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SEATTLE PUBLIC UTILITIES
COMBINED SEWER OVERFLOW REDUCTION

Genesee
Combined Sewer Overflow Reduction Project

Basis of Design Report

August 2011

HDR

CH2MHILL

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Seattle Public Utilities

Basis of Design Report

Genesee Combined Sewer Overflow Reduction Project

CERTIFICATION

This Basis of Design Report for the Genesee Combined Sewer Overflow Reduction Project for Seattle Public Utilities has been prepared under the direction of the following Registered Professional Engineer.

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Acronyms and Abbreviations

ºC	**degrees Celsius**
ºF	degrees Fahrenheit
AASHTO	American Association of State Highway and Transportation Officials
ac/hr	air changes per hour
AC	alternating current
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AWG	American wire gauge
BMP	best management practice
CADD	computer-aided design and drafting
CCBS	construction cost breakdown structure
CCTV	closed-circuit television
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CIP	cast-in-place
City	City of Seattle
City Standard Plans	City of Seattle Standard Specifications and Plans for Road, Bridge and Municipal Construction, 2011 Edition
CSCP	Construction Stormwater Control Plan
CSI	Construction Specifications Institute
CSO	combined sewer overflow
CT	current transformer
DIA	diameter
DPD	Seattle Department of Planning and Development
Ecology	Washington State Department of Ecology

f'c	compressive strength design value
F.O.B.	free on board
fpm	feet per minute
fps	feet per second
FRP	fiberglass-reinforced plastic
ft^2	square foot
ft^3	cubic foot
GIS	geographic information system
gpm	gallons per minute
GSI	Green Stormwater Infrastructure
Guide	SPU Cost Estimating Guide
HDPE	high-density polyethylene pipe
HDR	HDR Engineering, Inc.
HMA	hot-mix asphalt
HMI	human machine interface
hp	horsepower
HVAC	heating, ventilation, and air conditioning
I&C	instrumentation and control
I/O	input/output
IBC	International Building Code
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Fire Code
IMC	International Mechanical Code
ISA	International Society of Automation
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
lb	pound
lb/ft^2	pounds per square foot
lb/ft^3	pounds per cubic foot
LEED	Leadership in Energy and Environmental Design
LRFD	load and resistance factor design
MCC	motor control center
MG	million gallons
mgd	million gallons per day

MH	maintenance hole
MU	management unit
NEC	National Electrical Code
NEMA	National Equipment Manufacturers Association
NFPA	National Fire Protection Association
NPDES	National Pollutant Discharge Elimination System
NPW	non-potable water
O&M	operations and maintenance
OI	operator interface
Parks	Seattle Parks and Recreation
PCI	Precast Prestressed Concrete Institute
PLC	programmable logic controller
PSD	pipe storm drain
PLSO	Washington Department of Natural Resources, Public Land Survey Office,
psf	pounds per square foot
psi	pounds per square inch
PVC	polyvinyl chloride
RCW	Revised Code of Washington
SCADA	supervisory control and data acquisition
SCL	Seattle City Light
SDOT	Seattle Department of Transportation
SEPA	State Environmental Policy Act
SMC	Seattle Municipal Code
SPU	Seattle Public Utilities
UL	Underwriters Laboratories
UPARR	Urban Park and Recreation Recovery
UPS	uninterruptible power supply
V	volt
VFD	variable frequency drive
VMP	Vegetable Management Plan
w.c.	water column
WAC	Washington Administrative Code
WSDM	Washington State Water System Design Manual
WSDOT	Washington State Department of Transportation
WWHM	Western Washington Hydrology Model

1 Project Background

1.1 Introduction

This report discusses the basis of design for the Seattle Public Utilities (SPU) Genesee Combined Sewer Overflow (CSO) Reduction Project, which aims to reduce CSOs from Genesee Area basins. The report provides the technical basis for how the design team will proceed with production of the construction documents.

The Genesee Area extends from Seward Park and Andrews Bay northward to the Stan Sayres Memorial Park and Genesee Park along the western shoreline of Lake Washington. There are seven basins within the Genesee Area: Basins 37, 38, 40, 41, 42, 43, and 165. The basins are defined by the geographic limits of the sewer systems that contribute to CSOs discharging through outfalls.

Originally, the Genesee Area sewer system was constructed using “combined sewers,” meaning that both sanitary sewage and stormwater runoff are conveyed in the same pipes. The sewer system has been modified over time. Some portions of the Genesee Area now have “fully separated sewers,” meaning that sanitary sewage and stormwater are collected and conveyed in separate pipe systems. Other portions of the Genesee Area have “partially separated sewers,” meaning that stormwater from roof drains enters the sanitary sewer system while stormwater from roadways enters a separate drainage system.

For combined and partially separated systems, under wet weather conditions, flows are a combination of sewage and stormwater. As long as flow volumes are within the capacity of the sewer system, all flows are conveyed to a wastewater treatment plant. However, if flow volumes exceed the capacity of the sewer system, the excess volume of sewage and stormwater is discharged into receiving water bodies through outfalls. This is called a “combined sewer overflow” or “CSO.”

CSOs are required to be limited to a long-term average of no more than one untreated discharge per year per outfall, in accordance with the following:

Revised Code of Washington (RCW)

RCW 90.48.480: This law requires “the greatest reasonable reduction of combined sewer overflows.”

Washington Administrative Code (WAC)

WAC 173-245-020 (22): “‘The greatest reasonable reduction’ means control of each CSO in such a way that an average of one untreated discharge may occur per year.”

Basins 37, 38, 42, and 165 have a long-term average of no more than one untreated discharge per year.

Basins 40, 41, and 43 exceed a long-term average of one untreated discharge per year and are the focus of this basis of design report. Project components have been developed at two sites to limit CSOs in these basins. The first component, the 49th Avenue South Parking Lot site, will address needs at Basins 40 and 41. The second component, the 53rd Avenue South Parking Lot site, will address needs at Basin 43. Brief descriptions of the two sites are provided in the following sections. More detailed descriptions are provided in SPU’s *Genesee CSO Reduction Project Engineering Report* (May 2011).

1.2 49th Avenue South Parking Lot Overview

1.2.1 Overview

The project component at the 49th Avenue South Parking Lot site will install a 0.48-million gallon (MG) underground CSO storage tank in the parking lot on Lake Washington Boulevard South between 48th Avenue South and 49th Avenue South. The property is owned by Seattle Parks and Recreation (Parks). Exhibit 1 in Appendix A identifies the proposed site location of the offline storage tank, gravity sewer, and force main for this project component.

The 0.48-MG storage volume is based on modeling to reduce overflows at CSO Outfalls 40 and 41 to a long-term average of no more than one untreated discharge per year.

The main system components of the project work at the 49th Avenue South Parking Lot site will include the following:

- **Storage Facility:** A 0.48-MG offline storage tank located in a parking lot on Lake Washington Boulevard South. The storage facility will be located in Basin 38, but will store flows from Basins 40 and 41.
- **Facilities Vault:** Underground facilities vault containing odor control, mechanical, electrical, and control systems.
- **Conveyance:** Additional gravity sewer to convey flows to and from the new storage facility.
- **Modifications to Existing System:** A retrofit to better utilize existing storage at CSO Facility 11 and reduce overflows within Basin 40. The retrofit will include replacing the HydroBrake near the intersection of 49th Avenue South and South Dakota Street with a motor-operated gate to maximize flow from Basin 40 into the existing Lake Line. If power is lost, the motor-operated gate will remain open to prevent a sanitary sewer overflow.

1.2.2 Storage Tank

The proposed CSO storage tank will be a buried, rectangular structure with these approximate interior dimensions: 90 feet in length and 39 feet in width, with variations in depth from approximately 24 feet to 28.5 feet. The tank will be divided into two flushing channels that will extend along the length of the facility. Hydraulically, the facility will operate as one unit – both flushing channels will fill and drain at the same time and rate. Each flushing channel will be approximately 18 feet wide and designed to facilitate the post-event solids removal process. The flushing channels will be sloped to a common collection channel that will extend along one end of the facility.

The interior of the tank will have a non-rectangular geometry because of various design elements, including the slope of the flushing channels, collection channel, beams, internal walls, and sump. The floor elevation will vary from the tipping bucket end to the collection channel and at the sump. The dimensions of the tank have been determined to meet an approximate water storage volume of 0.48 MG.

During a storm event, excess flows from Basins 40 and 41B will be diverted to the new storage facility. Once flows have been conveyed to the storage facility, an interior drop connection will allow flows to enter the storage tank while minimizing splashing of sewage, thereby minimizing odors. This location for the connection to the tank and the use of the drop connection will provide an opportunity for larger suspended solids to settle near the bottom of the tank in the collection channel rather than be widely dispersed into the flushing channels as the tank is filled.

As the tank empties, the flows from the flushing channels will be gathered in the collection channel and directed to a common sump in the middle of the collection channel. Two submersible pumps will be located in the sump and will pump stored flows back into the sewer system through a force main that will discharge into the primary control structure, flowing into the Lake Line on Lake Washington Boulevard South.

A tipping bucket system will be used for post-event solids removal after the storage tank empties. Tipping buckets are long, cylindrical tubes or triangles that will be mounted at the top and upstream end of the tank. The buckets will be filled with potable water; once the water in the bucket has reached a certain level, gravity will cause the bucket to tip and discharge the flushing wave. The flushing wave will be sent through the tank, scouring the solids on the tank floor.

The size of a tipping bucket is a function of the height of the bucket above the tank floor and the length of the tank. The length of a tipping bucket is a function of the width of the flushing channels, which are designed to maintain the scouring effect of the wave of water. Each tipping bucket installed on this project component will have a capacity of approximately 1,250 gallons.

The tipping buckets will be filled from an external source of potable water. Water service is available from 48th Avenue South. A 3-inch-diameter service connection will provide adequate water to operate the flushing system and allow additional washdown from the surface by operators. Much of the water supply system equipment will be housed in the facilities vault. A fill pipe will be used to provide water from the facilities vault to the tipping buckets.

Access to the storage tank will be through hatches located at each end of the flushing channels. No ladders or additional access equipment will be provided. Additional access hatches at the tipping bucket ends of the flushing channels will be positioned over the hinges for maintenance access to the mechanical parts of the tipping buckets and fill pipe/valve actuator assemblies. The hatches at the tipping bucket end will be embedded into large, concrete, removable panels that could be lifted by crane to allow complete removal and replacement of an individual tipping bucket assembly or to facilitate the placement of equipment into the storage tank, such as a small Bobcat or other machinery used for inspection, cleaning, or repairs. These access hatches also will allow a pole-mounted video camera or a closed-circuit television (CCTV) camera to be lowered into the storage facility for inspection from the ground surface by SPU staff.

The geotechnical evaluation indicated several potential design issues. The base of the tank will likely be founded in glacial till, which will provide an adequate subgrade. The groundwater table may be near the surface, so this must be considered in the design phase. This high groundwater table condition could make this site difficult to excavate because of shoring and dewatering considerations. The tank also will require design consideration for buoyancy effects. No major underground utilities have been identified that will cause problems for the excavation, and there are no access issues for construction equipment at the site.

1.2.3 Facilities Vault

An underground facilities vault will contain the odor control system, mechanical equipment, electrical equipment, and control systems. The vault will be constructed as part of the storage tank structure and situated on the northwest side of the site. Access to the vault will be by hatches and stairways to grade level. The interior of the facilities vault will be approximately 35.5 feet in length and 22 feet in width. The vault will be buried to minimize impact on the use of the site after construction. Access hatches to the vault will be designed to maximize maintenance access and minimize visual presence at the surface.

The odor control system will consist primarily of a carbon adsorption scrubber vessel, grease filter/mist eliminator, and fan. Additional instruments and smaller components will be required but are not considered major equipment. The ventilation rate will provide a 0.1-inch water column (w.c.) of negative pressure (-0.036 pound per square inch [psi]) within the storage tank. The odor control system will be directly connected to the storage facility with buried, corrosion-resistant ductwork or piping (polyvinyl chloride [PVC] or fiberglass ductwork). Approximately 100 feet of buried, 8-inch-diameter ductwork is anticipated. The treated air will discharge at grade near the facilities vault. Heating, ventilation, and air conditioning (HVAC) ductwork will extend from the vault to intake or exhaust boxes nearby.

SPU provides onsite standby power for projects that are considered critical infrastructure and where there would be significant consequences if continuous power were lost: for example, a sewage pump station. The odor control equipment, sewage pumps, and other items requiring power on this project component are not considered critical to storing flows in the Genesee Area because the storage facility will fill by gravity. Loss of power would prevent the storage facility from being drained by the pumps after an event; however, this would not prevent the sewer collection system from continuing to operate. Furthermore, the design will not require an onsite, dedicated standby generator because it is anticipated that the storage facility will be used only a few times a year and the likelihood of back-to-back uses of the facility is very low. An onsite standby power source will not be provided. However, the design will include provisions for temporary standby power (e-plug). With this provision, SPU crews will have the ability to bring a portable standby generator to the site and operate the pumps to drain the facility during a power outage.

To provide water to the tipping buckets, water drawn from a new service water line tapped from the water main in 48th Avenue South will be routed through an air gap device and air break tank (within the facilities vault) as required by current health codes and stored in a reservoir inside the Electrical/Mechanical Room. The fill pumps located in the mechanical space will draw from the reservoir and pump the water into the tipping buckets.

1.2.4 Conveyance

Approximately 400 feet of 12-inch-diameter gravity diversion sewer will convey excess combined sewage from the new diversion structure (Maintenance Hole [MH] A, installed between existing MH 059-495 and MH 059-490) to the new primary control structure downstream of CSO Control Structure 41B, which will be abandoned as a CSO control structure and replaced by the new primary control structure.

Approximately 100 feet of 24-inch-diameter gravity sewer will convey excess combined sewage from a new primary control structure downstream of CSO Control Structure 41B (and upstream of MH 059-429) to the new offline storage tank. The gravity sewer will be located at the intersection of Lake Washington Boulevard South and 49th Avenue South.

Approximately 100 feet of 8-inch-diameter force main will transfer the combined sewage from the offline storage tank to the primary control structure downstream of CSO Control Structure 41B.

Approximately 20 feet of 18-inch-diameter gravity overflow will convey combined sewage from the new primary control structure downstream of CSO Control Structure 41B to CSO Outfall 40. This line will be used only when there is no available storage left in the offline tank and the Lake Line has no remaining capacity.

Approximately 20 feet of 18-inch-diameter gravity overflow will convey combined sewage from the new primary control structure downstream of CSO Control Structure 41B to CSO Outfall 41. This line will be used only when there is no available storage left in the offline tank and the Lake Line has no remaining capacity.

These conveyance components are illustrated in Exhibit 4 in Appendix A.

1.3 53rd Avenue South Parking Lot Overview

1.3.1 Overview

The project component at the 53rd Avenue South Parking Lot will install a 0.12-MG underground CSO storage tank in the parking lot on Lake Washington Boulevard South near the intersection of 53rd Avenue South and Lake Washington Boulevard South. The property is owned by Parks. Exhibit 9 in Appendix A identifies the proposed site location of the offline storage tank, facilities vault, and gravity sewer for this project component.

The 0.12-MG storage volume is based on modeling to reduce overflows at CSO Outfall 43 to a long-term average of no more than one untreated discharge per year.

The main system components of the project work at the 53rd Avenue South Parking Lot site will include the following:

- **Storage Facility:** A 0.12-MG offline storage tank located in a parking lot on Lake Washington Boulevard South near the intersection of 53rd Avenue South and Lake Washington Boulevard South. The storage facility will be located in and store flows from Basins 43 and 165.
- **Facilities Vault:** Underground facilities vault containing odor control, mechanical, electrical, and control systems.
- **Modifications to Existing System:** A retrofit to better utilize existing storage and reduce overflows within Basin 43. The retrofit will include replacing the HydroBrake at CSO Facility 9 with a motor-operated gate. This will provide better control of managing flows to the Lake Line, the existing CSO Facility 9, and the new storage tank at the 53rd Avenue South Parking Lot site. If power is lost, the motor-operated gate will remain open to prevent a sanitary sewer overflow.

1.3.2 Storage Tank

The proposed CSO storage tank will be a buried, rectangular storage structure with interior dimensions of approximately 120 feet in length and 24 feet in width, with variations in depth from approximately 13 feet to 18 feet. Flows will be diverted to the storage facility from the combined sewer system, over a storage diversion weir structure and motor-operated valve, and into piping that will convey flow into the tank.

The tank will have one flushing channel that will extend along the length of the facility. The flushing channel will be sloped to a common collection channel that will extend along one end of the facility.

The interior of the tank will have a non-rectangular geometry because of various design elements, including the slope of the flushing channel, collection channel, beams, internal walls, and the sump. The floor elevation will vary from the tipping bucket end to the collection channel and at the sump. The dimensions of the tank have been determined to meet an approximate water storage volume of 0.12 MG.

During a storm event, flows will divert into the proposed storage tank through an interior drop connection that will allow flows to enter the storage tank while minimizing splashing of sewage, thereby minimizing odors. This location for the connection to the tank and the use of the drop connection will provide an opportunity for larger suspended solids to settle near the bottom of the tank in the collection channel rather than be widely dispersed into the flushing channels as the tank is filled.

As the tank empties, stored flows will be released back into the lake line by pumping as downstream system capacity becomes available. After the storage tank empties, a tipping bucket system will be used for post-event solids removal. Tipping buckets are long, cylindrical tubes or triangles that will be mounted at the top and upstream end of the CSO tank. The buckets will be filled with water; once the water in the bucket has reached a certain level, gravity will cause the bucket to tip and discharge the flushing wave. The flushing wave will be sent through the tank, scouring the solids on the tank floor.

The size of a tipping bucket is a function of the height of the bucket above the tank floor and the length of the tank. The width of a tipping bucket is a function of the width of the flushing channels, which are designed to maintain the scouring effect of the wave of water. For this project component, there will be one tipping bucket.

The tipping bucket will be filled from the City’s potable water system. The water service connection will provide adequate water to fill the tipping bucket during a 4-hour period and allow additional washdown from the surface by operators. Much of the water supply system equipment will be housed in the facilities vault. A fill pipe will be used to provide water from the facilities vault to the tipping bucket. The fill pipe will be tapped with two connections, and each connection will have one valve. The valves will be controlled remotely and actuated at the facilities vault.

Access to the storage tank will be through hatches located at each end of the flushing channel. No ladders or additional access equipment will be provided. Additional access hatches at the tipping bucket end of the flushing channel will be positioned over the hinges for maintenance access to the mechanical parts of the tipping bucket and fill pipe/valve actuator assemblies. The hatch at the tipping bucket end will be embedded into a large, concrete, removable panel that could be lifted by crane to allow complete removal and replacement of the tipping bucket assembly or to facilitate the placement of equipment into the storage tank, such as a small Bobcat or other machinery used for inspection, cleaning, or repairs. This access hatch also will allow a pole-mounted camera or a CCTV camera to be lowered into the storage facility for inspection from the ground surface by SPU staff.

The geotechnical evaluation indicates several potential design issues. The base of the tank likely will be founded in silt, clay, and sand with silt, which may not provide an adequate subgrade. The groundwater table may be near the surface. This high groundwater table condition could make this site difficult to excavate because of shoring and extensive dewatering considerations. The tank also will require design consideration for buoyancy effects. No major underground utilities were detected that will cause problems for the excavation, and there are no access issues for construction equipment at the site.

1.3.3 Facilities Vault

An underground facilities vault will contain an odor control system room and a mechanical/ electrical/control systems room. Access to each room in the vault will be by separate hatches and stairways. The interior of the facilities vault will be approximately 35.5 feet in length and 22 feet in width. The vault will be buried to minimize impact on use of the site after construction. Access hatches to the vault will be designed to maximize maintenance access and minimize visual presence at the parking lot surface.

The odor control system will consist primarily of a carbon adsorption scrubber vessel, grease filter, and fan. Additional instruments and smaller components will be required but are not considered major equipment. The ventilation rate will provide 0.1-inch w.c. of negative pressure within the storage tank. The odor control system will be directly connected to the storage facility with buried, corrosion-resistant ductwork or piping (PVC or fiberglass ductwork). Approximately 100 feet of buried, 10-inch-diameter ductwork is anticipated. The treated air will discharge at grade near the facilities vault. HVAC ductwork will extend from the vault to intake or exhaust boxes nearby.

SPU provides onsite standby power for projects that are considered critical infrastructure and where there would be significant consequences if continuous power were lost: for example, a sewage pump station. The odor control equipment, sewage pumps, and other items requiring power on this project component are not considered critical to storing flows in the Genesee Area because the storage facility will fill by gravity. Loss of power would prevent the storage facility from being drained by the pumps after an event; however, this would not prevent the sewer collection system from continuing to operate. Furthermore, the design will not require an onsite dedicated standby generator because it is anticipated that the storage facility will be used only a few times a year and the likelihood of back-to-back uses of the facility is very low. An onsite standby power source will not be provided. However, the design will include provisions for temporary standby power (e-plug). With this provision, SPU crews will have the ability to bring a portable standby generator to the site and operate the pumps to drain the facility during a power outage.

Water drawn through a new service water line from the water main in 53rd Avenue South will be routed through an abovegrade, reduced-pressure backflow prevention device and a belowgrade air break tank inside the facilities vault. Auxiliary pumps located in the mechanical space will draw from the reservoir and pump the water into the tipping buckets. The air break tank, pumps, and associated valves and controls will be located within the facilities vault mechanical space.

1.3.4 Conveyance

Approximately 100 feet of 12-inch-diameter gravity diversion sewer will convey excess combined sewage from the new diversion structure (installed between existing MH 060W-019 and MH 060W-014) to the new offline storage facility.

Approximately 100 feet of 8-inch-diameter force main will transfer the combined sewage from the offline storage tank to the new diversion structure.

These conveyance components are illustrated in Exhibit 9 in Appendix A

1.4 General Project Design Criteria

The following sections discuss the general project design criteria, such as specifications and drawing format, public art, and Leadership in Energy and Environmental Design (LEED) requirements, property and easement requirements, and permitting.

1.4.1 Specifications and Drawing Format

The project specifications will follow a combined approach that best meets the project goals. The project will follow the 49-Division Master Format 2010 established by the Construction Specifications Institute (CSI). Specifications for Divisions 0 and 1, which are general bidding requirements and general project requirements, will be in accordance with SPU standard specifications. Divisions 2 through 49, the technical sections, will be provided by the consultant team of HDR Engineering, Inc. (HDR) and CH2M HILL. A preliminary list of specifications to be incorporated in the design is presented in Section 1.5.

Project drawings will follow City of Seattle (City) SPU computer-aided design and drafting (CADD) guidelines. SPU CADD guidelines were established to ensure that work created by consultants hired by the City could be easily translated into the City's geographic information system (GIS). SPU CADD guidelines address the major components of drawings, such as symbology, sheet naming, borders, and line weights. The CADD software to be used on this project will be AutoCAD 2009 Civil 3D. Sheet-naming conventions will follow the sheet set manager documentation created by SPU in 2010.

1.4.2 Public Art / LEED Requirements

The proposed project will consist primarily of belowgrade structures. Therefore, there will not be a requirement for a public art component to the project.

In general, utility projects have difficulty complying with and achieving LEED certifications. Therefore, the project will not be pursuing LEED accreditation. However, the project team will keep environmental and LEED design considerations in the forefront and work to create a sustainable project.

1.4.3 Property Restrictions and Easement Requirements

Currently, both the 49th Avenue South and 53rd Avenue South Parking Lots are used by recreational users to gain access to the Lake Washington waterfront and adjoining trails. Primarily, impacts to these properties will be limited to the existing paved surfaces surrounding the site and any applicable restrictions (grants, regulations/ordinances, and codes).

1.4.4 Permitting

The anticipated permits and approvals required for the project were identified through consultation with the involved agencies and experience with similar projects and can be summarized as follows:.

49th Avenue South Parking Lot

Washington State Department of Ecology (Ecology)

- Facility Plan Approval

- National Pollutant Discharge Elimination System (NPDES) Construction Stormwater General Permit
- Approval of changes to Seattle's Shoreline Master Program

Seattle City Council

- Initiative 42 Approval (Park Lands Conversion)
- Partial Transfer of Jurisdiction

Seattle Department of Planning and Development (DPD)

- Final approval of Shoreline Master Program Update to allow CSO facilities within Conservancy Recreation shoreline environment
- Master Use Permit II – State Environmental Protection Act (SEPA)
- Master Use Permit – Shoreline Substantial Development Permit
- Clear and Grade Permit
- Building Permit – Storage Tank, Facilities Vault, and Shoring
- Electrical Permit
- Plumbing Permit
- Mechanical Permit

Seattle Department of Transportation (SDOT)

- Street Use Permit
- Street Improvement Permit

Public Health – Seattle and King County

- Health Permit (Air Gap)

King County

- Industrial Waste Discharge Permit

Puget Sound Clean Air Agency

- Air Quality Permit

53rd Avenue South Parking Lot (Urban Park and Recreation Recovery [UPARR] Grant Conversion Area/Parks Mitigation Area)

National Park Service

- Land Use Approval (Grant Conversion)
- National Environmental Policy Act Compliance

U.S. Army Corps of Engineers

- Section 404 Permit

U.S. Fish and Wildlife Service/National Oceanic and Atmospheric Administration Fisheries

- Endangered Species Act Compliance

Washington State Recreation and Conservation Office

- Land Use Approval

Ecology

- Facility Plan Approval
- NPDES Construction Stormwater General Permit
- Section 401 Water Quality Certification
- Coastal Zone Management Certification

Washington Department of Fish and Wildlife

- Hydraulic Project Approval

Washington Department of Archaeology and Historic Preservation

- Section 106 Consultation

Seattle City Council

- Initiative 42 Approval (Park Lands Conversion)
- UPARR Grant Amendment
- Type V Land Use Decision
- Partial Transfer of Jurisdiction

DPD

- Master Use Permit II – SEPA
- Master Use Permit – Shoreline Substantial Development Permit
- Clear and Grade Permit
- Building Permit – Storage Tank, Facilities Vault, and Shoring
- Electrical Permit
- Plumbing Permit
- Mechanical Permit

SDOT

- Street Use Permit
- Street Improvement Permit

Public Health – Seattle and King County

- Health Permit (Air Gap)

King County

- Industrial Waste Discharge Permit

Puget Sound Clean Air Agency

- Air Quality Permit

1.5 Specification List

Table 1 provides a preliminary list of specifications that are anticipated for the Genesee CSO Reduction Project. This list will be updated and revised as needed as the project progresses. Specification numbers are based on HDR standards, following Master Format 2010 from the CSI.

Table 1. Preliminary Specifications List

SECTION	TITLE
DIVISION 00	BIDDING REQUIREMENTS, CONTRACT FORMS, AND CONDITIONS OF THE CONTRACT (DIVISION 00 ANTICIPATED TO BE PREPARED BY CONTRACTS GROUP OF SPU)
00 11 13	Invitation to Bid
00 21 13	Instructions to Bidders
00 41 00	Bid Form
00 43 13	Bid Bond
00 43 43	Prevailing Wage Rates Form
00 45 13	Bidder's Qualifications
00 45 39	Minority Business Enterprise Affidavit
00 51 00	Notice of Award
00 52 00	Agreement
00 55 00	Notice to Proceed
00 61 13	Performance and Payment Bond Form
00 65 13	Contractor’s Compliance Statement
00 72 00	General Conditions
00 73 00	Supplementary Conditions
DIVISION 01	GENERAL REQUIREMENTS (PORTIONS OF DIVISION 01 MAY BE PREPARED BY CONTRACTS GROUP OF SPU)
01 11 00	Summary of Work
01 22 13	Unit Price Measurement
01 22 16	Unit Price Payment
01 25 13	Substitution Procedures
01 29 73	Schedule of Values
01 32 13	Scheduling of Work
01 32 16	Construction Progress Schedule
01 33 00	Submittal Procedures

SECTION	TITLE
01 41 00	Regulatory Requirements
01 42 13	Abbreviations and Acronyms
01 42 19	Reference Standards
01 45 00	Quality Control
01 51 00	Temporary Utilities
01 52 00	Construction Facilities
01 55 26	Traffic Control
01 57 19	Temporary Environmental Controls
01 66 00	Product Storage and Handling Requirements
01 71 13	Mobilization
01 73 20	Openings and Penetrations in Construction
01 73 29	Cutting and Patching
01 74 13	Cleaning
01 75 00	Starting and Adjusting
01 76 00	Protection of Existing Facilities
01 77 00	Closeout Procedures
DIVISION 02	EXISTING CONDITIONS
02 41 00	Demolition
DIVISION 03	CONCRETE
03 05 05	Testing
03 09 00	Concrete
03 11 13	Concrete Forming
03 21 00	Concrete Reinforcing
03 31 30	Concrete, Materials, and Proportioning
03 31 31	Concrete Mixing, Placing, Jointing, and Curing
03 35 00	Concrete Finishing
03 41 33	Precast Concrete
DIVISION 04	MASONRY (NOT USED)
DIVISION 05	METALS
05 50 00	Metal Fabrications
05 52 02	Aluminum Railings

SECTION	TITLE
DIVISION 06	WOOD, PLASTICS, AND COMPOSITES
06 82 00	Glass-fiber-reinforced Plastic
DIVISION 07	THERMAL AND MOISTURE PROTECTION
07 16 16	Crystalline Cementitious Waterproofing
07 92 00	Joint Sealants
DIVISION 08	OPENINGS
08 31 00	Access Doors
08 90 00	Louvers and Vents
DIVISION 09	FINISHES
09 51 00	Acoustical Materials
09 91 00	Painting
DIVISION 10	SPECIALTIES
10 14 00	Identification Devices
10 14 23	Signage
10 44 33	Fire Extinguishers
DIVISION 11	EQUIPMENT (NOT USED)
DIVISION 12	FURNISHINGS (NOT USED)
DIVISION 13	SPECIAL CONSTRUCTION (NOT USED)
DIVISION 14	CONVEYING EQUIPMENT (NOT USED)
DIVISION 21	FIRE SUPPRESSION (NOT USED)
DIVISION 22	PLUMBING
22 20 00	Plumbing Fixtures and Equipment
DIVISION 23	HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)
23 05 93	HVAC Systems: Balancing and Testing
23 09 00	Instrumentation and Control for HVAC Systems
23 31 00	HVAC: Ductwork
23 80 00	HVAC: Equipment
DIVISION 25	INTEGRATED AUTOMATION (NOT USED)
DIVISION 26	ELECTRICAL
26 05 00	Electrical: Basic Requirements
26 05 09	Motors
26 05 13	Medium Voltage Cable

SECTION	TITLE
26 05 19	Wire And Cable: 600 Volt and Below
26 05 26	Grounding
26 05 33	Raceways and Boxes
26 05 43	Electrical: Exterior Underground
26 08 13	Acceptance Testing
26 09 13	Electrical Metering Devices
26 09 16	Control Equipment Accessories
26 12 19	Distribution Transformers
26 22 13	Dry-Type Transformers
26 23 00	Switchgear
26 24 13	Switchboards
26 24 16	Panelboards
26 24 19	Motor Control Equipment
26 27 26	Wiring Devices
26 28 00	Overcurrent and Short Circuit Protective Devices
26 28 16	Safety Switches
26 29 13	Reduced Voltage Solid State Starters - Low Voltage
26 29 23	Variable Frequency Drives - Low Voltage
26 43 13	Low Voltage Surge Protection Devices (SPD)
26 50 00	Interior and Exterior Lighting
DIVISION 27	COMMUNICATIONS
27 05 02	Telecommunication System
27 21 00	Telemetry Systems
DIVISION 28	ELECTRONIC SAFETY AND SECURITY
28 31 00	Fire Detection and Alarm
DIVISION 31	EARTHWORK
31 10 00	Site Clearing
31 23 00	Earthwork
31 23 19	Dewatering
31 23 33	Trenching and Backfilling
31 25 00	Erosion and Sedimentation Control
31 38 10	Geotextiles

SECTION	TITLE
31 41 00	Shoring
DIVISION 32	EXTERIOR IMPROVEMENTS
32 12 16	Asphaltic Concrete Vehicular Paving
32 16 13	Concrete Curb and Gutter
32 20 10	Concrete Sidewalk and Steps
32 84 00	Irrigation System
32 91 19.13	Topsoil Placement and Grading
32 92 00	Turf and Grasses
32 93 00	Plants
DIVISION 33	UTILITIES
33 05 13 33 05 16	Maintenance Holes and Structures Utility Structures
33 09 30	Instrumentation and Control for Sanitary Sewerage Utilities: General
33 11 13	Water Main Construction
33 12 19	Water Utility Distribution Fire Hydrants
33 40 00	Storm Drainage System
33 46 13	Foundation Drainage
DIVISION 34	TRANSPORTATION (NOT USED)
DIVISION 35	WATERWAY AND MARINE CONSTRUCTION (NOT USED)
DIVISION 40	PROCESS INTEGRATION
40 05 05	Equipment: Basic Requirements
40 05 13	Pipe and Pipe Fittings: Basic Requirements
40 05 16	Pipe Support Systems
40 05 23	Valves: Basic Requirements
40 20 13	Pipe: Steel
40 20 16	Pipe: Ductile
40 20 19	Pipe: Copper
40 20 23	Pipe: Plastic
40 41 13	Heat Tracing Cable
40 42 00	Pipe, Duct, and Equipment Insulation
40 50 05	Gate Valves
40 50 10	Plug Valves

SECTION	TITLE
40 50 15	Butterfly Valves
40 50 20	Ball Valves
40 50 25	Globe Valves
40 50 30	Check Valves
40 50 35	Miscellaneous Valves
40 60 05	Water Control Gates
40 90 00	Control Loop Descriptions
40 91 10	Primary Elements and Transmitters
40 93 00	Controllers
40 94 43	Programmable Logic Controller Control System
40 95 00	Recorders and Indicators
40 97 00	Control Auxiliaries
40 98 00	Control Panels and Enclosures
DIVISION 41	MATERIAL PROCESSING AND HANDLING EQUIPMENT
41 67 19	Plant Safety Equipment
DIVISION 42	PROCESS HEATING, COOLING, AND DRYING EQUIPMENT (NOT USED)
DIVISION 43	PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT
43 21 00	Pumping Equipment: Basic Requirements
43 21 09	Pumping Equipment: Horizontal Split Case Centrifugal Pumps
43 21 22	Pumping Equipment: Submersible Non-clog
43 41 23	Fiberglass Reinforced Plastic Tanks
DIVISION 44	POLLUTION AND WASTE CONTROL EQUIPMENT
44 31 00	Odor Reduction System
DIVISION 45	INDUSTRY-SPECIFIC MANUFACTURING EQUIPMENT (NOT USED)
DIVISION 46	WATER AND WASTEWATER EQUIPMENT
46 46 13	Tipping Sediment Flushing Tanks
DIVISION 48	ELECTRICAL POWER GENERATION (NOT USED)

1.6 Drawing List

Table 2 provides a preliminary list of drawings that are anticipated for the Genesee CSO Reduction Project. This list will be updated and revised as needed as the project progresses.

Table 2. Preliminary Drawing List

DRAWING NUMBER	TITLE
GENERAL	
G001	Cover Sheet and Vicinity Maps
G002	Drawing List, Sheet 1 of 2
G003	Drawing List, Sheet 2 of 2
G004	Standard Symbols
G005	Standard Abbreviations
G006	General Notes, Clearing and Grading, Sheet 1 of 2
G007	General Notes, Construction, Sheet 2 of 2
G008	Dewatering Treatment, System Schematic
G009	Hauling Routes, 49th Avenue South
G010	Traffic Control Plan, 49th Avenue South, Sheet 1 of 2
G011	Traffic Control Plan, 49th Avenue South, Sheet 2 of 2
G012	Construction Sequencing, and Staging - Phase 1, 49th Avenue South
G013	Construction Sequencing, and Staging - Phase 2, 49th Avenue South
G014	Hauling Routes, 53rd Avenue South
G015	Traffic Control Plan, 53rd Avenue South, Sheet 1 of 2
G016	Traffic Control Plan, 53rd Avenue South, Sheet 2 of 2
G017	Construction Sequencing, and Staging - Phase 1, 53rd Avenue South
G018	Construction Sequencing, and Staging - Phase 2, 53rd Avenue South
G019	Temporary Shoring, Design Criteria, Sheet 1 of 2
G020	Temporary Shoring, Design Criteria, Sheet 2 of 2
G021	Hydraulic Schematic, 49th Avenue South
G022	Hydraulic Profile, 49th Avenue South
G023	Hydraulic Schematic, 53rd Avenue South
G024	Hydraulic Profile, 53rd Avenue South
CIVIL	
C101	Overall Plan, 49th Avenue South
C102	Existing Site Plan and Survey Data, 49th Avenue South, Sheet 1 of 2
C103	Existing Site Plan and Survey Data, 49th Avenue South, Sheet 2 of 2
C104	TESC Plan, 49th Avenue South, Sheet 1 of 2

DRAWING NUMBER	TITLE
C105	TESC Plan, Storage Tank and Parking Lot, Sheet 2 of 2
C106	Site Clearing and Demolition Plan, Storage Tank and Parking Lot
C107	Grading and Paving Plan, Storage Tank and Parking Lot
C108	Grading Sections and Details, Storage Tank and Parking Lot
C109	Drainage Plan, Storage Tank and Parking Lot
C110	Jointing Plan, 49th Avenue South, SDOT
C111	Paving Plan, Lake Washington Boulevard, SDOT
C112	Intersection Grading, 49th Avenue South, SDOT
C113	Signing and Stripping, 49th Avenue South, SDOT
C114	Signing and Stripping, Lake Washington Boulevard, SDOT
C115	Diversion Sewer, Plan and Profile, 49th Avenue South
C116	Stormwater, Plan and Profile, 49th Avenue South
C201	Overall Plan, 53rd Avenue South
C202	Existing Site Plan and Survey Data, 53rd Avenue South, Sheet 1 of 2
C203	Existing Site Plan and Survey Data, 53rd Avenue South, Sheet 2 of 2
C204	TESC Plan, 53rd Avenue South, Sheet 1 of 2
C205	TESC Plan, Storage Tank and Parking Lot, Sheet 2 of 2
C206	Site Clearing and Demolition Plan, Storage Tank and Parking Lot
C207	Grading and Paving Plan, Storage Tank and Parking Lot
C208	Grading Sections and Details, Storage Tank and Parking Lot
C209	Drainage Plan, Storage Tank and Parking Lot
C210	Paving Plan, South Alaska St/53rd Avenue South, Seattle Department of Transportation (SDOT)
C211	Paving Plan, Lake Washington Boulevard, SDOT
C212	Intersection Grading, 53rd Avenue South, SDOT
C213	Signing and Stripping, South Alaska St/ 53rd Avenue South, SDOT
C214	Signing and Stripping, Lake Washington Boulevard, SDOT
C215	Diversion Sewer, Plan and Profile, South Alaska Street
C216	Diversion Sewer, Plan and Profile, 53rd Avenue South
C219	Drainage, Plan and Profile, 53rd Avenue South
C220	Drainage, Plan and Profile, South Alaska Street
C221	Force Main, Plan and Profile
C301	TESC General Notes

DRAWING NUMBER	TITLE
C302	TESC Site Preparation, Construction Notes, and Legends
C303	TESC Details
C304	Paving Notes, SDOT
C305	Paving Details, SDOT
C306	Miscellaneous Details and Sections
C307	Miscellaneous Details and Sections
C308	Miscellaneous Details and Sections
LANDSCAPING	
L101	Irrigation Plan, 49th Avenue South
L102	Planting Plan, 49th Avenue South
L103	Irrigation Plan, 53rd Avenue South
L104	Planting Plan, 53rd Avenue South
L105	Planting Schedule
L106	Planting Details
L107	Planting Details
L108	Irrigation Schedule
L109	Irrigation Details
L110	Irrigation Details
ARCHITECTURAL	
A001	Architectural, Facility Code Information
A002	Architectural, Schedules
STRUCTURAL	
S001	Structural, General Notes, Sheet 1 of 2
S002	Structural, General Notes, Sheet 2 of 2
S003	Structural, Statement of Special Inspection, Sheet 1 of 3
S004	Structural, Statement of Special Inspection, Sheet 2 of 3
S005	Structural, Statement of Special Inspection, Sheet 3 of 3
S006	Structural, Standard Details, Concrete
S007	Structural, Standard Details, Concrete
S008	Structural, Standard Details, Reinforcement
S009	Structural, Standard Details, Structural Steel
S010	Structural, Typical Details, Electrical and Mechanical Support

DRAWING NUMBER	TITLE
S011	Structural, Typical Details, Connections
S012	Structural, Typical Details, Connections
S101	Structural, 49th Avenue South—Storage Tank, Foundation and Bottom Plan
S102	Structural, 49th Avenue South—Storage Tank, Plan at Elevation
S103	Structural, 49th Avenue South—Storage Tank, Plan at Grade
S104	Structural, 49th Avenue South—Storage Tank, Cross-sections
S105	Structural, 49th Avenue South—Storage Tank, Cross-sections
S106	Structural, 49th Avenue South—Storage Tank, Partial Bottom Plans
S107	Structural, 49th Avenue South—Storage Tank, Partial Bottom Plans
S108	Structural, 49th Avenue South—Storage Tank, End Sump Plan
S109	Structural, 49th Avenue South—Storage Tank, Sections
S111	Structural, 49th Avenue South—Storage Tank, Sections
S201	Structural, 53rd Avenue South—Storage Tank, Foundation and Bottom Plan
S202	Structural, 53rd Avenue South—Storage Tank, Plan at Elevation
S203	Structural, 53rd Avenue South—Storage Tank, Plan at Grade
S204	Structural, 53rd Avenue South—Storage Tank, Cross-sections
S205	Structural, 53rd Avenue South—Storage Tank, Cross-sections
S206	Structural, 53rd Avenue South—Storage Tank, Partial Bottom Plans
S207	Structural, 53rd Avenue South—Storage Tank, Partial Bottom Plans
S208	Structural, 53rd Avenue South—Storage Tank, End Sump Plan
S209	Structural, 53rd Avenue South—Storage Tank, Sections
S210	Structural, 53rd Avenue South—Storage Tank, Sections
S211	Structural, Storage Tank, Details
S212	Structural, Storage Tank, Details
S213	Structural, Storage Tank, Beam Details and Schedule
S301	Structural, Facilities Vault, Foundation and Bottom Plan
S302	Structural, Facilities Vault, Top Slab Plan
S303	Structural, Facilities Vault, Sections
S304	Structural, Facilities Vault, Sections
S305	Structural, Facilities Vault, Details
S306	Structural, Facilities Vault, Details
S701	CSO 11 Retrofit (49th Avenue South), Diversion Structure, Plans

DRAWING NUMBER	TITLE
S702	CSO 11 Retrofit (49th Avenue South), Diversion Structure, Sections
S703	CSO 11 Retrofit (49th Avenue South), Diversion Structure, Details
S704	CSO 9 Retrofit (53rd Avenue South), Diversion Structure, Plans
S705	CSO 9 Retrofit (53rd Avenue South), Diversion Structure, Sections
S706	CSO 9 Retrofit (53rd Avenue South), Diversion Structure, Details
MECHANICAL	
M001	Mechanical Typical Details and Notes, Sheet 1 of 2
M002	Mechanical Typical Details and Notes, Sheet 2 of 2
M003	Pipe Hangers and Support Systems, Tables
M004	Pipe Hangers and Support Systems, Details
M005	Pipe Seismic Restraints, Details and Notes
M006	HVAC Ductwork, Details and Notes
M101	Yard Piping and Odor Control, Ductwork Plan, Storage Tank, and Parking Lot
M102	Mechanical, 49th Avenue South - Storage Tank, Plan
M103	Mechanical, 49th Avenue South - Storage Tank Pump Equipment, Plan and Sections
M104	Mechanical, 49th Avenue South - Storage Tank Valve Vault, Plan and Sections
M105	Mechanical, 49th Avenue South - Storage Tank Interior Piping, Plan and Sections
M201	Yard Piping and Odor Control, Ductwork Plan, Storage Tank and Parking Lot
M202	Mechanical, 53rd Avenue South - Storage Tank, Plan
M203	Mechanical, 53rd Avenue South - Storage Tank Pump Equipment, Plan and Sections
M204	Mechanical, 53rd Avenue South - Storage Tank Valve Vault, Plan and Sections
M205	Mechanical, 53rd Avenue South - Storage Tank Interior Piping, Plan and Sections
M206	Mechanical, Tipping Bucket Assembly, Plan and Sections
M207	Mechanical, Tipping Bucket Assembly, Fill Piping
M301	Mechanical, Facilities Vault, Plan
M302	Mechanical, Facilities Vault, Odor Control Room, Plan and Section
M303	Mechanical, Facilities Vault, Electrical/Mechanical Room, Plan and Section
M304	Mechanical, Facilities Vault, Valve Room, Plan and Section
M305	Mechanical, Facilities Vault, Sections and Details
M306	Mechanical, Facilities Vault, Sections and Details
M401	Mechanical, Air Gap Tank Construction, and Installation
M402	Mechanical, HVAC Details,

DRAWING NUMBER	TITLE
ELECTRICAL	
E001	Electrical Abbreviations and Symbols
E101	Electrical, Site Plan, 49th Avenue South
E102	Electrical, Power Plan, 49th Avenue South
E103	Electrical, Lighting Plan, 49th Avenue South
E104	Electrical, Site Plan, 53rd Avenue South
E105	Electrical, Power Plan, 53rd Avenue South
E106	Electrical, Lighting Plan, 53rd Avenue South
E201	Electrical, One-line Diagram
E201	Electrical, One-line Diagram
E202	Electrical, Block Diagram
E202	Electrical, Block Diagram
E301	Electrical, Equipment Elevations
E401	Electrical, Details 1
E401	Electrical, Details 1
E501	Electrical Schedules - Lighting, Panelboards, Conduit, and Cable
E501	Electrical Schedules - Lighting, Panelboards, Conduit, and Cable
E601	Electrical, Control Diagrams
E601	Electrical, Control Diagrams
E701	Electrical, CSO 11 Retrofit (49th Avenue South), Site Plan
E701	Electrical, CSO 11 Retrofit (49th Avenue South), One-line Diagram
E702	Electrical, CSO 11 Retrofit (49th Avenue South), Panelboard
E703	Electrical, CSO 11 Retrofit (49th Avenue South), Control Cabinet
E704	Electrical, CSO 9 Retrofit (53rd Avenue South), Site Plan
E704	Electrical, CSO 9 Retrofit (53rd Avenue South), One-line Diagram
E705	Electrical, CSO 9 Retrofit (53rd Avenue South), Panelboard
E706	Electrical, CSO 9 Retrofit (53rd Avenue South), Control Cabinet
INSTRUMENTATION AND CONTROLS	
P001	Instrumentation Legend
P002	Instrumentation Block Diagram
P101	Process and Instrumentation Diagram (P&ID), Odor Control System
P102	P&ID, Vault Ventilation

DRAWING NUMBER	TITLE
P103	P&ID, Gas Monitoring
P104	P&ID, Wash Water System
P105	P&ID, Sump Pumps
P106	P&ID, Cleaning Water Pumps
P201	Main Control Panel Elevation
P301	Standard Instrumentation, Details 1
P701	CSO 11 Retrofit (49th Avenue South), P&ID
P702	CSO 11 Retrofit (49th Avenue South), Power Distribution
P703	CSO 11 Retrofit (49th Avenue South), I/O Module Connections
P704	CSO 9 Retrofit (53rd Avenue South), P&ID
P705	CSO 9 Retrofit (53rd Avenue South), Power Distribution
P706	CSO 9 Retrofit (53rd Avenue South), I/O Module Connections
P707	CSO 11 Retrofit, Instrumentation Detail

2 Site Civil

This section details the design criteria for the civil engineering elements of site grading, drainage, pavement, access, erosion control, new and existing utilities, and site and yard piping for the project components at the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site.

