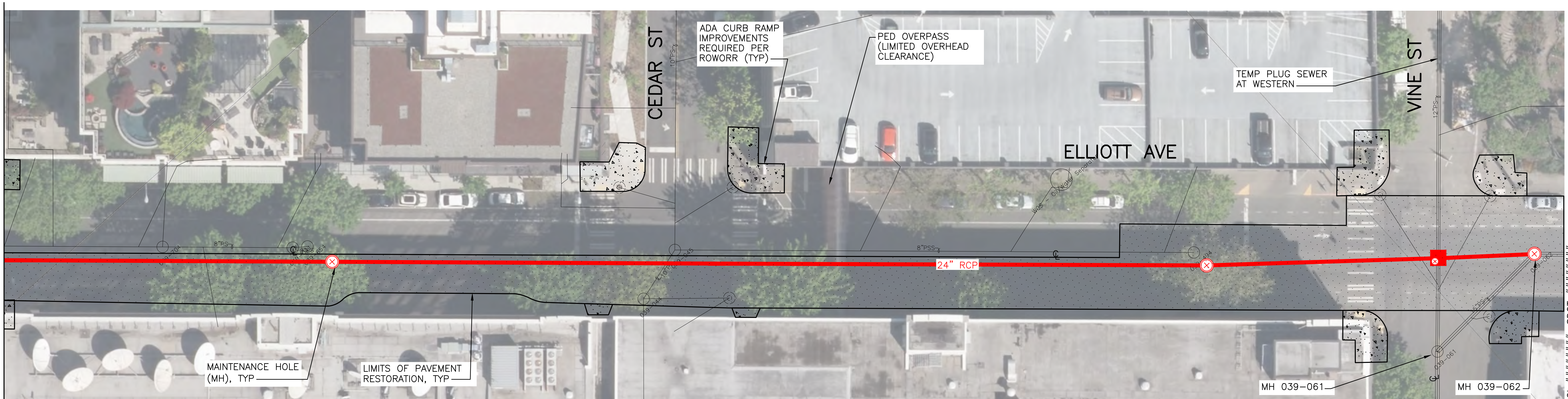
UTILITY PLAN
(SEE BELOW FOR AERIAL PLAN)



Note:
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SEATTLE, WASHINGTON .... 20 ..
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CITY PURCHASING & CONTRACTING SERVICES DIRECTOR

INITIALS AND DATE	INITIALS AND DATE
DESIGNED DSN	REVIEWED: DES. CONST.
CHECKED CHK	SDOT PROJ. MGR.
DRAWN HCM	RECEIVED
CHECKED DAK	REVISED AS BUILT

ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE CITY OF SEATTLE STANDARD PLANS AND SPECIFICATIONS AND OTHER DOCUMENTS CALLED FOR IN SECTION 0-02.3 OF THE PROJECT MANUAL.

PRELIMINARY (10% COMPLETE)

Seattle Public Utilities
ORDINANCE NO. ORD PW NO. PW
MISC
SCALE: 1"=20'

SPU VINE BASIN CSO CONTROL PROJECT
TRANSFER – ELLIOTT – 24" SEWER AND NEW EBI CONNECTION

JOB PC PO CO CO
VPI #
TR-E-3
SHEET 3 OF 3

VAULT SERIAL #	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

H:\EVT_Projects\18\2252 – SPU Vine Basin CSO Control Project\CAD\Sheets\18-2252-WA-C-ELLIOT TRANSFER.dwg
Nick.McFaddin Feb-15-19 11:40am