2.1 Existing Site Characteristics

2.1.1 49th Avenue South Parking Lot

Exhibit 1 in Appendix A shows an aerial view of the 49th Avenue South Parking Lot site. The site encompasses approximately 1 acre and is roughly triangular in shape. The parking lot is generally oriented northwest by southeast across the site. Access to the site currently is provided at two primary locations, one on the southeastern side (which is currently blocked off with bollards) of the area and one on the northern side. The northern access distributes vehicles onto Lake Washington Boulevard South; the southeastern access distributes vehicles onto both Lake Washington Boulevard South and 49th Avenue South. The unpaved part of the site is covered with turf and other forms of vegetation. The western and southern sides are landscaped with mature evergreen and deciduous trees.

The parking lot is at or slightly above the elevation of the Lake Washington Boulevard right-of-way to the north. The parking lot grading is generally from north to south, with an elevation differential of 4 feet between the higher, northern end and the lower, southern end. Onsite runoff from the paved portions of the site is collected by the storm drainage system in the southeast corner of the parking lot. Runoff from the remainder of the site infiltrates into the ground or runs into the right-of-way, where it is collected.

A curb, gutter, narrow landscaped area, and sidewalk are located along both sides of the 49th Avenue South right-of-way. The existing driving surface on 49th Avenue South is concrete pavement and is generally in good condition, with minimal rutting or potholing.

2.1.2 53rd Avenue South Parking Lot

Exhibit 9 in Appendix A shows an aerial view of the 53th Avenue South Parking Lot site. The existing parking lot at 53rd Avenue South and Lake Washington Boulevard South is nearly 1 acre in size and curves from the north to the south. Access to the site is provided at two primary locations, one on the northwestern side of the site and one on the southwestern side. Both locations distribute vehicles onto Lake Washington Boulevard South. The unpaved part of the site is covered with turf and other forms of vegetation.

The overall site is at or slightly below the elevation of the Lake Washington Boulevard right-of-way to the south. Site slope is generally from southwest to northeast, with an elevation differential of approximately 2 feet between the higher, southwestern end and the lower, northeastern end. Onsite runoff from the paved portions of the site is collected by the storm drainage system in the northeast side of the parking lot and discharged into Lake Washington. Runoff from the remainder of the site infiltrates into the ground.

2.2 Proposed Site and Right-of-way Modifications

2.2.1 49th Avenue South Parking Lot and Right-of-way

The southern portion of the site dedicated for improvements encompasses approximately 5,200 square feet (ft^2) of the total 46,000 ft^2 of the site. The storage tank footprint will encompass approximately 4,000 ft^2 or 0.09 acre. According to DPD, single-family residence zoning of the site requires a 5-foot setback from the northern and southern property lines. The existing site dimensions will provide adequate space for most excavation support systems around the storage tank sides, as well as space for construction workers to safely walk at grade around the open excavation on all sides.

Odor control and electrical and other mechanical equipment not installed inside the storage tank will be housed in an adjacent buried structure called the “facilities vault,” to be located to the southeast of the storage facility. The facilities vault will be approximately 25 feet wide by 40 feet long and consist of two separated spaces. Electrical gear including motor starters, control panels and other instrumentation, potable water pumps, flushing water storage tank, and miscellaneous mechanical equipment and other items associated with the flushing water system will be housed in the southernmost room. Odor control equipment including the carbon scrubber vessel, odor fan, and mist eliminator will be located in the northernmost space. HVAC equipment will be included in each room.

Exhibit 2 in Appendix A shows the conceptual final site plan for the site and the parts of the public rights-of-way along Lake Washington Boulevard and 49th Avenue South that will be disturbed. Additional improvements along 49th Avenue South and South Dakota Street are shown in Exhibit 1. A plan and profile of the diversion sewer is shown in Exhibit 4.

The 49th Avenue South Parking Lot site will modify the existing site and right-of-way with the following additions or changes:

- Approximately 400 linear feet of curb, gutter, and sidewalk along the western shoulder of the road between Lake Washington Boulevard South and South Dakota Street, along with new/replacement curb ramp landings
- Hatches to access new, buried facilities in the paved areas at the parking lot because of park restrictions
- New aboveground HVAC intake and exhaust vents
- New stormwater, water, and sewer piping at the site
- New sidewalk improvements to the rights-of-way at the intersection of Lake Washington Boulevard and 49th Avenue South
- Full-width concrete panel pavement replacement of 49th Avenue South between Lake Washington Boulevard and South Dakota Street
- Rebuilt northern entrance into the parking lot from Lake Washington Boulevard and elimination of southeastern parking lot entrance
- Underground stormwater treatment vaults locate offsite and in the parking lot
- Temporary contractor parking located on surrounding streets

Design criteria for abovegrade surface features (for example, electrical cabinets) and buried structures, stormwater structures and water quality features, and landscaping are discussed in other sections.

Pavement removal will be required to construct the storage diversion pipe across Lake Washington Boulevard South. Pavement removal and restoration in the right-of-way will conform to SDOT Director's Rule Street and Sidewalk Pavement Opening and Restoration Rules 2005-09.

2.2.2 53rd Avenue South Parking Lot

The new storage tank will be located in the southern portion of the 53rd Avenue South Parking Lot site. This area encompasses approximately 4,000 ft^2 of the total 44,000 ft^2 of the site. At its current design dimensions, the tank footprint will be approximately 2,500 ft^2. The existing site area will provide adequate space for construction of most excavation support systems around the tank sides, as well as space for construction workers to safely walk at grade on all sides of the open excavation.

Odor control and electrical and other mechanical equipment not installed inside the storage tank will be housed in an adjacent buried structure called the "facilities vault," located to the south of the storage facility. The facilities vault will be approximately 25 feet wide by 45 feet long and consist of two separated spaces. Electrical gear including motor starters, control panels and other instrumentation, potable water pumps, flushing water storage tank, and miscellaneous mechanical equipment and other items associated with the flushing water system will be housed in the southernmost room. Odor control equipment including the carbon scrubber vessel, odor fan, and mist eliminator will be located in the northernmost space. HVAC equipment will be included in each room.

Exhibits 10 and 11 in Appendix A show the conceptual final site plan for the site and the disturbed parts of the public rights-of-way along Lake Washington Boulevard. Additional improvements along 53rd Avenue South and South Alaska Street are shown in Exhibit 12 and 13.

The 53rd Avenue South Parking Lot site will modify the existing site and right-of-way with the following additions or changes:

- Approximately 650 linear feet of curb and gutter constructed along the western shoulder of 53rd Avenue South and along the northern shoulder of South Alaska Street
- Hatches to access new buried facilities in the paved areas at the parking lot because of park restrictions
- New abovegrade HVAC intake and exhaust plenums located in the planted median between the parking lot and Lake Washington Boulevard
- New stormwater, water, and sewer piping at the site
- Full-width concrete panel pavement replacement at the intersection of 53rd Avenue South and Lake Washington Boulevard
- Underground stormwater treatment vaults located offsite and in the parking lot
- Temporary contractor parking located on surrounding streets

Design criteria for abovegrade surface features (for example, electrical cabinets) and buried structures, stormwater structures, and water quality features, and landscaping are discussed in other sections.

2.2.3 53rd Avenue South Parking Lot – Right-of-way

Several ancillary features of the storage tank and facilities vault will be located in the planting median between Lake Washington Boulevard South and the parking lot. The ancillary features include two abovegrade air exhaust vents, an abovegrade backflow prevention device located within a protective cover, a belowgrade water service meter, an access hatch to the odor control system, and an access hatch for the carbon bed in the parking lot (related to the odor control system). Access hatches will be provided with non-slip coating to reduce the risk of slipping when wet.

Pavement removal will be required to construct the storage diversion pipe across Lake Washington Boulevard South. Pavement removal and restoration in the right-of-way will conform to SDOT Director's Rule Street and Sidewalk Pavement Opening and Restoration Rules 2005-09.

2.3 Civil Engineering Design Criteria

This section discusses the design criteria for the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site.

2.3.1 49th Avenue South Parking Lot

2.3.1.1 Site Demolition, Grading, and Earthwork

Site demolition at the 49th Avenue South Parking Lot site will consist of the following:

- Removal of existing parking lot pavement
- Removal of 50 linear feet of existing 8-inch stormwater pipe running from the northeast to the southwest through the center of the parking lot

Site grading and earthwork will be coordinated to minimize disturbance to the surrounding areas. Erosion and sedimentation controls will be integrated into the contract documents and into the final design. Both permanent and temporary movement of earth on development sites is regulated by Seattle's Stormwater Code. This regulation (Chapters 22.800 through 22.808 of the Seattle Municipal Code [SMC]) protects the graded site and adjoining public and private properties, preserves natural drainage patterns and watercourses, and controls pollution.

Grading at the 49th Avenue South Parking Lot site will be designed to direct surface water runoff away from hatches and openings and toward new stormwater collection structures. Earthwork will consist primarily of excavating and stockpiling materials for sorting, reuse, and disposal. Selective earthwork, including soil placement and fine grading, will be determined based on the landscaping/architectural finish refined during the design phase. Geotechnical data collected as part of final design for use in designing the underground structures will also be used for assessing site grading and other earthwork requirements.

Site Clearing and Grading

Areas for site clearing and grading will be identified with coordinates on the construction drawings. Protected trees and other vegetation at the 49th Avenue South Parking Lot site will be denoted with defined limits on the construction drawings. Trees and other vegetation within clearing zones will be cleared and grubbed as necessary, including stump removal. Organic soils will be stripped and stockpiled by the contractor for potential reuse on the project. Utilities required for the project and extensions of permanent structures will be located to reduce the removal of existing vegetation.

Survey control points will be set to control final grades. If a temporary grading plan is required and developed during the design phase, those control points will also be delineated on the drawings. The City of Seattle survey datum will be used for this project.

The site is currently graded and surfaced with asphalt concrete pavement. Areas surfaced with gravel and pavement is considered impervious surfaces based on the current City of Seattle Stormwater Management Manual. This project will replace more than 5,000 ft^2 of impervious surface, and is, therefore, required to analyze the downstream system within 0.25 mile of the site to ensure sufficient capacity of the drainage system (SMC 22.805.020.J). Further information on the stormwater system is provided in Section 3 3.

Final and temporary grading will minimize runoff velocities to the extent possible. Slopes will be adjusted as necessary to complete the design layout. Best management practices (BMPs) such as the use of hydroseeding, jute mat covers, and filter inserts will be incorporated into the final design to prevent erosion of exposed site soils and sedimentation of installed stormwater facilities. No final slopes will be greater than two horizontal to one vertical unless supported by an engineered retaining structure or other engineered methods.

Earthwork

Materials that are stockpiled onsite will be covered by a tarpaulin to minimize erosion and control fugitive dust during construction. Stockpiled soil piles will not be higher than 10 feet from the surrounding area and will be sloped no steeper than 1:1.

Limits of construction delineated on the construction drawings for facilities and utilities will provide adequate room for installing most types of shoring for deep excavations, making acceptable cutbacks for excavations where available, and using trench boxes where applicable. Shoring will be designed and installed by the contractor according to an approved shoring plan.

Fill will consist of earthen materials. Rocks and other irreducible material will be less than 4 inches in diameter and comprise less than 10 percent of the fill volume. Recycled materials (concrete, asphalt) will be allowed only as dictated in the City of Seattle Standard Specifications and Plans for Road, Bridge and Municipal Construction, 2011 Edition (City Standard Plans). Topsoil will not be used as fill material except for the upper 12 inches of any area that will not be subject to vehicular traffic.

2.3.1.2 Paving and Roadway Surfaces

Paved surfaces removed as part of the project will be replaced, with the exception of the north parking lot entrance. Replacement will be a standard pavement section of 4 inches of hot-mix asphalt (HMA) Class 1 over 6 inches of Type 2 crushed rock. Materials will be provided according to the City Standard Plans.

Asphalt and Cement Concrete Surfaces

- All surfaces will be HS-25 rated for loading.
- All asphalt concrete surfaces will be a minimum of 4 inches thick of HMA Class 1 asphalt paving installed in 2-inch lifts underlain by a 6-inch minimum lift of crushed base course.

- All cement traffic-bearing surfaces located on project site will be a minimum of 6 inches thick, underlain by a 6-inch minimum lift of crushed base course.
- All surfaces located within the public right-of-way for this project will be constructed according to the City Standard Plans.

Vehicle clearances and turning radii for maintenance vehicles currently owned by SPU will be used to size and locate access roads, driveways, turnarounds, and other surface features necessary to allow for full access by vehicles to the service locations at the facilities vault (for example, carbon fill ports, demister pad removal hatch, lifting slab). Emergency vehicles (fire department ladder truck) may also be used to analyze final clearances during design.

2.3.1.3 Accessibility (ADA Compliance)

The facility design will not include abovegrade structures or any structures that will be accessed by the public. However, future use of the site must account for accessibility in the design of site grading and other features. Accessibility will meet City and federal requirements, including compliance with the Americans with Disabilities Act (ADA) and ADA Accessibility Guidelines (ADAAG) for nonresidential buildings. The site design will not address existing accessibility issues outside the identified work limits for the project. Areas excluded will include existing areas that are outside the project work limits on the site and affected right-of-way areas.

ADA Standards for Accessible Design (Title 28, Chapter 38, of the *Code of Federal Regulations* [CFR]) will be used for design of ADA ramps, paved or marked walkways and access ways, and slopes across the site. City Standard Plan 420 will be used as the basis of design for ADA curb ramps at the street crossings at Lake Washington Boulevard and 49th Avenue South. City Standard Plan 422a and 422b will be used as the basis of design for ADA-compliant curb ramps to be located on the site.

2.3.1.4 Site Access

Site access is currently by two driveways. The northern driveway provides access for cars heading south along Lake Washington Boulevard, and the southeastern one provides access at the intersection of 49th Avenue South and Lake Washington Boulevard. Both of these accesses can be blocked off to traffic by Parks with bollards.

Temporary Vehicle and Pedestrian Access During Construction

Temporary construction vehicle access to the 49th Avenue South Parking Lot site during construction will be through the existing northern and southeastern entrances to the lot. Construction and emergency vehicles will be able to use these entrances for access to the site. Flaggers will control traffic accessing and exiting the site.

If required, specific temporary vehicle access design criteria will include the following:

- Temporary access routes will be surfaced with 4-inch quarry spalls.
- Temporary stabilized construction entrances or vehicle washes will be employed at access points to Lake Washington Boulevard in accordance with the City Standard Plans.

No pedestrian pathways currently exist in the 49th Avenue South Parking Lot site. The existing pedestrian pathway on the northeast side of Lake Washington Boulevard will not be affected or modified as part of this project. The sidewalk at the intersection of 49th Avenue South and Lake Washington Boulevard will be closed during construction of the new primary control structure and related piping. Pedestrian access to the east and west sides of 49th Avenue South may be limited at times during construction of the new sewer located in the street.

Permanent Site Access

Permanent access to the parking lot will be provided by the modified northern entrance from Lake Washington Boulevard. SPU operations and maintenance (O&M) vehicles and emergency vehicles will require access to and through the site. The following design requirements will be used for public, SPU O&M, and emergency vehicles:

- The entrance driveway will be 20 feet wide across the site to accommodate traffic in two directions.
- Curb cut spacing will conform to SMC 23.54.030 F.
- The new driveway will be constructed in accordance with City Standard Plan 430.
- A maximum slope of 10 percent will be used for the new driveway. This is approximately the slope of the existing driveway and is the maximum allowed by SMC 23.54.030 C.4.
- Parking spaces may not exceed 9 feet by 20 feet and must meet the loading requirements set forth in City Standard Plan 430 or 431.
- In accordance with the Seattle Land Use Code (Title 23 of the SMC), vertical curves may be required at the top and bottom of the driveway. The vertical curve will begin at the property line, not in the right-of-way.
- Driveway elevations at the property line will meet the elevations shown on the Building Grade Sheet and meet Seattle Land Use Code driveway slope and vertical curve requirements. The driveway will be designed so that any changes in driveway slope that may be needed as a result of future grading in the right-of-way will comply with driveway requirements specified in the Seattle Land Use Code.

Permanent access to the storage tank and facilities vault will be located in the southern end of the existing parking lot. Access hatches for routine and emergency maintenance will be located in the paved area. All access hatches will be rated for HS-25 loading. Removable lifting slabs will be configured in other areas of the tank lid for less frequent maintenance activities. Facilities vault access will be through hatches adjacent to the designated parking spaces within the parking lot.

2.3.1.5 Parking at 49th Avenue South Parking Lot

The 49th Avenue South Parking Lot site is currently used as a public parking lot for the adjacent Lake Washington Boulevard Park. The parking lot is typically closed to the public from dusk until sunrise. Parks controls access to the site with removable bollards on both entrances. There are no marked parking spaces on the site. Existing parking is informal across the site, which is generally wide open and surfaced for vehicular traffic.

Temporary Parking During Construction

Temporary parking for construction worker traffic will be provided offsite along 48th Avenue South and South Dakota Street. Space for up to approximately 20 vehicles will be provided within 0.5 mile of the site. Additional parking information, is provided in the SDOT parking rules and regulations and the project-specific SEPA document.

Permanent Parking Post-construction

Marked parking for O&M vehicles will be limited to two parking stalls located in the new paved parking lot at the 49th Avenue South Parking Lot site. In addition, approximately 20 marked parking spots will be provided for the public.

All parking stalls will conform to SMC 23.54.030 (Parking Space Standards). Relevant criteria include the following:

- "Large vehicle" means that the minimum size of a large vehicle parking space will be 8.5 feet in width and 19 feet in length.

2.3.1.6 Site Lighting

The current layout of the site will not have any lighting. Site lighting will be evaluated during design to consider proposed planting locations, access to the new buried storage tank and facilities vault, and O&M needs.

2.3.1.7 Temporary Erosion and Sediment Control

Temporary erosion and sediment control for the 49th Avenue South Parking Lot site will be developed in accordance with the 2009 Stormwater Code (SMC 22.800 through 22.808) and the City Standard Plans, including Sections 2-08 and 8-01. As required for the design, silt fences, straw bales, mulching, matting, sediment traps, protective berms, and other methods will be used to prevent sediment and runoff from creating problems in utilities and adjacent properties. For this project, temporary erosion and sediment control information will be developed on the site drawings and as part of the technical specifications.

During construction, the contractor will be required to incorporate practices that prevent or control erosion. A Construction Stormwater Control Plan (CSCP) will be prepared by the engineer and be reviewed by the City prior to construction to ensure that these requirements will be met.

2.3.1.8 Survey Control

Survey control will be established using monuments in Lake Washington Boulevard, 49th Avenue South, and South Dakota Street, as well as any benchmarks established by the project survey team during site surveys. These points will be confirmed by the contractor’s surveyor, and adjustments will be made as warranted prior to construction.

Monuments will be protected as required by RCW 65.04.045 and prescribed by the Washington Department of Natural Resources, Public Land Survey Office (PLSO).

The datum for the survey information provided by SPU will be NAD 83/91 for the horizontal adjustment and NAVD88 for the vertical adjustment.

2.3.1.9 Existing Utilities and Potential Impacts

Existing utilities in the vicinity of the 49th Avenue Parking Lot site can be separated into two locations: onsite at the parking lot and along the 49th Avenue South right-of-way. This section provides a brief description of the existing utilities and the possible impacts or required relocations that may occur in conjunction with the project and proposed new utilities. Existing utility information is based on record drawings, GIS, and limited survey information. Confirmation of utility alignments and depths will be made during final design.

Overhead obstacles such as power lines, power and light standards, and trees have been identified in the project area. The initial sitings of the storage tank and other site improvements have been coordinated among disciplines to minimize the number of modifications to existing utilities and the proximity to overhead obstacles. The design approach is to avoid relocation of existing utilities (buried power, gas, water, and telecommunications) wherever possible. If a utility is unavoidable, the design team will coordinate with the utility owner regarding relocation.

Water

Water service lines to residences along 49th Avenue South could be temporarily or permanently relocated, depending on the final diversion pipeline alignment.

Sanitary Sewer

Existing side sewers located in the right-of-way of 49th Avenue South will require temporary relocation to accommodate the installation of the diversion sewer to the storage tank.

Storm Drain and Surface Water Drainage

The existing stormwater system located at the intersection of 49th Avenue South and the Lake Washington Boulevard South right-of-way will require permanent relocation to accommodate the proposed control structure. Existing stormwater piping within the site also will require permanent relocation to accommodate the storage facility.

Surface water along 49th Avenue South and on the 49th Avenue South Parking Lot site currently is collected by inlets and catch basins and routed in the piped storm drainage system at the intersection with Lake Washington Boulevard South. During construction, several stormwater BMPs will be implemented to treat and mitigate the stormwater leaving the project site. The proposed stormwater treatment vault located near the northern end of the storage tank will require construction of permanent piped drainage.

Buried Power

Buried and abovegrade power located in the right-of-way may require temporary relocation. During construction, overhead wires and poles located on the western shoulder of 49th Avenue South may require temporary relocation to accommodate installation of excavation support system components and the diversion sewer to the storage tank.

Gas

Gas located in the right-of-way of 49th Avenue South may require temporary relocation to accommodate the installation of the diversion sewer to the storage tank.

2.3.1.10 Proposed New Utilities and Potential Impacts

New water, stormwater, and sanitary sewer connections are anticipated for this project. Utility connections to City utilities will be made in accordance with the City’s requirements.

2.3.1.11 Basin 40 Modification and New Diversion System

Modification will be made to the outlet of CSO Facility 11. A motor-operated gate will be installed (to replace the existing HydroBrake) to control the flow through Basin 40 to 1.9 million gallons per day (mgd). During wet weather events when flow in Basin 40 exceeds 1.9 mgd, flow will back up behind the motor-operated gate and fill the existing inline storage pipe upstream. When the inline storage pipe in CSO Facility 11 reaches a specified depth below the elevation of the CSO weir crest, flows will be diverted from a new diversion structure over a weir and through approximately 400 feet of gravity pipe into the new storage tank at the 49th Avenue South Parking Lot site.

2.3.1.12 Basin 40/41 Control Structure

The proposed control structure will be located to the south of the storage tank at the intersection of Lake Washington Boulevard and 49th Avenue South. The primary control will structure contain a storage diversion weir that redirects flow to the 24-inch-diameter diversion sewer that eventually conveys flow to the storage tank. The primary control structure also will contain the overflow weir to divert flow to the NPDES 40 and 41 outfalls once the storage tank is full. Additionally, the primary control structure will be where the force main from the storage tank will discharge. The diversion weir in the primary control structure will be set at the same elevation as the existing overflow weir for NPDES 41B. The primary control structure is shown on Exhibit 2 and a hydraulic profile of all improvements is shown on Exhibit 8 in Appendix A.

2.3.1.13 Force Main

After a rainfall event has passed, the 0.48-MG storage tank will empty through the force main, which will discharge into the primary control structure. Additional information on the sizing of the force main a pumps is provided in Section 7, Mechanical Design.

2.3.1.14 Water Service Connection

The water supply pressure in the project area is assumed to be 80 to 100 psi. A 3-inch-diameter service will tap the existing 8-inch-diameter cast iron pipe in 48th Avenue South to provide the anticipated flow rate for the proposed CSO storage tank. The service connection will be approximately 150 feet. Section 7, Mechanical Design, describes anticipated water demands for the site.

Consultation with the SPU Drinking Water Division will be required to confirm the size and type of the meter setting. A 3-inch-diameter commercial meter setting requires a large vault (4 feet by 6 feet by 5 feet deep) located near the property line. The dimensions will be confirmed as part of final design.

Water availability for the service connection will be required from SPU, and water availability for fire flows during construction has not been determined at this time. Discussions with the City of Seattle Fire Department will occur during final design once drawings have been completed to the 30 percent level of detail.

2.3.1.15 Power

Existing overhead power lines and poles are located on west side of 49th Avenue South. The overhead power lines and poles may require relocation or adjustment to accommodate construction traffic and the installation of the diversion sewer to the storage tank. Details for the power pole relocation or protection will be determined through discussions with Seattle City Light (SCL) during design. More detail about electrical service for the project is provided in Section 10.3.

2.3.1.16 Foul Air Duct

As part of the odor control system for the storage tank, buried air ducting will connect the tank to the odor control system located within the facilities vault. The buried section of the foul air duct will be constructed of 10-inch-diameter SDR 35 high-density polyethylene pipe (HDPE) or PVC pipe. More detail about the components of the odor control system, including discussion of the foul air duct, is provided in Section 8

2.3.1.17 Stormwater Facilities

Stormwater within the 49th Avenue South Parking Lot site, and from a portion of the 48th Avenue South right-of-way (equivalent to affected areas of 49th Avenue South) will be treated with media filters. The filters will use filter cartridges within MHs, catch basins, or small vaults to treat stormwater. Water quality flow rates will be calculated using the Western Washington Hydrology Model (WWHM) or equivalent software. Media filters will be sized and selected based on design flow rates requirements approved by Ecology. A hydrodynamic separator, catch basin, or other type of pretreatment unit approved by the City will be located upstream of the media filter vault. Treated stormwater will discharge to the existing storm drain system. Additional information about the stormwater facilities, is provided in Section 3.

2.3.2 53rd Avenue South Parking Lot

2.3.2.1 Site Demolition, Grading, and Earthwork

Site demolition at the 53rd Avenue South Parking Lot site will consist of the following:

- Removal of existing pavement of the parking lot
- Removal of approximately 30 linear feet of asphalt concrete pavement along Lake Washington Boulevard to accommodate new pipe and RTC conduits
- Modification of SPU CSO Facility 9 to replace the HydroBrake with an RTC gate valve
- Removal of northern sidewalk along South Alaska Street to accommodate RTC conduits
- Removal of eastern sidewalk along 53rd Avenue South to accommodate RTC conduits

Site grading and earthwork will be coordinated to minimize disturbance to the surrounding areas. Erosion and sedimentation controls will be integrated into the contract documents and into the final design. Both permanent and temporary movement of earth on development sites is regulated by Seattle's Stormwater Code. This regulation (SMC 22.800 through 22.808) protects the graded site and adjoining public and private properties, preserves natural drainage patterns and watercourses, and controls pollution.

Grading at the 53rd Avenue South Parking Lot site will be designed to direct surface water runoff away from hatches and openings and toward new stormwater collection structures. Earthwork will consist primarily of excavating and stockpiling materials for sorting, reuse, and disposal. Selective earthwork, including soil placement and fine grading, will be determined based on the landscaping/architectural finish refined during the design phase. Geotechnical data collected as part of final design for use in designing the underground structures will also be used for assessing site grading and other earthwork requirements.

Site Clearing and Grading

Areas for site clearing and grading will be identified with coordinates on the construction drawings. Protected trees at the 53rd Avenue South Parking Lot site, as well as other vegetation, will be denoted with defined limits on the construction drawings. Trees and other vegetation within clearing zones will be cleared and grubbed as necessary, including stump removal. Organic soils will be stripped and stockpiled by the contractor for potential reuse on the project. Utilities required for the project and extents of permanent structures will be located to reduce the removal of existing vegetation.

Survey control points will be set to control final grades. If a temporary grading plan is required and developed during the design phase, those control points will also be delineated on the drawings. The City of Seattle survey datum will be used for this project.

The site is currently graded and surfaced with asphalt pavement. Areas surfaced with gravel or pavement are considered impervious surfaces, based on the current City of Seattle Stormwater Management Manual. This project will replace more than 5,000 ft^2 of impervious surface and is, therefore, required to analyze the downstream system within 0.25 mile of the site to ensure sufficient capacity of the drainage system (SMC 22.805.020.J). Further information on the stormwater system is provided in Section 3.

Final and temporary grading will minimize runoff velocities to the extent possible. Slopes will be adjusted as necessary to complete the design layout. BMPs such as the use of hydroseeding, jute mat covers, and filter inserts will be incorporated into the final design to prevent erosion of exposed site soils and sedimentation of installed stormwater facilities. No final slopes will be greater than two horizontal to one vertical unless supported by an engineered retaining structure or other engineered methods.

Earthwork

Materials that are stockpiled onsite will be covered by a tarpaulin to minimize erosion and control fugitive dust during construction. Stockpiled soil piles will not be higher than 10 feet from the surrounding area and will be sloped no steeper than 1:1.

Limits of construction delineated on the construction drawings for facilities and utilities will provide adequate room for installing most types of shoring for deep excavations, making acceptable cutbacks for excavations where available, and using trench boxes where applicable. Shoring will be designed and installed by the contractor according to an approved shoring plan.

Fill will consist of earthen materials. Rocks and other irreducible material will be less than 4 inches in diameter and comprise less than 10 percent of the fill volume. Recycled materials (concrete and asphalt) will be allowed only as dictated in the City Standard Plans. Topsoil will not be used as fill material except for the upper 12 inches of any area that will not be subject to vehicular traffic.

2.3.2.2 Paving and Roadway Surfaces

Paved surfaces removed as part of the project on the 53rd Avenue South Parking Lot site will be replaced. The replacement will be a standard pavement section of 4 inches of HMA

Class 1 over 6 inches of Type 2 crushed rock. Materials will be provided in accordance with the City Standard Plans.

Asphalt and Cement Concrete Surfaces

- All surfaces will be HS-25 rated for loading.
- All asphalt concrete surfaces will be a minimum of 4 inches thick of HMA Class 1 asphalt paving installed in 2-inch lifts underlain by a 6-inch minimum lift of crushed base course.
- All cement traffic-bearing surfaces located on the site will be a minimum of 6 inches thick, underlain by a six-inch minimum lift of crushed base course.
- All surfaces located within the public right-of-way for this project will be constructed in accordance with the City Standard Plans.

Vehicle clearances and turning radii for maintenance vehicles currently owned by SPU will be used to size and locate access roads, driveways, turnarounds, and other surface features necessary to allow for full access by vehicles to the service locations at the facilities vault (for example, carbon fill ports, demister pad removal hatch, lifting slab). Emergency vehicles (fire department ladder trucks) may also be used to analyze final clearances.

2.3.2.3 Accessibility (ADA Compliance)

The current facility design will not include abovegrade structures or any structures that will be accessed by the public. However, future use of the site must account for accessibility in the design of site grading and other features. Accessibility will meet City and federal requirements, including compliance with the ADA and ADAAG for nonresidential buildings. The site design will not address existing accessibility issues outside the identified work limits for the project. Areas excluded will include existing areas that are outside the project work limits on the site and affected right-of-way areas.

ADA Standards for Accessible Design (28 CFR 36) will be used for design of ADA ramps, paved or marked walkways and access ways, and slopes across the site.

2.3.2.4 Site Access

Site access is currently by two driveways located in the northwestern and southeastern corners of the site. Both driveways provide access for cars driving along Lake Washington Boulevard.

Temporary Vehicle and Pedestrian Access during Construction

Temporary construction vehicle access to the 53rd Avenue South Parking Lot site during construction will be through the existing northwestern and southeastern entrances to the lot. Construction and emergency vehicles will be able to use these entrances for access to the site. Flaggers will control traffic accessing and exiting the site.

If required, specific temporary vehicle access design criteria will include the following:

- Temporary access routes will be surfaced with 4-inch quarry spalls.
- Temporary stabilized construction entrances or vehicle washes will be employed at access points to Lake Washington Boulevard in accordance with the City Standard Plans.

- The existing trail along the east side of the parking lot will be affected by the construction of the storage facility. During construction, this trail will be rerouted along the west side of Lake Washington Boulevard South to allow trail traffic to safely circumvent the site. A fence will be constructed around the entire project impact area to ensure that people do not enter the construction site without proper authority.

Permanent Site Access

Permanent access to the parking lot will be provided by the existing northwestern and southeastern entrances from Lake Washington Boulevard. SPU O&M vehicles and emergency vehicles will require access to and through the site. The following design requirements will be used for public, SPU O&M, and emergency vehicles:

- The entrance driveway will be 20 feet wide across the site to accommodate traffic in two directions.
- Curb cut spacing will conform to SMC 23.54.030 F.
- The new driveway will be constructed in accordance with City Standard Plan 430.
- A maximum slope of 10 percent will be used for the new driveway. This is approximately the slope of the existing driveway and is the maximum allowed in accordance with SMC 23.54.030 C.4.
- Parking pad: Parking spaces may not exceed 9 feet by 20 feet and must meet the loading requirements set forth in City Standard Plan 430 or 431.
- Vertical curves: In accordance with the Seattle Land Use Code, vertical curves may be required at the top and bottom of the driveway. The vertical curve will begin at the property line, not in the right-of-way.
- Driveway elevations at the property line will meet the elevations shown on the Building Grade Sheet and meet Seattle Land Use Code driveway slope and vertical curve requirements. The driveway will be designed so that any changes in driveway slope that may be needed as a result of future grading in the right-of-way will comply with driveway requirements specified in the Seattle Land Use Code.

Permanent access to the storage tank and facilities vault will be located in the southern end of the existing parking lot. Access hatches for routine and emergency maintenance will be located in the paved area. All access hatches will be rated for HS-25 loading. Removable lifting slabs will be configured in other areas of the tank lid for less frequent maintenance activities. Facilities vault access will be through hatches adjacent to the designated parking spaces within the parking lot.

2.3.2.5 Parking at 53rd Avenue South Parking Lot

The 53rd Avenue South Parking Lot site is currently used as a public parking lot for the adjacent Lake Washington Boulevard Park. There are no marked parking spaces on the site. Parking is informal across the site, which is generally wide open and surfaced for vehicular traffic.

Temporary Parking during Construction

Temporary parking for construction worker traffic will be provided offsite along 53rd Avenue South and South Alaska Street. Space for up to approximately 20 vehicles will be provided within 0.5 mile of the site.

Permanent Parking Post-Construction

Marked parking for SPU O&M vehicles will be limited to two parking stalls located in the new paved parking lot at the 53rd Avenue South Parking Lot site. In addition, approximately 20 additional marked parking spots will be provided for the public.

All parking stalls will conform to SMC 23.54.030 (Parking Space Standards). Relevant criteria will include the following:

- "Large vehicle" means that the minimum size of a large vehicle parking space will be 8.5 feet in width and 19 feet in length.

2.3.2.6 Site Lighting

The layout of the site will not have any lighting. Site lighting will be evaluated during design to consider proposed planting locations and new lighting needs for access to the new, buried storage tank and facilities vault and to ensure adequate lighting for O&M staff at the site.

2.3.2.7 Temporary Erosion and Sediment Control

Temporary erosion and sediment control for the 53rd Avenue South Parking Lot site will be developed in accordance with the 2009 Stormwater Code (SMC 22.800 through 22.808) and the City Standard Plans, including Sections 2-08 and 8-01. As required for the design, silt fences, straw bales, mulching, matting, sediment traps, protective berms, and other methods will be used to prevent sediment and runoff from creating problems in utilities and adjacent properties. For this project, temporary erosion and sediment control information will be developed on the site drawings and as part of the technical specifications.

During construction, the contractor will be required to incorporate practices that prevent or control erosion. A CSCP will be prepared by the engineer and reviewed by the City prior to construction to ensure that these requirements will be met.

2.3.2.8 Survey Control

Survey control will be established using monuments in Lake Washington Boulevard, 53rd Avenue South, and South Alaska Street, as well as any benchmarks established by the project survey team during site surveys. These points will be confirmed by the contractor’s surveyor and adjustments made as warranted prior to construction.

Monuments will be protected as required by RCW 65.04.045 and prescribed by the PLSO.

The datum for the survey information provided by SPU will be NAD 83/91 for the horizontal adjustment and NAVD88 for the vertical adjustment.

2.3.2.9 Existing Utilities and Potential Impacts

Existing utilities in the vicinity of the 53rd Avenue South Parking Lot site can be separated into two locations: onsite at the parking lot and along Lake Washington Boulevard and 53rd Avenue South right-of-way. This section provides a brief description of the existing utilities and the possible impacts or required relocations that will be associated with the project and proposed new utilities. Existing utility information is based on record drawings, GIS, and limited survey information. Confirmation of utility alignments and depths will be made during final design.

Overhead obstacles such as power lines, power and light standards, and trees have been identified in the project area. The initial settings of the storage tank and other site improvements have been coordinated among disciplines to minimize the number of modifications to existing utilities and the proximity to overhead obstacles. The current design approach is to avoid relocation of existing utilities (buried power, gas, water, and telecommunications) wherever possible. If a utility is unavoidable, the design team will coordinate with the utility owner regarding relocation.

Water

The 8-inch water main in Lake Washington Boulevard will be affected by the proposed 3-inch water service tap and the crossing of the proposed diversion piping. The 1-inch, irrigation water pipe with in the parking lot will be relocated to accommodate the new facilities.

Sanitary Sewer

The combined sewer along Lake Washington Boulevard will be affected by the installation of storage diversion structure.

Storm Drain and Surface Water Drainage

The existing stormwater system located at the 53rd Avenue South Parking Lot site is collected by inlets and catch basins and routed directly to Lake Washington. During construction, several stormwater BMPs will be implemented to treat and mitigate the stormwater leaving the project site. The proposed stormwater treatment vault located near the northern end of the storage tank will require construction of a permanent piped drainage system. Some existing drainage inlets and catch basins at Lake Washington Boulevard and 53rd Avenue South may be affected by utility trenching and diversion piping.

Buried Power

Buried power located in the right-of-way may require relocation if it is in conflict with the utility trenching and diversion piping.

2.3.2.10 Proposed New Utilities and Potential Impacts

All gas lines depicted on the base map should not be affected by the utility trenching and diversion piping. New water, stormwater, and sanitary sewer connections are anticipated for this project. Utility connections to City utilities will be made in accordance with the City's requirements.

2.3.2.11 Diversion Structure

A new diversion structure will be constructed over the Lake Line in the vicinity of the intersection of 53rd Avenue South and Lake Washington Boulevard. This structure will divert flow through a diversion sewer to the storage tank through a long weir when the Lake Line reaches a specified depth. The diversion structure is shown on Exhibit 9 and a hydraulic profile of all improvements is shown on Exhibit 18 in Appendix A.

2.3.2.12 Force Main

After a rainfall event has passed, the 0.12-MG storage tank will empty through the force main, which will discharge into the diversion structure. Additional information on the sizing of the force main pumps is provided in Section 7, Mechanical Design.

2.3.2.13 Water Service Connection

The water supply pressure in the project area is assumed to be 80 to 100 psi. A 3-inch-diameter service will tap the existing, 8-inch-diameter cast iron pipe in 53rd Avenue South to provide the anticipated flow rate for the proposed CSO storage tank. The service connection will be approximately 130 feet. Section 7, Mechanical Systems, describes the anticipated water demands for the site.

Consultation with the SPU Drinking Water Division will be required to confirm the size and type of the meter setting. A 3-inch-diameter commercial meter setting will require a large vault (4 feet by 6 feet by 5 feet deep) located near the property line. These dimensions will be confirmed as part of final design.

Water availability for the service connection will be required from SPU, and water availability for fire flows during construction has not been determined at this time. Discussions with the City of Seattle Fire Department will occur during final design once drawings have been completed to the 30 percent level of detail.

2.3.2.14 Power

Existing overhead power lines and poles are located on west side of 53rd Avenue South. The overhead power lines and poles may require relocation or adjustment to accommodate construction traffic and the installation of the associated utilities. Details for the power pole relocation or protection will be determined through discussions with SCL during design. More detail about electrical service for the project, is provided in Section 10.3.

2.3.2.15 Foul Air Duct

As part of the odor control system for the storage tank, buried air ducting will connect the tank to the odor control system located within the facilities vault. The buried section of the foul air duct will be constructed of 10-inch-diameter SDR 35 HDPE or PVC pipe. More detail about the components of the odor control system, including discussion of the foul air duct, is provided in Section 8.

2.3.2.16 Stormwater Facilities

To facilitate park use and SPU maintenance practices, offsite stormwater treatment of nearby streets is proposed instead of project site stormwater treatment. Stormwater from a portion of 52nd Avenue South and the South Snoqualmie Street right-of-way is identified for treatment with media filters. The filters will use filter cartridges within manholes, catch basins, or small vaults to treat stormwater. Water quality flow rates will be calculated using the WWHM or equivalent software. Media filters will be sized and selected based on design flow rates requirements approved by Ecology. A hydrodynamic separator, catch basin, or other type of pretreatment unit approved by the City will be located upstream of the media filter vault. Treated stormwater will discharge to the existing storm drain system to Lake Washington.

2.4 Utilities Design Criteria

2.4.1 Pipe Materials

A variety of materials (as listed below) is commonly used for construction of utilities (for example, combined sewers, storm drains, and ductwork). Each material offers specific advantages and disadvantages.

- Reinforced concrete pipe
- Non-reinforced concrete pipe (for 6- or 8-inch diameters)
- Ductile iron pipe
- HDPE
- PVC (not preferred by SPU for gravity sewers)
- Vitrified clay pipe (preferred by SPU for gravity sewers because of its longevity)

2.4.2 Maintenance Holes

MHs are the access points to a gravity flow pipe and are usually located at changes in flow direction, changes in pipe slope, and at regular intervals along the pipe alignment. Access through an MH provides for inspection and cleaning of the pipe and can be used to install flow-monitoring equipment or to install rehabilitation products such as cure-in-place liners. Appurtenances include access ladders and lids. Channels in the bottom of the structure direct the flow smoothly through the base section. Installation of new MHs is anticipated for final design of the Genesee CSO Reduction Project. Any modifications to existing maintenance holes will be done in accordance with the City Standard Plans.

2.4.3 Pipe Connections to Maintenance Holes

Pipes are connected to MHs in several ways, depending on the type of pipe material. One method involves placing the pipe through a hole in the MH wall and packing the void with a non-shrink grout or epoxy grout. While acceptable in some cases, this may lead to leaks, cracks in the grout, or even total grout failure between the pipe and MH. Another method is to install the pipe through a gasket-type fitting in the MH wall. The fitting may be cast into the concrete or clamped in place. Examples of this option are Kor-N-Seal® and A-Lok® seals. This method seems to be the most common and provides a flexible joint. The last method is to cast a pipe fitting into the MH concrete with a fitting designed specifically for the type of pipe. There are many options for fittings, but flexibility should be the main concern on this project. Pipe connections to MHs will comply with the City Standard Plans.

2.4.4 Installation Requirements

The bedding gravel or concrete slab under the MH must be adequate to support the MH without settlement and may be designed with additional slab thickness to prevent flotation of the structure. The geotechnical analyst will need to evaluate the potential for settlement, especially the differences in settlement between MHs and pipes, which are a common MHs failure mechanism for the MH/pipe connection. Bedding material used under or around maintenance holes will comply with the City Standard Plans.

2.4.5 Bedding and Backfill Materials

Bedding and backfill requirements will be based on the type of pipe selected for the diversion sewer and on geotechnical considerations. Factors to be considered in selecting appropriate bedding and backfill include pipe diameter, pressure (or stiffness) class, soil parameters, depth of cover, traffic loading, width of the trench, trench construction and shoring methods, and the groundwater table. Bedding and backfill materials will comply with the City Standard Plans.

Bedding and backfill requirements will vary, depending on the classification of pipe: pipe is either rigid or flexible. Concrete is an example of a rigid pipe, while PVC is an example of a flexible pipe. Flexible pipe readily deflects in response to external forces and relies heavily on the bedding and backfill materials to carry soil and surface loads. As the soil settles, the pipe deforms, which transfers the load to the bedding and backfill. Good-quality bedding and backfill materials and close attention to material placement and compaction are critical for good flexible pipe performance. A common failure mode for flexible pipe is continued deformation caused by poor or changing soil conditions. Rigid pipe retains its circular cross-section to the point of failure, regardless of the external forces acting upon it.

2.4.6 Trenches

Pipe bedding materials surround the pipe in the trench. The bedding is typically 6 inches below the pipe to 6 inches above the pipe crown. The diameter of the pipe also affects the width of the trench. Trenches that are too narrow make it difficult to properly bed the pipe, while trenches that are too wide may impose an increase in loading on the pipe. Trench width also significantly affects the cost for pipe installation. The bedding material must be compacted so that the pipe wall is well supported. For flexible pipes, the bedding material is intended to keep pipe wall flexure to a minimum. On this project, trenches will be designed in accordance with the City Standard Plans.

2.4.7 Drawings

Table 3 outlines required drawings and their contents.

Table 3. Site Civil Drawing List

DRAWINGS (IN ORDER)	WHAT MUST BE SHOWN
Site Plan	Proposed alignment of streets, pedestrian pathways, and paved areas Proposed locations of stormwater features Existing survey data, including utilities, contours, structures, and monuments Proposed structures, including fences, maintenance holes, and hand holes
Existing Site Plan	Existing survey data, including utilities, contours, structures, and monuments
TESC (Temporary Erosion and Sediment Control) Plan	Existing survey data, including utilities, contours, structures, and monuments Proposed alignment of streets, pedestrian pathways, and paved areas Proposed locations of temporary stormwater and sediment control features such as fences, tanks, and curb Proposed locations of permanent stormwater features
Site Clearing and Demolition Plan	Existing survey data, including utilities, contours, structures, and monuments Boundary of proposed clearing area Vegetation to be removed

DRAWINGS (IN ORDER)	WHAT MUST BE SHOWN
Grading and Paving Plan	Arrows indicating direction of proposed finished grade slope Proposed alignment of streets, pedestrian pathways, and paved areas Proposed structures and stormwater features Existing survey data, including utilities, contours, structures, and monuments Contours of proposed site grading
Grading Sections and Details	Section view of proposed finished grade and existing grade Detail showing components of pavement
Sewer and Drainage Plan and Profile	Existing survey data, including utilities, contours, structures, and monuments in plan Proposed pipe alignments Existing utilities and crossing Proposed conveyance features, including maintenance holes, and sumps Proposed alignment of streets, pedestrian pathways, and paved areas Proposed finished grade and existing grade in profile Proposed structure footprint in plan
Jointing Plan	Existing survey data, including utilities, contours, structures, and monuments in plan Proposed alignment of streets, pedestrian pathways, and paved areas Locations of joints in proposed pavement
Signing and Striping	Existing survey data, including utilities, contours, structures, and monuments in plan Proposed alignment of streets, pedestrian pathways, and paved areas Proposed locations of new or restored signs and roadway markings, including crosswalks Locations of existing signs
Details	Anything else that needs to be more clearly defined

2.5 Referenced Codes and Standards

Regulatory requirements are determined primarily by project location and scope. The project components planned for the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site will be located entirely within City limits. Therefore, the majority of the permitting and zoning will be coordinated with City agencies in accordance with the SMC and as enforced by DPD. The following codes and standards will be applicable to civil engineering components of the new facility construction:

- City Standard Plans
- Above Ground Telecommunications Facilities in the Public Right-of-Way – SDOT Rule 2-2009
- Crosswalks – SDOT Rule 04-01
- Green Streets – Design Guidelines and Review Process – SDOT Rule 2-07
- Street and Sidewalk Pavement Opening and Restoration – SDOT Rule 5-2009
- Right-of-way Improvements Manual – SDOT Rule 2-05 / DPD Rule 22-2005 (superseding DCLU DR 30-90 and SDOT DR 91-4)
- SMC (Title 23 – Land Use)

3 Stormwater

This section details the design criteria for stormwater conveyance, water quality treatment, and flow control for the Genesee CSO Reduction Project at the 49th Avenue South Parking Lot and 53rd Avenue South Parking Lot sites. Only specific design criteria related to stormwater management are included in this section. Aspects of stormwater design such as bedding materials for pipes, pipe materials, and separation requirements are addressed in Section 2.

3.1 Proposed Stormwater Modifications

Stormwater design will be coordinated with the proposed storage tank and facilities vault, and with other proposed site improvements at the two tank locations. All aspects of the designs will follow the intent of the City's Stormwater Code and associated Director Rules. Conceptual layouts for stormwater modifications discussed in this section are shown in Appendix A on:

- Exhibit 3 – 49th Avenue South Parking Lot
- Exhibit 12 and 13 – 53rd Avenue South Parking Lot

3.2 Stormwater Design Criteria

3.2.1 Water Quality Treatment Facilities

This project will include the addition of more than 5,000 ft^2 of new and/or replaced pollution-generating impervious area associated with both project sites. Calculation of the size of pollution-generating impervious areas included all roads and parking lots. This disturbed pollution-generating impervious area will trigger code requirements for treating runoff from the site to meet water quality standards. Because both sites are tributary to Lake Washington, a designated receiving water body, flow control will not be required by the Stormwater Code.

The total replaced impervious area (including sidewalks and hatches plus the pollution-generating impervious surface described above) will exceed 2,000 ft^2, triggering Green Stormwater Infrastructure (GSI) requirements to the maximum extent feasible. As water quality is also being triggered, facilities that meet both GSI and water quality treatment goals, including belowgrade and abovegrade facilities, are being considered. GSI facilities will be sized using the GSI calculator provided in the *GSI to Maximum Extent Feasible Draft Director's Rule (SPU DR 2009-07*). If GSI facilities are also used to meet a water quality treatment requirement, additional modeling will be required, based on the design criteria in Section 5.4.1 of Volume 3 of the Stormwater Code, Director's Rule 2009-07). Media filter vaults do not provide GSI credit but do provide water quality treatment. Media filter vaults will be modeled using the design criteria in Section 5.4.1 of Director's Rule 2009-17 and sized in accordance with Ecology and manufacturer's guidelines. Because of improvements both within the right-of-way and on storage sites, these project components are classified as "joint projects," requiring that both parcel-based and roadway requirements be met (SMC 22.805.070).

3.2.2 49th Avenue South Parking Lot

The parking lot's surface water currently drains to a catch basin in the southeast corner of the site. In addition, there is an 8-inch pipe storm drain (PSD) that crosses the lot and conveys stormwater from 48th Avenue South to Lake Washington. Because of a direct conflict, this PSD will be relocated around the footprint of the proposed tank. Along the route of the proposed diversion sewer, surface water from 49th Avenue South is currently collected by inlets and catch basins, then routed to an outfall near its intersection with Lake Washington Boulevard.

Abovegrade GSI options such as swales and bioretention were considered initially but were determined to be infeasible because of site constraints. The GSI standard does not require projects to provide offsite GSI when they are determined to be infeasible onsite. The constraints on GSI feasibility within the project site are summarized below:

- Parks (the property owner) requires preservation of the current use of the grass area between the parking lot and Lake Washington Boulevard.
- There would be potential conflicts with a new storm drain and the proposed sewer pipes at the lot's south driveway.
- Groundwater elevations at the site would not provide the desired separation between groundwater and the bottom of those facilities (less than 1 foot).
- Permeable surfacing is also not feasible because of the presence of the storage vault under the parking lot.

Due to the GSI limitations mentioned above Belowground options were considered to minimize the footprint and groundwater issues. Media filter vaults in catch basins and MHs or vaults are proposed to provide treatment of pavement and parking lot surface.

Treatment of street runoff on 49th Avenue South is constrained by the proposed sewer conveyance structures at the intersection of 49th Avenue South and Lake Washington Boulevard. Therefore, water quality treatment requirements will be provided by treating an equivalent pavement area from 48th Avenue South. An onsite option is the use of a media filter MH /vault near the lot's north edge, where the 8-inch PSD will be relocated around the new tank. An offsite option is to use the same type of treatment on higher ground above the site on 48th Avenue South behind the existing sidewalk. Other GSI strategies for the parking lot and South 53rd Street include the planting of new street trees and amended soils within existing planter strips (with Parks and SDOT approvals).

3.2.3 53rd Avenue South Parking Lot

Treatment of the parking lot will consist of two catch basin media filters with treated flows directed to existing outfalls in Lake Washington. The existing stormwater system in the parking lot consists of one catch basin in the middle of the lot near the existing asphalt trail where the lot's surface water is directed. There also are two PSDs and a CSO outfall (Basin 42) that cross the lot and discharge to Lake Washington. The proposed storage tank and facilities vault will be located between these pipes. Surface water from 53rd Avenue South currently is collected by inlets and a catch basin and then flows though the 6-inch PSD, crossing the parking lot to Lake Washington.

Aboveground GSI options such as swales and bioretention were considered initially but were determined to be infeasible because of site constraints. The GSI standard does not require projects to provide offsite GSI where it is determined to be infeasible onsite. The constraints on GSI feasibility within the project site are summarized below:

- Parks requires preservation of direct trail access from the parking lot and minimization of impacts to the raised planting strip.
- High groundwater elevations and shallow drainage structures at the site will not provide the desired separation between groundwater and those facilities.

To address space and park use limitations, offsite treatment of an equivalent amount of affected pavement is proposed. Because constraints typical of urban streets, such as utility-related conflicts, adjacent slopes, and right-of-way impacts, are prevalent near the project site, belowgrade options were considered to minimize footprint and space issues. The use of media filter vaults in catch basins and a vault or MH is proposed to provide treatment of pavement surfaces. Two options near the project site were identified that could be implemented at 52nd Avenue South and South Snoqualmie Street on a grass strip on the east side of the street. At this intersection, a PSD discharges from Basin 42 down the slope and across the parking lot to Lake Washington.

- One option would split off a portion of flows equivalent to the project's water quality flow in the existing 15-inch PSD on South Snoqualmie Street to a pretreatment BMP and media filter vault. Treated flows would then discharge back to the existing, 21-inch PSD. The system could be adjusted later to treat additional flows in the PSD.
- A second option would treat two nearby blocks of pavement: both sides of 52nd Avenue South between South Alaska Street and South Snoqualmie Street and half of the street between South Snoqualmie Street and South Oregon Street. New inlets, catch basins, a pretreatment BMP, and a media filter vault would convey and treat flows, then discharge back to the existing, 21-inch PSD.

Other potential GSI strategies for the parking lot and South 53rd Street include the planting of new street trees and amended soils within existing planter strips (with Parks and SDOT approvals).

3.3 Water Quality BMP Design Criteria

This section discusses the BMPs considered for the two sites.

3.3.1 Green Stormwater Infrastructure

It has been determined that GSI is not feasible within the project site (SMC 22.805.020.F). However, the proposed tree replacement and planting plan may offer some GSI benefit.

3.3.2 Media Filter Vaults

Media filter type MHs, catch basins, and vaults use media-filled filter cartridges to treat stormwater. Water quality flow rates required for treatment using media filter vaults will be calculated using the MGS Flood Model or equivalent software. Media filters will be sized and selected based on allowable flow rates per cartridge as approved by Ecology. An oversized catch basin, hydrodynamic separator, or other type of approved pretreatment will be located upstream of the media filter MHs /vaults. Treated water from the media filters will discharge to the existing storm drain system.

3.4 Pipes, Maintenance Holes, Catch Basins, and Inlets

Pipe materials and storm drainage structures installed and constructed on the project will conform to the City Standard Plans. Existing pipe diameters for stormwater conveyance will be matched unless the contributing areas to a pipe reach have been changed in total area or percentage of impervious surface. These reaches will be evaluated using the WWHM.

3.5 Flow Control Facilities

This project will replace 5,000 ft^2 or more of impervious surface and is, therefore, required to analyze the downstream system within 0.25 mile of the site to ensure sufficient capacity of the drainage system (SMC 22.805.020.J). The conveyance system between the project sites and Lake Washington is not considered to be capacity-constrained, based on communications with SPU. Should the downstream system be determined to have insufficient capacity (based on the peak flows' 4 percent annual probability or 25-year recurrence interval), peak flow control or improvements to the drainage system may be necessary. The locations for such improvements would be coordinated with SPU.

The existing drainage system at both project locations drains to Lake Washington, which is classified by the City as designated receiving water and, therefore, will not require the project to implement flow control.

3.6 Referenced Codes and Standards

- City Standard Plans
- Green Streets – Design Guidelines and Review Process – SDOT Rule 2-07
- Client Assistance Memorandum, Guidelines for Public Storm Drain Facilities (CAM 1180) August 2008
- Street and Sidewalk Pavement Opening and Restoration – SDOT Rule 5-2009
- Right-of-way Improvements Manual – SDOT Rule 2-05 / DPD Rule 22-2005 (superseding DCLU DR 30-90 and SDOT DR 91-4)
- SMC 22: City of Seattle Stormwater Code
- Director's Rule for SMC 22.800 through 22.808, Volume 3, Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual, Director's Rule 2009-05, GSI to the Maximum Extent Feasible, Director's Rule 2009-07.
- Volume II – Construction Stormwater Control Technical Requirements Manual, Director's Rule 2009-16

4 Landscape Design

4.1 Introduction

Lake Washington Boulevard is one of the longest green corridors in Seattle. The tree-lined boulevard was originally envisioned by the Olmsted Brothers in 1903 as a part of the "Emerald Necklace" for a citywide parks master plan. The boulevard allows for stunning views of Lake Washington and the Cascade Range and provides numerous public access points to the water and shoreline.

The CSO reduction projects at the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site will minimally disturb significant existing vegetation. Any new landscaping will be designed to blend in with the surroundings of the boulevard.

Parks has developed a Lake Washington Boulevard Vegetation Management Plan (VMP). This comprehensive document details the existing vegetation along the boulevard and outlines the requirements for any proposed landscaping. The Lake Washington Boulevard VMP will serve as the primary reference document for the landscape design of the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site.

A temporary irrigation system will be installed for both sites in all proposed landscape areas. The temporary system will be coordinated with any existing irrigation systems and Parks standards and will be for plant establishment only (approximately 3 years).

4.2 49th Avenue South Parking Lot

4.2.1 Introduction

The design of the 49th Avenue South Parking Lot site will involve installing a storage tank and equipment within an existing parking lot. The design also proposes installing a new sidewalk that replaces an alternate entrance to the parking lot. When vegetation is removed, proposed replacement landscaping will be done with species native to the Puget Sound region and will conform to requirements in the Lake Washington Boulevard VMP and other applicable City requirements.

4.2.2 Existing Vegetation

This project site is dominated by a large expanse of lawn that separates the crescent-shaped parking lot and Lake Washington Boulevard. Two large Deodar cedars flank either side of the lawn. The southern cedar is severely topped and has damaged branches. The northern cedar is an excellent specimen tree. Both trees are relatively healthy, but the long-term vitality of the southern cedar is doubtful.

On the west side of the parking lot, there is a small patch of lawn that leads to a mix of deciduous and evergreen trees forming a wooded hillside. Evergreen trees include several large western red cedars in good condition. Deciduous trees include several flowering cherry trees. The understory planting of the hillside includes a variety of mostly native shrubs and groundcover. The VMP identifies nine trees, three of which are rated in fair condition and six of which are rated in good or excellent condition. An arborist's review and report should be conducted to provide further analysis of the health and significance of the trees onsite.

An ornamental hedge and lawn is located near the southern entrance to the parking lot.

4.2.3 Vegetation to be Removed

Vegetation to be removed because of trenching for pipes and other equipment will primarily consist of lawn. The southern cedar tree needs to be evaluated further because of its proximity to the new conveyance pipes.

Additional landscaping may need to be removed in the planting strip on the western side of the 49th Avenue right-of-way. Hillside vegetation may also need to be removed to accommodate pipes and other equipment. It is expected that this would be a minimal amount.

No vegetation will be disturbed on the east side of Lake Washington Boulevard.

4.2.4 Proposed Landscaping

Proposed landscaping will conform to the VMP. According to the VMP, the project site contains portions of the Boulevard management units (MUs) and the Slope MU. A majority of the site resides within the Boulevard MU and includes a large, landscaped area between the parking lot and the Boulevard (median). This MU specifically addresses the boulevard as one of the defining characteristics of the Lake Washington Boulevard corridor. These characteristics include deciduous street trees and open lawns. The original Olmsted vision for the park included unifying the corridor through the use of simple elements and repeated themes. This is expressed in the Boulevard MU. The proposed landscaping will maintain this character and original vision.

The VMP contains detailed plans for proposed tree types, based on a series of typologies throughout the corridor. The project site is within the “open typology” theme, with a recommended tree spacing of 60 feet on center. This typology emphasizes an open Lake Washington Boulevard with small-to-medium deciduous street trees.

The VMP includes a “medium” priority for planting additional trees on either side of the right-of-way. Trees will be selected from the open typology street tree palette in the VMP. Examples of appropriate trees could include flowering cherry trees, hedge maple, and Japanese snowbell. Existing trees nearby will be evaluated so that replacement trees reinforce a sense of unity within the corridor.

Most of the existing median will be restored with lawn to maintain the open views to Lake Washington. Although a majority of the corridor in the Boulevard MU contains deciduous street trees and lawn, consideration will be given to planting shrubs when necessary.

Special attention will be given to the existing flowering cherry trees to the west of the parking lot. These trees are part of a continuing tradition along the corridor. Many of the flowering cherry trees along Lake Washington Boulevard were from a gift to the City from Japan. The VMP recommends coordination with the Seattle Cherry Blossom and Japanese Cultural Festival Committee on any changes to existing cherry trees or on proposals to plant new trees of an appropriate variety.

The wooded hillside resides in the Slope MU. The Slope MU is characterized by native evergreen trees, smaller deciduous trees, and a mix of native understory plants. Tree hazards from topping or invasive species are common in the Slope MU. Construction activities within the Slope MU will allow for the removal of invasive species and replanting with native species in accordance with the VMP. Plant spacing will conform to the VMP.

Because of the proximity of Lake Washington Boulevard and the parking lot, proposed vegetation in the Slope MU will form a backdrop for the corridor while applying principles of crime prevention through environmental design.

4.3 53rd Avenue South Parking Lot

4.3.1 Introduction

The design of the 53rd Avenue South Parking Lot will include installing a storage tank and equipment within an existing parking lot. The design layout will limit disturbance to existing vegetation. When it is necessary to remove vegetation, proposed replacement landscaping will be species native to the Puget Sound region and conform to VMP requirements and other applicable City requirements.

4.3.2 Existing Vegetation

The existing vegetation on this project site includes a mix of mature deciduous street trees, evergreen trees, shrubs, open lawns, and groundcover.

An arborist evaluated 37 trees surrounding the site for their preservation value and to develop maintenance recommendations. The tree locations were also evaluated with respect to the proposed construction activities to determine which trees may need to be removed or relocated.

The landscape median between the parking lot and Lake Washington Boulevard contains a variety of trees, shrubs, and groundcover. Deciduous trees include several Norway maple and two Stewartia. Several evergreen Plumosa false cypress and large Mugo pines are located in the median. Recently planted native groundcover is mixed among trees. The arborist indicated that several of the mature street trees are located too close to the curb, resulting in stress from trunk damage and compacted soil.

Vegetation to the west of Lake Washington Boulevard consists of large amounts of open lawn, with scattered deciduous and evergreen trees.

Existing vegetation surrounding the parking lot to the immediate north, south, and east includes open lawn and deciduous trees. These trees include flowering cherry, Norway maple, ash, and black cottonwood. Varieties of shoreline vegetation are located between the parking lot and Lake Washington.

4.3.3 Vegetation to be Removed

Limited amounts of vegetation will need to be removed because of the proposed storage tank location within the parking lot and its attendant network of pipes and surface hatches, ducts, and vents. A majority of the groundcover and shrubs that will be removed are located within the landscaped median. According to the arborist's report, three False cypress, a Norway maple, and a Stewartia will need to be removed within the landscaped median because of construction activities. The arborist's report lists these trees with a high preservation value except for the Norway maple, which has extensive trunk damage. Careful consideration of other tree roots during construction will help to reduce damage to other trees.

Three cherry trees surrounding the parking lot will need to be removed to allow for construction access.

During construction, a temporary pedestrian path is proposed for the west side of Lake Washington Boulevard. The materials and final layout of this path should be carefully planned so that existing trees are minimally disturbed. The arborist's report recommends further evaluation of proposed activities. One western red cedar will need to be removed for the pedestrian path.

Four other street trees along South Alaska Street will need to be removed because of the installation of conveyance improvements within the right-of-way.

4.3.4 Proposed Landscaping

Proposed landscaping will conform to VMP requirements. According to the VMP, the project site mainly resides within the Boulevard MUs. This MU specifically addresses the boulevard as one of the defining characteristics of the entire Lake Washington Boulevard corridor. These characteristics include deciduous street trees and open lawns. The original Olmsted vision of the park included unifying the corridor through the use of simple elements and repeated themes. This principle is expressed in the Lake Washington Boulevard MU. The proposed landscaping will maintain this character and original vision.

The VMP contains detailed plans for replacing tree types based on a series of typologies throughout the corridor. The project site is within the "enclosed typology," area with a recommended tree spacing of 45 feet on center. This typology emphasizes a complete tree canopy cover over Lake Washington Boulevard, with medium-to-large deciduous street trees. The VMP includes details for the project site labeled as a "high" priority for planting additional trees on either side of the right-of-way. Trees will be selected from the enclosed typology street tree palette of the VMP. Examples include American linden, green ash, and sugar maple. Existing, nearby trees will be evaluated so that replacement trees reinforce a sense of unity within the corridor.

Although a majority of the corridor in the Boulevard MU contains deciduous street trees and lawn, considerations are given to planting shrubs when it may be necessary to delineate specific spaces (for example, between Lake Washington Boulevard and the parking lot). Proposed groundcover and shrubs within the median will provide a visual buffer and pedestrian safety screen between Lake Washington Boulevard and the parking lot. Proposed groundcover and shrubs will conform to the lists outlined in the VMP and will be native to the Puget Sound region. Shrubs and groundcover will include plants with a maximum 3-foot height at maturity. Shrubs and groundcover will be selected from the Boulevard MU shrub plant palette. Examples are Salal, Kinnikinnick, and Sword fern.

Special attention will be given to the existing flowering cherry trees to the west of Lake Washington Boulevard. These trees are part of a continuing tradition along the corridor. Many of the flowering cherry trees were a gift to the City from Japan. The VMP recommends coordination with the Seattle Cherry Blossom and Japanese Cultural Festival Committee for any changes to existing cherry trees or proposals to plant new trees of an appropriate variety.

It is not expected that any shoreline restoration work will be done immediately adjacent to the parking lot. If any shoreline restoration work is to occur, proposed landscaping will conform to the Lakeside MU in the VMP and other City regulations pertaining to environmentally critical areas and shoreline restoration work. Shoreline restoration work to the south of the parking lot is being done by Parks under a grant conversion requirement.

Other street right-of-way improvements along 53rd Avenue South and South Alaska Street will conform to SDOT requirements for landscaping in rights-of-way.

4.4 Referenced Codes and Standards

Regulatory requirements are determined primarily by project location and scope. The 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site are located entirely within City limits. Therefore, the majority of the permitting and zoning will be coordinated with City agencies in accordance with the SMC and as enforced by DPD. The following codes and standards will apply to both project sites:

VMP

- Comprehensive plan for vegetation throughout Lake Washington Boulevard

SPU Standards for GSI

- Details and plant palettes for GSI features

SDOT Standards for Landscaping in Right-of-way

- Requirements for tree spacing, offsets, size, and details

Parks Standards

- Various requirements pertaining to standards for planting and irrigation design within Seattle parks

SMC 25.09.200, Development Standards for Fish and Wildlife Habitat Conservation Areas

- Specifies criteria for development within 200 feet of shoreline
- Requires new landscaping to promote wildlife habitat
- Requires use of native plant species to the Puget Sound region

DPD Director's Rule 16-2008, Designation of Exceptional Trees

- Specifies criteria for designation and preservation of exceptional trees

SMC 25.11.070 – Tree Protection

- Specifies regulations for the preservation of existing trees. Existing exceptional trees should be protected during construction.
- Encourages the preservation of existing trees greater than 6 inches in diameter. Provides flexibility for development in the protection zone of existing trees greater than 2 feet in diameter.
- Allows for removal of exceptional trees and trees greater than 2 feet in diameter if replacement trees are provided. Size, quantity, and species of replacement trees are determined by the DPD Director.

5 Architectural Design

This section focuses on the general architectural design criteria for the Genesee CSO Reduction Project. The odor control and electrical/mechanical facilities that will be included in these designs, will house odor control equipment and piping, as well as related electrical equipment.

All aspects and components of the CSO facilities will be designed in accordance with the requirements of applicable codes and standards for occupancy group, construction types and materials, access/egress, and overall safety. Aesthetic standards and requirements for the sites will deal primarily with landscape plantings and related features, pavement, sidewalks, and topographic features, as well as the appropriate treatment and integration into the site of access facilities to the belowgrade structures, as may be required.

5.1 Proposed Structures

Odor control structures will be located below grade wherever possible and practicable. These facilities may have the top of the structure either below grade or at grade and integrated into the pavement and landscaping at the site. The site layout above the structure will be driven largely by the access facilities to get into the belowgrade structure. In most cases, these will include both one or more stair structures and at least one equipment access hatch. The stair structures may include either a horizontal access door, at or just above grade, or an enclosed structure above grade, with a regular door for access. These access facilities will need to be carefully integrated into the topography and landscaping of the overall site and their surroundings, so that they blend into the fabric of the immediate neighborhood in the least obtrusive way.

5.2 Codes and Standards

Architectural features of the proposed CSO facilities will be designed in accordance with the most recent editions (in effect as of the Service Agreement Date) of the following applicable codes and standards, as amended by the City where applicable:

- 2009 International Building Code (IBC)
- 2009 International Fire Code (IFC)
- 2009 International Plumbing Code
- 2009 International Mechanical Code (IMC)
- 2009 National Electric Code (NEC)
- 2009 State of Washington Non-Residential Energy Code

6 Structural Design

This section establishes the structural design criteria applicable to the proposed structures of the Genesee CSO Reduction Project. Applicable codes and standards for the design, loading criteria, computer aids to be used in design, potential construction materials, and other special considerations are discussed. Other related aspects of project design such as site civil, stormwater, landscaping, and mechanical systems are addressed in other sections.

6.1 Underground Storage Tank and Facilities Vault Sizes

The primary substructures to be located at the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site are underground, rectangular CSO storage tanks and facilities vaults to meet electrical, mechanical, and odor control requirements. The structural configuration and shape, as well as construction methods, are limited by site constraints, adjacent properties, and existing structures or utilities. Preliminary dimensions of the underground, rectangular CSO storage tanks and facilities vaults are listed in Table 4. The layout and size of both facilities vaults will be identical.

The substructures will be buried approximately 1.5 to 2 feet below grade. The structural design will account for the potential use of the site as a future parking lot. Exhibits 5 and 19 in Appendix A provide a plan view of the proposed 49th Avenue South Parking Lot storage tank and facilities vault. Exhibits 15 and 19 in Appendix A provide a plan view of the proposed 53rd Avenue South Parking Lot storage tank and facilities vault.

Table 4. Preliminary Dimensions of Storage Tanks and Facilities Vaults

STRUCTURE	PRELIMINARY DIMENSIONS
49th Avenue South Parking Lot Storage Tank	Capacity 0.48 MG Length 90 feet (interior) Width 39 feet (interior) 2 flushing channels Depth below grade 24 feet (top of base slab) at shallow end
53rd Avenue South Parking Lot Storage Tank	Capacity 0.12 MG Length 120 feet (interior) Width 17 feet (interior) 1 flushing channel Depth below grade 13 feet (top of base slab) at shallow end
Facilities Vaults (identical at each location)	Length 35.5 feet (interior) Width 22 feet (interior) Depth below grade 8.5 feet (top of base slab)

6.2 Design Criteria

6.2.1 Materials

Reinforced cast-in-place (CIP) concrete will be the primary construction material used for the Genesee CSO structures because it is the industry-preferred material for similar applications. All structural concrete for the purposes of this project will have a compressive strength (f'c) design value of 4,500 to 5,000 psi minimum and satisfy the appropriate codes and the following specifications unless specified otherwise in design documents:

- Cement – American Society for Testing and Materials (ASTM) C150, Type II or Type I mixed with fly ash
- Pozzolan (Fly Ash) – ASTM C618. Class C or F
- Sand and Coarse Aggregate – American National Standards Institute (ANSI)/ASTM C33
- Reinforcing Steel – Deformed Bars ASTM A615, Grade 60 or ASTM A706, Grade 60, where required or where welding of rebar is permitted by Engineer
- Nonshrink Grout – ASTM C1107

6.2.2 Design Loads

Design loads will be determined based on geographic location and surroundings, material weight, code compliance, geotechnical data, and other operational requirements of the storage tanks and facilities vaults. Structures for water treatment or conveyance fall into the Occupancy Category III as determined by the American Society of Civil Engineers (ASCE 7).

6.2.2.1 Dead Loads

Dead loads are the actual weights of the construction materials and fixed service equipment:

- Concrete = 150 pounds per cubic foot (lb/ft^3)
- Steel = 490 lb/ft^3
- Equipment loads = mechanical and electrical equipment weight multiplied by a factor of 1.25

6.2.2.2 Live Loads

Live loads include vertical loads that are projected onto the structure by transient causes, such as surcharge loads caused by traffic loads acting on the finished grade. Heavy vehicle live loads may be caused by fire trucks, mobile cranes used for equipment placement or removal, and construction or maintenance vehicles such as Vactor™ trucks. Pedestrian traffic is also a live load. Live lateral loads may include surcharge because of traffic loads. The following loads comply with ASCE 7 and Washington State Department of Transportation (WSDOT) requirements:

- Vehicular live load = HS-25 loading
- Passenger vehicle barrier loading = 6,000 lb (applied in accordance with ASCE 7)
- Truck vehicle barrier loading = in accordance with American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Highway Bridges
- Process structure slabs subject to pedestrian traffic only = 100 pounds per square foot (lb/ft^2)
- Equipment platforms = 100 lb/ft^2

- Process and pump room floors = 250 lb/ft^2
- Stairs, landing, walkways = 100 lb/ft^2
- Grating = equal to adjacent floor loads
- Hand and guard rails = concentrated load of 200 pounds (lb) applied in any direction at any point and a uniform load of 50 lb per foot at the top of the hand and guardrails

6.2.2.3 Fluid Loads

Fluid loads are the lateral load of water or combined sewage on walls and the vertical load on slabs from the inside of the substructure. Fluid loads are caused by stored combined sewage in the tank or high groundwater outside of the tank.

- Fluid unit weight = 62.4 lb/ft^3

6.2.2.4 Earthquake (Seismic) Loads

Earthquake (seismic) loads are defined by parameters set forth by the geotechnical report and defined by the geological conditions of the site. Seismic loads will be further defined in conjunction with finalization of the geotechnical report and ASCE 7.

- Soil site class = E
- Occupancy category = III
- Seismic importance factor, I = 1.25
- Seismic design category = D
- Short-period site coefficient (at 0.2 s-period), F_a = 0.9
- Long-period site coefficient (at 1.0 s-period), F_v = 2.4
- Mapped, spectral response acceleration parameter at short periods, S_s 0.2 sec = 1.50g
- Mapped, spectral response acceleration parameter at a period of 1 s, S_1 1.0 sec = 0.51g
- Design, spectral response acceleration parameter at short periods, S_{DS} = 0.90g
- Design, spectral response acceleration parameter at a period of 1 s, S_{D1} = 0.82g
- Seismic response coefficient, C_s = to be determined
- Response modification coefficient, R= 2
- System overstrength factor = 2
- Deflection amplification factor, C_d = 2

6.2.2.5 Lateral Loads

Lateral loads are generally caused by earth pressure or other bulk materials. Earth pressure loads are defined in the geotechnical report and must be represented with pressure diagrams. The following loads are addressed in the geotechnical report:

- Hydrostatic soil load
- Soil density = 130 pounds per square foot (psf)

- At-rest effective pressure coefficient, K_o = 0.47
- Active effective pressure coefficient, K_a = 0.31
- Passive soil resistance effective pressure = 390 lb/ft^2
- Vehicular surcharge pressure (at-rest condition) = 133 lb/ft^2
- Vehicular surcharge pressure (active condition) = 90 lb/ft^2
- Lateral pressure associated with seismic earth loads = as specified in geotechnical report (Appendix B)

6.2.2.6 Snow Loads

Snow loads will be determined based on parameters such as location and climate by ASCE 7 or applicable permitting offices (City). Snow buildup at grade elevation will impose loads on the top of substructures or at roof elevation on abovegrade facilities.

- Snow load = 25 lb/ft^2
- Exposure factor, C_e = 1.0
- Thermal factor, C_t = 1.0
- Importance factor, I = 1.1

6.2.2.7 Wind Loads

Wind loads will be calculated by using the simplified procedure outlined in ASCE 7 with factors such as the geographic location of the structure, the importance type of the structure, and the dimensional values (such as roof slope and building height, width, and length) of the structure. In addition, wind loads are not applicable when designing substructures and piping systems because these elements are underground and will not be exposed to wind loads.

- Basic Wind Speed = 85 miles per hour
- Importance Factor, I = 1.15
- Exposure Category = D

6.2.2.8 Rain Loads

Rain loads will not be taken into account for substructures because the project components are underground and will not be exposed to rain loads. Proper drainage will be provided so that no water pooling occurs above the sub-grade tank.

6.3 Structural Analysis

All design and analysis, regardless of material or structural element, will use the strength design method, or load and resistance factor design (LRFD) method, unless otherwise noted. Structural calculations may be completed by hand or with the aid of RISA 3D or STRAAD, a finite element analysis software. Other calculation software that may be used includes PCA Column, StruCalc, Visual Analysis, Microsoft Excel, and Mathcad.

6.4 Structural Configuration Evaluation

The configuration of the storage tank will be highly limited in variability because of the parameters and constraints of the property and operational requirements. In the conceptual development and alternative study stages of this project, different shapes were evaluated. A rectangular design was selected to provide the required volume of storage and not exceed property limitations or temporary construction easements. Exhibits 5, 6, 13, and 14 in Appendix A show preliminary structural configuration and dimensions of the storage tanks.

6.4.1 Roof System

The roof system for the storage tanks and facilities vaults will be designed to support a parking lot with live traffic loads, the significant weight of Vactor™ trucks required for O&M purposes, and several feet of fill on top of the slab. Openings, or removable concrete hatches and slabs, are required so that additional or replacement equipment can be lowered into the storage tank. Visual inspection of the conditions of the storage tank will also take place through openings in the top slab. For preliminary structural design purposes, it is assumed that the access openings will have removable lids constructed of precast concrete, or traffic-rated steel hatches.

Reinforced CIP concrete will be used for the roof systems and is commonly used for constructing water-containing structures. Reinforced CIP concrete is resilient against corrosion caused by the treatment chemicals inside the tanks or the natural properties of the earth and soil on the exterior surfaces of the tank; surface coatings and admixtures can provide variable levels of concrete protection.

A grid pattern throughout the inside of each storage tank of reinforced-concrete columns and beams will be used to support the top slab. Column dimensions (width and depth) can be developed so that the columns do not protrude into the flushing channels and create an area for potential sediment buildup. For instance, the column width will be limited by the dimension of the training wall between the flushing channels, but the length will be as long as necessary to fully support the axial weight and flexural forces acting on the column. The columns will tie into beams, which will support the top slab as well as offer internal shear support to the external walls.

One issue to be cognizant of when using columns is the shear effect on the base slab. The gravity weight transferred from the top slab to the columns will ultimately act on the base slab. If columns are used, the base slab should be designed to withstand the punching shear loads from the columns, especially if a ballast slab is not used.

6.4.2 Walls

The preliminary design of the storage tank features four large external side walls and the roof supported internally by a grid of internal columns and beams. The walls will support the load path from the roofing system, as well as lateral hydrostatic, seismic, and fluid loads from the external vertical walls. Because of the heavy loading on the storage tank, it is expected that substantial wall thicknesses will be necessary and specific requirements will be calculated using finite element analysis software. It is anticipated that the walls for both the facilities vaults and the storage tanks will be constructed with reinforced CIP concrete coated with the appropriate water proofing, as determined during design.

Any backfill behind concrete walls should not be placed prior to the complete construction and complete curing of the concrete roof.

6.4.3 Foundation and Buoyancy

Analytical results for soil borings completed to date indicated that the 49th Avenue South Parking Lot and 53rd Avenue South Parking Lot sites have competent soils that are capable of supporting the operational weight of the structures; bearing should not be an issue, and it is not anticipated that a pile foundation will be required for bearing purposes. For bearing purposes, a mat foundation will be adequate for the foundation design, and an allowable bearing capacity of 6,000 psf should be used for design in accordance with the geotechnical recommendations.

As indicated in the geotechnical report (Appendix B), the soils may be susceptible to liquefaction and lateral spreading. Further geotechnical recommendations are required to address these concerns and to determine the design parameters for the tank foundations.

The potential for high or perched groundwater, or both, at these sites will influence foundation design. The structural design will incorporate the use of a ballast slab or tie-down anchors to resist buoyancy. A ballast slab will consist of a mass concrete base slab that will resist the buoyant uplift force with its weight. Tie-down anchors are steel rods or steel-reinforced sections that are tied into the foundation of the structure, anchored into a soil or rock layer below, and grouted into place with cement. Tie-down strength and spacing plans are dependent on geotechnical recommendations.

The recommendations for the ballast slab and tie-down anchors are subject to change based on the finalized geotechnical report. The report must expand on both construction and operational considerations. Construction issues include proper anchor installation methods and anchor verification testing prior to the commission of the structure. Operational and design issues to be discussed include allowable anchor zone adhesion values, local and global uplift resistance stability of anchors, estimated capacity per foot of the tie-down anchor, global stability of the soil block under buoyancy forces, angle and inclination of the anchors, and anchor cone pullout forces. Uplift loads caused by groundwater must be designed for normal conditions with a factor of safety against buoyancy of 1.25. For 100-year flood conditions, the factor of safety against buoyancy will be 1.10.

Also, temporary dewatering and shoring during construction may be necessary at both sites. Shoring will be designed by the contractor or (GCCM) and must accommodate the minimal dimension between the structure's outer limit and site constraints.

6.5 Special Considerations

6.5.1 Facilities Vaults

In addition to underground storage tanks, this project includes the design and construction of underground facilities vaults to meet electrical, mechanical, and odor control requirements. The facilities vaults will consist of two rooms (an odor control room and an electrical/mechanical room) that will house mechanical controls and electrical equipment. These substructures will be buried, with access stairs to grade level elevation; the facilities vaults will have two main entrance hatches and several access hatches. The facilities vaults will be constructed using reinforced concrete and precast panels or steel hatches for the access hatch lids.

6.5.2 Mechanical Supports

The storage tanks will require supports for mechanical equipment including the basin drain pumps and tipping buckets (one per flushing channel). The tipping buckets will be supported inside the structure. Although the recommendation of the support type for the tipping buckets will be made by the manufacturer, the design for the supports will be developed by the structural engineer. The pump supports can be constructed with reinforced CIP concrete to form support systems for the mechanical equipment; this method is the easiest and least expensive alternative. Another possibility is to use metal connections and supports built from structural steel; however, using metal is less favorable because metal within the storage tank must be hot-dip galvanized or otherwise protected against corrosion.

The facilities vaults will contain both mechanical and odor control equipment that will require supports. Mechanical equipment in the mechanical rooms will require concrete equipment pads. It is anticipated that the carbon adsorption vessels in the odor control rooms will require design for anchorage to the base slab or walls, or both, for equipment and seismic loads.

6.5.3 Equipment Access

Access into the storage tanks and facilities vaults will be required for the large equipment to be lowered into the structure. The tipping buckets, pumps, carbon adsorption vessel, and other O&M equipment will need to be lowered into and raised out of these substructures through access hatches. Equipment and access hatches are indicated on the plan view of the storage tanks and facilities vaults on Exhibits 5, 13, and 16 in Appendix A.

The openings for these hatches must be large enough to accommodate large equipment, and the hatch lids should be strong enough to support any type of heavy loading that will act on the slab. The use of precast concrete panels for the lids to these access hatches will work well; not only will these panels be designed for heavy loads, but they will also be designed to be easily removed. Pick points, or the points at which the precast panels will be lifted to provide an opening in the storage tank, will need to be evaluated and designed for sizable point loads. Instead of precast concrete panels, steel hatches may be used. Metal hatches will deform under repeated subjection to traffic; however, steel hatches are more resilient than other metals to such dynamic loading conditions. Steel hatches will require additional protection against corrosion or weathering. With either steel or precast hatches, both the location and the number of access hatches will influence the location and placement of internal columns and bracing.

6.5.4 Operations and Maintenance Accommodations

The following items are O&M issues that will influence design decisions for the substructures.

6.5.4.1 Sight Lines

To visually survey the condition of the storage tank, maintenance personnel must have a clear line of sight from access hatches or maintenance holes in the top slab. These visual inspection points will be located in two locations, at each end of every flushing channel. To maintain unobstructed sight lines, certain limitations will be placed on the transverse internal bracing walls or columns within the storage tank. Because of the loads acting on the tank, it is unlikely that internal supports can be completely eliminated; however, the use of columns will minimize sight line obstructions.

6.5.4.2 Surface Area

Sewage and waste can build up on the surfaces within the tank. For maintenance considerations, reducing the surface area within the tank will be beneficial; the less surface area there is to clean, the lower O&M costs will be. Surface area can be reduced by minimizing the number or size of internal supports or increasing the spacing between bracing intervals.