Appendix H1

Preliminary Basis of Estimate

	Basis of Capital Estimate-Before Stage Gate 2 **Note this BOE is for estimating the Total Cost Projection	
Title	**Vine Basin CSO Control Project Options Analysis April 5, 2019 AACE Class 4 OPCC**	
1. Project Information:	* Activity Name/Number	Basin 69 CSO Control Project - Elliott Avenue Flow Transfer
	* LOB Representative and Project Manager	Shailee Sztern, SPU PM Rick Johnson, SPU LOB Rep.
	* Cost estimator	Nichole Kruse, PE - Murraysmith
	* Estimate Reviewer(s)	Brian Bartle, PE - Murraysmith
2. Project Objectives	The Vine Basin CSO Control Project seeks to brainstorm alternatives and select recommended improvements to reduce the frequency of combined sewer overflows (CSOs) experienced in the Vine Basin (NPDES 069) to no more than one event per year on a 20-year moving average to meet State performance requirements (reference Consent Decree).	
3. Project Scope	This project consists of transferring excess sewer flow to King County's Elliott Bay Interceptor (EBI) via a new 24-inch diameter sewer in Elliott Ave. to reduce CSO event frequency. The sewer will be installed from the intersection of Vine St. and Elliott Ave. to the intersection of Bay St. and Elliott Ave. The project area is within an urban area within in downtown Seattle. The project will include the following: • Excavation to expose a portion of King County's EBI (approx. 20-ft deep) • Installation of a 24-inch connection to King County's EBI with KC Oversight o The connection will be made while the EBI is in use (active flow) • Installation of approximately 1,800 linear feet of 24-inch diameter RCP with MHs (approx. 15-ft deep) • Replacement of an existing MH near Vine St. and Elliott Ave. • Installation of a bypass vault within the intersection of Vine St. and Elliott Ave. • Right-of-Way restoration including concrete pavement with asphalt overlay replacement and ADA curb ramp improvements. • GSI and/or community benefits that are not yet defined.	
4. Location	The proposed sewer alignment is located in Elliott Ave. between Vine St. and Bay St.; refer to the attached preliminary layout figure. The alignment is located within SDOT Right-of-Way. <u>Site Constraints:</u> • Extensive traffic control will be required during construction within Elliott Ave. (anticipate having min. of 1 lane open; two traffic lanes and parking will be closed). • Groundwater is expected to be encountered when excavation and trenching. • There is potential for soil contamination and groundwater contamination in Elliott Ave. • Vibration and settlement monitoring of the adjacent cast iron water main will be required. • The proposed sewer alignment is within close proximity of multiple SCL vaults and ductbanks. • Limited staging areas are available within close proximity of the site. • Pedestrian and vehicle access to businesses and residences to be maintained.	

5. Schedule	Draft Engineering Report Submission to WDOE - 06/28/2019 Final Engineering Report Submission to WDOE - 11/2019 Stage Gate 2 Approval - 11/2019 Final Design Completion - 12/2021 Construction Contract Award and NTP - 03/2022 Construction Activities - 07/2023 (16 months) 1-year Commissioning - 07/2024	
6. Labor Resourcing Strategy	Consultant team will deliver design; SPU will provide design direction, review and oversight. Consultant team will provide engineering support during construction and will produce record drawings. SPU will provide site survey data and benchmarking for design. SPU will provide geotechnical report; geotechnical borings will be required prior to design. SPU will review construction material submittals. SPU will provide Construction Management/Construction Oversight. All construction activities will be completed by a construction contractor.	
7. Construction Contracting Strategy	Construction work will be procured using a traditional design-bid-build (DBB) procurement with award to the lowest responsible and responsive bidder. • Assumed construction work week will be Monday through Friday. • Assumed construction work hours will be 9am to 3pm to avoid periods of high-volume traffic. • SPU will not provide any construction materials (not materials to be furnished by owner) or services.	
8. Conceptual Design	* Design Assumptions * Conceptual drawing/sketch * Specifications (if applicable)	24-inch diameter RCP gravity sewer pipe. Sewer bedding will be Class B per CSO Std. Plan 285. MHs will be precast per CSO Std. Plan 204a/b. Refer to 10% Layout Drawing 2017 City of Seattle Standard Specifications.
9. Basis of Quantity:	* Take-off by LOB * Take-off by Engineering * Take-off by SPU Consultant	☐ ☐ ☑