6.5.4.3 O&M Requirements

General O&M requirements will include regular and event inspections, equipment inspection or replacement, and internal storage tank cleaning, among others. Not only will these cleaning and inspection events require access into the tank, they also will pose a significant increase in temporary loading on the tank. To properly clean the tank, a Vactor™ truck may be required onsite. Also, equipment replacement and repairs may require a crane to move equipment in and out of the tank. SPU O&M staff will use cranes and full Vactor™ trucks that conform to the standard HS-25 loading, to ensure that the tank roof structure is not overloaded.

6.6 Codes and Standards

The structural aspects of project components will be designed in accordance with the current edition of the IBC and its referenced standards in effect as of the service agreement date. The following editions are the standards referenced by the current edition of the IBC:

- IBC 2009
- ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
- American Concrete Institute (ACI) 350-06, Environmental Engineering Concrete Structures
- ACI 3503, Seismic Design of Liquid-Containing Concrete Structures and Commentary
- ACI 318-08, Building Code Requirements for Structural Concrete
- ADM 1-05, Aluminum Design Manual
- American Institute of Steel Construction (AISC) Steel Construction Manual, 13th Edition
- AISC 341-05, Seismic Design Manual
- American Iron and Steel Institute (AISI) S100-09, North American Specification for the Design of Cold Formed Steel Structural Members
- WSDOT Geotechnical Design Manual 2006
- LRFD Bridge Design Specifications, Customary U.S. Units, 4th Edition, with 2008 and 2009 Interim Revisions
- Precast Prestressed Concrete Institute (PCI) Handbook, Precast and Prestressed Concrete 6th Edition, 2004

The structural design for project components will also conform to current applicable industry standards. Societies, industry groups, organizations, institutes, and agencies issuing these standards include the following:

- ASCE
- International Code Council
- ACI
- PCI
- AISC
- ANSI
- AISI
- WSDOT
- AASHTO
- ASTM
- American Water Works Association (AWWA)

7 Mechanical Design

7.1 Introduction

This section focuses on the mechanical equipment design criteria associated with the proposed underground storage tanks at the 49th Avenue South Parking Lot and 53rd Avenue South Parking Lot. Each item of mechanical equipment will perform a specific function in normal operation of the proposed storage tanks. This section describes the purpose, operation, design criteria, and general layout and arrangement of each mechanical item. The descriptions, including preliminary sizing information, will form the basis of final design for mechanical equipment associated with the proposed storage tanks.

The following equipment is discussed in this section:

- Basin drain pumps
- Tipping buckets
- Non-potable water (NPW) tank and air gap
- Tipping bucket fill pumps
- Facilities vault sump pumps
- Motor-operated valves – CSO control structures
- Motor-operated valves – diversion flow control

A buried facilities vault will be located adjacent to each of the storage tanks. The facilities vault will consist of two rooms, one for mechanical and electrical equipment and the other for odor control equipment. The mechanical room will house the NPW tank, tipping bucket fill pumps, and the motor-operated diversion flow control valves. The tipping buckets will be located on one side of each storage tank, and the storage tank drainage pumps will be located on the other side of the storage tank.

7.2 Basin Drain Pumps

7.2.1 Purpose

The purpose of the basin drain pumps will be to empty the storage tanks and pump flow into the combined sewer system after a storm event. The basin drain pumps will also be used to remove the remaining solids and flush water after an automatic cleaning cycle is performed. At each site, two basin drain pumps are proposed. A CSO storage tank is not deemed a critical facility; therefore, no standby pump will be provided. If one of the basin drain pumps does not function properly, the length of time to drain the tank will increase. The pumps will operate based on a level sensor (in the primary control structure) that is recording the available capacity in the lake line.

Valving for the pumps and associated force mains will be contained in a valve vault adjacent to each storage tank. The valve vaults will contain check valves and isolation plug valves for each of the pumps. After the valving, each pump discharge pipe will connect together in a pipe manifold in the vault to form a single force main. Section 2, Site Civil, contains further discussion of the force main.

Basin drain pumps a will re typically be of the submersible type and located at the low point in each storage structure. The pumps will be designed for pumping raw wastewater and capable of passing solids at least 3 inches in diameter. Vortex, recessed, impeller-type pumps similar to those manufactured by ITT Water & Wastewater (Flygt) are recommended for this application because of their resistance to clogging. The basin drain pumps will be installed in a sump to allow flow and solids to be removed. Guide rails will be provided beneath the access hatches so that the pumps can be removed and maintained.

The drain pumps will be designed to operate under the full range of anticipated system hydraulic conditions. Both new and old pipe conditions will be evaluated, along with the various combinations of operating pumps and minimum and maximum flows, to determine the highest head and lowest head pumping conditions. The system will be designed to prevent a pump from operating for long periods beyond the pump manufacturer's recommended normal operating range.

Hydraulic transients will also be considered during design of the pumping and force main system. All systems will be conceptually reviewed for the possibility of damaging hydraulic transients. Hydraulic transients can cause a number of damaging and costly conditions to the facility.

7.2.2 Location

7.2.2.1 49th Avenue South Parking Lot

At the 49th Avenue South Parking Lot site, the basin drain pumps will be located at the southeast end of the storage tank within a sump, as shown on Exhibit 5 in Appendix A. The sump will be approximately 1.4 feet deep by 6 feet wide by 4 feet long. Exhibit 6 in Appendix A shows the general proposed pump and piping arrangement for the tank drain sump pumps. Guide rails will be provided beneath the access hatches so that the pumps can be removed and maintained.

As shown in Exhibit 5 (Appendix A), the valve vault will be a separate structure, located adjacent to the storage tank structure. This will provide maintenance access from the ground surface. The inside of the valve vault will be approximately 6 feet deep by 5 feet wide by 6 feet long.

7.2.2.2 53rd Avenue South Parking Lot

At the 53th Avenue South Parking Lot site, the basin drain pumps will be located at the northwest end of the storage tank within a sump, as shown on Exhibit 15 in Appendix A. The sump will be approximately 1.3 feet deep by 6 feet wide by 4 feet long. Exhibit 16 in Appendix A also shows the general pump and piping arrangement for the tank drain sump pumps. Guide rails will be provided beneath the access hatches so that the pumps can be removed and maintained.

As shown in Exhibit 15 (Appendix A), the valve vault will be a separate structure, located adjacent to the storage tank sump. This will provide maintenance access from the ground surface. The valve vault will be approximately 6 feet deep by 5 feet wide by 8 feet long.

7.2.3 Design Criteria

7.2.3.1 49th Avenue South Parking Lot

There are two competing design criteria for draining the storage tank: drain the tank as fast as possible, and do not overwhelm the downstream system. It is assumed that approximately one-half to two-thirds of the downstream system (Lake Line) will be available for draining the storage tank. Based on this criterion, the basin drain pumps should be sized to produce 300 to 650 gallons per minute (gpm) total. The size of the force main will be selected to provide a flow velocity between 3 and 7 feet per second (fps).

The basin drain pumps will need to operate in a submerged condition and be able to pass solids, similar to a wet well pump. Table 5 lists the design criteria for basin drain pumps. Each pump will be sized for approximately 300- to 650-gpm flow, based on Lake Line capacity. Based on this flow rate, pipes carrying flow from the sump to the valve vault will be sized at 6 inches. Values in Table 5 are the result of calculations based on this preliminary pipe sizing condition.

Table 5. Design Criteria for Basin Drain Pumps – 49th Avenue South Parking Lot

PARAMETER	PRELIMINARY DESIGN CONDITION
Design Flow (each pump)	300 to 650 gpm
Total Dynamic Head (TDH) at Design Flow	14-25 feet
Speed	1,800 revolutions per minute (rpm)
Horsepower	5 horsepower (hp)
Pump Efficiency (minimum)	60%
Starter/Control	Constant Speed

Figure 1 below shows the approximate system curve for the basin drain pumps. This is based on an 8-inch-diameter force main, and an assumption for bends and fittings because the design is still in progress. The pump curves shown are for Flygt LT pumps, model number 3102. These are shown for comparison only and do not reflect the final pump selection.

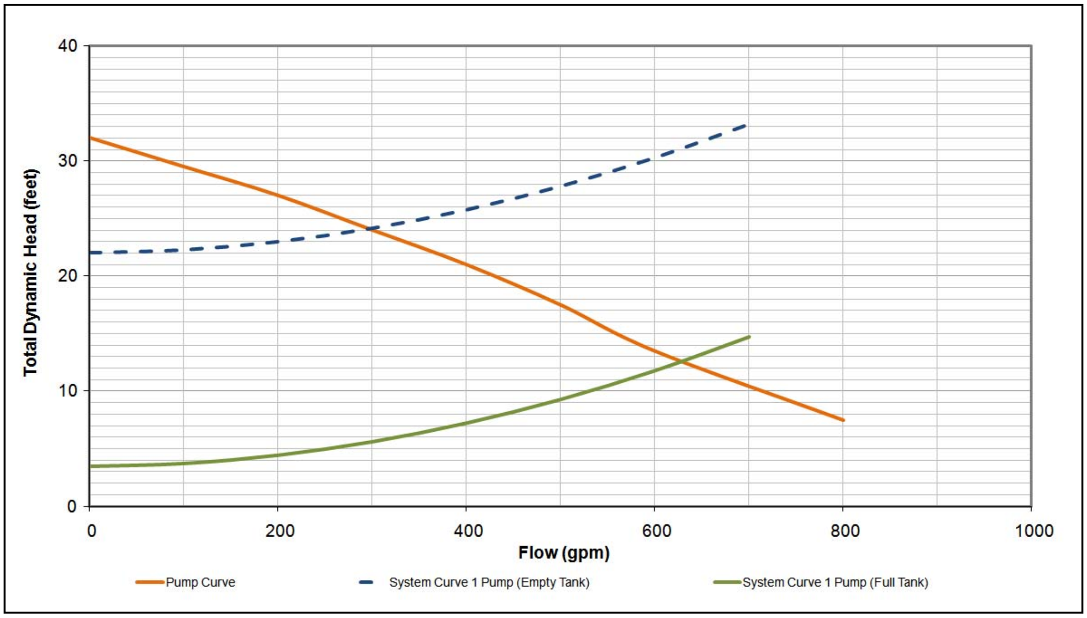


Figure 1. Basin Drain Pump System and Pump Curve – 49th Avenue South Parking Lot

7.2.3.2 53rd Avenue South Parking Lot

There are two competing design criteria for draining the storage tank: drain the tank as fast as possible, and do not overwhelm the downstream system. It is assumed that approximately one-half to two-thirds of the downstream system (Lake Line) will be available for draining the storage tank. Based on this criterion, the basin drain pumps should be sized to produce approximately 1050 to 1,300 gpm each, based on Lake Line capacity. The size of the force main will be selected to provide a flow velocity of 3 to 7 fps.

The basin drain pumps will need to operate in a submerged condition and be able to pass solids, similar to a wet well pump. Table 6 lists the design criteria for basin drain pumps. Each pump will be sized for approximately 1,050 gpm of flow. Based on this flow rate, pipes carrying flow from the sump to the valve vault were sized at 6 inches. Values in Table 6 are the results of calculations based on this preliminary pipe sizing condition.

Table 6. Design Criteria for Basin Drain Pumps – 53rd Avenue South Parking Lot

PARAMETER	PRELIMINARY DESIGN CONDITION
Design Flow (each pump)	1,050 to 1,300 gpm
Total Dynamic Head (TDH) at Design Flow	40 feet
Speed	3,600 revolutions per minute (rpm)
Horsepower	7.5 horsepower (hp)
Pump Efficiency (minimum)	60%
Starter/Control	Constant Speed

Figure 2 shows the approximate system curves for the basin drain pumps. These curves are based on an 8-inch-diameter force main and an assumption for bends and fittings because the design is still in progress. The pump curves shown are for Flygt LT pumps, model number 3127. These are shown for comparison only and do not reflect the final pump selection.

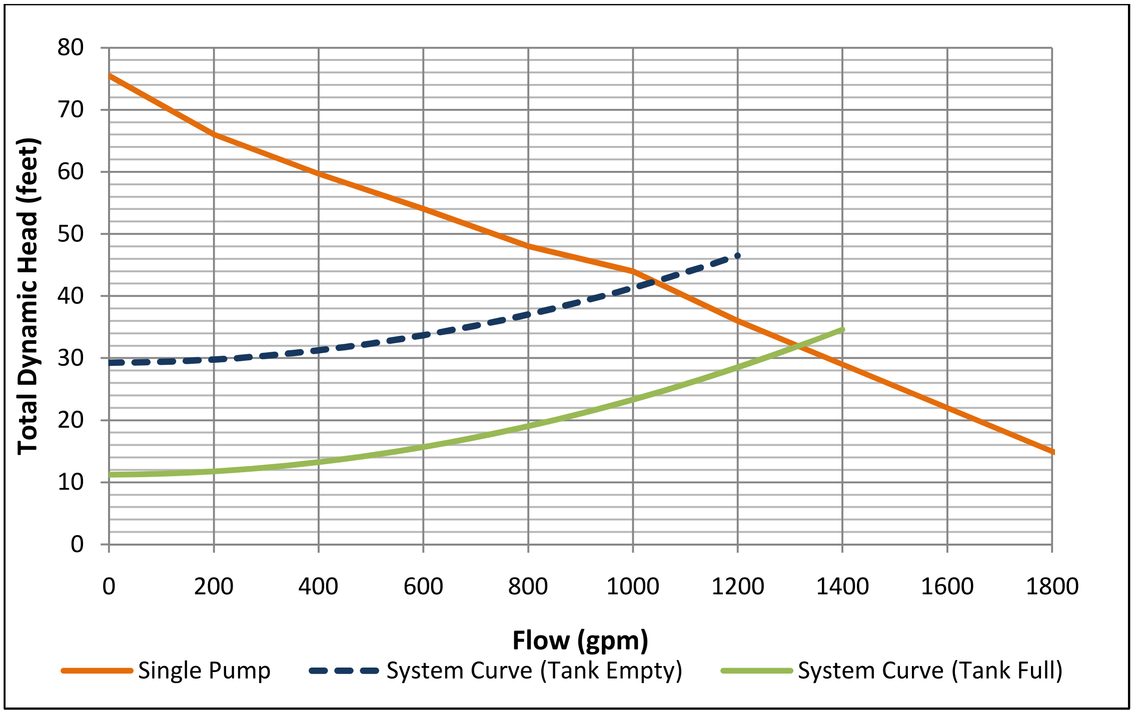


Figure 2. Drain Pump System and Pump Curve – 53rd Avenue South Parking Lot

7.2.4 Description of Operation

7.2.4.1 49th Avenue South Parking Lot

Drainage of the storage tank will occur when downstream capacity is available. The two basin drain pumps will cycle on in an effort to keep the primary control structure and Lake Line full. If the pumps are providing more flow than can be conveyed downstream, the additional flow will pass over the storage diversion weir in the primary control structure and return the excess flow to the storage tank.

The pumps will operate based on both the water level in the control structure and the water level in the storage tank sump. Pressure transducer level probes, indicated in the hydraulic schematic on Exhibit 7 in Appendix A, will be used as the primary control for starting and stopping the pumps. A float will be provided as a backup control mechanism. The number of pumps operating will be determined by the available capacity in the combined system downstream of control structure.

When the tank is full, the level will continue to rise in the control structure and, eventually, flows will overtop the CSO overflow weirs and be directed to Basin 40 and 41 outfalls.

7.2.4.2 53rd Avenue South Parking Lot

The storage tank will begin to drain (via the basin drain pumps) once downstream capacity has become available, as indicated by the level sensor in the primary control structure. The two basin drain pumps will cycle on in an effort to maintain level in the Lake Line. If the pumps are providing more flow than can be conveyed downstream, the additional flow will pass over the storage overflow weir in the control structure and return to the storage tank.

The pumps will operate based on both the water level in the Lake Line and the water level in the sump in the storage tank. Pressure transducer level probes, indicated in the hydraulic schematic on Exhibit 17 in Appendix A, will be used as the primary control for starting and stopping the pumps. A float will be provided as a backup control mechanism. The number of pumps operating will be determined by the available capacity in the combined system downstream of control structure.

The maximum water surface level in the storage tank will be of lower elevation than the diversion point. To prevent the area around the storage tank from flooding when the tank is full, the diversion flow control valves will be used to stop flow from entering the tank. When the valves are closed, the drain pumps will stop pumping until the water level lowers in the overflow structure at CSO Control Structure 43.

7.3 Tipping Buckets

7.3.1 Purpose

For both project sites, after an event that has diverted excess combined sewer flow to the storage tank, some solids will have settled out during storage and will not be removed during tank drainage. These solids must be removed to prevent odors from developing. An automated flushing system using tipping buckets will be implemented for removing solids that have accumulated on the bottom of the tank.

7.3.2 Flushing Channels

7.3.2.1 49th Avenue South Parking Lot

The exterior of the proposed storage tank at the 49th Avenue South Parking Lot site will be approximately 45 feet wide and 90 feet long. The elevation of each tipping bucket, from the bottom slab to the approximate centerline of the tipping bucket, will be approximately 18.5 feet. The storage tank will be divided into two flushing channels that will extend along the length of the facility and be separated by a training wall. The training wall will help to direct the wave released by the tipping buckets to flush the solids to the collection channel. Each flushing channel will be approximately 18.5 feet wide. Each flushing channel will be sloped at 2 percent and will have a vertical drop from the flushing channel to the collection channel. The vertical drop of the flushing channels will increase the velocity of the flushing wave through the basin and will facilitate the scouring of solids on the tank floor. This general arrangement is shown on Exhibits 5 and 6 in Appendix A.

7.3.2.2 53rd Avenue South Parking Lot

The exterior of the proposed storage tank at 53rd Avenue South Parking Lot will be approximately 22 feet wide and 125 feet long. The height of the tipping bucket, from the bottom slab to the approximate centerline of the tipping bucket, will be approximately 11 feet. The storage tank will have one flushing channel that will extend along the length of the facility. The flushing channel will help to direct the wave released by the tipping bucket to flush the solids to the collection channel. The flushing channel will be approximately 17 feet wide. The flushing channel will be sloped at 2 percent and will have a vertical drop from the flushing channel to the collection channel. The vertical drop of the flushing channel will increase the velocity of the flushing wave through the basin and will facilitate the scouring of solids on the tank floor. This general arrangement is shown on Exhibits 14 and 15 in Appendix A.

7.3.3 Description of Operation

Tipping buckets will be installed (one at the head of each channel) in the storage tank. Tipping buckets are long troughs that are mounted at the top of a tank at the upstream end. After the tank has been drained following a storm event, the tipping bucket will fill with an external source of water until it begins to rotate on its center axle. This will send a flushing wave down the channel, scouring the solids on the tank floor.

An external source of water is required to fill the tipping buckets. This water will be supplied by tipping bucket fill pumps (Exhibit 19, Appendix A). Once the tipping bucket has filled, it will rotate on its central axle and the proximity switch will send a signal to the fill pump to stop pumping.

7.3.4 Criteria

Tipping buckets require an external source of water for flushing. The quantity of water required—the flush volume—will determine the tipping bucket size and be based on the following five key constraints:

- Flush way length: flush volume increases with increasing length.
- Height from the floor of the tank to the centerline of the tipping bucket: flush volume decreases with increasing height.
- Adjustment for flush way slope: flush volume decreases with increasing slope.
- Adjustment for flushway width versus tipping bucket length: flush volume increases with this ratio.
- Adjustment for excessive flushway height: flush volume increases if the height is greater than 20 feet.
- Bucket-style flow against the back wall and use of kinetic energy to flush.

7.3.5 Tipping Bucket Sizing

49th Avenue South Parking Lot

Tipping bucket size will be determined by the flushing volume required to scour the solids from the channel. For this project, the tipping buckets have been preliminarily sized to have 73 gallons per foot of flush volume, based on vendor recommendations for tipping bucket size, given the proposed storage tank dimensions. The number of flushing channels will not affect the gallons per foot of flush volume required. Table 7 summarizes the relevant design elements that were taken into consideration by the proposed vendor (Grande Water Management Systems) for calculating the flushing volume.

Table 7. Summary of Tipping Bucket Sizing – 49th Avenue South Parking Lot

CRITERION	VALUE
Tipping Bucket Elevation (feet)	18.5
Flushing Channel Width (feet)	18.5
Flushing Channel Length (feet)	90
Flushing Volume (gallons/foot)	73
Total Flushing Volume per Channel (gallons)	1,250 to 1,350

53rd Avenue South Parking Lot

For the 53rd Avenue South Parking Lot, the tipping buckets have been preliminarily sized to have 73 gallons per foot of flush volume, based on vendor recommendations for tipping bucket size, given the proposed storage tank dimensions. The number of flushing channels will not affect the gallons per foot of flush volume required. Table 8 summarizes the relevant design elements that were taken into consideration by the vendor (Grande Water Management Systems) for calculating the flushing volume.

Table 8. Summary of Tipping Bucket Sizing – 53rd Avenue South Parking Lot

CRITERION	VALUE
Tipping Bucket Elevation (feet)	11
Flushing Channel Width (feet)	17
Flushing Channel Length (feet)	113
Flushing Volume (gallons/foot)	73
Total Flushing Volume per channel (gallons)	1,200 to 1,300

7.4 Non-potable Water Reservoir / Air Gap Tank

7.4.1 Purpose

The purpose of the proposed NPW reservoir in the facilities vault is to provide water supply for the tipping bucket fill pumps. The design approach is for a potable water connection to supply water to the NPW tank. The facilities vault and storage tank will be located underground, and a backflow preventer and an air gap will be provided. The system could be configured such that the Reservoir could serves as the air gap tank as well.

7.4.2 Location

The NPW reservoir will be located in the mechanical/electrical room of the underground facilities vault at both project locations (Exhibit 19, Appendix A). The air gap will also be located in the facilities vault. A backflow preventer will be located upstream of the air gap on the water line, at ground surface adjacent to the facilities vault.

7.4.3 Criteria

The NPW reservoir will be sized to meet the demands of the tipping bucket fill pumps and other NPW uses (for example, hose bibs). Coordination with the City will be critical when tapping into its water system. SPU will provide all connections to its system and will construct the service facilities (including the meter) up to the property line.

7.4.3.1 49th Avenue South Parking Lot

There is an existing 8-inch-diameter SPU water line located on 48th Avenue South. The size of the water service to the NPW reservoir will be evaluated during design, and will likely be 2 to 3 inches in size. The design approach is to size an NPW reservoir to store 500 gallons to meet the pumping demands of the tipping bucket fill pumps, based on the criteria listed in Table 9.

7.4.3.2 53rd Avenue South Parking Lot

There is an 8-inch-diameter SPU water line located on 53rd Avenue South. The size of the water service to the NPW reservoir will be evaluated during design and will likely be 2 to 3 inches in size. The design approach is to size an NPW reservoir to store 500 gallons to meet the pumping demands of the tipping bucket fill pumps, based on the criteria listed in Table 9.

Table 9. Design Criteria for Non-potable Air Gap Water Tank

CRITERIA	VALUE
Non-potable Water Tank Capacity	500 gallons
Backflow Preventer	1 (on the Water Connection)
Location of Non-potable Air Gap Water Tank	Belowgrade (in the facilities vault)
Air Gap	1 (belowgrade, in the facilities vault)

7.4.4 Description of Operation

The backflow preventer will be located at the ground surface in an insulated enclosure to guard against freezing and damage. The enclosure will be upstream of the NPW reservoir and air gap tank, as indicated in the Site Civil Plans on Exhibits 2 and 9 in Appendix A. The NPW line from the air gap will be routed to a reservoir with a capacity of 500 gallons. The reservoir will contain a shutoff valve, high-water level float switch, and a low-water-level indicator. The function of the high-water-level float switch will be to close the shutoff valve so that the NPW cannot enter the reservoir. The low-level water indicator's function will be to open the shutoff valve and allow NPW flow into the reservoir.

The NPW reservoir will act as the suction wet well for the tipping bucket fill pumps. A 2-inch-diameter header from the reservoir will feed these pumps. Exhibit 19 in Appendix A shows the proposed general arrangement of the NPW reservoir in the facilities vault mechanical room.

7.5 Tipping Bucket Fill Pumps

7.5.1 Purpose

The purpose of the proposed tipping bucket fill pumps is to provide the required flushing volume to the tipping buckets. The design approach for this project to provide pumping capacity to fill one tipping bucket at a time. Two pumps, one duty and one standby, are proposed.

7.5.2 Location

The tipping bucket fill pumps will be located in the facilities vault, as shown on Exhibit 19 in Appendix A. Access to the facilities vault will be through large hatches. Discharge piping from the tipping bucket fill pumps will lead to a splitter manifold with motor-operated valves.

7.5.3 Criteria

Pump capacity for the tipping bucket fill pumps was determined by the flushing volume requirement for the tipping buckets. The design approach is that the tipping buckets will be filled one at a time. Table 10 lists the design criteria for the tipping bucket fill pumps.

Table 10. Design Criteria for Tipping Bucket Fill Pumps

CRITERION	49th AVENUE SOUTH PARKING LOT	53RD AVENUE SOUTH PARKING LOT
Flushing Volume per Tipping Bucket	1,250 to 1,350 gallons	1,200 to 1,300 gallons
Time Required to Fill One Tipping Bucket	10 to 15 minutes	10 to 15 minutes
Flow Rate for Tipping Bucket Fill Pumps	100 to 120 gpm	100 to 120 gpm
Total Dynamic Head	30 feet (preliminary)	30 feet (preliminary)
Starter/Control	Constant speed	Constant speed

7.5.4 Description of Operation

Under normal operating conditions, after the storage tank has been emptied of the diverted combined sewage by the drain pumps, the tipping bucket fill pumps will start and begin filling the tipping buckets one at a time.

The currently proposed approach is to operate the tipping bucket fill pumps automatically by sending a signal from the supervisory control and data acquisition (SCADA) system to the pumps. A signal from SCADA will be sent when the following conditions have been met:

- Basin drain pumps have finished draining the storage tank and have been idle for 15 minutes.
- The water surface level in the interceptor is below a certain depth (indicating availability of downstream capacity).

Once the tipping bucket has filled, it will rotate on its center axle and the proximity switch located at the tipping bucket will send a signal to the pump to stop pumping. This process will be repeated to clean each of the individual flushing channels. The proposed storage tank sump is sized to contain one tipping bucket's volume. Between flushes, the basin drain pumps will drain the volume from the tipping bucket in preparation for the next flush. The maintenance personnel will have the ability to run the pumps in manual mode if they deem it necessary to scour a channel more than once.

7.6 Facilities Vault Sump Pumps

7.6.1 Purpose

The purpose of the proposed facilities vault sump pumps is to drain the rooms of the underground facilities vault in the event that water is collected on the floor. The facilities vault sump pumps are shown on Exhibit 19, Appendix A.

7.6.2 Description

At both project locations, sump pumps will be located in each room of the facilities vault (electrical/ mechanical and odor control). Each room will have two sump pumps, one duty and one standby. Each room will have a trough along one side of the room to collect water and convey flow to a sump where the facilities vault sump pumps will be located.

When water is collected in the sump, the sump pumps will turn on and drain to the nearest combined sewer maintenance hole.

Each room must have separate sump pumps and drain systems because of different room classifications. Section 10, Electrical Design, provides more discussion of room classifications.

7.6.3 Design Criteria

Table 11 lists preliminary design criteria for the facilities vault sump pumps.

Table 11. Design Criteria for Facilities Vault Sump Pumps

CRITERION	VALUE
Flow Rate for Facilities Vault Sump Pumps	10 to 20 gpm
Total Dynamic Head	25 feet (Preliminary)
Starter/Control	Constant Speed

7.7 Motor-operated Gate – CSO Facility 9

7.7.1 Purpose

The purpose of the proposed modifications in CSO Facility 9 is to modulate flows through the existing storage at CSO Facility 9 and divert excess flow to the proposed underground storage tank at 53rd Avenue South Parking Lot. The HydroBrake located in MH 060W-047 at CSO Facility 9 will be replaced with a motor-operated gate that will modulate based on flow downstream in the Lake Line.

7.7.2 Equipment

Motor-operated Gate

The existing HydroBrake in the MH 060W-047 flow control vault will be replaced with a motor-operated gate over the existing penetration in the weir wall for the HydroBrake sleeve. The HydroBrake sleeve will be removed and a bore will be made in its place. The channel will be re-grouted for front entry to the new gate. The gate will be a 304 stainless steel slide gate set in a flange-mounted frame. The flange will be installed with a 1-inch grout pad by the contractor. The size of the gate will be determined during design.

The design of the actuator will be similar to that of the belowgrade actuator used for the CSO Control Structure 22 Retrofit Project near Windermere Park. The electric motor actuator for the gate will be located in an enclosure constructed between the top of the existing flow control vault and the existing grade elevation. The flow control vault ceiling will be bored for penetration by the gate stem.

7.7.3 Electrical and Instrumentation and Control

The electrical and instrumentation and control (I&C) requirements for project components are provided in Section 10, Electrical Design, and Section 11, Instrumentation and Control.

7.8 Motor-operated Isolation Valves – Diversion Flow Control

7.8.1 Purpose

The diversion point to the 53rd Avenue South Parking Lot will be approximately 20 feet above the maximum water surface elevation within the new storage tank. The elevation difference could create a flooding situation at the storage tank if there are no controls in place to stop the flow coming down the hill to the tank.

7.8.2 Description

The primary and redundant diversion flow control valves will be installed in a vault outside the tank. The control valves will be electrically controlled, 18-inch plug valves installed on the diversion pipeline. The primary valve will operate off the level transducer in the storage tank. The secondary control valve will have a redundant float switch in the tank that will automatically shut the secondary valve.

7.8.3 Electrical and Instrumentation and Control

The electrical and I&C requirements for project components are provided in Section 10, Electrical Design, and Section 11, Instrumentation and Control.

7.9 Motor-operated Gate – CSO Facility 11

7.9.1 Purpose

The purpose of the proposed modifications in CSO Facility 11 is to maintain flows to the existing system by replacing the existing HydroBrake (located in MH 059-490) with a modulating, motor-operated gate at CSO Facility 11. As the gate modulates closed, the combined sewer levels will rise and eventually overtop the new diversion weir. The excess flows will divert to the proposed underground storage tank at the 49th Avenue South Parking Lot.

7.9.2 Equipment

Motor-operated Gate

The existing HydroBrake in the MH 059-490 flow control vault will be replaced with a motor-operated gate over the existing penetration in the weir wall for the HydroBrake sleeve. The HydroBrake sleeve will be removed and a bore will be made in its place. The channel will be re-grouted for front entry to the new gate. The gate will be a 304 stainless steel slide gate set in a flange-mounted frame. The flange will be installed with a 1-inch grout pad by the contractor. The size of the gate will be determined during design.

The design of the actuator will follow that for the belowgrade actuator used for the CSO Control Structure 22 Retrofit Project near Windermere Park. The electric motor actuator for the gate will be located in an enclosure constructed between the top of the existing flow control vault and the existing grade elevation. The flow control vault ceiling will be bored for penetration by the gate stem.

7.9.3 Electrical and Instrumentation and Control

The electrical and I&C requirements for project components are provided in Section 10, Electrical Design, and Section 11, Instrumentation and Control.

7.10 Drawings

Table 12 outlines required drawings and their contents.

Table 12. Mechanical Drawing List

DRAWINGS (IN ORDER)	WHAT IS TO BE SHOWN
Site Plan	Proposed structures Locations of proposed mechanical installations Proposed pipe alignments connecting to structures Existing survey data, including utilities, contours, structures, and monuments
Yard Piping Plan	Proposed structures Proposed alignment of belowgrade pipes and ductwork on the site Existing below grade pipes and ductwork

DRAWINGS (IN ORDER)	WHAT IS TO BE SHOWN
Facility Plans, Sections, Details	Proposed structures Proposed mechanical equipment installations and equipment tag numbers Arrows indicating direction of flow
Interior Piping and Ductwork	Proposed structures Proposed pipe supports and hanger locations Proposed pipes, fittings, and valves
Process and Instrumentation Diagram (P&ID) Joint effort with I&C Engineer	Process connections and piping Process equipment Process instruments (use given instrument abbreviations) Vendor control panels Process instrumentation, control, and equipment tag numbers
Details	Anything else that needs to be more clearly defined

7.11 Referenced Codes and Standards

The following codes and standards are applicable to mechanical elements of the design:

- Washington State Water System Design Manual (WSDM) (August 2001)
- Applicable AWWA standards
- Applicable National Science Foundation standards
- IBC (2009)
- IFC (2009)
- Right-of-Way Improvements Manual – SDOT Rule 2-05 / DPD Rule 22-2005 (superseding DCLU DR 30-90 and SDOT DR 91-4)
- City Standard Plans
- Above Ground Telecommunications Facilities in the Public Right of Way – SDOT Rule 2-2009

8 Odor Control System

This section describes the odor control design criteria for the Genesee CSO Reduction Project. The proposed odor control systems discussed in this section will be located within the 49th Avenue South Parking Lot and the 53rd Avenue South Parking Lot sites.

8.1 Odor Control System Engineering Design Criteria

The purpose of the odor control proposed for the Genesee CSO storage facilities is to minimize potential odor emissions from the storage facilities. Negative pressure within the storage tank will be maintained to minimize fugitive odor emission.

Corrosion of the storage tank is not anticipated because the historical data show no corrosion at similar SPU facilities, and the flushing mechanism in the new storage tanks will reduce the debris after service. Therefore, corrosion control through the odor control system will not be considered.

The proposed odor control systems for the storage facilities will be located in an underground vault, just like the storage tanks and the facilities vaults. The odor control vault and the facilities vault will be adjacent to each other at each site. Access to each vault will be provided by a hatch and stairs from the ground level. More hatches will be available for equipment and carbon access from the ground level. The odor control vault will house the odor control system, HVAC system, and sump pump.

The odor control system will consist of a grease filter/mist eliminator, a centrifugal fan, a deep bed carbon vessel, and ductwork. A fan will either push or pull air through the activated carbon vessel, after the air passes through the grease filter/mist eliminator. The treated air will be discharged at grade, inside or outside the facility footprint, depending on the specific site condition. No aboveground discharge stack will be included.

8.1.1 Operating Conditions

There is no specific regulatory requirement for ventilation of small, offsite wastewater storage tanks. According to, National Fire Protection Association (NFPA) 820, if combined sewers and storage facilities are not ventilated, or are ventilated at less than 12 air changes per hour (ac/hr), the enclosed space within the facility is to be a Class I, Division 1, Group D area. Conversely, if the facility is ventilated at 12 ac/hr or more, the area is to be declassified to Class I, Division 2, Group D. Because there will be few electrical components within these storage facilities, and providing 12 ac/hr of ventilation is not required to contain the odors, maintaining a Class I, Division 1, Group D area within the spaces at a lower ventilation rate is a cost-effective approach. Therefore, the design will be based on providing the minimum ventilation to prevent fugitive odor emissions from the storage tanks and making the electrical equipment within the tanks explosion-proof. The following criteria were used to estimate the required ventilation rates at storage tanks at various locations.

- No positive makeup air will be supplied to the storage tanks. This will eliminate any abovegrade air intake. Fresh air will be pulled into the tank through hatches/MH cracks and the influent pipe, by the interior versus exterior pressure differential.
- W.c. negative pressure of at least 0.1-inch will be maintained inside the tanks by pulling air from tanks via the odor control fan. Collected air will be treated continuously before exiting to the atmosphere.

- An air vent will be provided at the top of the influent pipe in the tank, extending above the maximum water level. The vent will be sized to allow an appropriate amount of air to enter into the tank when the influent pipe outlet is submerged. The influent pipe outlet will be submerged in a water trap at all times so that the vent becomes the only place where the makeup air flow through the influent pipe is controlled.
- If the air path in the influent pipe is blocked because of the full flow, the constant-speed odor control fan will operate to the left of the curve, resulting in slightly less air flow and a higher system pressure drop (but outside the unstable region).
- The design ventilation air flow will always be higher than the flow of air displaced by the wastewater flowing into the storage tank on an hourly basis.

Figure 3 illustrates the concept of ventilation of the storage tanks.

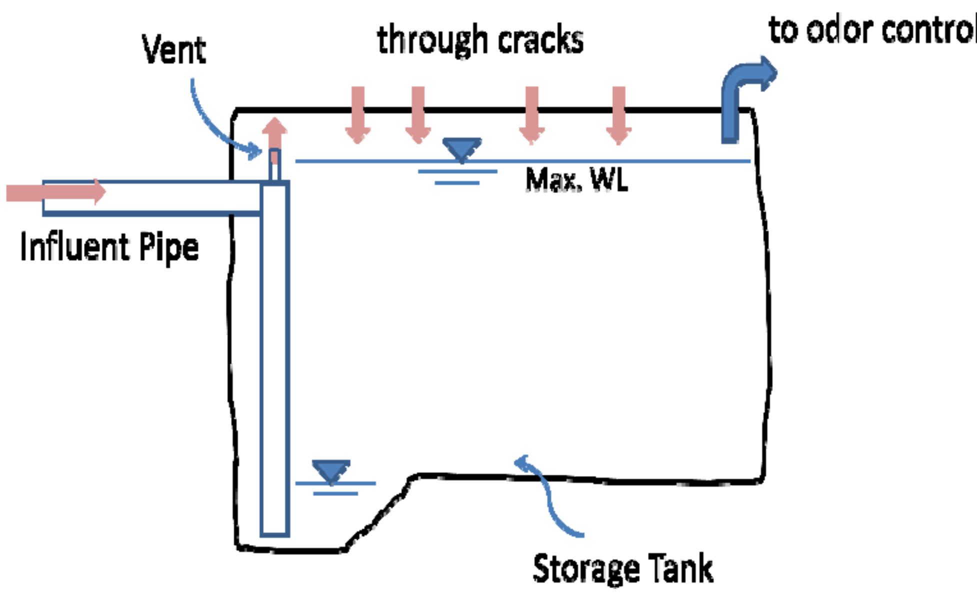


Figure 3. Storage Tank Ventilation Schematic at Genesee CSO Facilities

Based on the approaches described above and the intent to standardize the odor control systems, the design airflows and pressures for the odor control system at these two Genesee sites are summarized in Table 13.

Table 13. Ventilation Air Flow and Design Pressure

	ODOR CONTROL AIRFLOW (cfm)	NEGATIVE PRESSURE INSIDE TANK	DESIGN SYSTEM PRESSURE DROP
Genesee Odor Control System	500	0.1-inch w.c.	10-inch w.c.

Ventilation air flow (500 cubic feet per minute [cfm]) was determined based on the total of the air pulled through the hatches and MH cover cracks, and the air pulled through the influent pipe and vent under a differential pressure no less than a 0.1-inch w.c. This design flow was checked against other extreme conditions described in the operating criteria. As described, when the air pulled through the influent pipe is blocked, the odor control fan will operate at a lower flow but a higher system pressure drop. When a high flow of wastewater enters the tank to displace a noticeable volume of air in the tank, the odor control fan will operate at a higher flow but a lower system pressure drop. The hydraulic model projected the peak instantaneous CSO flow (~2.5 minutes duration, two to three occurrences during 32 years) that is likely higher than the design ventilation rate; however, this will not become a concern because of the short duration of the event and diluted wastewater strength.

These criteria were developed to provide odor containment and treatment within the CSO storage facilities. The proposed odor control systems will not evacuate air or provide odor control for the associated upstream sewer collection system. Similarly, the proposed odor control systems will not be designed to control corrosion because corrosion concerns within the storage tanks are not anticipated. Finally, the proposed odor control systems will not provide sufficient ventilation to allow declassification of the tank areas or allow personnel entry without additional confined space equipment.

8.1.2 Carbon Vessel

Odor control using activated carbon was selected for the proposed SPU CSO facilities because this technology is the most feasible and economically favorable to handle the intermittent and low-level odors from these facilities. The permanently installed (non-removable), 500-cfm carbon vessel will be a polypropylene, vertical, cylindrical vessel with a single horizontal carbon bed. Normally, foul air will be routed into the vessel from the bottom, flow upward through the carbon bed, and exhaust out the top discharge. Because of the relatively small size of the vessel, the entire lid will be removable during carbon changeout. The outlet on the top will be connected to a flexible hose with camlock for quick disconnection when the lid needs to be removed. An aluminum platform and stairs will be provided around the vessel to allow the operator access and easy operation.

Table 14 below summarizes the design criteria for the carbon vessels.

Table 14. Carbon Vessel Design Criteria

ODOR CONTROL SYSTEM	VESSEL CONFIGURATION	VESSEL DIMENSION	NUMBER AND DEPTH OF CARBON BEDS	FACE VELOCITY (FPM)	MEDIA VOLUME (FT^3)
Genesee Odor Control System	Vertical	4-foot DIA X 5.5 H	1 x 3 feet	40	37

8.1.3 Fan and Motor Assembly

The odor control fan will be an industrial, centrifugal, fiberglass-reinforced-plastic (FRP) fan suitable for wastewater emissions containing hydrogen sulfide and other wastewater contaminants. The fan will be belt-driven and have a single-speed motor with an across-the line starter. A differential pressure gauge will provide monitoring of pressure loss across the fan. Fan failure will be alarmed on a local panel and to SPU's Operations Center control room by a SCADA system. Table 15 summarizes the design criteria for the odor control fan.

Table 15. Odor Control Fan Design Criteria

ODOR CONTROL SYSTEM	FAN TYPE	DESIGN FLOW (cfm)	DESIGN PRESSURE DROP	MOTOR HORSEPOWER
Genesee Odor Control System	Centrifugal FRP	500	10 inch w.c.	5 hp

When the influent pipe is full or the storage tank water level reaches the crown of the pipe where the vent is connected, the makeup air normally pulled through the influent pipe will be blocked. This will cause the odor control fan to operate to the left of its fan curve. Eventually, the system will balance itself by pulling more air through the cracks and generating a higher negative pressure inside the tank. Because the majority of the system pressure loss will be from the activated carbon and grease filter/mist eliminator, the operating point will not move significantly. Therefore, the increased negative pressure inside the tank will be insignificant compared to the total system pressure.

8.1.4 Ducts

Duct materials for the odor control system foul air will be FRP, PVC, or HDPE. FRP will be used for any abovegrade exposed ductwork, ductwork within the buried vault, and sensitive connection points (for example, vault penetrations); HDPE or PVC pipe will be used for buried ductwork where possible. All mechanical connection fasteners will be stainless steel, Type 316. Exposed FRP ductwork will be resistant to ultraviolet degradation. The actual duct materials to be used will be determined during final design. Joints of FRP ductwork will be butt-wrapped, plain end or flanged at transition of materials or connections to carbon vessels, grease filter/mist eliminator, expansion joints, butterfly dampers, or mechanical equipment to facilitate easy disassembly.

The sizing of ductwork will be based on an air velocity range of 800 to 1,500 feet per minute (fpm) to minimize system head loss while minimizing the cost of ductwork. No duct silencer will be required for the odor control systems because the activated carbon vessel will be immediately downstream of the odor control fan and will function as a silencer.

8.2 Miscellaneous Mechanical Equipment

8.2.1 Grease Filter / Mist Eliminator

The grease filter/mist eliminator will consist of two-stage filter pads housed in an FRP enclosure. The first pad will be a stainless steel pad for grease removal. The second pad will be a woven polypropylene pad for mist (moisture) removal. These pads will be removable and washable. The individual pads will be approximately 2 feet tall by 2 feet wide by 6 inches deep to allow for easy removal and cleaning without use of lifting aids. For both large and small odor control systems, the grease filter/mist eliminators will be at floor level. Maintenance personnel will be able to remove and replace the individual pads easily inside the vault and take the blinded pads out of the vault by way of the stairs to the Operations Center for cleaning.

The grease filter/mist eliminator will be equipped with differential pressure gauge for monitoring static pressure across the pads and for assisting in determining the pad cleaning schedule.

The design criteria for the grease filter/mist eliminator are listed in Table 16.

Table 16. Grease Filter/Mist Eliminator Design Criteria

DESCRIPTION	CRITERION
Material of construction	FRP housing with two-stage pads
Capacity	Accommodate the airflow range of the odor control system
Static Pressure Loss	2-inch w.c. maximum

8.2.2 Dampers

Butterfly dampers will be installed on the ductwork for isolation as required. A balancing damper may be installed to adjust airflow through the entire facility. Dampers will be constructed of FRP. The maximum leakage rate of these dampers will be 5.25 cfm/ft^2 of damper area, at a differential pressure of 30 inches w.c. Dampers will be installed at a level for easy access whenever possible. Chain wheel operators will be provided for dampers located too high to reach.

8.3 Codes and Standards

Regulatory requirements are determined primarily by project location and scope. The 49th Avenue South Parking Lot site and 53rd Avenue South Parking Lot site are located entirely within City limits. Therefore, the majority of the permitting and zoning will be coordinated with City agencies in accordance with the SMC and as enforced by DPD. The following codes and standards are applicable to odor control components of the new facility construction:

- NFPA 820 – 2008 Edition(Standard for Fire Protection in Wastewater Treatment and Collection Facilities)
- NFPA 90A – 2002 (Standard for Installation of Air Conditioning and Ventilation Systems)
- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) standards
- Applicable local plumbing, mechanical, and building codes

9 HVAC and Plumbing System

This section focuses on the plumbing and HVAC design criteria for the facilities vaults proposed to be located at 49th Avenue South Parking Lot and 53rd Avenue South Parking Lot sites. These vaults will be large, underground structures that will house electrical/mechanical and odor control equipment in separate rooms. Exhibit 19 in Appendix A provides plan and section views of the vaults.

9.1 Plumbing/Heating and Ventilation Design Criteria

9.1.1 Plumbing Design Criteria

9.1.1.1 Sanitary Drainage System

Equipment drains will be provided to drain condensate from several pieces of equipment in the odor control room of the facilities vault, including the foul air exhaust fan, grease/mist eliminator, localized duct drains, and carbon vessel. A floor drain system and trench sump along one wall will be included and will drain to a larger sump equipped with submersible sump pumps. Where installed, floor drains will be provided with traps and vents. Sanitary drains and equipment drains will be connected to the drainage system and pumped from the sump to the nearest SPU combined sewer main line. The drainage and sanitary piping materials for the embedded interior drain system will be polypropylene or PVC pipe. The drain line is discussed further in Section 2, Site Civil.

9.1.1.2 Water Piping Systems

A 3-inch-diameter water line will be branched from the City's ductile iron mains in 48th Avenue South for the 49th Avenue Parking Lot and 53rd Avenue South for the 53rd Avenue South Parking Lot storage facilities. The water service will supply up to 100 gpm of potable water to each facility. A water meter and reduced pressure backflow assembly will be provided. Additionally, an air gap tank (located in the facilities vault) will be required to provide physical separation of the domestic piped water system from the wastewater storage facility. A "hot box" or similar insulated enclosure and heat tracing will be used for exposed abovegrade piping. Piping will be Type K copper. Mechanical systems are described in detail in Section 7, Mechanical Systems.

9.1.2 Heating and Ventilation System Design Criteria

The following design criteria will be used for the HVAC system at the facilities vaults:

- Site elevation: 24 feet above mean sea level
- Site location: Seattle, Washington
- Ambient design temperatures, based on ASHRAE 2009:
    - Winter: dry bulb, 24 degrees Fahrenheit (°F) (heating, 99.6 percent)
    - Summer: dry bulb/wet bulb, 82.3 / 63.9 (cooling, 1 percent)

Table 17 lists the indoor design criteria for the Genesee CSO Reduction Project.

Table 17. Indoor Design Criteria

AREA	SUMMER DESIGN TEMPERATURE (°F)	WINTER DESIGN TEMPERATURE (°F)	VENTILATION REQUIREMENTS	CONTROL AND MONITORING SYSTEM
Odor Control Room	Ambient plus 10°F	55	Air change rate as scheduled below	Continuous operation. Flow switch to monitor air flow. Alarm at local and Operations Center control panels.
Electrical Room	Ambient plus 10°F	55	Air change rate as scheduled below	Continuous operation. Flow switch to monitor air flow. Alarm at local and Operations Center control panels.

Table 18 and Table 19 list the ventilation system design data for the odor control, and mechanical room. The typical ventilation rate requirement in accordance with standard building codes, as well as the NFPA 820 ventilation rate requirement, is listed for each space of the facilities vault. The data are provided so that designers can review specific code requirements as design progresses and ensure that the most conservative standard of care (higher ventilation rate) is maintained in the structures' spaces.

Table 18. Odor Control Room Ventilation System Design

DESCRIPTION	VALUE	REMARKS
Odor Control Room Volume/Area	4,860 ft^3 / 405 ft^2	Buried Odor Control Room
NFPA 820 Requirement	6 ac/hr	NFPA 820 Table 4.2, Row 20, Line b
Ventilation Rate	8 ac/hr	NFPA 820 Table 4.2, Row 20
Supply Air Fan Capacity (single-speed fan, constant volume fan)	650 cfm @ 1.75 inch w.c.	Provided filter
Supply Air Fan hp	1 hp	
Exhaust Air Fan Capacity	750cfm 1.75 inch w.c. max	~15% more than the supply air to maintain negative pressure
Exhaust Air Fan hp	1 hp	

Table 19. Electrical/Mechanical Room Ventilation System Design

DESCRIPTION	VALUE	REMARKS
Electrical Room Volume/Area	4,320 ft^3 / 360 ft^2	Buried Electrical Equipment Room
NFPA 820 Requirement	None	Non-classified room
Ventilation Rate	~ 24 ac/hr	Based on total sensible heat load If loads change Minimum Ventilation Rate will be 6 ac/hr
Supply Air Fan Capacity (single-speed, constant volume fan)	1,000 cfm @ 1.75 inch w.c.	Provided with inline duct heater, filter, and two speed fan

DESCRIPTION	VALUE	REMARKS
Supply Air Fan hp	1 hp	
Exhaust Air Fan Capacity	900 cfm @ 1.75 inch w.c.	Less than the supply air to maintain positive pressure next to Odor Control Room
Exhaust Air Fan hp	1 hp	

9.1.3 Electrical Room HVAC System

The electrical room will be served by a single-speed, constant-volume supply fan. The final air supply and size of the fan will be sized based on the electrical loads in the space. The volume of air will be based on a goal of maintaining a space temperature not to exceed 93°F in summer. There will be no mechanical heating in the space.

9.1.4 Odor Control Room HVAC System

The odor control room will be served by a single-speed, constant-volume supply fan. The air supply will be approximately eight ac/hr to accommodate the six ac/hr required by NFPA 820 to declassify the space and miscellaneous heat loads in the space. There will be no mechanical heating in the space.

9.1.5 Fan and Motor Assembly

The supply and exhaust fans will be belt-drive, centrifugal, inline fans. The fan motors will be single-speed, three-phase, squirrel cage induction type.

9.1.6 Ducts

The sizing of ductwork will be based on an airflow velocity range of 600 to 900 fpm to minimize system pressure loss. The ductwork inside the electrical room and odor control room at each site will be galvanized steel. Where the ductwork exits the vault, the ductwork will transition inside the vault from galvanized to HDPE pipe.

9.1.7 Intake and Exhaust Design

Given the location of the site, aesthetics and noise are important design criteria. The following two options for intake and exhaust systems will be evaluated as final design progresses. The best option for the project will be determined and included in the final design.

Option 1: To eliminate the possibility of rainwater entering the ductwork, the intake and exhaust ducts will need to terminate above grade. The ductwork will exit the facilities vault below grade and be routed approximately 50 feet horizontally below grade to a grassy area next to where the parking asphalt stops. The ductwork will then terminate above grade in a custom, acoustical, louvered structure that will look similar to a park trash receptacle. The louvers will be sized for a maximum airflow velocity of 900 fpm to reduce the possibility of water entering the supply air louver. The supply and exhaust ducts will be sloped, and a drain line will be connected to them to drain any water that enter the ducts. The supply and exhaust ducts from the vault will need to terminate a minimum of 10 feet away from one another to eliminate the possibility of exhaust air reentering the vault through the supply air system. To reduce the quantity of belowgrade ductwork, the supply ductwork from the odor control room and the supply ductwork from the electrical room may be combined between the intake structure and the vault. The exhaust ducts from the two rooms will need to remain separate from the exhaust structure to the exhaust fans.

Option 2: To eliminate the possibility of rainwater entering the system, the intake and exhaust ducts will need to terminate in a horizontal wall in the belowgrade vault. There will need to be two separate vaults, one for the supply air and one for the exhaust air, a minimum of 10 feet away from one another. Each vault will need to have traffic-rated grading and a drain system to convey water captured in the vault to the nearest storm drain. The louvers will be sized for a maximum airflow velocity of 900 fpm to reduce the possibility of water entering the supply air louver.

9.1.8 NFPA 820

The odor control room will contain equipment that houses flammable gasses. This type of room/area and its ventilation requirements are identified in Row 20 of Table 4.2 in NFPA 820.

Ventilation Requirements

- If no ventilation: entire area Class I, Division II.
- If ventilated continuously at six ac/hr: Areas within 3 feet of leakage sources such as fans, dampers, un-welded ductwork, etc. are Division II. Areas beyond 3 feet are Unclassified.

Although not required, it is suggested that a negative room pressure relative to ambient air pressure be maintained.

The electrical room is physically separated from the odor control room by a concrete wall. All electrical duct penetrations connecting the two spaces will use appropriate conduit seals to maintain the space classifications. The electrical/mechanical room will not contain any flammable gasses.

Ventilation Requirements

- No ventilation requirements apply; room is unclassified.
- Although not required, it is suggested to maintain a positive differential pressure relative to the adjacent odor control room.

9.1.9 Washington State Energy Code

The following items pertain to applicable parts of the Washington State Energy Code.

- According to Section 302.3, King County is in Zone 1.
- In accordance with Section 1302, the design will use electric resistance duct heaters with greater than 1.0 W/ft^2

Table 13-1 (Minimum Insulation R-value for Climate Zone 1)

- Walls must be R-21.

- Roof must be R-38.

9.2 Referenced Codes and Standards

Regulatory requirements are determined primarily by project location and scope. The 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site are located entirely within City limits. Therefore, the majority of the permitting and zoning will be coordinated with City agencies in accordance with the SMC and as enforced by DPD. The following codes and standards are applicable to HVAC and plumbing components of construction of the proposed facilities:

- 2009 IBC
- 2009 IFC
- 2009 Uniform Plumbing Code
- 2009 IMC
- 2009 NEC
- 2009 State of Washington Energy Code
- 2009 State of Washington Ventilation Code
- 2008 NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities
- DPD Director' Rules for SMC 21.16, Requirements for Design and Construction of Side Sewers (Drainage and Wastewater Discharge), Director's Rule 4-2011

The HVAC mechanical design for the proposed CSO control projects will follow the most current applicable industry standards. Professional societies, industry groups, organizations, institutes, and agencies issuing these standards include the following:

- American Society of Mechanical Engineers
- ASTM
- Manufacturers Standardization Society
- NSF International (formerly National Sanitation Foundation)
- NFPA
- Underwriters Laboratories (UL)

10 Electrical Design

10.1 Introduction

This section focuses on the design criteria for the proposed electrical improvements for the Genesee CSO Reduction Project at the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot. There will also be electrical improvements at the existing CSO Facility 9 and CSO Facility 11 sites. This section summarizes the following electrical design elements for each site:

- Electrical service options
- Basic electrical design assumptions
- Electrical design criteria

Electrical loads associated with equipment and lighting at each site are identified in this section, and the equipment proposed for each site is described in detail in other sections This section discusses only design issues associated with electrical supply. I&C associated with these sites is discussed in Section 11.

10.2 Electrical Service and Utility Coordination

10.2.1 General

The proposed CSO facilities will comply with SCL utility requirements and requirements in the latest version of SCL's "Requirements for Electrical Service." The designer will complete the SCL Electrical Service Application, and SPU will submit the application to SCL. The contractor scope of work will include the following:

- Furnish and install all required service entrance equipment, including, but not limited to, the service entrance conductors, conduits, meter base, and utility transformer pad.
- Install conduit from the current transformer (CT) enclosure: if a CT enclosure is required, to the meter base.
- Obtain an approved electrical inspection from the authority having jurisdiction.

SCL will supply and install the kilowatt-hour (kWh) meter. The SCL revenue meter will be on the secondary side (480-volt [V]) of the utility transformer.

10.2.2 49th Avenue South Parking Lot

Three-phase power is available at the intersection of South Genesee Street and 49th Avenue South. The existing service poles carrying single-phase power along 49th Avenue South are not adequate to be upgraded to carry three-phase power; the existing service poles will need to be replaced with new, larger poles and will be topped with cross-arms to carry 26.2-kilovolt (kV), three-phase power. The power serving the facility will be located underground from the base of the nearest overhead service pole to an underground vault with submersible transformers. The electrical service meter will be located above grade. The location of the CT cabinet, if required, will be evaluated during final design. Further coordination with SCL will be required during final design.

10.2.2.1 Existing CSO Facility 11

Single-phase power is readily available at this site. Further evaluation will be conducted in final design to determine whether the site should be fed from the 49th Avenue South Parking Lot site or directly from SCL.

10.2.3 53rd Avenue South Parking Lot

Three-phase power is available at the intersection of South Alaska Street and 53rd Avenue South. New, larger poles may be required and will be topped with cross-arms to carry the 26.2-kV, three-phase power. The power serving the facility will be located underground from the base of the nearest overhead service pole to an underground vault with submersible transformers. The electrical service meter will need to be located above grade. The location of the CT cabinet, if required, will be evaluated during final design. Further coordination with SCL will be required during final design.

10.2.4 Existing CSO Facility 9

Single-phase power is readily available nearby. Further coordination with SCL will occur during final design.

10.3 Design Criteria

This section describes the design criteria that will be used throughout the project design phase. The design will conform to SPU electrical standards where applicable.

10.3.1 Portable Standby Generator Receptacle

The 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site will each be provided with an abovegrade portable generator receptacle and manual transfer switch. SPU prefers to have the utility meter, transfer switch, and standby generator receptacle in a single cabinet. The utility CT cabinet may also be part of this aboveground cabinet.

10.3.2 Raceways, Duct Banks, and Separation

10.3.2.1 Raceways and Ducts

Minimum conduit size will be 3/4-inch (interior) or 1-inch (buried or in duct banks). All duct banks should be marked with traceable warning tape, located above the duct bank. Duct banks should have 20 percent spare conduits or a minimum of one of each size in the duct bank section.

Table 20 identifies conduit requirements.

Reinforced-concrete-encased duct banks will be used under roadways and parking lots.

Table 20. Conduit Requirements

CONDUIT	ABBREVIATION	USE
Galvanized Rigid Steel	GRS	Exposed All other areas not defined below
PVC-coated GRS	PVC-GRS	Exposed wet areas Exposed corrosive areas
PVC Schedule 80	PVC	Direct buried Non-reinforced concrete encased duct banks Reinforced concrete encased duct banks
Liquid-tight Flexible Steel Conduit	FLEX-LT	Final connection to motors, process equipment, transformers

Minimum conduit sizes and materials for SCL and Qwest will be in accordance with requirements of each body; the sizes will not be less than those identified in this section.

10.3.2.2 System Isolation/Separation

Power and signal/communications/control systems will be designed to maintain separation where required as sound engineering practice or by code provisions.

Minimum spacing will be maintained (as measured from the outside of each conduit) between parallel conduit and piping runs in accordance with the following when the runs are greater than 30 feet:

- Between instrumentation and telecommunication: 1 inch
- Between instrumentation and 600-V and lower alternating current (AC) power or control: 6 inches
- Between instrumentation and greater than 600 VAC (volts AC) power: 12 inches
- Between process, gas, air and water pipes: 6 inches

10.3.3 Wire and Cable

All conductors will be copper. All conductor insulation will be rated for 600 V for all systems operating at lower than 600 V. Minimum conductor sizes will be as follows:

- No.12 AWG (American wire gauge) for all power and lighting circuits
- No.14 AWG for discrete control circuits
- No.16 AWG for analog signal circuits (twisted shielded pair)

Conductor insulation systems will be as follows:

- 600-V cables: type XHHW-2 rated for 90 degrees Celsius (ºC)

All conductors will be color-coded or phase-taped in accordance with the requirements shown in Table 21 (unless otherwise required by the NEC).

Table 21. Conductor Color-coding or Phase-taping Requirements

CONDUCTOR	120/208 120/240	277/480
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Grey
Ground	Green	Green

10.3.4 Boxes, Panels, and Cabinets

Enclosures will be selected based on the location and environmental conditions in accordance with the requirements shown in Table 22.

Table 22. Enclosure Type

LOCATION	CONDITION	ENCLOSURE
Interior	Dry/Finished Dry/Unfinished (includes electrical rooms, mechanical rooms, and attic spaces) Wet/Corrosive	NEMA 12 NEMA 1 Gasketed NEMA 4X
Exterior Interior/Exterior	All Hazardous Class I, Divisions 1 or 2	NEMA 4X NEMA 7

10.3.5 Street Lighting

New street lighting is not anticipated for this project. If any street lighting is disturbed, it will be replaced by SCL to conform to SCL standards.

10.3.6 Electrical Loads

Table 23 provides an approximation of the electrical loads equal to or greater than 5 kilowatts (kW) or 5 horsepower (hp) to be included in the project. Actual equipment quantities and power requirements are to be determined in final design. The equipment names shown in Table 23 are not official and the power requirements are estimates only.

Table 23. Electrical Loads

EQUIPMENT	QUANTITY	POWER
Odor Control Exhaust Fan	1	5 hp
Basin Drain Pump	2	5 hp

EQUIPMENT	QUANTITY	POWER
Tipping Bucket Fill Pump	2	1.5 hp
Panelboard and Transformer	1	30 kilovolt amperes (kVA)

10.3.7 Uninterruptible Power Supply for Motor-operated Valves and Gates

Motor-operated valves and gates (inlet valves at Basin 43 storage tanks and gates at CSO Control Structures 9 and 11) will use an uninterruptible power supply (UPS) to enable actuation in the event of power failure. The size (and number of phases—whether single-phase or three-phase) of each UPS for each motor-operated gate will be determined in final design and will be based on the assumption of a single actuation operation in the event of utility power failure.

10.3.8 Equipment Control

10.3.8.1 Local Disconnects

Local disconnects at the equipment, rather than lockouts at the motor control center (MCC), will be provided. The status (Open/Close) of the local disconnect will be monitored by the programmable logic controller (PLC) through use of an auxiliary contact.

All HVAC equipment will be provided with a power disconnect switch located at the equipment. Disconnects will be fused if required by the equipment manufacturer to maintain UL listing of the equipment.

10.3.8.2 Local Control Stations

Control will be provided at the MCC unless directed otherwise by SPU during final design.

10.3.9 Storage Tank Lighting and Inspection

No permanent lighting fixtures will be installed in the storage tank. The storage tank will be inspected through use of a portable pole-mounted or CCTV camera and light apparatus.

10.3.10 Submersible Pump Cable Termination

The SPU standard arrangement for submersible pump cable termination enclosures will be used. Submersible pump cable terminations will not be located in the storage tank. The preferred location for submersible pump cable terminations is below grade in a dedicated vault adjacent to the storage tank.

10.3.11 Underground Electrical Room

Having an electrical room below grade will increase the risk of flooding. Precautions will be taken to reduce this risk by providing adequate drainage and by providing a barrier between rooms. The electrical room will have a dedicated sump with pump to remove any water that enters the room.

10.3.12 Power System Analysis and Arc Flash Study and Labeling

The power system analysis will include the utility service protective device downward to the 480-V feeder circuit breakers and panelboard branch circuit breakers.

The contract documents must require an Arc Flash Study and the electrical equipment to carry Arc Flash labeling.

10.3.13 Grounding

Grounding will be in accordance with the contract drawings and, at a minimum, comply with requirements of the NEC. Grounding also will meet the following requirements.

Building ground grid and duct bank ground conductors will be #4/0 bare copper. All ground rods will be copper-clad steel, with a minimum size of 3/4-inch by 10 feet. A ground conductor will be routed in each duct bank. All metallic parts of electrical handholes and MHs will be grounded; a ground rod will be installed in each handhole and MH.

Each conduit containing AC power conductors will contain an equipment grounding conductor sized in accordance with the NEC requirements.

10.3.14 Lighting

10.3.14.1 Interior Lighting

Lighting levels in maintained foot-candles are to be 50 for each of the facility rooms (or as required by the Illuminating Engineering Society of North America or SPU).

10.3.14.2 Lighting Calculations

Lighting will meet Seattle Energy Code and Washington State Energy Code requirements, and the required calculations will be provided.

10.3.14.3 Lighting Systems

Facility lighting will be controlled by a manual switch at each entrance.

10.3.14.4 Emergency Lighting Systems

Emergency illumination will be provided in all appropriate spaces as required by code to provide life safety, property, and equipment protection.

Emergency illumination will consist of “bug-eye” type lights in areas without fluorescent lighting. The emergency lights will have battery backup capable of sustaining egress lighting for 90 minutes.

Adequate lighting levels will be provided to maintain safe building egress and critical process functions.

10.3.14.5 Site Lighting

Site lighting is not planned for either of the sites; however, site lighting may be revisited during final design.

10.3.15 Lightning Protection and Surge Suppression

Surge-protective devices will be provided at each of the following levels of electrical distribution: MCC, panel board, PLC control panel, control cabinets, and I&C compartment of the control cabinets.

10.3.16 Seismic Criteria

Electrical equipment, anchorage, support, and bracing will comply with IBC 2006 and ASCE 7-05 and specific seismic criteria defined in Section 6 – Structural Design.

10.3.17 Identification

I&C system loop tag numbers will be used for all motors, I&C system devices, and process equipment. All major electrical equipment and power conduits will be designated with unique identification equipment designations.

10.3.18 Miscellaneous SPU Preferences and Requirements

Final design will include conduit; cable trays will not be used unless prior approval from SPU is provided.

Electric heaters will be used within the facilities vaults, instead of gas heaters.

During final design, SPU's preference for 120/240 single-phase or 120/208 three-phase panelboard will be determined.

SPU standards or SPU input will be used to address the following preferences or requirements during final design:

- Digital electrical metering at each MCC
- Light fixture preferences
- Color standards for lights and pushbuttons
- Hatch intrusion switches for each entrance in the facilities and at the control cabinets at CSO Facility 9 and CSO Facility 11

10.3.19 Variable Frequency Drives

Avoid the use of variable frequency drives (VFDs) unless required by the process. If VFDs are used, harmonic mitigation in the form of active harmonic filters will be employed as required to meet Institute of Electrical and Electronics Engineers (IEEE) 519 voltage and current distortion requirements at the point of common coupling. Active harmonic filters will be capable of injecting one-third of the current of all six-pulse drives on the bus.

10.3.20 Motors, Motor Protection and Control

Three-phase motors will be rated 460-V for operation on 480-V systems. Motors rated 0.5-hp and greater will be 460-V, three-phase. All motors will be three-phase except for fractional-horsepower motors less than 0.5 hp.

All motors will be high-efficiency, in accordance with the Washington State Energy Code. Motors will be sized to a maximum of 95 percent of the motor rating used at 100 percent of driven load rating.

Motors will be fed from MCCs using combination starters, where practical. Low-voltage over-current protection will be provided by magnetic-only circuit breakers, as applicable, and will be sized in accordance with NEC and manufacturers' recommendations. All MCCs will be rated and sized in accordance with National Equipment Manufacturers Association (NEMA) standards.

For each motor, the question of whether thermal protection of motor windings should be required will be evaluated. Submersible pumps will be required to have leak detection.

Any reduced voltage starters will be by means of solid-state devices. Solid-state, reduced-voltage starters will be used for motors 15 hp and larger.

The MCCs will have NEMA-rated starters housed in NEMA-1 gasketed MCC enclosure. Standalone starters located outdoors will be housed in NEMA 4X enclosures. All across-the-line and reduced-voltage motor starters will be combination-type with a pad-lockable motor circuit protector. Motor control circuits will be 120-V AC, derived from a control power transformer located in each low-voltage motor starter.

10.3.21 Classified (Hazardous) Area Designations

Room classifications are established by NFPA 820, the Standard for Fire Protection in Wastewater Treatment and Collection Facilities. Table 24 summarizes the classified area designations for this project; identifies the specific assumptions upon which those classifications are based; and identifies the relevant table, row, and line within NFPA 820.

Table 24. Classified Area Designations

DESCRIPTION	CLASSIFICATION	NFPA 820 REFERENCE	MINIMUM REQUIRED AIR CHANGES PER HOUR
Electrical Room	Unclassified	Table 4.2, Row 17, Line a	6
Mechanical Room	Unclassified	Table 4.2, Row 31, Line b	6
Odor Control Room (< 3 feet from joints)	Class I, Div. 2	Table 4.2, Row 20, Line b	6
Odor Control Room (> 3 feet from joints)	Unclassified	Table 4.2, Row 20, Line c	6
Tank	Class I, Div. 1	Table 4.2, Row 34, Line a	Varies

A Class I, Division 1 area is one in which explosive vapors may be present under normal operation conditions, and a Class I, Division 2 area is one in which explosive vapors will only be present under abnormal conditions, such as failure of a container or failure of the ventilation system. Equipment in classified areas must be able to prevent an explosion; motor and control stations must be explosion-proof, instruments must be UL-listed for that area (instruments do not use the same explosion-proof terminology as motors), conduits entering the classified area must be sealed off to prevent migration of explosive gases, and signal wiring at the control panel will require intrinsic barriers to limit power to any device not otherwise rated for a classified area. This information is intended as a brief explanation of classification designation and the associated design requirements; it is not exhaustive. Equipment will be suitable for the area in which it is located.

The odor control room will contain a combustible gas detection system and a fire detection system in accordance with NFPA 820.

10.3.22 Security

Space will be provided in the electrical room for a security cabinet (Hoffman Enclosure A60H3616SS6LP) 60 inches high by 36 inches wide by 16 inches deep. The security system will include a camera pointed at the entrance. Only the conduit will be provided; SPU will provide camera installation and will pull cabling.

10.3.23 Drawings

Table 25 identifies required drawings and their contents.

Table 25. Drawing List and Descriptions

DRAWINGS (IN ORDER)	WHAT SHOWN
Site Plan	Utility service location (including any pad-mount transformers). Exterior duct banks. Anything requiring electrical connection that is not shown anywhere else.
Power Plan	Locations of, and space occupied by, electrical equipment. Connections from field devices shown using homeruns. Each field device will be tagged. Generally, everything shown schematically on the one-line should also appear on this plan. One homerun for each installed conduit from field device to source, including power conductors and equipment ground. NEMA rating requirement for each room and conduit type (for example, wet, wet and corrosive)
Instrumentation Plan	Basically similar to Electrical Plan, but showing instrumentation instead. Generally, everything that is shown schematically on the control wiring block diagram should appear on this plan. Representation is by homerun with each homerun representing a single conduit. Separate raceways for analog and control wiring.
Lighting Plan	Use symbols from Legend to show locations of lights, switches, and receptacles. Next to each symbol, indicate fixture type (from Lighting Fixture Schedule), panelboard circuit, and controlling switch.

DRAWINGS (IN ORDER)	WHAT SHOWN
One-line Diagram	Electrical equipment identification (tag and description). Bus ratings (ampacity and short circuit) and voltage. Transformer sizes (including primary and secondary voltages). Breaker sizes. Motor Circuit Protector sizes. Conduit and conductor sizes. Utility metering (including CT enclosure if required). Motor sizes (in hp). Field control stations. For motor starters and VFDs indicate the proper Control Diagram. Other pertinent information that is not shown on the other electrical drawings or specifications. Panelboards will only appear as boxes on the One-Line (details are found on the schedule).
Elevation	Show arrangement of Motor Control Center buckets in elevation.
Control Wiring Block Diagram	Similar to the Electrical One-Line, but for instruments. Show power, control, and instrumentation wiring as required, using call-outs as found on the Conduit and Cable Schedule.
Schedules (Conduit and Cable / Lighting Fixture / Panelboard)	Use the provided Conduit and Cable Schedule. Conform any new fixture to the provided Lighting Fixture Schedule format. Use the format in the provided Panelboard Schedule to fully define the Panelboard.
Control Diagrams	Show wiring and control circuitry for controlled equipment, including switches, relays, contacts, fuses, and other items.
Details	Show how to mount equipment and devices. Show how conduit should penetrate floor slabs and route to equipment. Anything else that needs to be more clearly defined.

10.3.24 Miscellaneous Design Criteria

The following criteria will guide the electrical design for this project:

- The electrical service for each facility site will be approximately 200-ampere, 480-V, three-phase (final size to be determined during final design).
- There will be no onsite standby generator.
- The storage tank will be a classified area (Class I, Division 1); the purpose of tank ventilation is only to create enough negative pressure to prevent fugitive odor emissions.
- Each motor-operated gate will perform a single operation in the event of power failure.
- Design will be based on SPU electrical design standards.

10.4 SPU Electrical Contact

The primary contact at SPU for electrical questions is Tim Kim (206-733-9133, tim.kim@seattle.gov).

10.5 Applicable Codes and Standards

Regulatory requirements are determined primarily by project location and scope. The sites and project components are located entirely within City limits. Therefore, the majority of the permitting and zoning will be coordinated with City agencies in accordance with the SMC and as enforced by the DPD. The following codes and standards are applicable to electrical engineering components of the proposed new facility construction:

- NFPA 70 NEC
- NFPA 70E
- IEEE C2, National Electrical Safety Code
- Illuminating Engineering Society of North America Lighting Handbook Latest Edition
- NEMA
- National Electrical Manufacturers Association, NEMA-MG1, Motors and Generators
- Life Safety Code, NFPA-101-HB85
- ANSI
- National Electrical Contractors Association "Standards of Installation"
- IEEE
- International Society of Automation (ISA)
- Insulated Cable Engineers Association
- Occupational Safety and Health Act
- Washington Industrial Safety and Health Act
- National Electrical Testing Association
- ASTM
- UL
- 2009 Washington State Energy Code
- 2008 Seattle Electrical Code
- Factory Mutual
- IBC

11 Instrumentation and Control

11.1 Introduction

This section details the design criteria that will guide the I&C improvements at the 49th Avenue South Parking Lot site and the 53rd Avenue South Parking Lot site. Equipment at each site is described in detail in other sections. Section 10, Electrical, discusses the supply associated with each site. The content of this section is applicable to both sites unless noted otherwise. This section summarizes the following I&C design elements associated with each site:

- Outline of basic I&C design assumptions
- Design criteria
- Operational and control strategy overview

11.2 Design Criteria

11.2.1 General

Design will be based on SPU process measurement, control, communications, and software standards where applicable; otherwise, standards will be assigned by the consultant team.

SPU will be able to sole-source equipment, provided there is justification. If necessary, SPU will develop sole-source equipment procurement justification documentation for these improvements.

11.2.2 Assumptions

Typical site and PLC monitoring points will be provided by SPU to HDR at the beginning of final design.

A current copy of SPU's latest applicable design standards documents will be provided by SPU to HDR at the beginning of final design. SPU changes to the design standards will be provided by SPU to HDR as soon as possible.

The following design details will be identified and defined during final design:

- Instrument numbering and tag numbering scheme
- Location of equipment controls (for example, local, panel, and MCC)
- Automatic and manual backup control needs
- Alarms
- Equipment, power, and communication failure scenarios
- PLC diagnostics
- Operator interface (OI) locations and needs for remote human machine interface (HMI) and local OI functions
- The process I&C system will provide operators with information needed during CSO fill, drain, and flushing operations.

- There are no provisions for standby power generation at either of the sites.
- Because this is not a critical facility, the use of hot backup PLCs is not required.
- There will be no communication, instrumentation, or control interface between nearby SPU facilities; the proposed facilities and retrofits will operate independently of existing SPU facilities.

11.2.3 System Integration Approach

SPU will use a competitive bid approach with the contractor (through the contractor's system integrator) for supplying the hardware. SPU will not do the system integration itself, nor will it sole-source system integration services.

11.2.4 Programming

SPU will provide applications software development for all of the following equipment (the System Integrator will provide the hardware and SPU will configure it):

- Wonderware HMI
- Red Lion Local Operator Interface Unit
- PLCs
- Central SCADA system
- Communication components

11.2.5 Telemetry and SCADA

SPU currently uses a central SCADA system to monitor and control remote sites distributed throughout the service area. SPU uses Internet Protocol (IP) based frame relays provided by Qwest for communication between the central SCADA system and the remote sites. SPU is satisfied with the reliability of Qwest's frame relay services.

SPU normally handles Qwest frame relay circuit ordering, the Qwest representative who works with SPU on frame relay requests is Jim Edgar: (w) 206.224.1062, (f) 206.613.1520, (m) 425.761.5110, Diana.Johnson2@qwest.com (Email). Contact Irina Sinitsyna (206-733-9141, irina.sinitsyna@seattle.gov) prior to any communication with Qwest.

The SCADA block diagram (Figure 4) illustrates the standard communication arrangement that will be followed for this project.

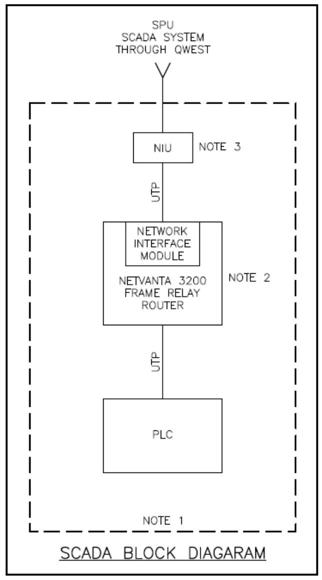


Figure 4. SCADA Block Diagram

The PLC will be provided by the contractor and installed in the control cabinet (Note 1 on Figure 4). The Adtran NetVanta 3200 Router with frame relay interface module will be provided by SPU to the contractor for installation (Note 2 on Figure 4). The network interface unit will be provided and installed by Qwest, or installed by the contractor if required to maintain UL listing (Note 3 on Figure 4). Cabling between devices will be provided by the contractor.

11.2.6 Hazardous Locations

NFPA 820 will be used as the standard to identify and define classified locations within the project limits. Where possible, devices will be installed outside hazardous locations. Devices installed in hazardous locations will be provided with an approved rating for the area classification or in explosion-proof enclosures. Control circuits such as switches or transmitters will be protected using intrinsically safe barriers, which limit the amount of energy available to prevent sparking events.

Section 9, HVAC and Plumbing System, and Section 10, Electrical Design, provide further discussion and definition of the classified areas in the project.

11.2.7 Control Strategy

Control strategies (also known as “control loop descriptions”) will be written for each site and included in the contract documents to facilitate applications software development by SPU staff and for testing, startup, and commissioning purposes by the contractor.

11.2.8 Functions and Monitored I/O Points

Table 26 lists the standard functions and input/output (I/O) points that will be monitored and implemented by the site’s SCADA system. For the types of equipment listed below, I/O points will be added as required by the application (for example, high-pressure shutdown). The I/O nomenclature shown in Table 26 will be used in the design documents.

Table 26. Functions and Monitored I/O Points

EQUIPMENT DESCRIPTION	FUNCTION OR MONITORED I/O POINT
Equipment with Constant Speed Motor	Local Motor Overtemp Bearings Overtemp Overload Excess Vibration (where applicable) Remote Running Fault Call to Run
Equipment with VFD-Driven Motor (ONLY IF REQUIRED BY THE PROCESS)	Local Remote Running Fault Call to Run Speed Command Speed Feedback
Open/Close Motor-Operated Actuator	Local Remote Open Closed OT High Torque on Open High Torque on Closed Fault Call Open Call Close
Modulating Motor-Operated Actuator	Local Remote Open Closed OT High Torque on Open High Torque on Closed Fault Position Command Position Feedback
Ultrasonic Level Transmitter	Level Loss of Echo
Battery Backup	Charging Replace Battery Battery Voltage Battery Low AC Fail Phase Fail

EQUIPMENT DESCRIPTION	FUNCTION OR MONITORED I/O POINT
Solenoid Valve	Remote Call Open
HVAC System	System fail

11.2.9 Instrumentation Abbreviations

The instrumentation abbreviations shown in Table 27, which are based on ISA standards, will be used.

Table 27. Instrumentation Abbreviations

INSTRUMENT TYPE	DESCRIPTION
ANALYZERS (PH, CL2, TURBIDITY, ETC.)	
AE	Analytical Element or Sensor
AI	Analytical Indicator
AIT	Analytical Indicating Transmitter
ASL	Low Analytical Switch
ASH	High Analytical Switch
ASLL	Very Low Analytical Switch
ASHH	Very High Analytical Switch
FLOW	
FM	Flow Meter
FE	Flow Element or Sensor
FI	Flow Indicator
FIT	Flow Indicating Transmitter
FQIT	Flow Totalizer/Indicator/Transmitter
FSL	Low Flow Switch
FSH	High Flow Switch
FSLL	Very Low Flow Switch
FSHH	Very High Flow Switch
ELECTRICAL	
VOLTAGE (kV)	
EE	Voltage Element or Sensor
EI	Voltage Indicator

INSTRUMENT TYPE	DESCRIPTION
EIT	Voltage Indicating Transmitter
CURRENT	
IE	Current Element or Sensor
II	Current Indicator
IIT	Current Indicating Transmitter
POWER (kW)	
JE	Power Element or Sensor
JI	Power Indicator
JIT	Power Indicating Transmitter
LEVEL	
LS	Level Switch
LE	Level Element or Sensor
LI	Level Indicator
LIT	Level Indicating Transmitter
LSL	Low Level Switch
LSH	High Level Switch
LSLL	Very Low Level Switch
LSHH	Very High Level Switch
SBD	Sludge Level Monitor
PRESSURE	
PE	Pressure Element or Sensor
PI	Pressure Indicator
PIT	Pressure Indicating Transmitter
PSL	Low Pressure Switch
PSW	Pressure Switch
PSH	High Pressure Switch
PSLL	Very Low Pressure Switch
PSHH	Very High Pressure Switch
DIFFERENTIAL PRESSURE	
PDI	Pressure Differential Indicator
PDIT	Differential Pressure Indicating Transmitter
PDSL	Low Differential Pressure Switch

INSTRUMENT TYPE	DESCRIPTION
PDSH	High Differential Pressure Switch
PDSLL	Very Low Differential Pressure Switch
PDSHH	Very High Differential Pressure Switch
SPEED OR FREQUENCY	
SE	Speed Element or Sensor
SI	Speed Indicator or Tachometer
SIT	Speed Indicating Transmitter
SSL	Low Speed Switch
SSH	High Speed Switch
SSLL	Very Low Speed Switch
SSHH	Very High Speed Switch
TEMPERATURE	
TE	Temperature Element or Sensor
TI	Temperature Indicator
TIT	Temperature Indicating Transmitter
TSL	Low Temperature Switch
TSH	High Temperature Switch
TSLL	Very Low Temperature Switch
TSHH	Very High Temperature Switch
POSITION	
ZE	Position Element or Sensor
ZI	Position Indicator
ZIT	Position Indicating Transmitter
ZSO	Open Position Switch
ZSC	Closed Position Switch

11.2.10 Equipment Tag Numbers

An equipment tag numbering system will be determined during final design following the 30 percent design level and, if needed, will be based on meetings between SPU and applicable members of the design team.

11.2.11 Control Hierarchy

The facilities will normally operate in automatic mode. Some process areas may require hard-wired backup control in the event of PLC, communications, or SCADA system failure. All equipment will be provided with manual backup control.

11.2.11.1 Automatic Control

The facilities will normally operate in automatic control mode, being controlled by the PLC system, being monitored by the SCADA system (including supervisory alarm or control set points, or both), and functioning according to the control strategies determined during final design.

11.2.11.2 Hard-wired Backup Control

The applicability of hardwired backup control will be evaluated during final design and will be based on existing SPU standards whenever applicable. Hardwired backup control will provide backup control in the event of PLC failure and will be independent of PLC operations.

During final design, hardwired backup control requirements will be determined, if needed, for process control at the following locations:

- 49th Avenue South Parking Lot site (including CSO Facility11)
- 53rd Avenue South Parking Lot site (including CSO Facility 9)

11.2.11.3 Manual Control

Local control stations, consisting of “Jog” and “Lockout-Stop” or “Emergency Stop,” will be provided. All other controls, such as “Hand-Off-Auto” switches, will be located at the MCC or the control cabinet, based on SPU standards or preferences.

11.2.12 Control Locations and Relationships

11.2.12.1 Field Controls Manual Control

Field Controls Manual Control is addressed in Section 10, Equipment Control Section of Electrical section.

11.2.12.2 MCC Controls

MCC controls are addressed in Section 10 , Equipment Control section of Electrical section.

11.2.12.3 Safety Interlocks

All personnel and equipment safety interlocks will be implemented through hardwired connections to the equipment motor control circuits. Interlocking for personnel and equipment safety will not be done through the PLC or SCADA system. Safety interlocks will be manually reset at the motor control center or near the controlled equipment. Equipment protection interlocks recommended by the equipment manufacturer, or as requested by SPU, will be provided.

11.2.12.4 Vendor Control Panel

Control and monitoring between each site's PLC and equipment supplied with a vendor control package will be through hardwiring, not networking, to PLC I/O.

11.2.12.5 PLC Control Panel

SPU has standardized the use of the Opto 22 PLC, which will be used at all proposed sites. SPU has developed standards for the design, fabrication, and installation of control cabinets, and these standards will be followed on this project. See Section 11.5, Referenced Codes and Standards.

One notable exception to the SPU standards documents is that SPU uses a power supply with battery charger and batteries for backup power, rather than a UPS. Power supply circuit designs (and connected loads) for this project will be designed in accordance with UL508A requirements.

A local OI will be installed at the control cabinet of each site.

11.2.12.6 Control Cabinets

A control cabinet at each CSO Facility 9 and CSO Facility 11 location will be provided by the contractor in accordance with existing SPU standards.

Battery backup power will be provided in each control cabinet. SPU uses 24-V batteries in conjunction with battery chargers for backup power in control cabinets. SPU does not use UPSs in its control cabinets.

The control cabinets at CSO Facility 9 and CSO Facility 11 will be provided with an OI.

11.2.13 Intrusion Detection

Intrusion detection for the tank facilities for SPU SCADA will consist of intrusion switches (limit switches and door switches as appropriate) at each facility entrance. Tank access hatches will not be equipped with intrusion switches.

Each control cabinet will be equipped with intrusion detection through intrusion switches on the cabinet doors.

For SPU security, intrusion detection will consist of intrusion switches on each facility entrance. Although conduit will be provided to and between locations as directed by SPU security personnel, design related to security components will not be conducted.

11.2.14 Equipment Manufacturer Preferences

For standardization purposes, SPU has expressed equipment preferences shown in Table 28 (although there are no requirements for sole-sourcing the equipment listed).

Table 28. Equipment Preferences

EQUIPMENT	MANUFACTURER
Surge Suppressor	Phoenix
Power Supply	PULS
DC UPS	PULS
DC to DC Power Supply	PULS
Battery	CSB
Panel Lighting	Ledtronics
Indicators	Red Lion
PLC	Opto 22

11.2.15 Drawings

Table 29 outlines required drawings and their contents.

Table 29. Drawings and Contents

DRAWING	WHAT MUST BE SHOWN
Control Panels	Plans and Elevations of control panel (interior, exterior, and any swing out or side panels) Schedule of Nameplates and Legends Separation into various sections for power, instrumentation, etc per SPU standards Door locking requirements
Control Cabinet Power Distribution Schematic	Show how power comes into the panel and gets transformed and distributed to the instruments. Show the main power conversion components and typical for the devices and instruments. Battery and charger location
Control System Network Block Diagram	Interconnections between PLC, Frame Relay Router, Qwest Network Interface Unit, and SPU SCADA System Interconnections between PLC and OI Panel
P&IDs	Process connections and piping Process equipment Process instruments (use given instrument abbreviations) Vendor control panels PLC I/O Process instrumentation, control and equipment tag numbers
Control Cabinet Typical Control Wiring Diagrams	Shows how the instruments connect to the PLC I/O
Instrumentation Details	Shows wiring details for control auxiliaries Instrument installation requirements (elevations, set points, mounting hardware, materials of construction, etc.) Instrument mounting or scale range elevation information

11.2.16 Level Control Strategies

11.2.16.1 General

Level control in the structures will be automated. Automatic control will not require operator intervention. Manual backup level control will be provided in accordance with SPU standards.

11.2.16.2 CSO Control Structures

There will be a motor-operated gate located in both MH 060W-047 (CSO Facility 9) and MH 059-490 (CSO Facility 11).