	Basis of Capital Estimate-Before Stage Gate 2	
Title	**Vine Basin CSO Control Project** **Options Analysis** **April 5, 2019** **AACE Class 4 OPCC**	
10. Basis of Labor, Materials & Equipment Pricing (aka Unit Price)	* Historical unit costs (aka parametric estimating)	
	* Similar completed project (aka analogous estimating)	
	* Engineering Judgment	Nichole Kruse, PE - Murraysmith Brian Bartle, PE - Murraysmith
	* Semi-detailed unit costs	2017 Cost Estimate Template
11. Allowance For Indeterminates:	30% AFI as a % of the hard costs; per SPU CEG Table 4-1, Note 6 an AFI is appropriate if the scope is well defined and based on construction bid items rather than parametric or analogous cost estimates. 25% AFI is appropriate for 30% design per SPU CEG Table 4-1. We have added the AFI at this stage since we have completed a detailed OPCC based on bid items.	
12. Sales Tax	* Sales Tax Applicable	10.10%
	* Sales Tax Not Applicable	
13. SPU Field Crew Costs/Misc. Hard Costs	• SPU Construction Management/Oversight • SPU materials lab for material submittal review and approval.	
14. Soft Cost	* From SPU CEG	49% (soft costs as a % of hard costs) per SPU CEG Table 4-2
	* Not from SPU CEG	
15. Property Acquisition Cost	No property acquisition is anticipated to be required for this option.	
16. Contingency Reserve	* From SPU CEG Recommended Range	25% per SPU CEG Table 5-1
	* Not from SPU CEG	
17. Management Reserve	* From SPU CEG	20% per SPU CEG Table 5-2
	* Not from SPU CEG	
18. Inflation	* Yes	☑ Apply the current inflation amount of 2.3% to the Total Cost
	* No	☐
19. Escalation Adjustment	* Yes	☑ Apply the current escalation adjustment of 1.0% to the construction contract amount.
	* No	☐

20. Other Assumptions:	• No in-water work will be performed. • No betterments or replacements beyond those indicated on the layout. • No replacement or relocation of other utilities unless specifically indicated on the layout. • No odor control facilities are included. • No automation, instrumentation, or online monitoring is included. • No rock excavation will be required. • No vibration monitoring of adjacent structures is included. • No cost for additional/new art is included. • Cultural resource monitoring of excavations will be performed. • Complete street closures are not acceptable. At least one lane must always be kept open. • Traffic control and signage will be required. • Peace officers will be required during work within intersections. • Open-cut construction will be utilized; no trenchless construction methods will be used. • Right-of-way surface restoration will be completed in accordance with the ROWORR and per current City of Seattle Standards. • Excavations will require interlocking steel sheet piles. • At utility crossings, hand-digging will be required and special shoring will be required. • Static stainless steel plate/orifice restriction will be installed at MH prior to EBI connection for flow control. • Trench dewatering will be required; assumed sump pumps will be used. Discharge will be treated with Baker Tanks and oil absorbent filters prior to sewer discharge; KC approval required. • Groundwater contamination sampling will be required. • Construction schedule will overlap with wet season. • Limited bypass pumping will be required when replacing MH 039-062 and installing new bypass vault at Vine St. and Elliott Ave. Bypassing will be above grade and will not be trenched or require pavement restoration. • Additional temporary power supply will be required during construction for dewatering pumps and bypass pumps. • Private parcel will be rented for construction staging and parking. • Excavated soils will require contaminated soils testing and potentially disposal. • Roadway is assumed to be concrete pavement with asphalt overlay.
21. Exceptions:	
22. Risks	• Potential for survey and potholing data to identify conflict with proposed alignment. • Potential for encountering historical or archeological artifacts during construction. • Potential for damaging KC EBI when making discharge connection. • Potential for spill during bypass pumping. • Potential for encountering conflicting utilities during excavation. • Potential for utility crossing conflicts. • Potential for vibration and settlement limits of adjacent water main being exceeded. • Potential for business access impacts. • Potential for encountering mature tree roots greater than 2-inch diameter. • Potential for noise complaints during concrete pavement sawcutting. • Potential for damaging overhead crossings (Sculpture Park and Skywalk) during construction. • KC approval required for contaminated construction dewatering discharge. Potential for hydrocarbons, heavy metals, creosote and other. Additional site assessment is recommended. • Potential for encountering soil contamination beyond preliminary estimation and assumptions made for this OPCC. No formal investigation has been conducted; OPCC is based on limited information and anecdotal evidence. Additional site assessment and geotechnical investigation are recommended.