Gate position for CSO Facility 09 will be automatically controlled by the level in the Lake Line at the new transfer weir for the new storage facility.

Gate position will be automatically controlled based on the level in the new associated primary control structure for CSO Facility 11.

In the event of utility power failure, the motor-operated gate will perform a single actuation to a predetermined position. The actuator for the motor-operated gate will provide position feedback. No field visit will be required by SPU once power has been restored.

11.2.17 HVAC System Fail Indication

At each entry hatch for an electrical room, mechanical room, or odor control room, a visual indicator will be provided to notify personnel of ventilation failure.

11.2.18 Level Measurement

Unless directed otherwise by SPU, level monitoring will be accomplished through redundant instruments: one ultrasonic level sensor and transmitter and one submersible pressure sensor/transmitter. For consistency, the instruments used as the basis of design in final design for CSO Control Structure 22 (Windermere CSO Basin) will serve as the basis of design on this project.

11.3 Operational and Control Strategy Overview

The information provided in this section is intended as a very general overview of how the proposed storage tanks will work. The information is current as of August 2011 but may undergo revision and expansion in final design.

11.3.1 Proposed Control Strategy

11.3.1.1 49th Avenue South Parking Lot Storage Tank

The following items describe the intended operational sequence for this storage tank:

- During a wet weather event, excess flow from Basin 40 will begin to accumulate and fill CSO Storage Facility 11.
- Mid to higher liquid level in CSO Storage Facility 11 will cause closure of the motor-operated gate in the main line.

- After the gate closes, the combined sewer will overtop the new diversion weir and direct flow to the new diversion sewer, en route to the new control structure.
- At the primary control structures, the diverted flows from Basin 40 will combine with the flows from Basin 41B. Once flows have exceeded the capacity of the Lake Line, the level in the control chamber will start to rise and eventually will overtop the storage transfer weir.
- Once flow has overtopped the storage transfer weir, the 0.48-MG tank will begin to fill.
- The storage tank will fill until it is completely full. When the storage tank is full, the level in the control structure will continue to rise, overtop the Basin 40 and Basin 41 CSO overflow weirs, and discharge to Lake Washington at NPDES CSO Outfalls 40 and 41.
- Once capacity has become available, as determined by the level sensor in the primary control chamber, the storage tank will empty through basin drain pumps and the motor-operated gate will open.
- Upon indication that the tank has been drained, the tank flushing sequence will begin.
- Tipping bucket fill pumps will sequentially fill each tip bucket, drawing water from the NPW tank. The basin drain pumps will empty the flushing flows from the tank back into the sewer system.
- The odor control system will run continuously (Section 8 discusses operating conditions).
- The NPW tank will fill from the City water main through an air gap separation inlet.
- After each use cycle, the storage tank will be clean and ready to begin the next use cycle.

11.3.1.2 53rd Avenue South Parking Lot Storage Tank

The following items describe the intended operational sequence for this storage tank:

- During a wet weather event, flows from Basins 43 and 165 to the downstream Lake Line will increase until the capacity of the Lake Line is exceeded.
- Flow then will overtop the storage diversion weir located between MH 060W-018 and MH 060W-017, which will be set at the crown of the 15–inch-diameter Lake Line.
- The new storage tank at the 53rd Avenue South Parking Lot will begin to fill.
- Once the new storage tank is half full, the motor-operated gate at MH 060W-047 will close to 25 percent of its full opening height, to begin filling the existing inline storage pipe at CSO Facility 9.
- Once the new storage tank is three-fourths full, the motor-operated gate at MH 060W-047 will close to 10 percent of its full opening height to continue filling the existing inline storage pipe.
- Once the new storage tank is completely full, the motor-operated gate at MH 060W-047 will close fully to continue filling the existing inline storage pipe.
- Once the existing inline storage tank in Basin 43 is full, flow will overtop the Basin 43 CSO overflow weir located in MH 060W-049 and discharge to Lake Washington at NPDES CSO Outfall 43.

- Once the level in the Lake Line adjacent to the new storage tank at the 53rd Avenue South Parking Lot has receded below the crown of the pipe, the pumps in the new tank will begin draining the tank.
- Once the level in the new storage tank has begun dropping, the motor-operated gate at MH 060W-047 will open to 10 percent of its full opening height.
- Once the new storage tank has drained one-fourth of its volume, the motor-operated gate at MH 060W-047 will open to 25 percent of its full opening height.
- Once the new storage tank has drained half of its volume, the motor-operated gate at MH 060W-047 will open to its full opening height.
- Upon indication that the new storage tank has been drained, the tank flushing sequence will begin.
- Tipping bucket fill pumps will sequentially fill each tip bucket, drawing water from the NPW tank. The basin drain pumps will empty the flushing flows from the tank back into the sewer system.
- The odor control system will run continuously (Section 8 discusses operating conditions).
- The NPW tank will fill from the City water main through an air gap separation inlet.
- After each use cycle, the storage tank will be clean and ready for the next use cycle.

11.4 SPU SCADA and I&C Contacts

The primary contacts at SPU for SCADA and I&C questions are Irina Sinitsyna (206-733-9141, irina.sinitsyna@seattle.gov), and James Jacobson (206-386-1829), james.jacobson@seattle.gov).

11.5 Referenced Codes and Standards

Regulatory requirements are determined primarily by project location and scope. The Genesee CSO project sites are located entirely within City limits. Therefore, the majority of the permitting and zoning will be coordinated with City agencies in accordance with the SMC and as enforced by DPD. The following codes and standards are applicable to control systems and electrical engineering components of the new facilities:

- NEC
- NFPA
- UL
- NEMA
- 2011 Seattle Electrical Code
- ANSI
- IEEE
- ISA
- NFPA 820
- SPU Standards, Section 10 – SCADA and I&C

12 O&M and Security

This section focuses on the various aspects of O&M at the proposed facilities and the related security measures. Section 12.1 focuses on O&M objectives for this project and how the design will implement the objectives. It does not discuss anticipated frequency of O&M activities. Section 12.2 focuses on the goals of the SPU Security Team, storage tank security, and facilities vault security. Equipment and facilities referenced in this section are described in detail in other sections.

12.1 Operations and Maintenance

The two facilities will need regular, routine maintenance to reach their design life and to facilitate proper operation during a storm event. The storage tank and facilities vault will be operated intermittently, which means they will not require continuous attendance by O&M staff. Initially, the staff may visit the site when the flow is being diverted into the storage tank to verify operation of the system. Ultimately, it is anticipated that the facilities will operate unattended for the majority of the events and visits to the facilities will be limited to regular maintenance or after-event use, as detailed in the following sections.

12.1.1 Objectives

The main O&M objectives are based on input from SPU operations staff:

- Provide SPU with the ability to monitor the system during operation to confirm that the facilities are working as intended.
- Design the facilities to "keep it simple" for O&M.
- Design the tanks and pipes to be maintainable from the ground surface whenever possible.
- Design so that maintenance staff will not need to routinely enter the storage tanks.
- Provide provisions for entry and maintenance, if needed.

O&M activities at the storage tank and the facilities vault can be broadly divided into three categories: (1) recurring routine O&M activities, (2) recurring after-use O&M activities, and (3) infrequent O&M activities. The O&M objectives listed in this section will be integrated into the design of the facilities for all three types of O&M activities.

12.1.2 Recurring Routine O&M Activities

O&M activities that will be scheduled on a regular basis are referred to as "recurring routine O&M activities." These activities will include the O&M tasks that need to be done at regular intervals at the facilities. Recurring maintenance activities will occur on the following items:

- Tipping buckets
- Mechanical equipment
- Motor-operated gates and valves
- Hatches

12.1.2.1 Tipping Buckets

Tipping buckets have been included in the design of the storage tanks to reduce O&M requirements. Tipping buckets are self-activated flushing systems that reduce sediment buildup on the floor of a tank. Reducing sediment buildup reduces the frequency at which O&M crews need to enter the tanks and perform manual cleaning.

Tipping buckets require some routine maintenance. The tipping buckets installed on this project will be located near the ground surface and will be accessible from hatches. The hatches will be located over the supports of the tipping buckets to facilitate visual inspection of bearings. Visual inspection of tipping buckets will consist of checking for degradation of the tipping bucket, tipping bucket bearings, and the flushing water supply connection to the tipping bucket.

12.1.2.2 Mechanical Equipment

Routine maintenance is anticipated for mechanical equipment such as the tipping bucket fill pumps, foul air fan, facilities vault sump pumps, and supply and exhaust fan. Routine maintenance typically will consist of replacing belts, bearings, filters, or lubricants. Access to the facilities vault will be through access hatches that expose the stairways into the facilities vault rooms.

12.1.2.3 Hatches on the Storage Tank and Facilities Vault

O&M personnel will require access to the storage tank and facilities vault to perform maintenance, repairs, and cleaning. Access to the storage tank will be provided by access hatches and removable concrete panels. Hatches will be located at the ground surface and allow access to equipment from the ground surface. Storage tank hatches will be provided for access and inspection of equipment such as the tipping buckets and basin drain pumps. The design approach for access is that inspection and routine maintenance work will be performed from the surface by opening the access hatches. Access hatch locations are shown on Exhibits 2 and 9 in Appendix A.

Access to the facilities vault will be provided by large stairwell hatches. The facilities vault will also be provided with access hatches over the carbon vessel to aid in replacing the carbon media.

All access hatches will include fall prevention safety grating. Access hatches will be rated for HS-25 traffic loading. Access hatches can be single-leaf or double-leaf, depending on the size and use of the hatch.

The hatches will require routine maintenance. Inspection of hatches on the storage tank and the large leaves at the facilities vault will consist of checking the locks on the hatches and the large leaves and checking the hatch and leaves operation. Inspection will be accomplished by ensuring proper operation of the locks and by opening and closing the hatches and leaves on a monthly basis. Security measures are discussed further in Section 12.2.

Tipping Buckets

Access hatches will be provided over the tipping buckets located in the storage tank. The hatches will be located over each of the supports of the tipping bucket to facilitate visual inspection and performance of maintenance work. The hatches over the tipping buckets are proposed to be 6 feet long by 4 feet wide.

Basin Drain Pumps

An access hatch will be provided over the basin drain pumps to facilitate removal of the pumps for maintenance. The hatch will also be able to be used to perform a visual inspection of the basin drain pumps.

Facilities Vault Access and Equipment

Access to the inside of the facilities vault will be by stairways. The current design of the facilities vault has one stairway to each room. Access to the stairs will be through hatches approximately 12 feet long by 4 feet wide. The stairs are currently designed to be 4 feet wide, and it is anticipated that the stairs will be used for personnel entry and for carrying small hand tools or light loads.

To facilitate removal and replacement of some of the larger components, access hatches will be located above the component, providing access from the surface without entering the structure. Removal of large tools and other components from the rooms in the facilities vault will be achievable by employing lifting devices at the surface. Smaller hatches will be located above the carbon fill port to facilitate the filling and emptying of the carbon scrubber.

Removable Concrete Panels

There will be large, removable, concrete panels that will allow larger equipment to be lowered or removed from the storage tank or facilities vault. For example, large, removable concrete panels will be installed over the tipping buckets to allow removal of the tipping buckets and to allow placement of large equipment (for example, a Bobcat) into the storage tank, if needed.

Removal of concrete panels will be a large-scale undertaking for maintenance personnel and is anticipated to be infrequent. The access hatches above the basin drain pumps are being sized so that the pumps can be removed through them; therefore, it is not anticipated that removable concrete panels will be needed to access the basin drain pumps. Lifting equipment to remove the concrete panels will be brought onsite by O&M staff.

12.1.3 Recurring After-use O&M Activities

O&M activities that will be performed after the storage tank has been emptied after a storm event are referred to as “recurring after-use activities.” It is anticipated that, approximately six to seven times per year, the excess flow from a storm events will be diverted from the combined sewer pipes into each of the storage tanks. After the storm event recedes, combined sewer flow collected in the storage tank will be pumped out by the basin drain pumps and then pumped back into the combined sewer system. After the combined sewage has been removed from the storage tank, an automatic cleaning cycle will be performed by the tipping buckets. The tank will next be emptied of flushing water by the basin drain pumps. O&M personnel will then visit the site to inspect and, if necessary, perform maintenance on the tipping buckets and the storage tank. Recurring after-use O&M activities will occur on the following project components:

- Tipping buckets
- Storage tank
- Basin drain pumps and sump

12.1.3.1 Tipping Buckets

Visual inspection of the tipping buckets will be performed after an event to assess the tipping buckets, bearings, and flushing water supply connection. If deemed necessary by O&M personnel, tipping bucket bearings will be lubricated to ensure proper operation.

12.1.3.2 Storage Tank

Visual inspection of the storage tank will be performed after an event to verify that the cleaning cycle occurred. Inspection will be performed by opening the hatches located along the storage tank roof and inspecting the condition of the storage tank from the ground surface.

Hatches will be placed at both the tipping bucket end and the collection channel end of the storage tank. The hatches will be located so that each hatch is positioned over one of the flushing channels. The total number of hatches will depend on the total number of flushing channels, to be determined during design. Exhibits 5 and 12 in Appendix A show the locations of the hatches on the storage tanks.

A pole-mounted camera or CCTV tractor camera will be lowered through the hatches for closer visual inspection. Additional flush cycles could be performed by the tipping buckets if deemed necessary.

12.1.3.3 Basin Drain Pumps and Sump

The design intent is to locate submersible pumps (basin drain pumps) in the sump of the storage tanks. These basin drain pumps will be used to pump out the combined sewer flows that have collected in the tank after an event. These pumps will also be used to pump flushing water and debris out of the storage tank back into the combined sewer system after a cleaning cycle has been completed.

Visual inspection of the basin drain pumps and the sump will be performed after an event to ensure cleanliness of the sump and the basin drain pump operation. The flushing channels are being designed so that they slope toward the collection channel and the sump. If debris were to build up in the tank, it would probably do so at the end of the tank (at the sump). Washdown hoses at the ground surface could be used for further sump cleaning/flushing through the ground surface hatches.

12.1.4 Infrequent O&M Activities

"Infrequent O&M activities," in this instance, is defined as O&M activities that need to be performed by the O&M personnel once a year or once in several years. Infrequent O&M will occur on the following project components:

- Basin drain pumps
- Storage tank cleaning
- Odor control system

12.1.4.1 Basin Drain Pumps

The basin drain pumps will be attached to lifting rails, and hatches will be provided over the pumps to allow for removal of the pumps. Existing equipment owned by SPU, consisting of a truck with a rear-mounted crane, will be used to remove the pumps. Adequate space, free of trees and obstructions, will be provided around the hatches over the basin drain sump pumps for access. It is anticipated that SPU will need to remove the basin drain pumps from the storage tank once a year for regular maintenance work.

12.1.4.2 Storage Tank Cleaning

It is anticipated that the storage tanks will receive personnel entry and cleaning approximately once every 5 to 7 years as part of maintenance activities. Because it is anticipated that personnel entry into the storage tank will be very infrequent, the design approach is to not provide ladders, lighting, ventilation, retrieval, or other permanent entry equipment within or above the tanks. Provision for storage tank access is through the hatches. When entry is needed, all necessary equipment will be brought onsite by the maintenance crew. If access is required for larger equipment or if removal of the tipping buckets is required, removable concrete panels above the tipping buckets will be provided. The storage tank will need to be ventilated using blowers, which will be brought onsite by the maintenance staff before entering the storage tank.

12.1.4.3 Odor Control System

The odor control system will require O&M activities mainly for the grease filter/mist eliminator, the carbon adsorption vessel, and the odor control fan.

It is recommended that maintenance personnel to perform weekly inspection on all differential pressure gauges. The grease filter/mist eliminator pads will need to be replaced and cleaned when the differential pressure across the unit exceeds the set point (typically, 2-inch w.c.). The actual frequency of pad cleaning will depend on how much fat, oil, and grease the combined sewerage contains. The activity will involve replacing fouled pad panels with clean ones and removing the fouled pads to a more suitable location for cleaning using hot water or steam. Each pad section will be not larger than 4 ft^2 and will be easily handled by one person. The complete operation typically will take approximately 1 hour of onsite work, followed by 2 hours to clean the removed media pads offsite.

It is expected that the activated carbon will be replaced every 2 to 5 years, depending on the odor strength in the foul air. The activated carbon will physically break down after 5 years of operation and will require changeout, even if the adsorption capacity is not completely spent. The operator will be able to rely on the following methods to determine the frequency of carbon changeout:

- The differential pressure gauges across the carbon bed, and across the odor control fan inlet/out—high differential pressure readings will indicate potential carbon compaction or plugging.
- The hydrogen sulfide sampling results at the outlet side of the carbon vessel— high exhaust hydrogen sulfide level will indicate carbon breakthrough.

Alternatively, the interior condition of the carbon could be assessed by means of sample ports on the exterior of the carbon vessel.

A platform will be provided around the vertical carbon vessel to provide maintenance personnel access to the top of the vessel. The entire lid of the vessel could be removed with the disconnectable outlet hose. Replacement of carbon will involve using a Vactor™ truck to remove the carbon pellets from the ground surface through a hatch. New carbon pellets will be poured into the carbon vessel through a fill port from the surface or from the platform.

Regular inspection and maintenance will be required for the centrifugal odor control fan. The thermal sensors built in the fan motor and the differential pressure gauge across the fan will provide protection and aid in trouble-shooting, if needed.

12.1.5 Summary

Table 30 summarizes the anticipated O&M activities and the anticipated frequency of these activities for the SPU CSO Reduction Project.

Table 30. Operations and Maintenance Activities

EQUIPMENT	O&M ACTIVITY	FREQUENCY
Hatches on Storage Tank and Facilities Vault	Visual Inspection/ Routine Maintenance	Monthly
Tipping Buckets	Visual Inspection/ Routine Maintenance	Monthly and After-use of the storage tank
Tipping Bucket Fill Pumps	Routine Maintenance	Weekly
Basin Drain Pumps	Visual Inspection	Yearly and After-use of storage tank
Foul Air Fan	Routine Maintenance	Weekly
Motor Operated Gates	Visual Inspection/ Routine Maintenance	Monthly
Storage Tank	Visual Inspection and Cleaning	After-use of the storage tank and every 5 to 7 years
Grease and Mist Filter	See Odor Section	Yearly
Carbon Adsorption Vessel	Replacement Carbon Media	Every 2 Years
HVAC Supply and Exhaust Fans	Routine Maintenance	Monthly
Heaters	Routine Maintenance	

12.2 Security Measures

12.2.1 Existing SPU Security System

The SPU Security Team will specify security measures to be followed by the utility and consultants and will respond to security incidents and issues. SPU has a security monitoring center that has the ability to dispatch teams to address security issues. The Security Team will be based out of the SPU Operations and Control Center.

12.2.2 SPU Security Team Objective

The objective of the SPU Security Team is to protect against critical, single-point failures in the SPU system. Current measures for security are in place at drinking water, wastewater, and stormwater facilities, and at transfer stations. The level of security at these places varies with the type of facility and frequency and type of O&M activities. At this time, the security requirements for Genesee tanks have not been specified. The SPU Security Team will provide the design team with security specifications during design. The information presented in the following sections is based on discussions with the SPU Security Team that took place during the feasibility analysis stage of the project.

12.2.3 Security System Goals

The following list summarizes the main goals of the security system at the project sites:

- As few points of access as possible to the storage tank and facilities vault are desired.
- Strike a balance between security and O&M needs for access and use of the facility.
- If alarms are used at the facility, cameras should also be installed to verify the cause of alarm in the event that the alarm is triggered.
- Install a master “Arm/Disarm” feature that can be used by the maintenance crew when they are onsite to disarm all or most security features at once.
- To prevent loitering, avoid sunken walkways or places that can be out of sight.
- Incorporate elements of crime prevention through environmental design to avoid potential security issues in design; for example, avoiding trees that block sight lines for security cameras.

12.2.4 Storage Tank Security

Access to storage tanks will be by the hatches located on the tanks. The access hatches will be located at both ends of the flushing channels of the storage tanks. The current design direction is to provide regular padlocks on the access hatches.

The alternative to padlocks will be CyberLocks™, which are a hybrid between a standard padlock and an electronic strike system. They include an electronic key with a computer chip that is synced to a housing unit. The benefit of using CyberLocks™ is that, if CyberLock™ keys are lost, the chips can be reprogrammed easily and it is inexpensive to replace them, compared with re-coring conventional keys and padlocks. At this time, CyberLocks™ are not specified for the Genesee facilities.

Provisions for electrical conduits could be incorporated into the design in case electronic strike cards are deemed necessary for the hatches on the storage tanks. Security cameras pointing at the hatches on the storage tanks will be incorporated into the design.

If fencing is provided at the site, it is anticipated that strike cards and video surveillance will also be required. At this time, fencing around the sites is not planned.

12.2.5 Facilities Vault Security

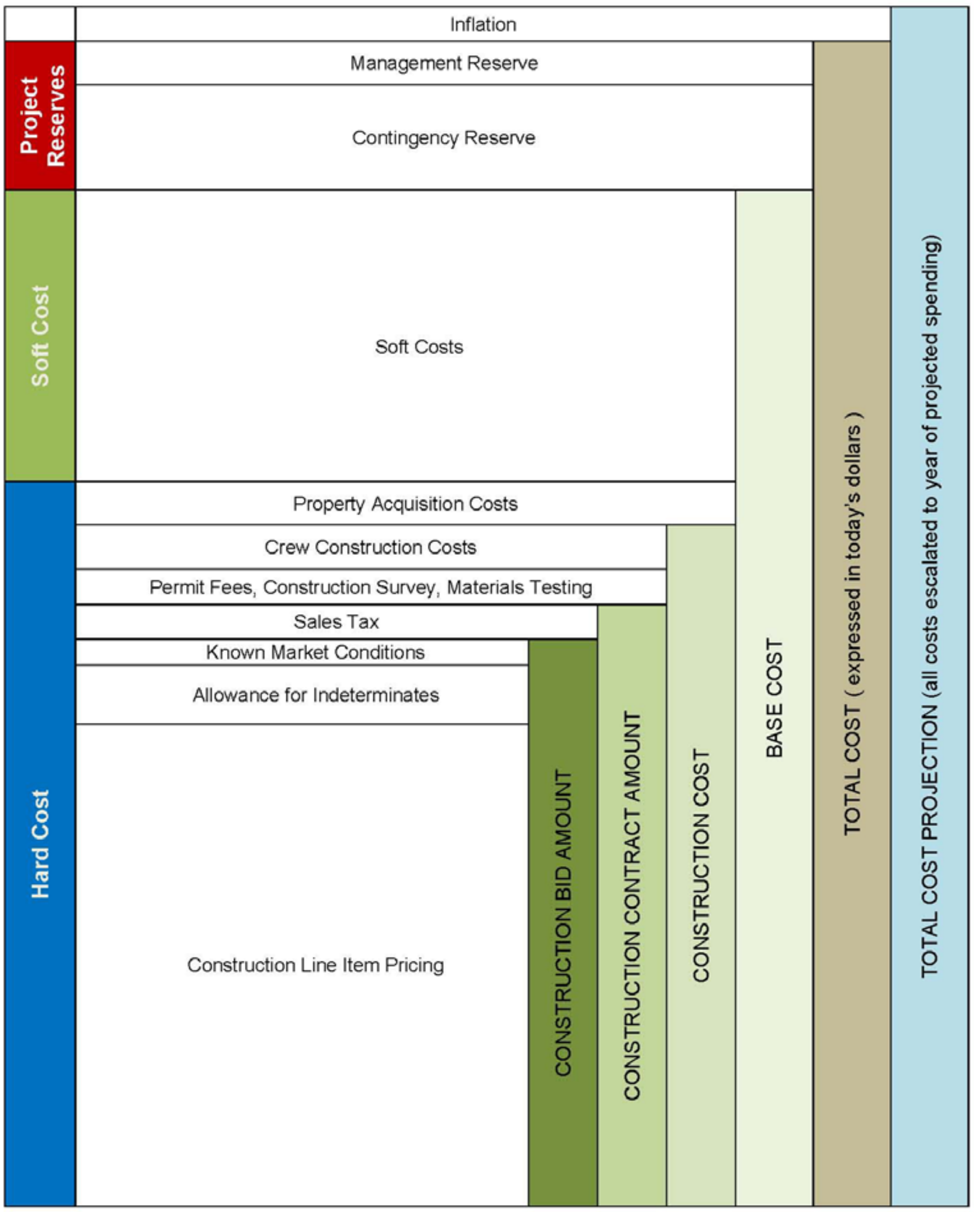
Access to the facilities vault will be through large access hatches that open to stairways. The current design direction is to provide padlocks for the entrance to the facilities vault and the access hatches located on the facilities vault. Provisions for electrical conduits will be incorporated into the design in case electronic strike cards are deemed necessary. Previous project experience with SPU suggests that cameras inside the facilities vaults, directed at the access hatches, will be required.

13 Cost Estimate

This section contains general criteria for preparation of cost estimates.

13.1 SPU Cost Estimating Guide

Cost estimates will be prepared in conformance with the SPU Cost Estimating Guide (Guide) Final Draft dated May 6, 2011, and the final Guide when it becomes available. Cost estimate components, attributes and uses, and methods specified in the current version of the Guide are summarized in Figure 5, Figure 6, and Figure 7, which are taken from the current version of the Guide.



Phase	Initiation	Options Analysis	Design					Construction & Close Out
			30%	60%	90%	Final	Bid	
What activity is cost estimate used or updated for?	Comprehensive Planning Portfolio Prioritization Project Identification Financial Planning	Feasibility Analysis/Select Preferred Option	Project Management and Control			Advertise and Inform Bidders	Portfolio Management	Portfolio Management
Stage Gate/Funding Request	1. Approve Funding for Options Analysis	2. Approve Preferred Option, Funding for Design, Placeholder for Total Cost Projection and O&M				3. Approve Construction Cost	4. Approve Const. Contract	5. Approve Project Close Out & Asset Costing
Rates and Budget	6 Yr. CIP Budget,	Annual Spending Plan						Depreciation Schedule
Project Management Plan	May Be Used for Options Analysis		Cost Estimate Used to Set Baseline				Update Cost Estimate in PMP	
Value Analysis/ Value Engineering		Estimate Required for VA	Updated Estimate Required for VE					
Who's responsible for cost estimate?	Specifier	Specifier	Project Manager				Project Manager	Project Manager
AACE Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1			
Basis of Estimate	On Problem Statement/Project Objectives, Project Schedule. Construction Costs Based on Historical Unit Costs, Costs of Similar Completed Projects, and/or Expert Judgement. Soft Costs Based on SPU Recent Soft Costs.		Project Scope, Schedule. CCBS for construction cost and WBS for soft cost. Vendor Quote, industry data and historical costs.	Project Scope, Schedule. Preferred Design Solution. Construction Costs based on CCBS and Soft Costs based on WBS			Apparent Low or Best Value Bidder	Actual and Anticipated Cost
Construction Bid Cost	Historical Unit Costs, Costs of Similar Completed Projects, and/or Expert Judgement		Line Item Costs for Major Items and Equipment	Line Item Costs for Major Items and Equipment; Semi-detailed Line Item Unit Costs for Remainder	Line Item Costs for Major Items and Equipment; Increased Detailing of Remainder	Detailed Take Off, Unit Costs	Apparent Low or Best Value Bidder	Including Change Orders
Allowance for Indeterminates	Included in Base Cost		15% to 25% of Bid Cost	5% to 15% of Bid Cost	0% to 5% of Bid Cost	0% of Bid Cost	N/A	N/A
Property/Permit Fees	Include KC assessment if site determined	Desktop Geotech, Property based on KC Assessor and $/sq ft for Easements	Based on Appraisals and Site Conditions					
Soft Cost	Recent SPU Soft Costs	By Phase/Org, Based on Recent SPU Soft Costs	Based on PMP and Consultants SOW					
Contingency	25% to 40% of Base Cost	15% to 25% of Base cost	Based on PMP Risk Register					
Management Reserve	10% to 25% of Base Cost	10% to 20% of Base Cost	5% to 15% of Base Cost	5% to 10% of Base Cost	0% to 5% of Base Cost	0% to 5% of Base Cost	0% to 5% of Base Cost	0% to 5% of Base Cost

Base Cost (Construction Bid Cost through Soft Cost)

Reserves (Contingency and Management Reserve)

Total Cost (in today's dollars); Total Cost Projection (all costs escalated to year of projected spending)

CIP - Capital Improvement Project, SOW - Scope of Work, CCBS - Construction Cost Breakdown Structure, WBS - Work Breakdown Structure, KC - King County, PMP - Project Management Plan,

Figure 6. Cost Estimate Attributes and Uses by Project Phase

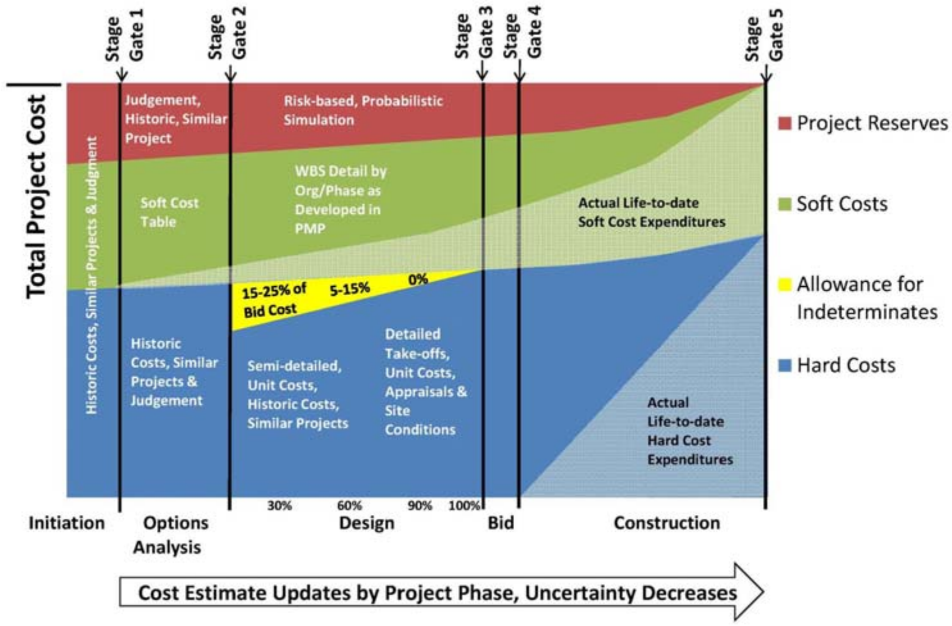


Figure 7. Cost Estimate Methodology by Project Phase

13.2 Construction Cost Breakdown Structure

13.2.1 Format

The construction cost breakdown structure (CCBS) for each of the two storage project components will be prepared in CSI format.

13.2.2 Quantity Takeoffs

Quantity takeoffs will be the basis of the CCBS. Lead designers will be responsible for the quantity takeoffs. The basic organization of quantity takeoffs will be by drawing sheet. Each quantity takeoff submittal will include copies of drawing sheets clearly marked to show the items included and their locations so as to facilitate checking and verification of quantity calculations and subsequent changes to the CCBS. Also, the applicable specification section for each item will be referenced.

Some line items that are likely to be included in quantity takeoffs for the Genesee CSO Reduction Project are listed in Table 31. Volume quantities for earthwork and aggregates will be in place. The estimator will apply appropriate conversions (such as cubic yards to tons) and factors for estimating material volumes in the loose or uncompacted condition if needed. Before beginning quantity takeoff, HDR will check with the estimator regarding the appropriate parameters and units for items not listed in the table.

Table 31. Quantity Takeoffs Items and Units

ITEM	DESCRIPTION	UNIT
Demolition		
Pavement Removal	Material, thickness	Square yards
Sidewalk Removal	Material	Square yards
Curb or Curb and Gutter	Material	Linear feet
Pavement Planning	Pavement material	Square yards
Saw Cutting	Material	Linear feet
New Construction		
Sidewalk	Material	Square yards
Curb or Curb and Gutter	Length	Linear feet
Aggregates	Type (for example, crushed surfacing and pipe bedding), SPU or other appropriate specification reference	Cubic yards
Excavation	Unclassified or classified	Cubic yards
Backfill	Placing and compacting excavated material	Cubic yards
Imported Backfill	Providing the material at the site and waste of the material that is displaced by the imported material	Cubic yards
Geotextile	Type, woven or unwoven, unit weight, other	Square yards
Pipe	Material, size and other dimensional parameters, joint type, length, numbers and types of fittings, lining, coating	Linear feet
Major Equipment	General description, performance parameters, weight(s) price quotation F.O.B. site if possible (include testing (factory, witnessed, field), manufacturer representative onsite requirements, O&M materials, training, special warranties, spare parts, unit responsibilities, and other special requirements), delivery time	Each
Structural Concrete	Type (slab on grade, walls and columns, suspended slabs and beams, miscellaneous), strength, special requirements	Cubic yards
Reinforcing Steel	Use (slab on grade, walls and columns, suspended slabs and beams, miscellaneous)	Tons
Asphalt Concrete Pavement	Class, SPU or other specification reference, thickness	Square yards
Cement Concrete Pavement	SPU or other specification reference, thickness	Square yards
Precast Concrete Items	Type, size, dimensional parameters, other parameters as applicable	Each
Large and Special Valves	Type, size, end type operator	Each
Fabricated Metal	Type, size, special features	Each

13.2.3 Temporary Facilities

Quantities such as the following will be provided for temporary facilities:

- **Traffic control:** Include hours for labor and supervisor, numbers and durations of need for signs and devices, and hours for preparation of traffic control plan.
- **Sediment and erosion control:** Include hours for preparation of plans, materials, installation, inspection, maintenance, replacement, and removal.
- **Temporary accommodation of sewage flow:** Include pumps, piping, required modification of existing facilities, installation, inspection, maintenance, replacement, and removal.
- **Staging:** Include field offices as specified and allowances for specific estimates as applicable for transporting personnel and materials from offsite locations.

13.2.4 Quantities for Other Work

Include estimated quantities for work such as surveying performed by the contractor for layout and check of the work and for obtaining as-built information.

13.2.5 Price Quotations

Price quotations and other specific information that may aid in preparing the CCBS with quantity takeoffs for major equipment will be included. HDR will confirm with the manufacturer or vendor that all specification requirements can be met and that price quotations include all specified requirements such as options, provisions for monitoring, testing (factory, witnessed, field), manufacturer representative onsite requirements, O&M materials, training, special warranties, spare parts, unit responsibility coordination costs, vibration analysis, and seismic analysis. It is preferred that the quotations be free on board (F.O.B.) the site. Quotations will be obtained for each equipment item from three manufacturers if possible.

Appendix A – Exhibits

1. 49th Avenue South Parking Lot – Vicinity
2. 49th Avenue South Parking Lot – Site Civil Plan - Storage Facility Components
3. 49th Avenue South Parking Lot –Site Civil Plan - Drainage, Grading, Site Improvements
4. 49th Avenue South Parking Lot – Basin 40 Diversion Sewer Plan & Profile
5. 49th Avenue South Parking Lot – Tank Top Plan
6. 49th Avenue South Parking Lot – Tank Sections
7. 49th Avenue South Parking Lot – Hydraulic Schematic
8. 49th Avenue South Parking Lot – Hydraulic Profile
9. 53rd Avenue South Parking Lot – Vicinity
10. 53rd Avenue South Parking Lot – Site Civil Plan - Storage Facility Components (1 of 2)
11. 53rd Avenue South Parking Lot – Site Civil Plan - Storage Facility Components (2 of 2)
12. 53rd Avenue South Parking Lot – Site Civil Plan - Drainage, Grading, Site Improvements (1 of 2)
13. 53rd Avenue South Parking Lot – Site Civil Plan - Drainage, Grading, Site Improvements (2 of 2)
14. 53rd Avenue South Parking Lot – Conveyance Plan and Profile
15. 53rd Avenue South Parking Lot – Tank Top Plan
16. 53rd Avenue South Parking Lot – Tank Sections
17. 53rd Avenue South Parking Lot – Hydraulic Schematic
18. 53rd Avenue South Parking Lot – Hydraulic Profile
19. Facilities Vault Plan and Section

AUGUST 2011

EXHIBIT 1
49TH AVENUE SOUTH PARKING LOT VICINITY

VAULT SERIAL NO.	DATE	MARK	NATURE	MADE	CHK'D	REV'D
####			REVISIONS			

HDR Engineering, Inc.

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BY:
PURCHASING & CONTRACTING SERVICES DIRECTOR

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GENESEE CSO
REDUCTION PROJECT

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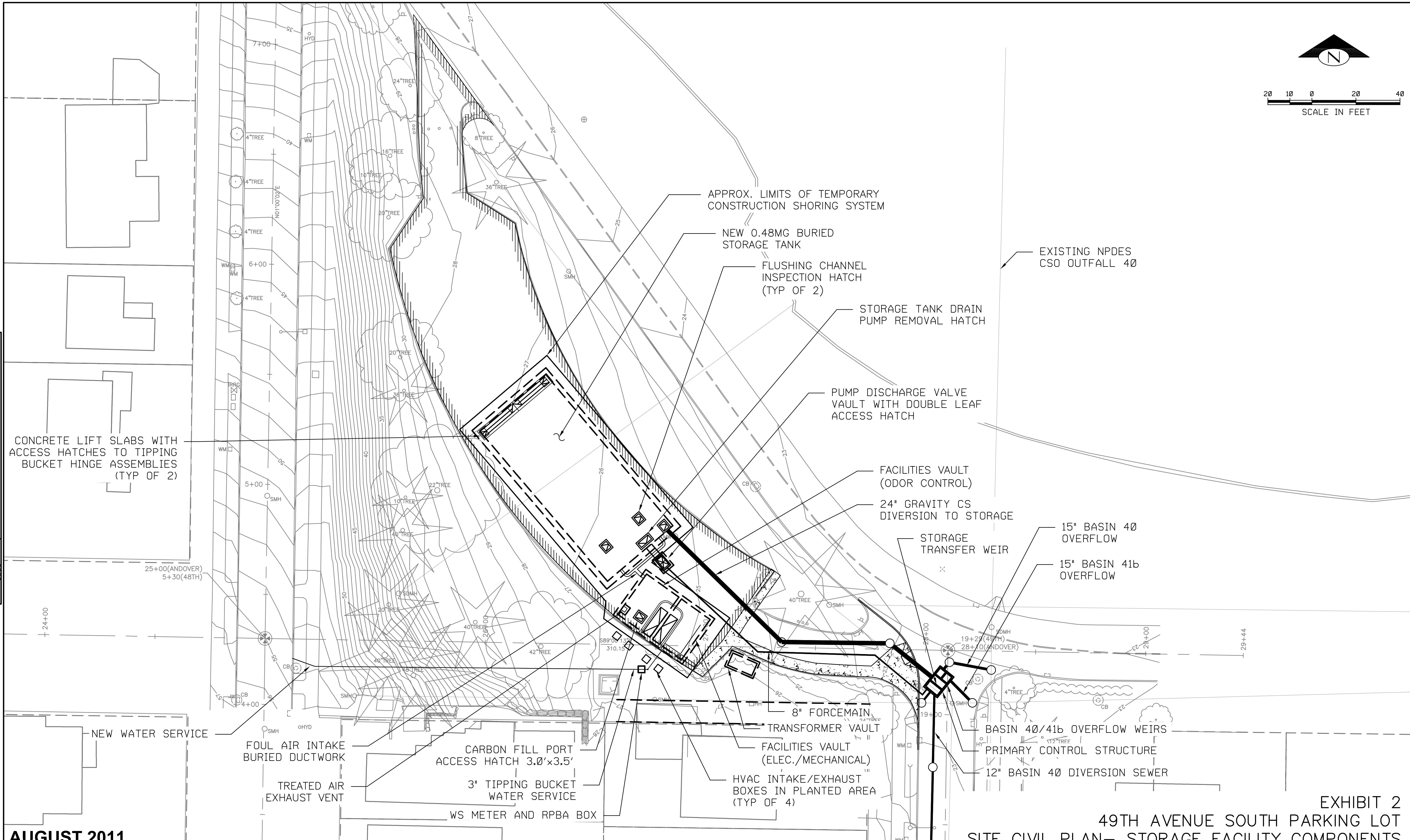

EXHIBIT 2
49TH AVENUE SOUTH PARKING LOT
SITE CIVIL PLAN— STORAGE FACILITY COMPONENTS

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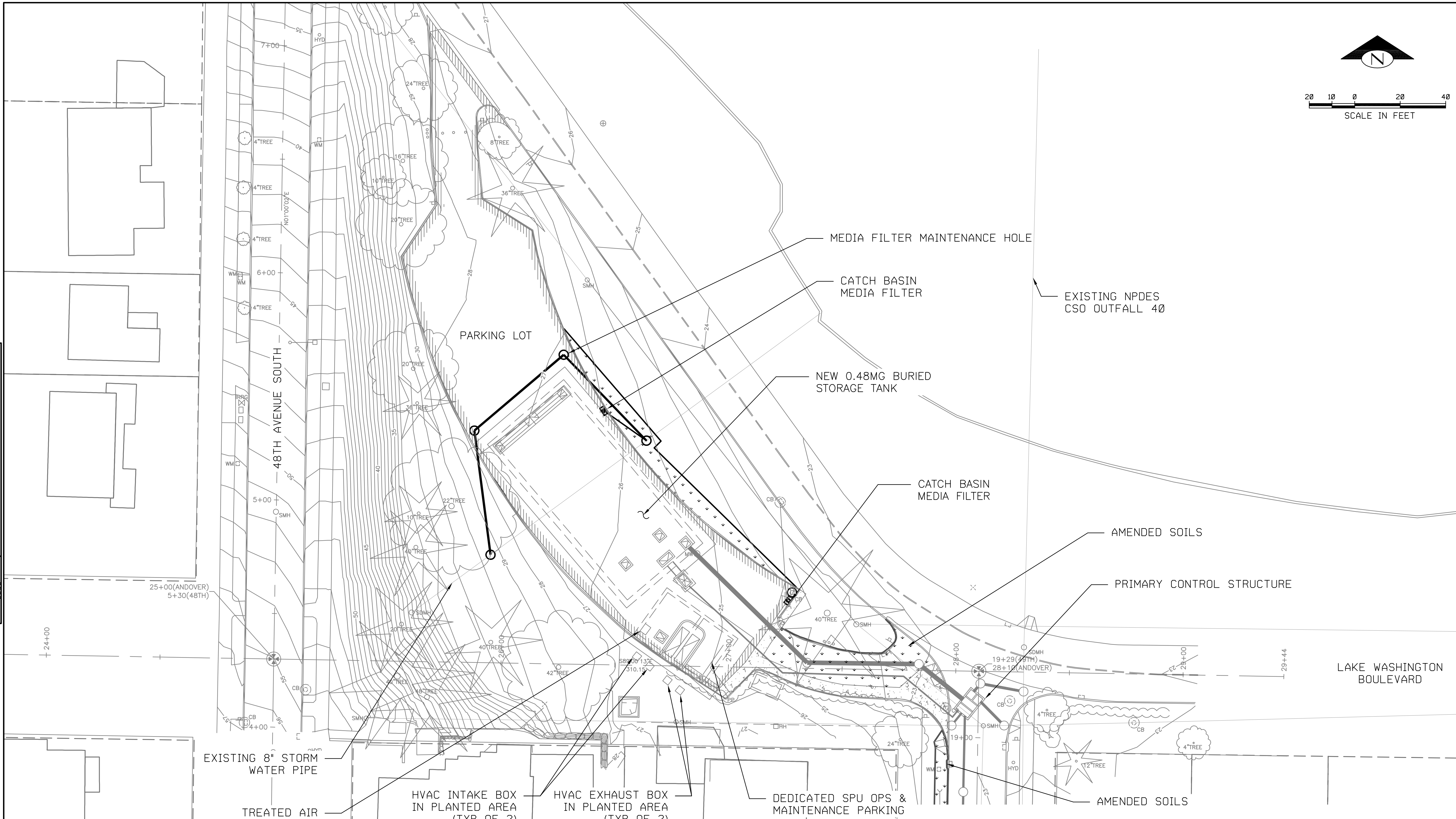

EXHIBIT 3
49TH AVENUE SOUTH PARKING LOT
SITE CIVIL PLAN – DRAINAGE, GRADING, SITE IMPROVEMENTS

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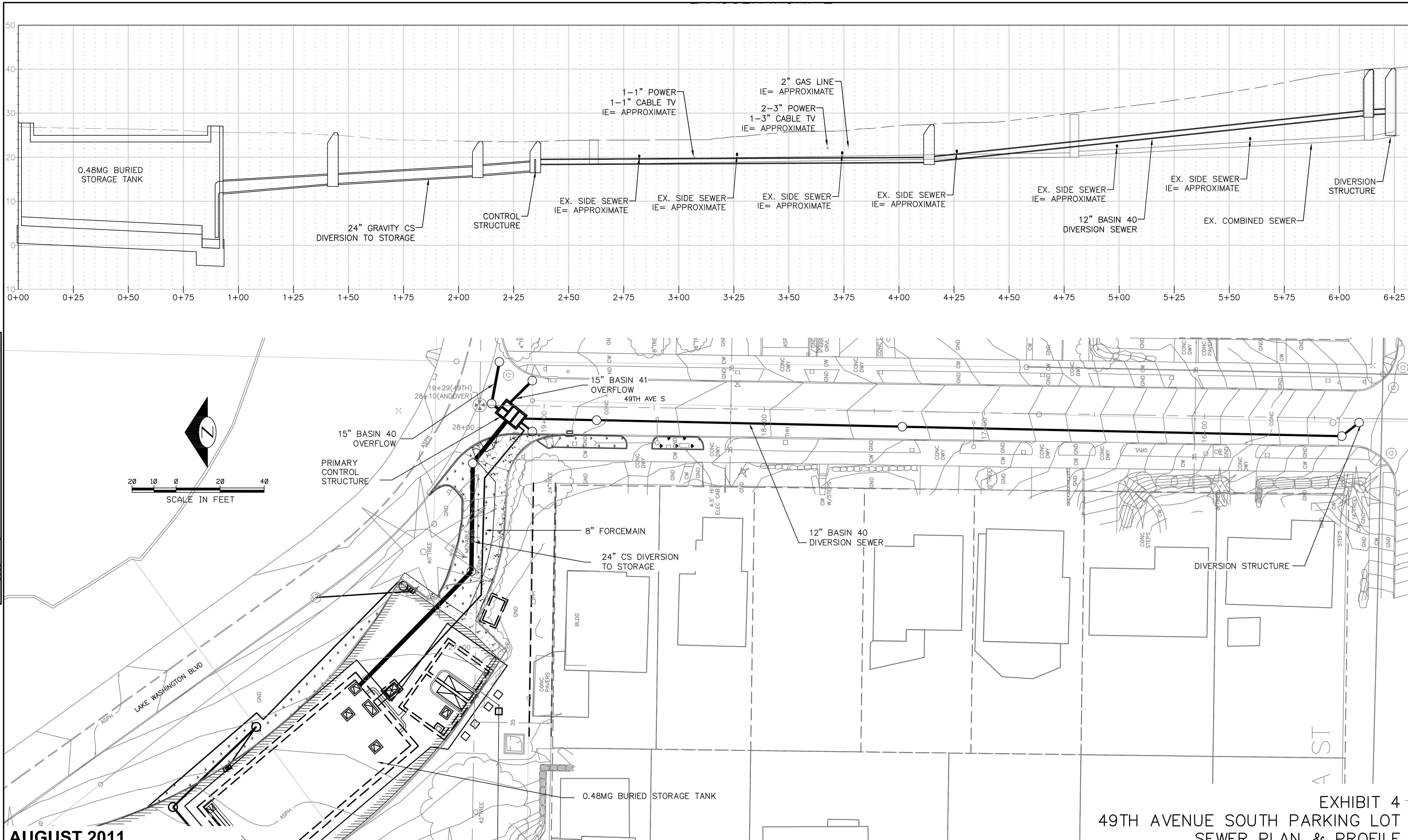

EXHIBIT 4
49TH AVENUE SOUTH PARKING LOT
SEWER PLAN & PROFILE

AUGUST 2011

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####			REVISIONS			

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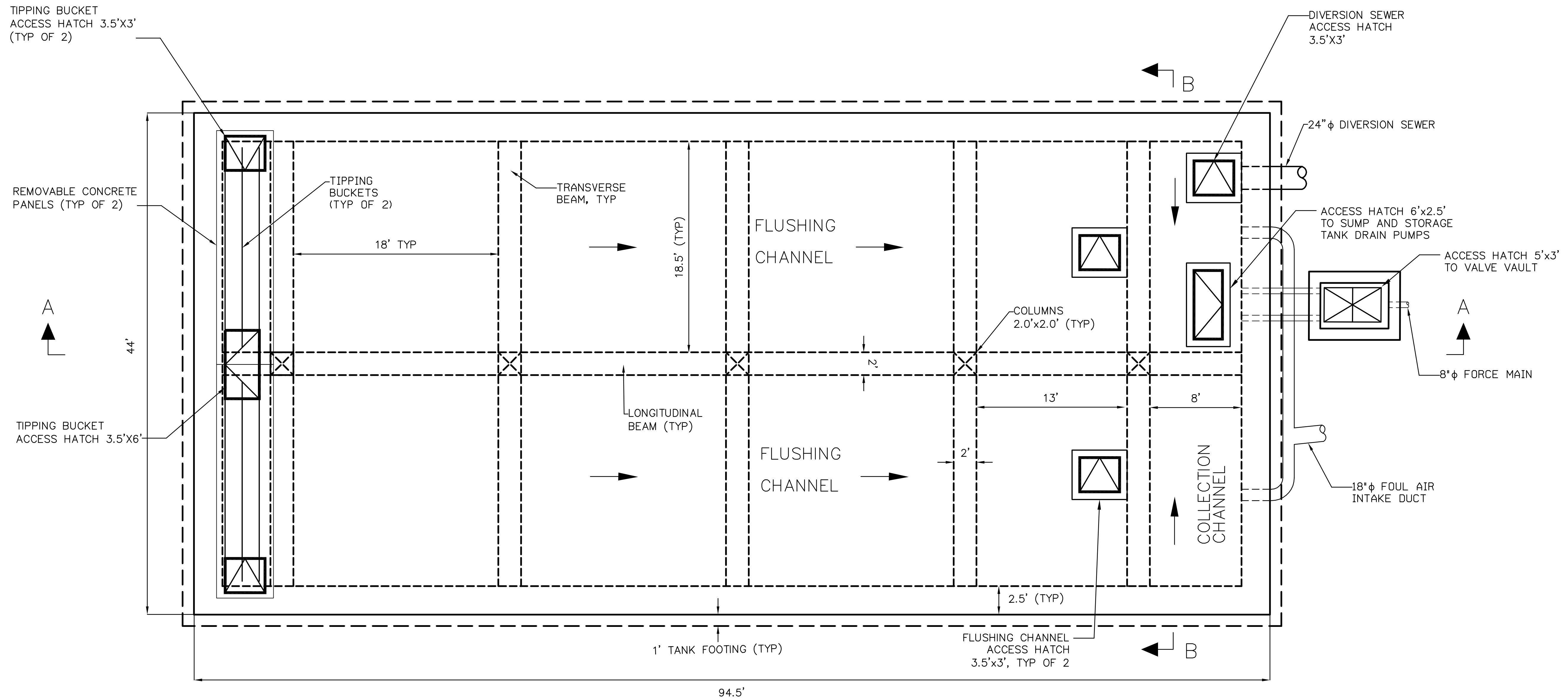
VAULT PLAN NO. ####
SHEET ---- OF SHEE



STORAGE TANK

SCALE 1"=10'

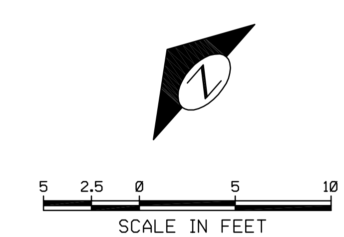


EXHIBIT 5
49TH AVENUE SOUTH PARKING LOT
TANK TOP PLAN

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D
####						

C:\pwworking\sea\d0619239\C303103-P-SITE-TANK-TOP-PLAN_05242011.dwg
Xrefs: | C303103-X-SECT-GENESEE BASIN 40 |
bshuck Aug-18-11 2:27pm
Layout Tab: FIGURE 10-2

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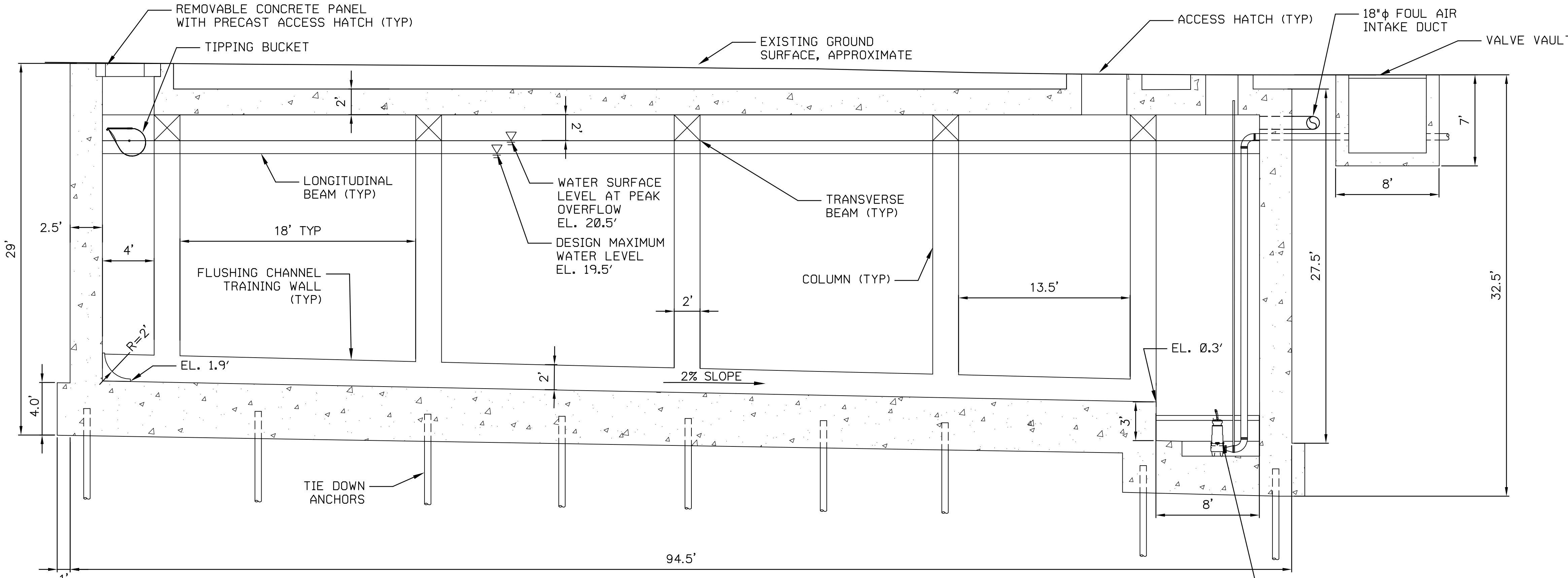
FUND:
SCALE: #### INSPECTOR'S BOOK

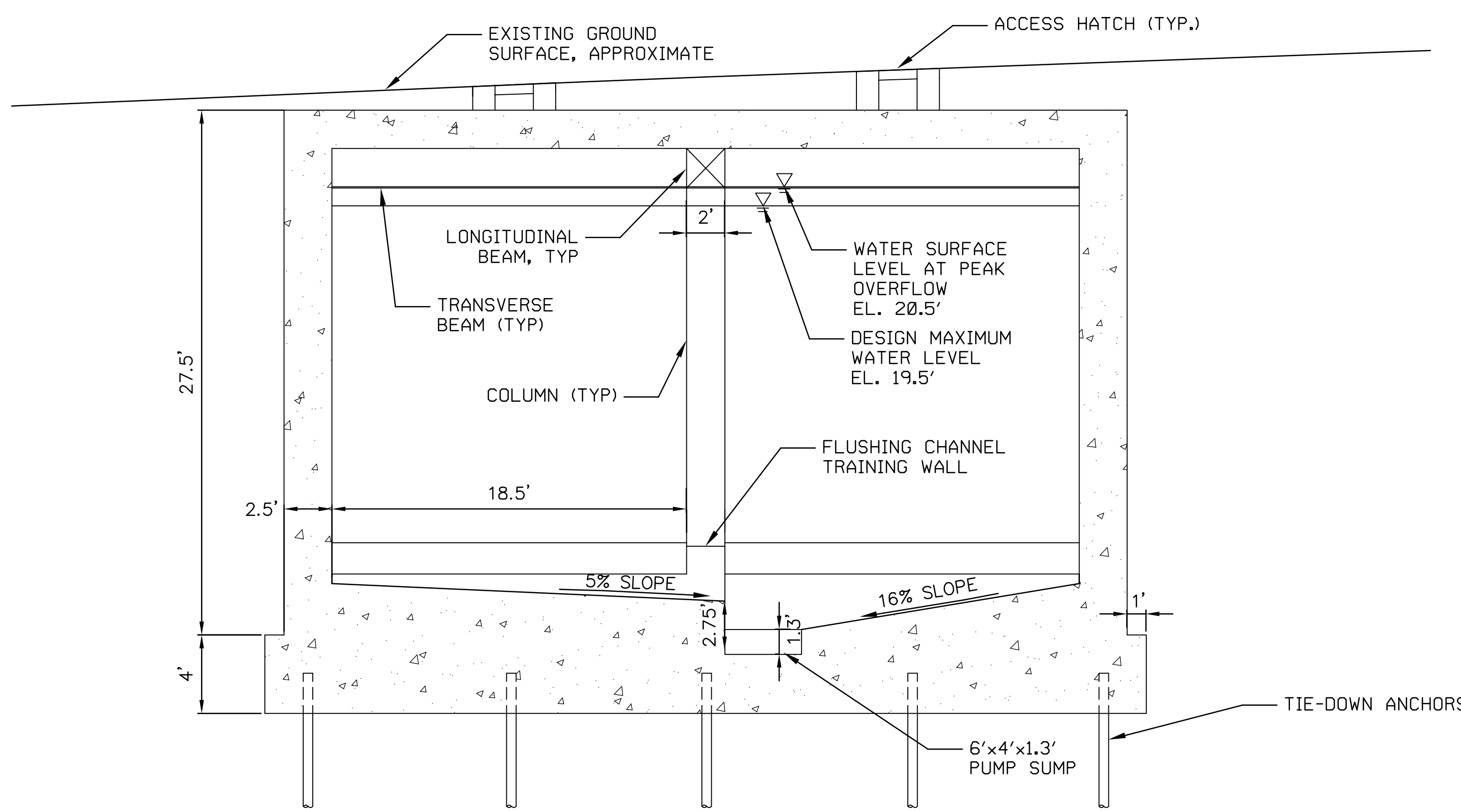
SEATTLE PUBLIC UTILITIES
GENESEE CSO
REDUCTION PROJECT

JOB NO. PC #### R/W #### CO ####
VAULT PLAN NO. ####
SHEET --- OF SHEE



SECTION A–A

SCALE 1"=10'



SECTION B–B

SCALE 1"=10'

5 2.5 0 5 10
SCALE IN FEET

EXHIBIT 6
49TH AVENUE SOUTH PARKING LOT
TANK SECTIONS

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REDUCTION PROJECT

JOB NO. PC #### R/W #### CO ####
VAULT PLAN NO. ####
SHEET --- OF SHEE

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bshuck Aug-18-11 2:43pm
Layout Tab: FIGURE 10-6

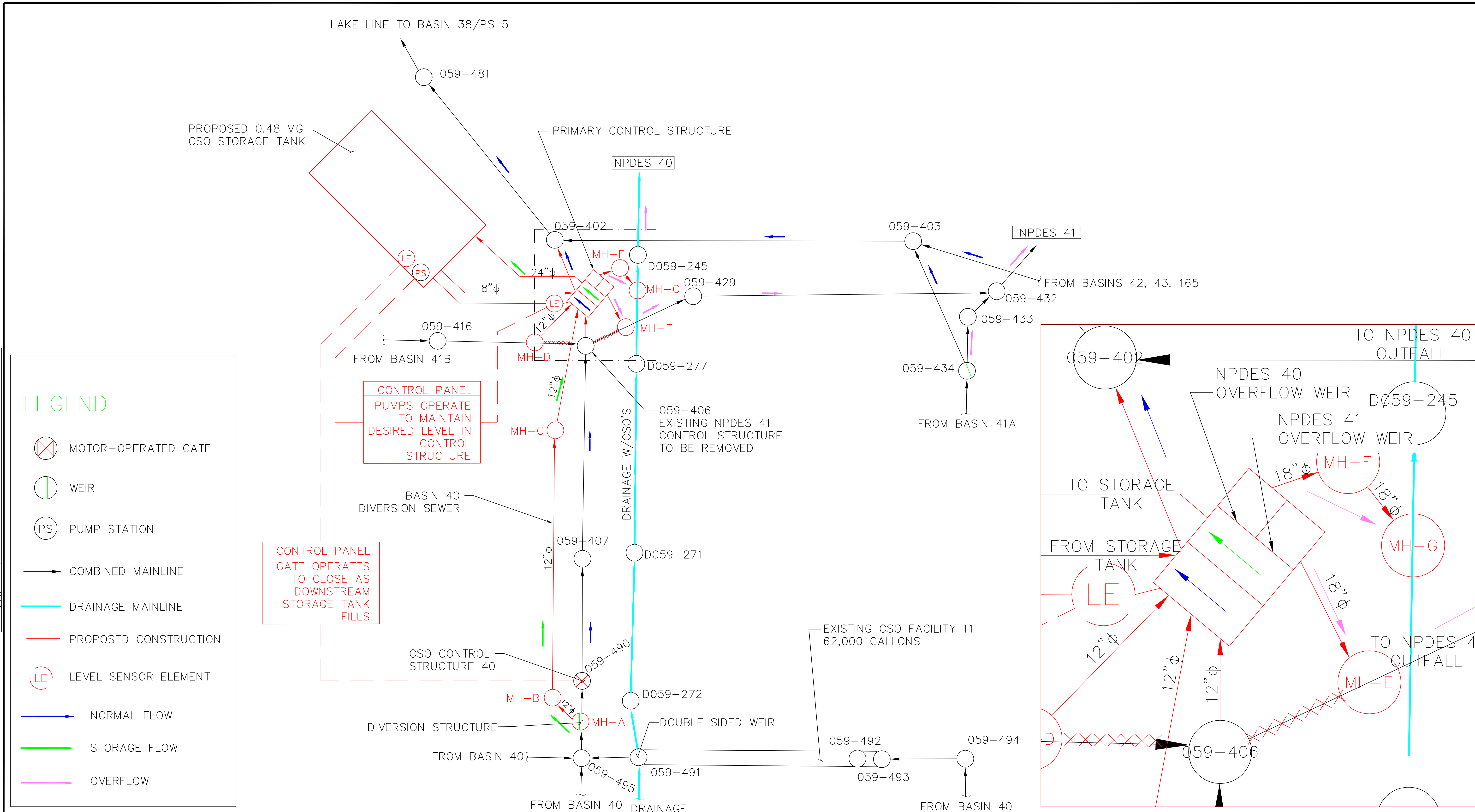

EXHIBIT 7
49TH AVENUE SOUTH PARKING LOT
HYDRAULIC SCHEMATIC

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REDUCTION PROJECT

JOB NO. PC ####
R/W ####
CO ####
VAULT PLAN NO. ####
SHEET ___ OF SHEE

C:\pwworking\sea\d0619239\C303103-P-HYDRAULIC-SCHEMATIC.dwg
Xrefs:
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Layout Tab: Exhibit 7

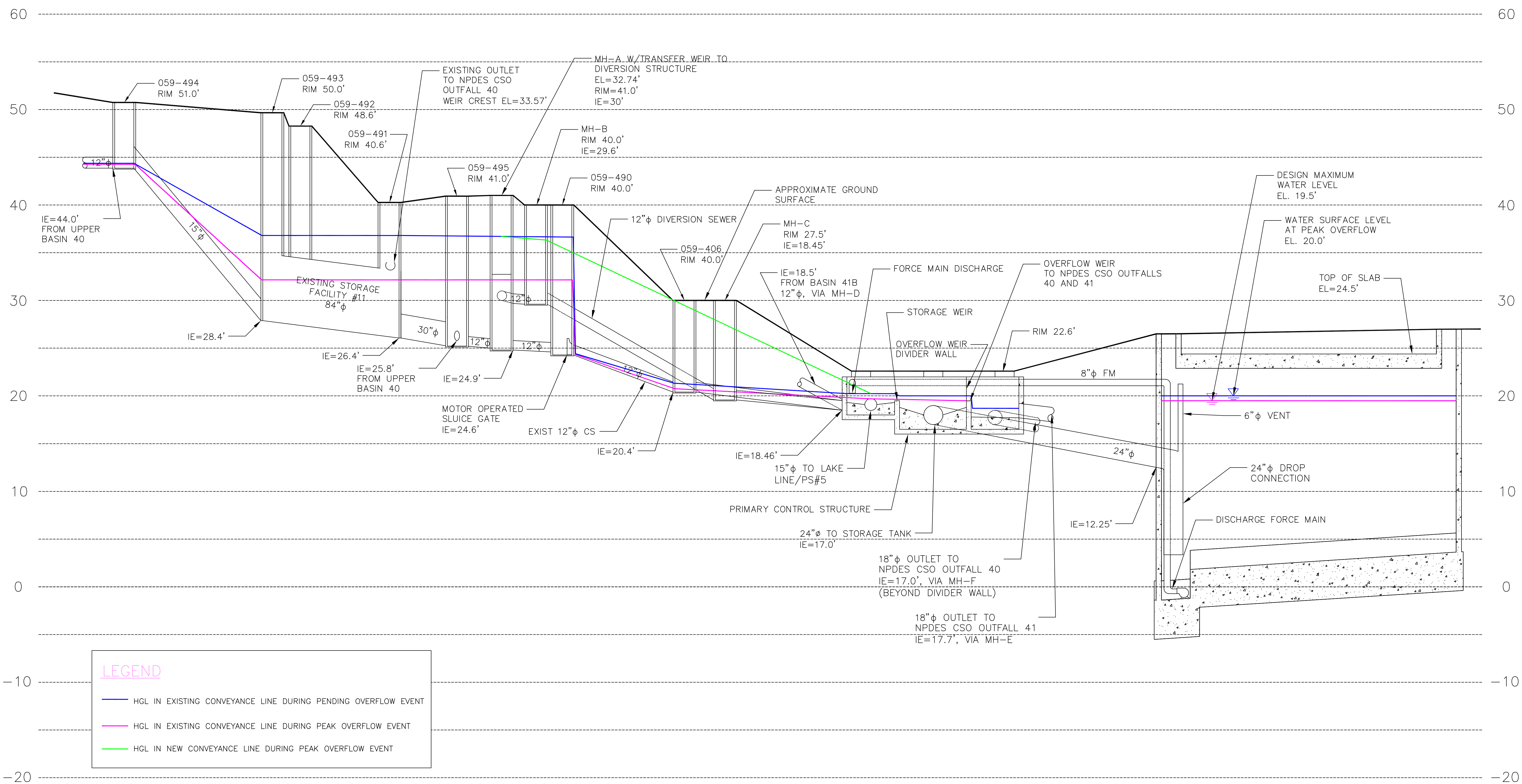

EXHIBIT 8
49TH AVENUE SOUTH PARKING LOT
HYDRAULIC PROFILE

AUGUST 2011

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DATE	MARK	VAULT SERIAL NO. ####	

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CHECKED ####	DES. #### CONST. ####
	SDOT #### PROJ. MGR. ####
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SCALE: #### INSPECTOR'S BOOK

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REDUCTION PROJECT

JOB NO. PC #### R/W #### CO ####
VAULT PLAN NO. ####
SHEET — — OF SHEE

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Xrefs: | C303103-P-HYDRAULIC-PROFILE |
tshuck Aug-26-11 9:43am
Layout Tab: FIGURE 10-7b

EXHIBIT 9
53RD AVENUE SOUTH PARKING LOT VICINITY

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REDUCTION PROJECT

JOB NO.	PC C303103
	R/W
	CO

VAULT PLAN NO.

SHEET 1 OF 10

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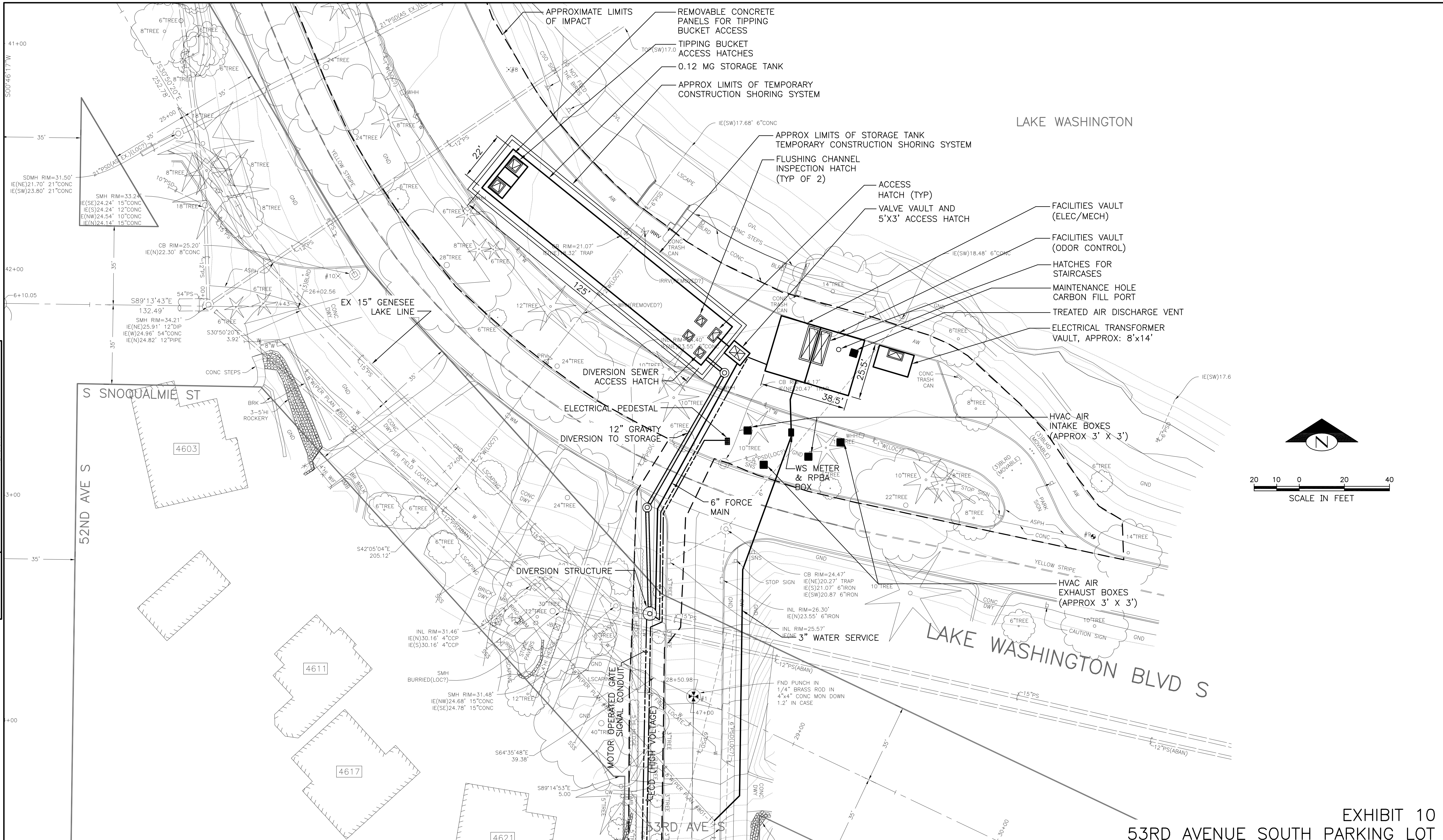

EXHIBIT 10
53RD AVENUE SOUTH PARKING LOT
SITE CIVIL PLAN – STORAGE FACILITY COMPONENTS (1 OF 2)

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MATCHLINE – SEE EXHIBIT 11

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REDUCTION PROJECT

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R/W
CO
VAULT PLAN NO.
SHEET 2 OF 10

VAULT SERIAL NO. | DATE | MARK | NATURE REVISIONS | MADE | CHK'D | REV'D

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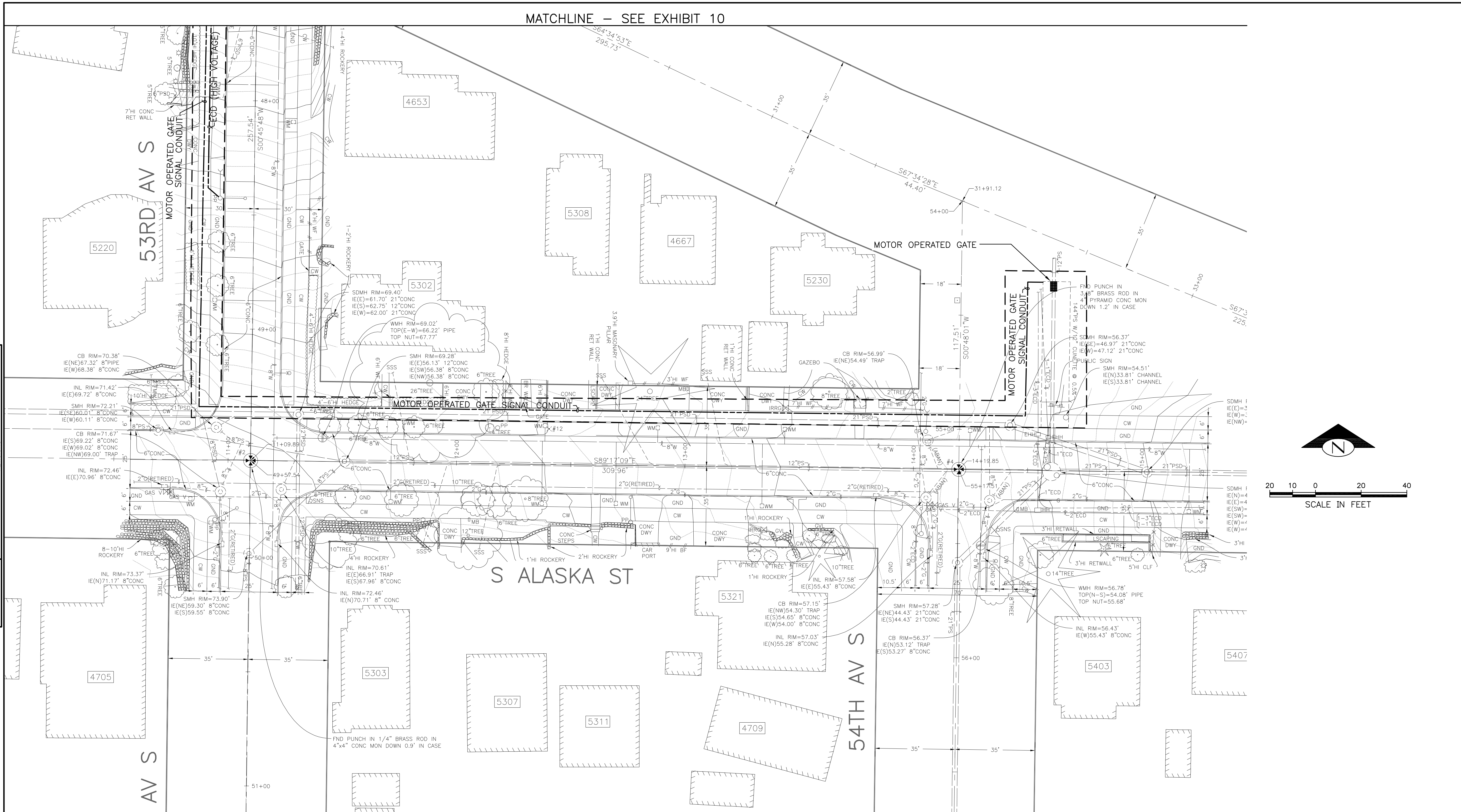

AUGUST 2011

EXHIBIT 11
53RD AVENUE SOUTH PARKING LOT
SITE CIVIL PLAN – STORAGE FACILITY COMPONENTS (2 OF 2)

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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	SDOT PROJ. MGR.
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CHECKED	REVISED AS BUILT

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FUND:
SCALE: H. 1"=20', V. 1"=10' INSPECTOR'S BOOK

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REDUCTION PROJECT

JOB NO.	PC C303103
	R/W
	CO
VAULT PLAN NO.	
SHEET 3 OF 10	

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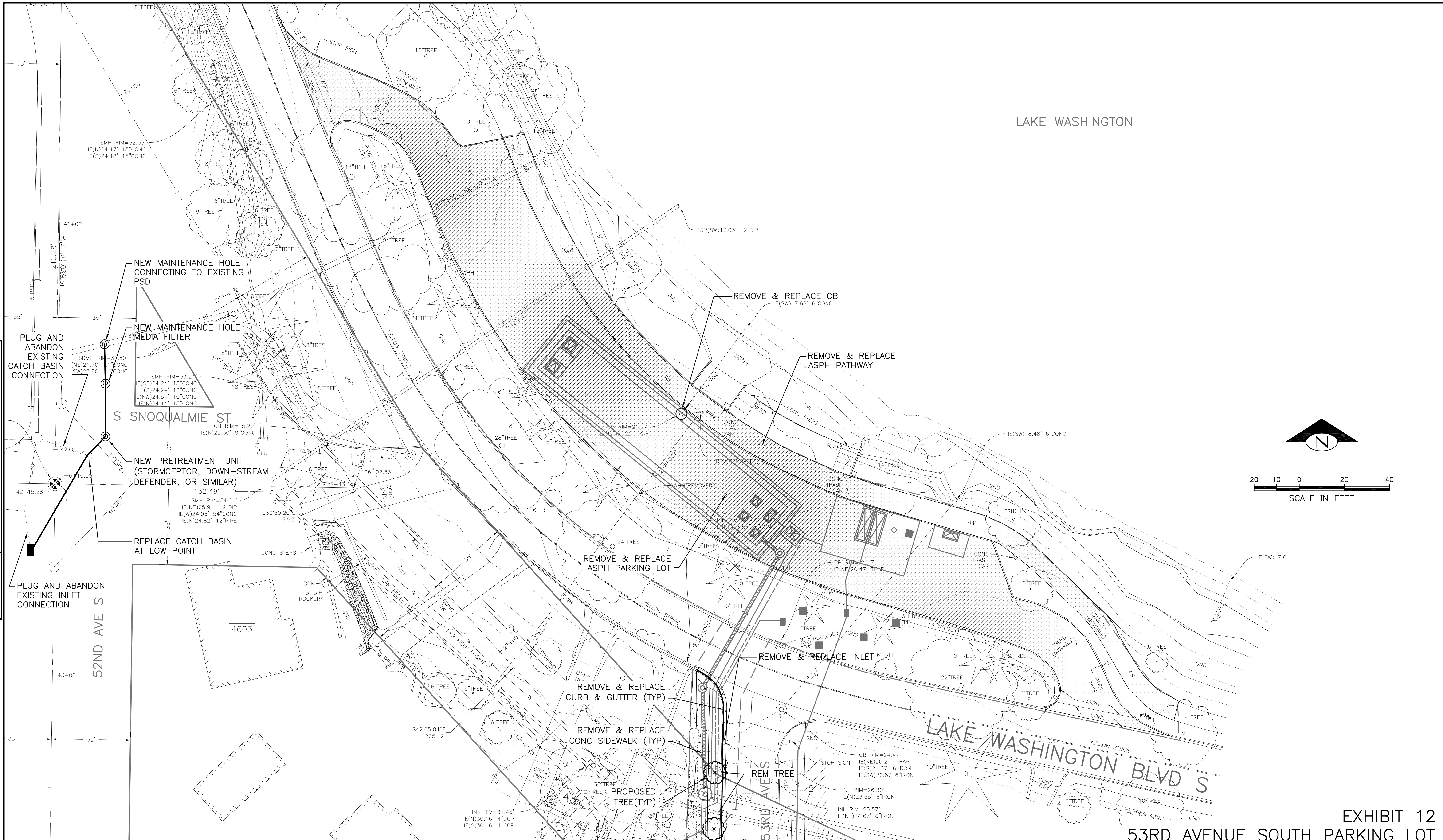

EXHIBIT 12

53RD AVENUE SOUTH PARKING LOT

SITE CIVIL PLAN – DRAINAGE, GRADING, SITE IMPROVEMENTS (1 OF 2)

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CHECKED	SDOT	PROJ. MGR.
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SCALE: H. 1"=20', V. 1"=10' INSPECTOR'S BOOK

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REDUCTION PROJECT

JOB NO. PC	C303103
R/W	
CO	
VAULT PLAN NO.	
SHEET 4 OF 10	

VAULT SERIAL NO.	DATE	MARK	NATURE	MADE	CHK'D	REV'D
			REVISIONS			

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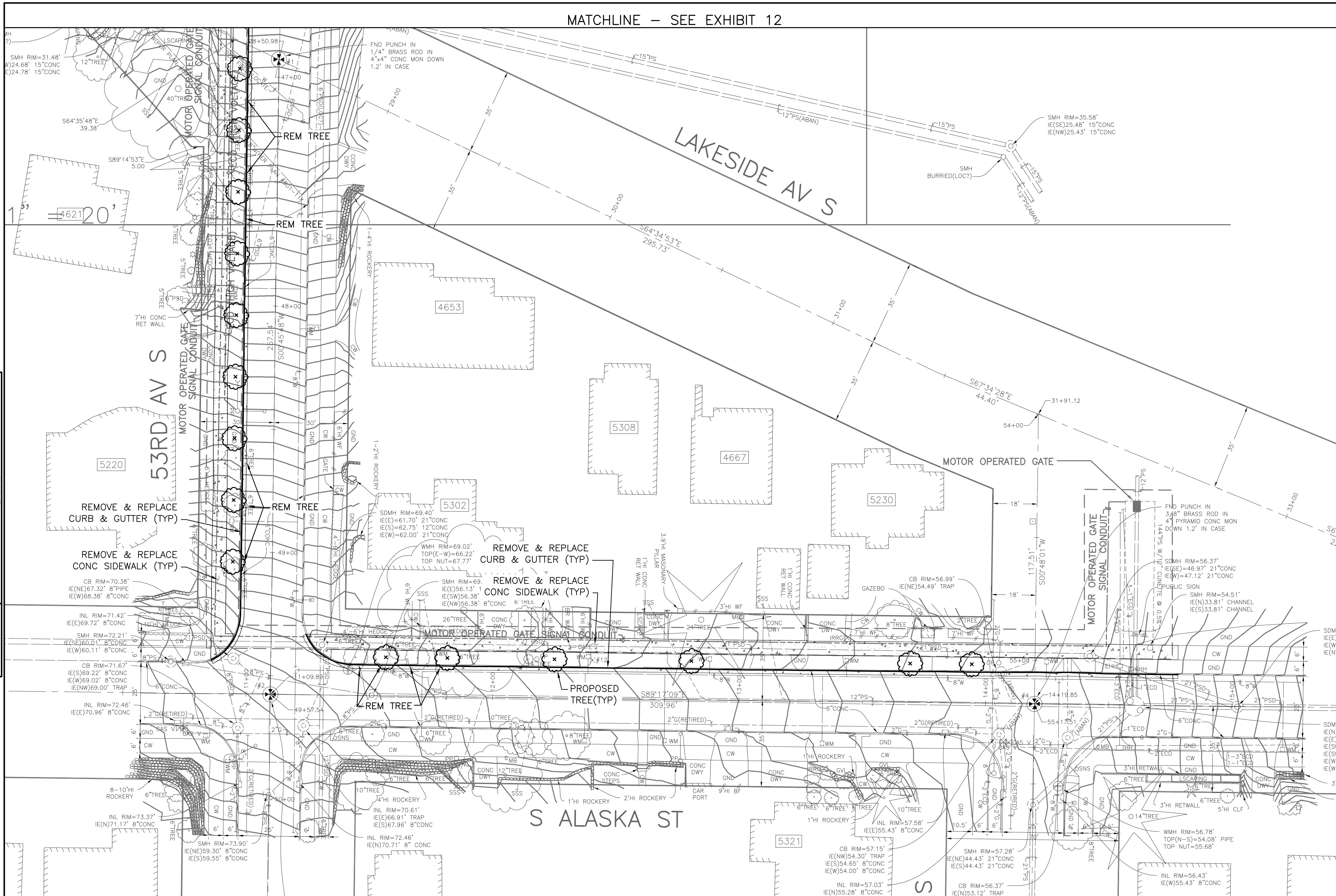

EXHIBIT 13
53RD AVENUE SOUTH PARKING LOT
SITE CIVIL PLAN – DRAINAGE, GRADING, SITE IMPROVEMENTS (2 OF 2)

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FUND:
SCALE: H. 1"=20', V. 1"=10' INSPECTOR'S BOOK

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REDUCTION PROJECT

JOB NO. PC C303103
R/W
CO
VAULT PLAN NO.
SHEET 5 OF 10

VAULT SERIAL NO. | MARK | DATE | NATURE | MADE | CHK'D | REV'D
REVISIONS

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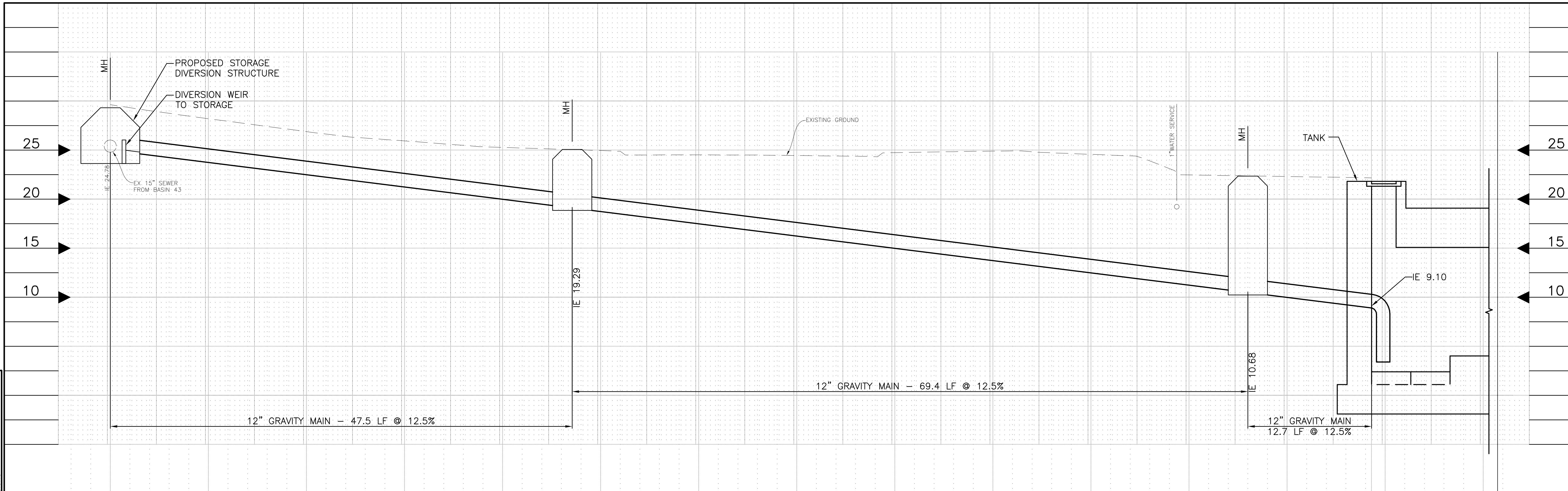