23. Basis of Estimate Reviews and Benchmarking	* How/Why Estimate Has Changed	N/A
	* Benchmarking	N/A
	* Attachments	See preliminary layout.

Appendix H2

Preliminary Opinion of Probable Construction Cost (OPCC)

Total Cost Projection Estimates - Projects in Initiation

Project Name: Vine Basin CSO Control Project
Project ID: 18-007-S
Project Phase: Options Analysis
Cost Estimator(s): Nichole Kruse, Murraysmith
Estimate Reviewer(s)
Date: 08.23.2019

#	Summary Cost Item Description	Unit	Quanitity	Elliott Avenue Flow Transfer Unit Price	Elliott Avenue Flow Transfer Estimated Cost
1	Mobilization, Safety, Traffic Control and Other	LS	1	$ 1,209,716	$ 1,209,716
2	Sewer Installation, Connections and Other Utilities	LS	1	$ 3,030,607	$ 3,030,607
3	ROW Restoration	LS	1	$ 1,339,486	$ 1,339,486
4	Community Benefit and GSI	LS	1	$ 47,192	$ 47,192
5	1-Year Commissioning Support	LS	1	$ 10,000	$ 10,000
				Construction Bid Amount	**$ 5,637,001**
				Sales Tax %	10.10%
				Allowance for Indeterminates %	30.00%
				Construction Contract Amount	**$ 7,897,438**
				SPU Crew Construction Costs	$ 10,000
				Miscellaneous Hard Costs	$ 175,000
				Construction Cost Total	**$ 8,082,438**
				Soft Cost %	49%
				Soft Cost	$ 3,960,395
				Property Acquisition Costs	$ -
				Base Cost Total	**$ 12,042,833**
				Contingency Reserve %	25%
				Contingency Reserve	$ 3,010,708
				Management Reserve %	20%
				Management Reserve	$ 2,408,567
				Project Reserves	**$ 5,419,275**
				Total Cost	**$ 17,462,108**
				Inflation Cost Projection	**$ 1,827,746**

Escalated Cash Flow Distribution

Current Year	2017	Enter Current Year
Inflation Assumption	2.3%	See Guidance on Inflation and Escalation Adjustment Rates
Escalation Adjustment Assumption	1.0%	See Guidance on Inflation and Escalation Adjustment Rates
Actual Costs to Date	$0	Enter Actual Costs to Date
Total Cost	$ 17,462,108	from Total Cost on previous tab
Construction Contract Amount	$ 7,897,438	from Construction Contract Amount on previous tab

	Life to Date Actuals	Remaining in 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	
Elliott Ave Flow Transfer												
% costs to be spent by year	NA	0.0%	0.0%	0.0%	0.0%	62.5%	37.5%	0.0%	0.0%	0.0%	0.0%	100%
Percent of Total Cost	$ -	$ -	$ -	$ -	$ -	$ 10,913,817	$ 6,548,290	$ -	$ -	$ -	$ -	
Construction Contract Amount		$ -	$ -	$ -	$ -	$ 4,935,899	$ 2,961,539	$ -	$ -	$ -	$ -	
Cost of Inflation	$ -	$ -	$ -	$ -	$ -	$ 1,039,245.87	$ 788,499.80	$ -	$ -	$ -	$ -	**$ 1,827,746**
Cost of Escalation Adjustment	$ -	$ -	$ -	$ -	$ -	$ 200,417.29	$ 151,068.27	$ -	$ -	$ -	$ -	**$ 351,486**
Cost Projection	$ -	$ -	$ -	$ -	$ -	$ 12,153,480.63	$ 7,487,858.55	$ -	$ -	$ -	$ -	***$ 19,641,339***

APWA 2017						
Bid item	**Item/Description**	**Take-Off QTY**	**Unit**	**Total Cost Unit 2017**	**Estimate Total**	**NOTES**
Sect 1-07	**Legal Relations & Responsibilities**					
107005	SAFETY AND HEALTH PROGRAM-CSI (REF)	16	MO	$1,725.00	***$27,600***	Unit Cost from CSI Tab
	Existing Conditions					
FROM CSI	CONSTRUCTION SURVEY (2 MAN CREW)	25	DAY	$1,800.00	***$45,000***	Unit Cost from CSI Tab
FROM CSI	UTILITY POTHOLING {QTY >10 EA}	15	EA	$1,000.00	***$15,000***	Unit Cost from CSI Tab; lowered cost since minimal restoration required when done during construction
	General Requirements					
ADDED	STAGING AREA RENTAL	16	MO	$10,000.00	***$160,000***	Estimated
FROM CSI	AS-BUILT RECORDS, MIN. BID	30	EA	$400.00	***$12,000***	Unit Cost from CSI Tab; Assumed 30 Drawings
Sect 1-09	**Measurement & Payment**					
109005	MOBILIZATION-CSI (REF)	1	LS	$511,545.54	***$511,546***	10% of total
Sect 1-10	**Temporary Traffic Control**					
110005	MAINTENANCE & PROTECTION OF TRAFFIC CONTROL INCLUDING FLAGGING-CSI (REF)	300	DAY	$895.00	***$268,500***	Needed throughout in street work since high traffic - 5 days/week, 4 weeks per month, 15 months
ADDED	PARKING METER HOODS BY SDOT	1	LS	$2,000.00	***$2,000***	Estimated (per Casseday)
ADDED	SDOT SIGNAL MODIFICATION (BY SDOT)	1	LS	$20,000.00	***$20,000***	Estimated, modified signals (per Casseday)
ADDED	PARKING FEES (PER SPACE PER DAY; MON-SAT)	4,200	DAY	$25.00	***$105,000***	Estimated, 25 street parking spaces to be impacted; est. phased construction; 6 days/week; 7 months, 4 weeks per month (per Casseday)
110020	TRAFFIC CONTROL PEACE OFFICERS	360	HR	$97.00	***$34,920***	Needed at Intersections (3 intersections, 4 weeks per intersection, 6 hour days, 5 days per week) (per Casseday)
Sec 2-02	**Remove, Abandon, Or Relocate Structures and Obstructions**					
202035	REMOVE CEMT. CONCR. SIDEWALK {QTY >50}	544	SY	$17.00	***$9,242***	Curb ramps
202045	REMOVE CEMT. CONCR. SIDEWALK {QTY >50}	4,935	SY	$21.00	***$103,630***	Full depth pavement/roadway removal
202145	REMOVE CURB {QTY>50}	900	LF	$11.00	***$9,900***	Assumed some damaged to curb
202767	SAWCUT Cement Concrete Sidewalk, Full Depth {QTY>50LF}	360	LF	$7.00	***$2,520***	2 saw cuts at each ADA ramp; Assumed 10' each
202770	SAWCUT Rigid Pavement, Full Depth {QTY >500 LF}	5,684	LF	$12.00	***$68,208***	Trench sawcut and pavement restoration sawcut
Sec 2-03	**Structural Demolition**					
203011	Remove Pre-Cast MH Over 8' Deep	16	VLF	$260.00	***$4,160***	FROM CSI; MH at Vine and Elliott
Sec 2-04	**Excavations**					
204005	COMMON Excavation {QTY >500}	107	CY	$52.00	***$5,547***	Excavation at EBI
Sec 2-07	**Protective System**					
207010	SAFETY SYSTEM IN TRENCH EXCAVATION {16-22 Feet Deep}	54,000	SF	$30.00	***$1,620,000***	15' deep ex. X 1800lf x 2 sides; Updated Unit Price per HWA assuming Sheet Pile Shoring
	Dewatering					
FROM CSI	Dewatering - Pumping Water (3" Pump) to Baker Tank - Small to Mid-rang Water Flow Capacity	150	Day	$1,500.00	***$225,000***	Assumed 30 days per month for 5 months; assumes discharge to sewer
Sec 2-10	**Backfilling**					
210052	BORROW MINERAL AGGREGATE TYPE 2 {QTY>50TN}	2,430	TN	$31.00	***$75,330***	
FROM CSI	Contaminated Soils Disposal	2,430	TN	$125.00	***$303,750***	Assumed 15' D x 6'w x 1800'L trench; 25% of excavated soils would be contaminated; 120 lb./ft3 unit weight
Sec 3	**Geotechnical Instrumentation and Monitoring**					
ADDED	VIBRATION AND SETTLEMENT MONITORING (1625 LF Pipe/Monthly)	10	MO	$7,500.00	***$75,000***	Unit Cost from CSI Tab, Updated to Include Settlement Monitoring
ADDED	Cultural Resource Monitoring	512	HR	$135.00	***$69,120***	Assume 32 hrs/week x 4 weeks x 4 months
Sec 5-04	**Hot Mix Asphalt (HMA) & Warm Mix Asphalt (WMA) Pavement**					
504045	PAVEMENT, HMA (CL 1/2 IN) {QTY>50 TN}	537	TN	$225.00	***$120,748***	For pavement restoration area, 2" thick; 145 Lb./ft3 unit weight
504260	PAVEMENT PATCH, TEMPORARY {QTY>50TN}	783	TN	$265.00	***$207,495***	Cold patch for trench width: 6'wx1800'Lx1'D; 145 Lb./ft3 unit weight
Sec 5-05	**Cement Concrete for Roadway and Related Work**					
505144	ROADWAY Cem Conc., HES (72HR), 10IN {QTY>50SY}	4,935	SY	$120.00	***$592,173***	Roadway Restoration Area
FROM CSI	MINERAL AGGREGATE TYPE 2	1,665	TN	$50.00	***$83,274***	Roadway Base; 6-inch thick
505310	DOWEL Bar {QTY > 25EA}	3,600	EA	$6.00	***$21,600***	Est. # of panels = 2 joints, 1800 lf each, 1 dowel per ft.
505315	TIE Bar With Drill Hole {QTY >25EA}	880	EA	$4.00	***$3,520***	20' wide restoration area, bar every 3 ft, 15'wide panels for 1800' l
Sec 7-05	**Maintenance Hole, Catch Basins and Inlets**					
705008	MAINTENANCE HOLE, TYPE 204A {QTY>5 EA}	8	EA	$4,000.00	***$32,000***	
705020	MAINTENANCE HOLE, Type 210A {QTY<=5 EA}	1	EA	$20,500.00	***$20,500***	For vault structure in Vine and Elliott
705108	EXTRA Depth, Type 204A Maintenance Hole	40	VF	$260.00	***$10,400***	Assumed extra 5' per MH
705120	EXTRA Depth, Type 210A Maintenance Hole	5	VF	$920.00	***$4,600***	Assumed extra 5' for vault structure in Vine and Elliott
Sec 7-08	**Miscellaneous Pipe Connections**					
ADDED	Pipe Connection to KC EBI	1	LS	$7,000.00	***$7,000***	Estimated
ADDED	KING COUNTY OVERSIGHT	1	LS	$5,000.00	***$5,000***	Estimated
Sec 7-17	**Storm Drains and Sanitary Sewers**					
717024	BEDDING, CL B, 24 IN Pipe {QTY >50LF}	1,800	LF	$22.00	***$39,600***	24" RCP Bedding, Class B
717724	PIPE, PSS, Conc Reinf C76 CLIV, 24 IN {QTY > 50 FT}	1,800	LF	$140.00	***$252,000***	24" RCP Pipe
717985	TEMPORARY SEWER BYPASS {Length-250-500 FT}	1	LS	$20,000.00	***$20,000***	For MH replacement and Vine/Elliott added vault
717990	TELEVISION INSPECTION {QTY >200FT 1 MOB}	1,800	LF	$4.50	***$8,100***	
Sec 7-20	**Adjustment of New and Existing Utility Structures to Finish Grade**					
720005	ADJUST Existing MH, CB, or VC {QTY <=5EA}	5	EA	$615.00	***$3,075***	Allowance for roadway restoration
720020	ADJUST Existing Valve Box {QTY <=5EA}	5	EA	$515.00	***$2,575***	Allowance for roadway restoration
Sec 7-21	**Bioretention**					
721002	BIORETENTION Soil {QTY >20CY}	435	CY	$82.00	***$35,670***	Allowance for GSI
Sec 8-01	**Construction Stormwater Pollution Prevention**					
801001	CONSTRUCTION Storm Water & Erosion Control Plan - CSECP {Project Value $3-$5M} CSI (REF)	1	LS	$15,500.00	***$15,500***	Had to Manually Enter Unit Costs
801002	TREE Vegetation & Soil Protection Plan - TCSPP {Project Value $3-$5M} CS (REF)	1	LS	$7,575.00	***$7,575***	Had to Manually Enter Unit Costs
801003	SPILL Plan SP {Project Value $3-$5M} CSI (REF)	1	LS	$4,300.00	***$4,300***	Had to Manually Enter Unit Costs
801004	TEMPORARY Discharge Plan TDP {Project Value $3-$5M} CSI (REF)	1	LS	$5,125.00	***$5,125***	Had to Manually Enter Unit Costs
Sec 8-02	**Landscape Construction**					
ADDED	TREE PROTECTION	20	EA	$250.00	***$5,000***	Estimated
802048	TREE, Deciduous, 6 Ft to 8 FT	10	EA	$510.00	***$5,100***	Community Benefit and GSI Allowance
802360	TREE Root Barrier {QTY >20 LF}	160	LF	$12.00	***$1,920***	Assumed 4'x4' tree box; Community Benefit and GSI Allowance
802380	FLEXIBLE POROUS SURFACE TREATMENT - 1.5" Thick (Black Material)	1	CY	$4,558.00	***$4,502***	Assumed 12 tree boxes, 4'x4' ea.; Community Benefit and GSI Allowance
Sec 8-04	**Cement Concrete Curb, Curb and Gutter**					
804005	CURB, CEM CONC {QTY >500}	900	LF	$36.00	***$32,400***	Curb repair; match length of curb removed
Sec 8-12	**Chain Link Fence and Wire Fence**					
812001	CHAIN LINK Fence, Type 1 {QTY > 200 LF}	1,000	LF	$31.00	***$31,000***	Allowance for temp. construction fencing
812014	CHAIN LINK Gate, Double 14 Ft Wide {QTY <=5 EA}	2	EA	$1,625.00	***$3,250***	Allowance for temp. construction fencing
Sec 8-14	**Cement Concrete Sidewalk**					
814021	CURB RAMP {QTY >5SY}	544	SY	$270.00	***$146,790***	All curb ramps
814030	DETECTABLE Warning Plate {QTY > 20SY}	30	SY	$71.00	***$2,146***	Assumed 34 ramps, 2' d x 4' w ea.
Sec 8-22	**Pavement Marking**					
822018	PAVEMENT MARKING, Thermo, 8 IN Stripe {QTY<=200 LF}	3,600	LF	$30.00	***$108,000***	lane markings
822020	PAVEMENT MARKING, Thermo, Legend/Symbol {QTY>5 EA}	7	EA	$205.00	***$1,435***	7 crosswalks
Sec 8-27	**Project Identification Sign**					
827020	SIGN, INSTALL PROJECT IDENTIFICATION, POST MOUNTED {Size-Large-8'x10'}	1	EA	$1,400.00	***$1,400***	
Sec 8-31	**Traffic Signal System**					
831306	DETECTOR LOOP, 6 FT DIA {QTY > 5 EA}	9	EA	$915.00	***$8,235***	Broad and Elliott
Sec 8-33	**Conduit and Trenching**					
833400	Relocate Handhole {QTY<=5EA}	2	EA	$510.00	***$1,020***	ADA ramp work
				TOTAL	**$5,627,001**	