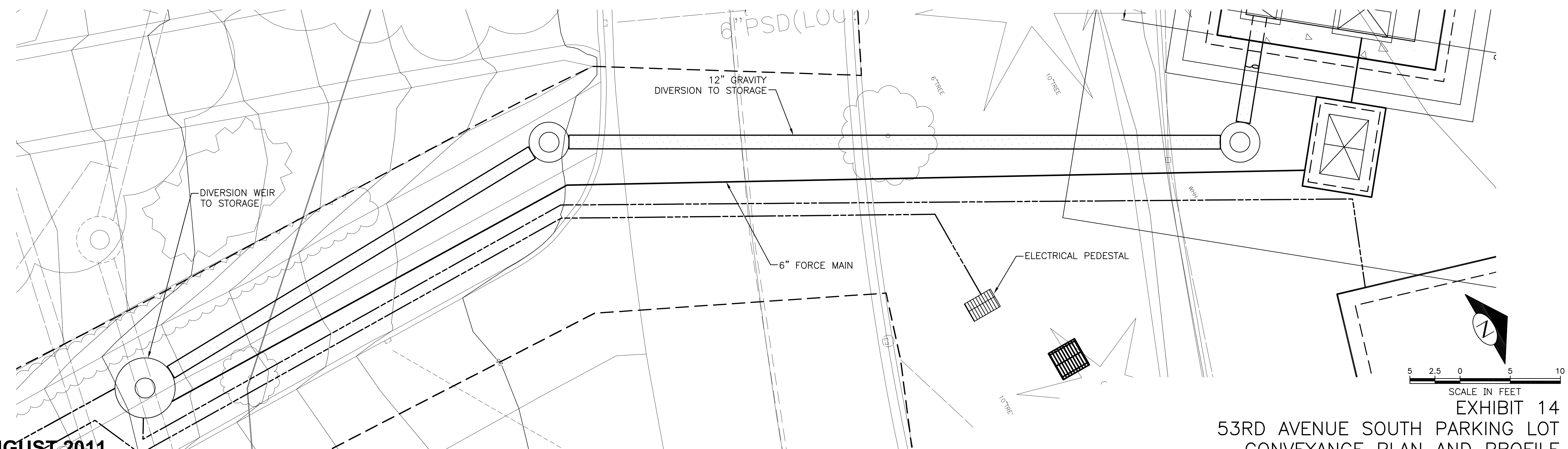

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

EXHIBIT 14
53RD AVENUE SOUTH PARKING LOT
CONVEYANCE PLAN AND PROFILE

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SCALE: H. 1"=5', V. 1"=5' INSPECTOR'S BOOK

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REDUCTION PROJECT

JOB NO. PC C303103
R/W
CO
VAULT PLAN NO.
SHEET 6 OF 10

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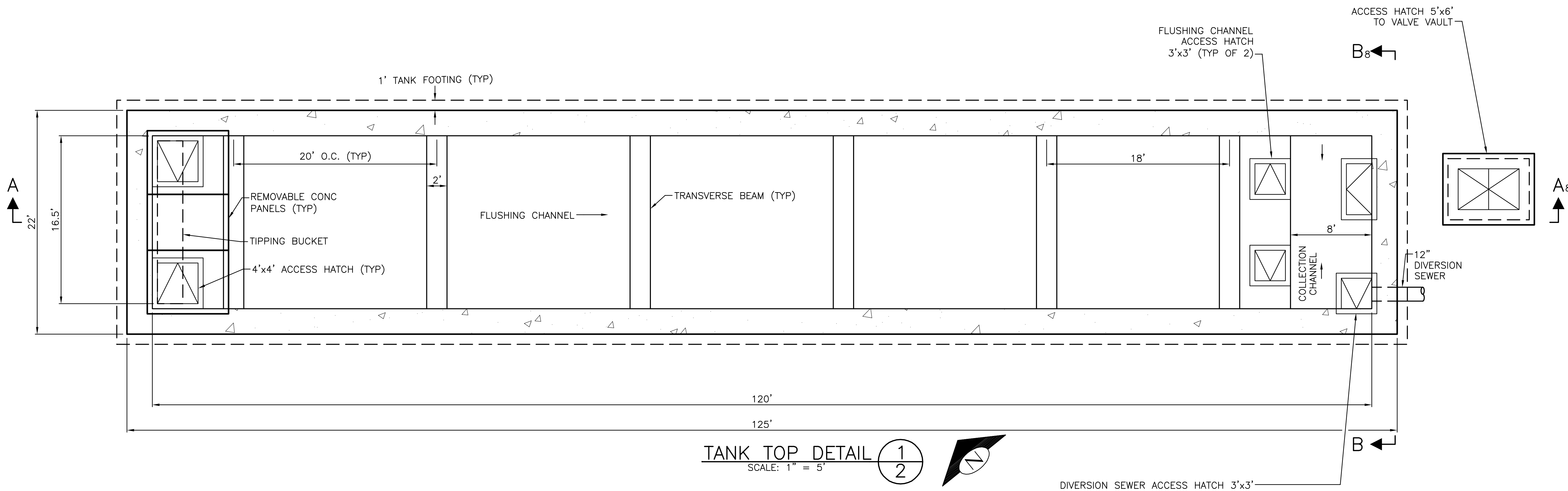

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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JonesJC Aug-25-11 4:06pm

EXHIBIT 15
53RD AVENUE SOUTH PARKING LOT
TANK TOP PLAN

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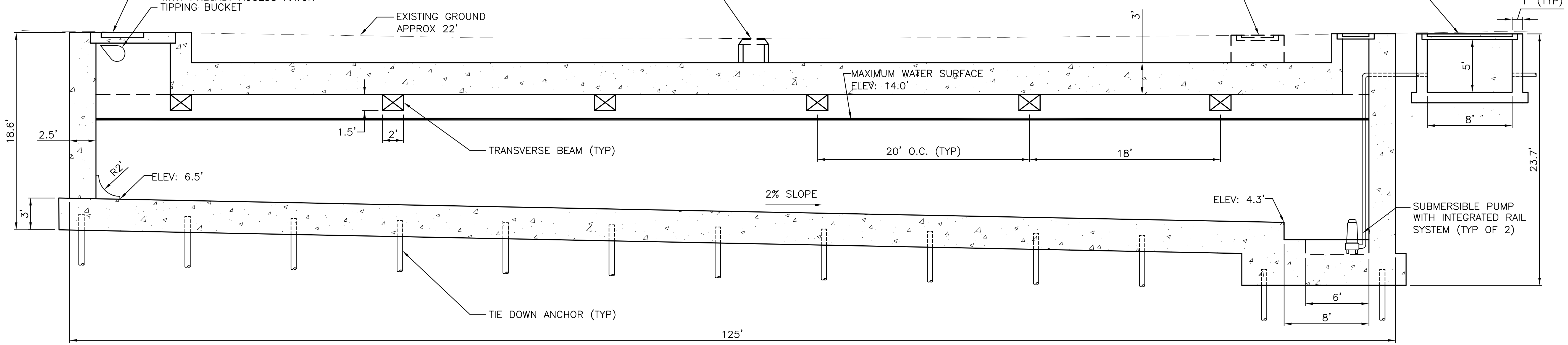
R/W
CO
VAULT PLAN NO.
SHEET 7 OF 10



SECTION A–A 7
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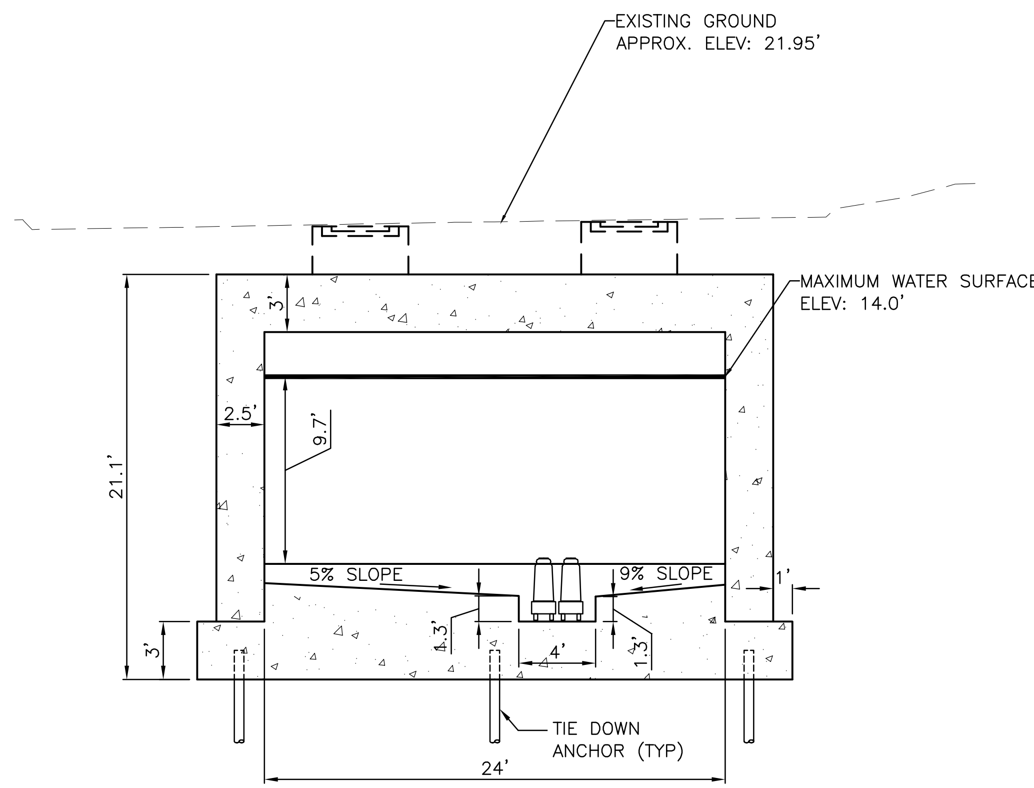

SECTION B–B 7
SCALE: 1" = 5'

EXHIBIT 16
53RD AVENUE SOUTH PARKING LOT
TANK SECTIONS

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REDUCTION PROJECT

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R/W
CO
VAULT PLAN NO.
SHEET 8 OF 10

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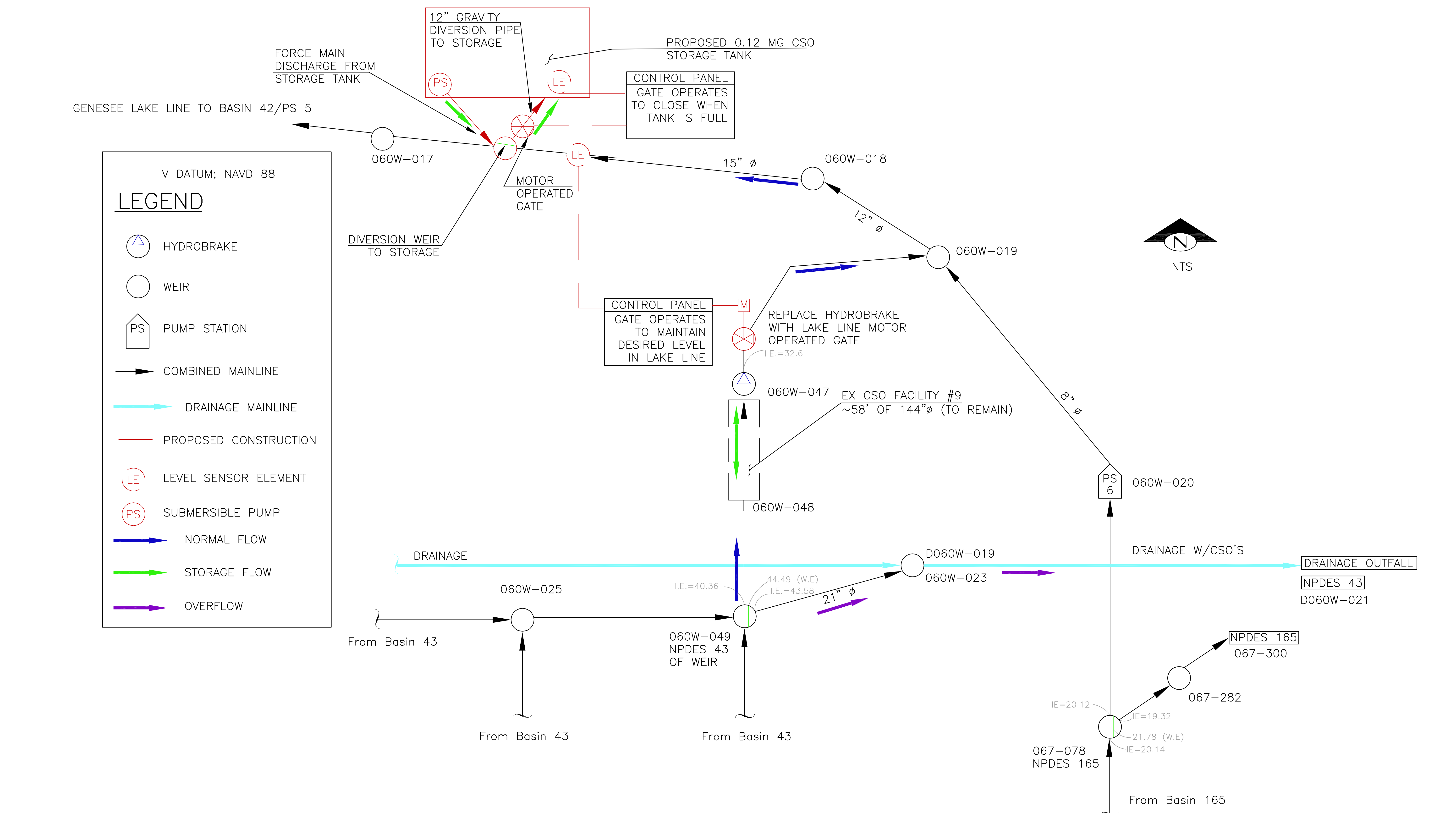

EXHIBIT 17
53RD AVENUE SOUTH PARKING LOT
HYDRAULIC SCHEMATIC

AUGUST 2011

VAULT SERIAL NO.	DATE	MARK	NATURE REVISIONS	MADE	CHK'D	REV'D

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JonesJC Aug-25-11 4:08pm

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GENESEE CSO
REDUCTION PROJECT

JOB NO. PC C303103
R/W
CO
VAULT PLAN NO.
SHEET 9 OF 10

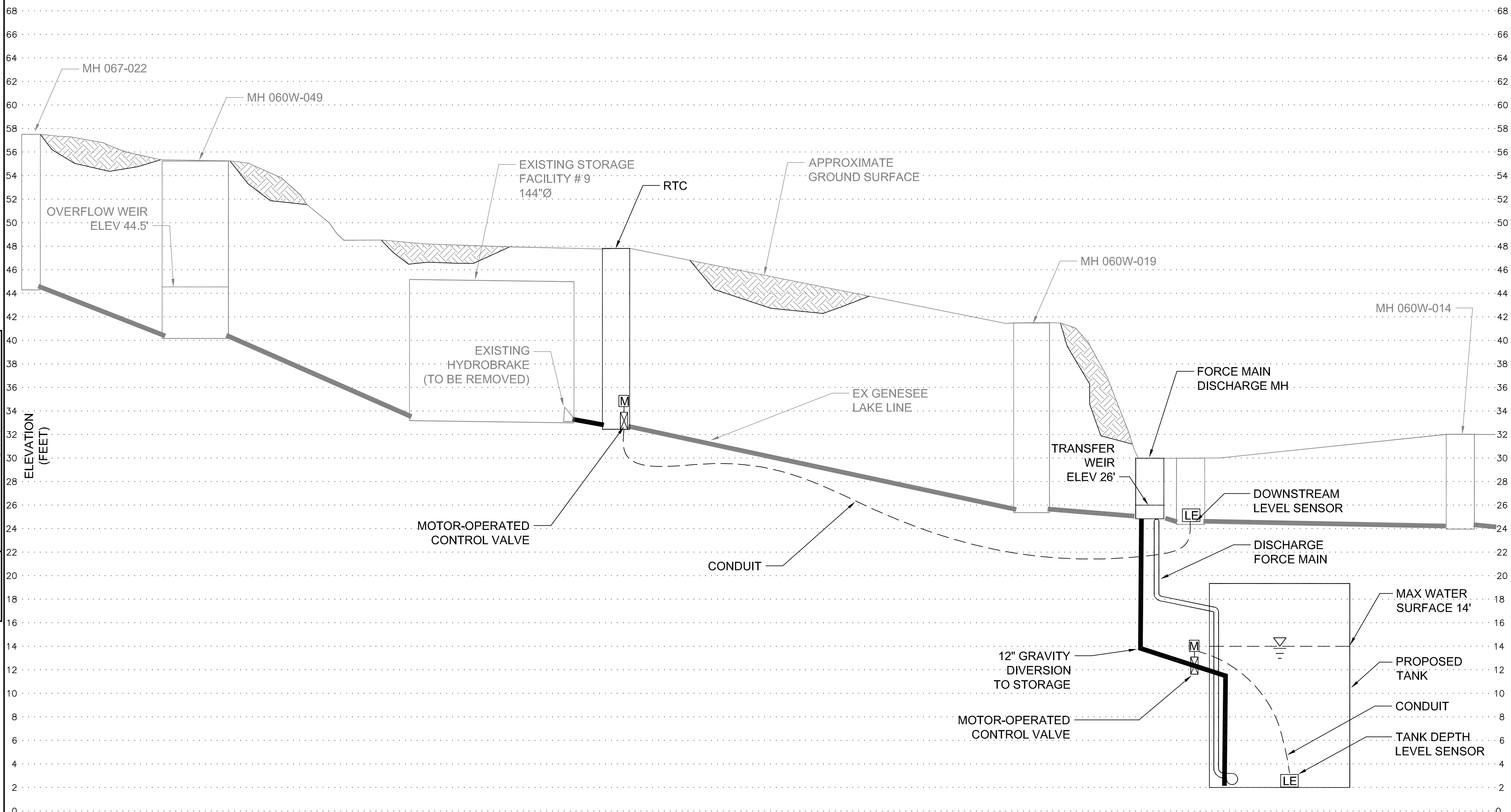

EXHIBIT 18
53RD AVENUE SOUTH PARKING LOT
HYDRAULIC PROFILE

AUGUST 2011

MARK	DATE	NATURE REVISIONS	MADE	CHK'D	REV'D

VAULT SERIAL NO.

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R/W
CO

VAULT PLAN NO.

SHEET 10 OF 10

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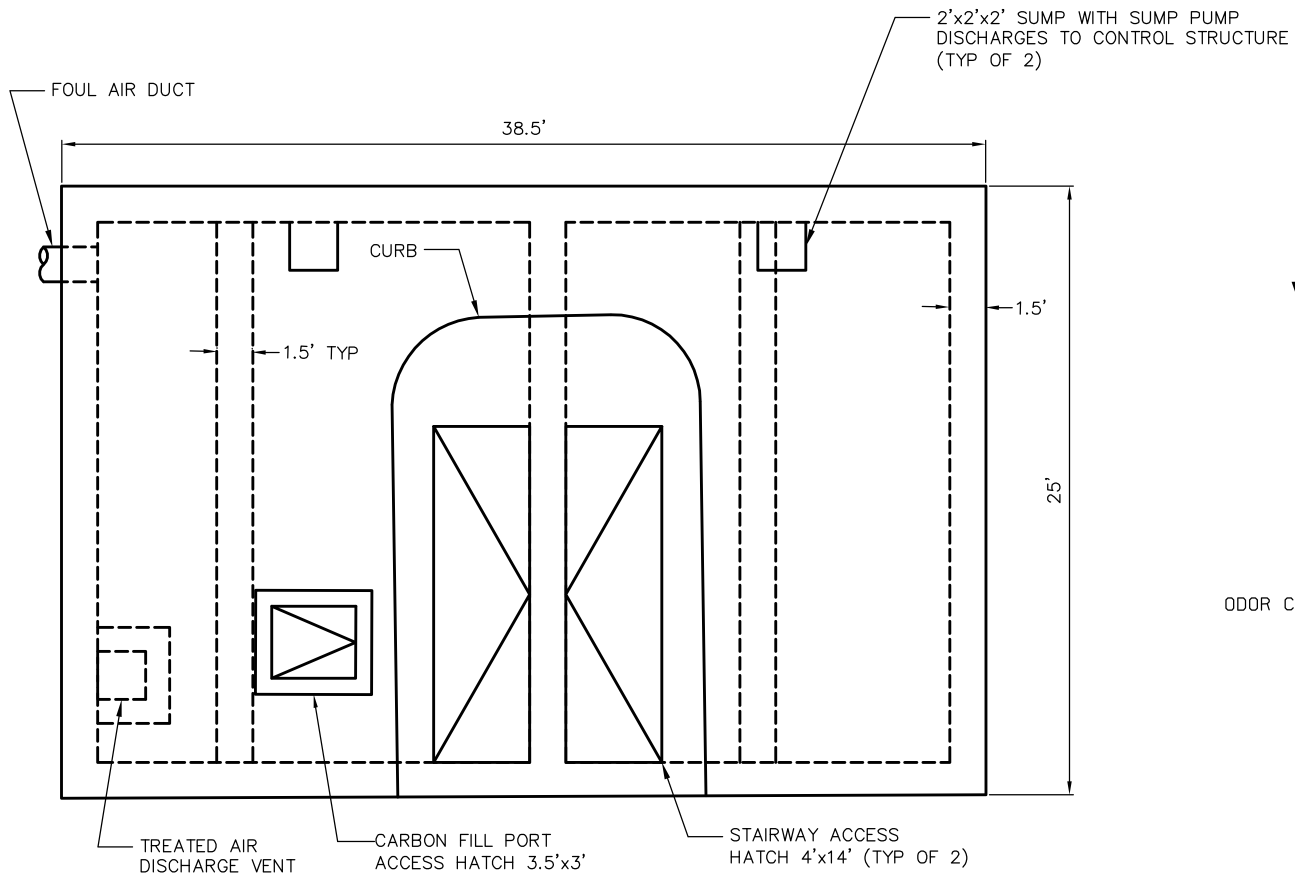
JonesJC Aug-25-11 4:09pm



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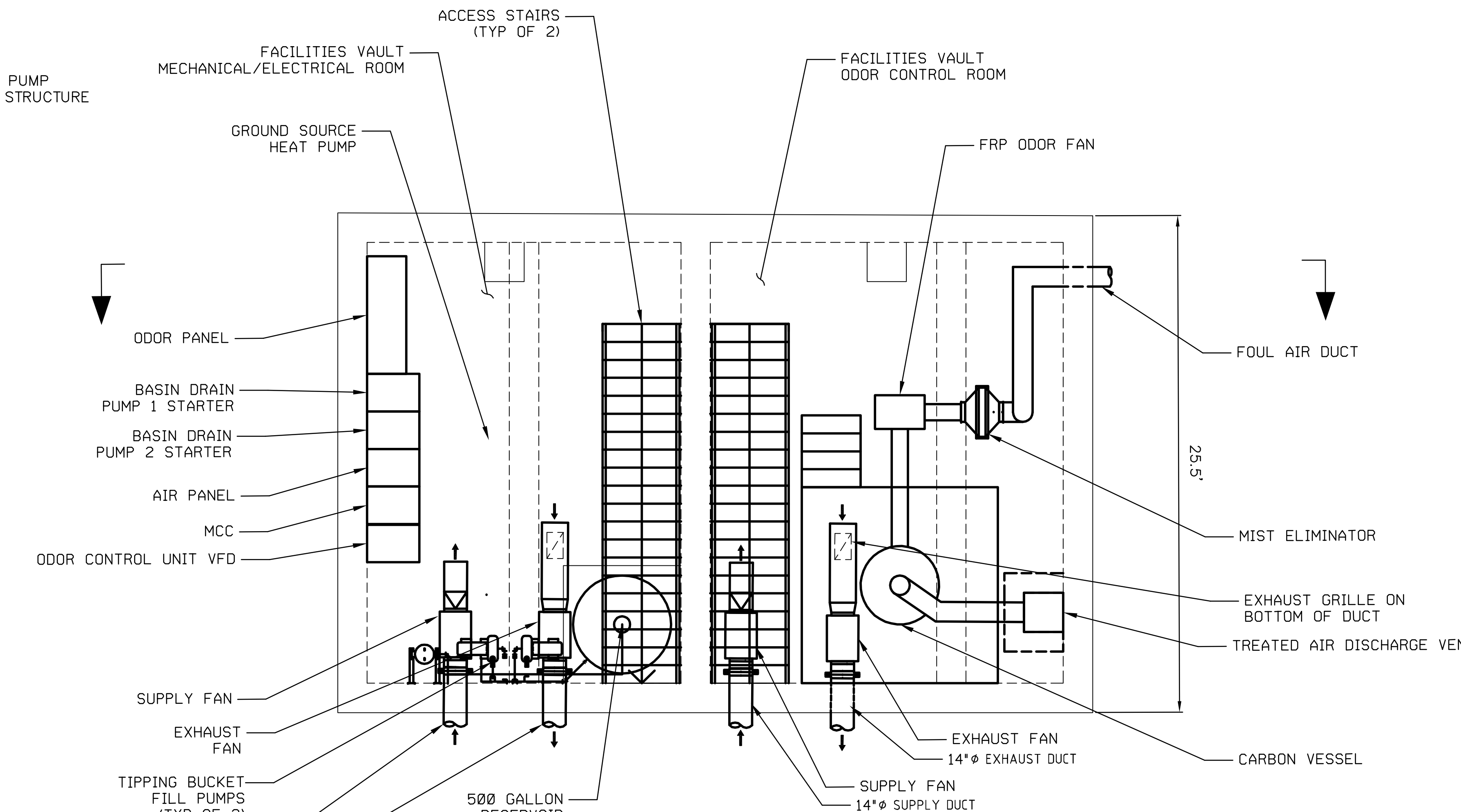

PLAN VIEW

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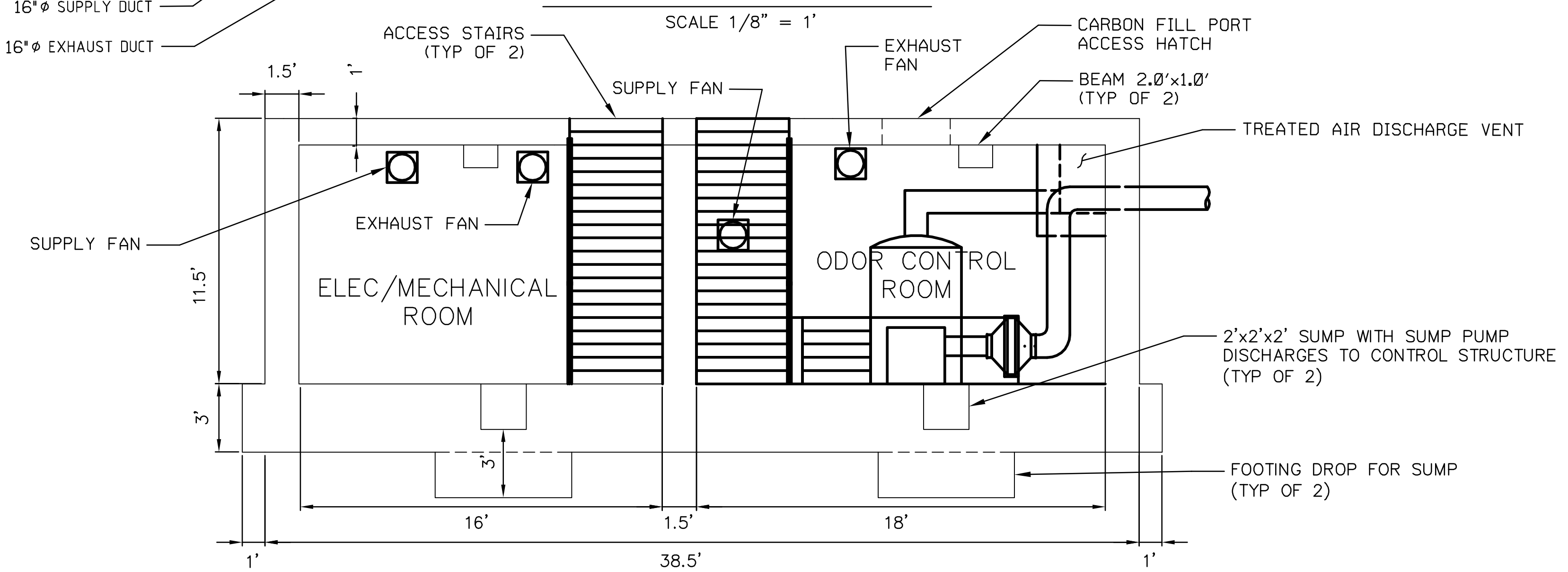

SECTION VIEW

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EXHIBIT 19

FACILITIES VAULT PLAN AND SECTION

AUGUST 2011

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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.

Seattle Public Utilities

City of Seattle
Ray Hoffman, Director
ORDINANCE NO. APPROVED
FUND:
SCALE: #### INSPECTOR'S BOOK

SEATTLE PUBLIC UTILITIES
GENESEE CSO
REDUCTION PROJECT

JOB NO. PC #### R/W #### CO ####
VAULT PLAN NO. ####
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Appendix B - Geotechnical Reports

GEOTECHNICAL REPORT
GENESEE COMBINED SEWER OVERFLOW STORAGE PROJECT
SEATTLE, WASHINGTON

Work Authorization No.: C303103
October, 2010

Seattle Public Utilities Materials Laboratory

707 South Plummer Street
Seattle, Washington 98134

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GEOTECHNICAL REPORT
GENESEE COMBINED SEWER OVERFLOW STORAGE PROJECT
SEATTLE, WASHINGTON

1.0 INTRODUCTION

1.1 GENERAL

The Seattle Public Utilities (SPU) Materials Laboratory was retained to complete a geotechnical engineering study for the Genesee Combined Sewer Overflow (CSO) project in the Columbia City neighborhood of Seattle, Washington. The Genesee CSO project is for Basins 40 and 41, and involves new storage/conveyance structures within Basins 43 or 38 at one of three potential site locations, and evaluation of an existing hydrobrake in Basin 40. A vicinity map of the project area is shown on Figure 1.

This geotechnical engineering study focuses on the proposed storage/conveyance structures for Basins 43 and 38. We understand that the Genesee CSO Project Team has identified two potential sites for the Basin 43 facility, and one potential site for the Basin 38 facility. The Project Team requires further geotechnical recommendations to explore design options at the proposed sites.

The Project Team has designated the sites as:

- Basin 43- Alternative OFF-109-43 (South Alaska Street), or Alternative IN-103-43 (54th Avenue South);
- Basin 38- Alternative OFF-113-38 (Triangle Park).

Basin 43: Alternative OFF-109-43 (South Alaska Street). The structures proposed at South Alaska Street include three 12-foot diameter, 70-foot long off-line storage pipes and an underground odor control facility (Figure 2). Storage capacity of the off-line pipes will be approximately 0.19 MG and will be located adjacent to the existing CSO Facility 9.

Basin 43: Alternative IN-103-43 (54th Avenue South). A 10-foot diameter, 400-foot long in-line storage pipe along 54th Avenue South and an odor control facility at the intersection of 54th Avenue South and South Angeline Street are proposed for this site (Figure 2). The in-line pipe will have a total storage capacity of 0.19 MG.

We understand that the Project Team has requested 15% design recommendations for each of the Basin 43 alternatives, which includes:

- Description of subsurface conditions,

- Description of groundwater conditions and impacts to design and construction such as dewatering potential, discharge estimates, and uplift considerations,
- Geologic hazards as applicable to each site (liquefaction, lateral spread, ground motions, soft soil settlement, landslides, etc),
- Seismic design criteria for project areas,
- Recommended foundation types for structures and/or subgrade considerations for pipes,
- Recommended shoring type(s) and temporary excavation slopes,
- Tunneling considerations, and
- Potential impacts to nearby structures and utilities from construction (i.e. vibrations, settlement from dewatering or tunneling, etc).

Basin 38: Alternative OFF-113-38 (Triangle Park). An off-line storage tank measuring 43 feet wide, 85 feet long and 31.9 feet deep with an approximate capacity of 0.43 million gallons (MG) and an underground odor control facility have been proposed for this site (Figure 3). The facilities are to be located near existing CSO control structure 41B and at the corner of 49th Avenue South and Lake Washington Boulevard South. The site is within 100 feet of the Lake Washington shoreline.

We understand that the Project Team is requesting 30% design recommendations for this site, which will include the 15% design recommendations listed above and the following items:

- Earth pressure diagrams,
- Foundation design values,
- Uplift design values,
- Site-specific seismic design criteria, and
- Construction considerations (i.e. vibrations, settlement monitoring, etc).

1.2 Authorization and Scope of Work

Our work was requested and authorized by Kathy Robertson of the SPU Project Management and Engineering Division. Our scope of work included:

- Reviewing readily available geotechnical/geologic information for the sites and vicinity;
- Conducting a geotechnical exploration program including the completion of six soil borings;

- Installing groundwater monitoring wells instrumented with pressure transducers to record groundwater data;
- Collecting groundwater monitoring data from field piezometers once a month over a 12 month period;
- Performing laboratory testing and engineering analyses to develop geotechnical recommendations as presented herein; and,
- Preparing this report, which summarizes our investigations, conclusions and recommendations;

2.0 METHODOLOGY

2.1 DOCUMENT REVIEW AND PREVIOUS STUDIES

SPU Materials Laboratory conducted a document review of geotechnical reports/explorations performed in the vicinity of the project site. Seattle Engineering Department (SED, 1985) completed four explorations for the Seward Park and Mt. Baker Combined Sewer Overflow Phase I project. Two explorations, one near Basin 38 and one near Basin 43 were reviewed; the boring logs are included in Appendix A. Approximate locations of these explorations are shown on Figures 2 and 3. These explorations were used in conjunction with onsite data collected for this project for the overall subsurface characterization of the site. The logs of these previous borings were referenced from the GeoMapNW online database (http://geomapnw.ess.washington.edu/).

We reviewed a preliminary geotechnical evaluation completed by Shannon and Wilson, Inc. in 2009 for the Genesee and Henderson Combined Sewer Overflow project. Their report assessed potential geotechnical issues regarding the conceptual project features in Genesee CSO Basins 38 and 43 amongst others.

2.2 FIELD INVESTIGATION

SPU Materials Laboratory personnel conducted subsurface explorations on June 7th through June 10th by completing six soil borings (B-101 through B-106). Appendix B describes our investigation in detail. The soil borings ranged from 31.5 to 61.5 feet deep; their locations are shown on Figures 2 and 3. Summary logs of the subsurface explorations are included in Appendix B as Figures B-2 through B-7. Figure B-1 is a key to the terms and symbols used on the logs.

2.3 LABORATORY TESTING

Geotechnical laboratory tests were performed on selected samples to determine index and engineering properties of the soil encountered. Laboratory tests performed included natural moisture content, grain size determination, and Atterberg Limits. A description of the test methods and the results are presented in Appendix C. The natural water content results are graphically indicated at the appropriate sample depth on the summary logs.

3.0 SITE DESCRIPTION

3.1 General Geology

The general geologic condition of Seattle is a result of glacial and non-glacial activity that occurred in the area over the course of millions of years. The most recent and extensive glacial activity in the Puget Sound area was the Vashon stade of the Fraser glaciation that ended about 10,000 years ago (10 ka). Preceding the Fraser glaciation, were the Olympia nonglacial interval (60-15 ka) and the Posession glaciation (80-60 ka, Borden and Troost, 2001). Due to discontinuous and poorly constrained exposures of these units, we define deposits that are older than Fraser glacial deposits as pre-Fraser nonglacial and glacial. The glacial deposition in the project area is a result of these glacial periods.

Review of a geologic map (Troost, et al, 2005) indicates that the project sites are underlain by lake deposits (Alternative OFF-113-38) and Vashon glacial till (Alternative OFF-109-43 and IN-103-43). Lake deposits are relatively young, are very soft to medium stiff silt and clay with intermittent sand layers, peat and other organics. Vashon glacial till is characterized by poorly sorted silt, sandy silt and silty sand that was deposited during glacial advance and subsequently overridden by the advancing glacier, resulting in dense to very dense deposits.

The subsurface borings completed for Alternative OFF-109-43 generally agree with the mapped geology of Vashon glacial till. Other soil units mapped in the area include mass wastage deposits, and pre-Fraser deposits. We did encounter both of these units in the subsurface borings at Alternative OFF-113-38. Mass wastage deposits result from the downslope movement of colluvium, soil, and landslide debris of indistinct morphology under the direct influence of gravity. Pre-Fraser deposits are generally very dense and hard, thickly interbedded silt, sand, and gravel.

In the subsurface borings completed for Alternative IN-103-43 we did not encounter the mapped unit of Vashon glacial till, rather, recessional lacustrine deposits were encountered. Recessional lacustrine deposits are characterized by fine grained sand, silt and clay with finely disseminated organics. Deposition resulted from melt-water streams issuing from the retreating glacier, thus resulting in a loose to medium dense and soft to stiff deposit.

In the vicinity of all project areas, the native deposits have been disturbed by cut and fill operations for roadway construction and residential development.

3.2 Site Conditions

Surface, subsurface, and groundwater conditions as described in the following text are organized by Basin Alternatives. Subsurface conditions for each Alternative are based on our exploration program and review of existing subsurface data.

3.3 South Alaska Street

3.3.1 Site Surface Conditions

Alternative OFF-109-43 includes three 12-foot diameter, 70-foot long off-line storage pipes and a below ground odor control facility. The total storage capacity of the pipes will be approximately 0.19 MG. Proposed structure locations are within Mt. Baker Park near S. Alaska Street and 54th Avenue S. The site is approximately 200 feet west of Lake Washington. The site slopes gently to moderately down toward the east and is generally an open grass space with few trees. Elevations within the site range from about 58 feet at the west site construction boundary to 38 feet at the east boundary as identified through the City GIS system[1]. A portion of this site is identified as an "Environmentally Critical Area (ECA) – 40% Steep Slope" by the City of Seattle's Department of Planning and Development (DPD). The topography of the study area is shown on Figure 3.

3.3.2 Site Subsurface Conditions

Boring B-104 was completed for Alternative OFF-109-43. Below are descriptions of the soil deposits encountered in our exploration in the order of stratigraphic sequence, with the youngest unit described first, followed by a description of groundwater conditions.

3.3.2.1 Fill

Soil boring B-104 encountered fill to a depth of 9.5 feet bgs. The fill consists of stiff silt (ML)[2] and clay (CL). Moisture contents within the fill were 24 and 25 percent. The N-

[1] NAVD88 elevation datum used throughout this report.

[2] Soil classification in accordance with the Unified Soil Classification System (USCS).

[3] N-value is defined as the number of blows required to drive a 2.0-inch outside diameter sampler one
[2] Soil classification in accordance with the Unified Soil Classification System (USCS).

values[3] for this unit were 10 to 11, with an average of 11. The fill is characterized by low shear strength, low to moderate compressibility, and low permeability.

3.3.2.2 Vashon Glacial Till

Vashon glacial till was observed in soil boring B-104 underlying the fill and extended to the terminus of the boring at 36.5 feet bgs. This unit consists of medium dense to very dense silty sand (SM). N-values for the glacial till samples ranged from 21 to 50/6" with an average value of 50. The natural water content of the samples collected ranged from 9 to 19 percent with an average of 12 percent. The deposit is characterized by high shear strength, low compressibility, and low to moderate permeability.

3.3.2.3 Groundwater

Groundwater was encountered at the time of drilling, at approximately 30 feet bgs, or elevation 22 feet. The groundwater elevation is slightly higher than Lake Washington surface water elevation (19 feet).

A monitoring well was installed in boring B-104 and instrumented with a pressure transducer to provide semi-continuous measurement of the groundwater table (see Appendix B for details). Our monitoring of the pressure transducer between June and September indicates groundwater depth is between 29 to 30 feet bgs, or elevation 22 to 23 feet. The groundwater table also fluctuates in response to changes in lake elevation. Possible perched water conditions may also exist during rainfall accumulation. We will continue to collect additional groundwater data until May 2011 to observe seasonal fluctuations.

We anticipate that groundwater levels will be below excavation depths for the off-line storage pipes and odor control facility. However, perched water conditions may require some dewatering. Groundwater dewatering considerations are discussed in Section 4.2.2.2.

3.4 54TH AVENUE SOUTH

3.4.1 Site Surface Conditions

Alternative IN-103-43 includes a 10-foot diameter, approximately 400-foot long, in-line storage pipe along 54th Avenue South. The total storage capacity of the in-line storage

[3] N-values are defined as the number of blows required to drive a 2.0-inch outside diameter sampler one foot, using a 140-pound hammer falling a distance of 30 inches. Refer to ASTM D-1586 (ASTM, 2007).

pipe will be approximately 0.20 MG. A below ground odor control facility is proposed at the intersection of 54th Avenue South and South Angeline Street. The site location is primarily within paved non-arterial roadways in a residential neighborhood. 54th Avenue South is generally flat with elevations sloping gently to the east from 60 feet to 58 feet. Elevations near the proposed odor control facility slope moderately east from about 58 feet to 52 feet as identified through the City GIS system. The proposed depth of the pipe is approximately 26 feet below the existing ground surface. The approximate proposed minimum elevations of the pipe are 34.5 feet at South Angeline Street, sloping south to elevation 32.5 feet at South Alaska Street. DPD designated ECAs are not mapped within the project site. The topography of the study area is shown on Figure 3.

3.4.2 Site Subsurface Conditions

Soil borings B-105 and B-106 were completed for Alternative IN-103-43. Below are descriptions of the soil deposits encountered in our explorations in the order of stratigraphic sequence, with the youngest unit described first, followed by a description of groundwater conditions.

3.4.2.1 Fill

Borings B-105 and B-106 encountered fill to a depth of 7 feet and 8 feet bgs, respectively. The fill consists of soft to stiff silt (ML) and clay (CL). Moisture contents within the fill ranged from 20 to 34 percent, with an average of 30 percent. The N-values for this unit ranged from 4 to 13, with an average of 8. The fill is characterized by low shear strength, low to moderate compressibility, and low permeability.

3.4.2.2 Recessional Lacustrine

Recessional lacustrine deposits were encountered within both soil borings underlying the fill and extending to the terminus of the borings at 41.5 feet bgs. This unit consists of loose to very dense sand (SP), sand with silt (SP-SM), and silty sand (SM) and medium stiff to hard sandy silt and silt (ML) and sandy clay (CL). N-values for the recessional lacustrine samples ranged from 7 to 65 with an average value of 33. The natural water content of the samples collected ranged from 9 to 33 percent with an average of 24 percent. The deposit is characterized by moderate shear strength, moderate compressibility, and low to moderate permeability.

3.4.2.3 Groundwater

Groundwater was encountered during our investigation in soil boring B-106. At the time of drilling, the groundwater depth was approximately 12 feet bgs, or elevation 47 feet.

A monitoring well was installed in boring B-106 and instrumented with a pressure transducer to provide semi-continuous measurement of the groundwater table (see Appendix B for details). Our monitoring of the pressure transducer between June and September indicates groundwater depth is between 21 to 24 feet bgs, or elevation 35 to 38 feet. We would expect the groundwater table to fluctuate throughout the year and be at its highest during the late winter and spring seasons and its lowest during the late summer and early fall seasons. We will continue to collect additional groundwater data until May 2011 to observe seasonal fluctuations.

We anticipate that groundwater levels may impact construction of the in-line storage pipe and odor control facility. Groundwater dewatering considerations are discussed in Section 4.3.2.2.

3.5 Triangle Park

3.5.1 Site Surface Conditions

Alternative OFF-113-38 includes a 0.43 MG off-line storage tank and a below ground odor control facility. The structures will be located within Triangle Park and can be accessed via Lake Washington Boulevard between 48th Avenue South and 49th Avenue South. The site is within 100 feet of the Lake Washington shoreline, and is roughly equal parts asphalt parking area and manicured lawn with several medium to large trees. A moderate slope exists on the west side of the site. City GIS identifies a scarp at the top of this slope and mass wasting within the western half of the site. The east half of the site is generally flat lying. Elevations within the site range from about 54[2] feet near the southwest corner to 24 feet at the east extent of the site. The topography of the study area is shown on Figure 2. This site is identified as part of an "ECA - 1000 foot methane buffer" by the City of Seattle's DPD.

3.5.2 Site Subsurface Conditions

Borings B-101 through B-103 were completed for Alternative OFF-113-38. Below are descriptions of the soil deposits encountered in our explorations in the order of stratigraphic sequence, with the youngest unit described first, followed by a description of groundwater conditions.

3.5.2.1 Fill

Soil borings B-101 and B-102 encountered fill soils to a depth of 6.5 feet and 9 feet bgs, respectively. The fill consists of loose to medium dense, sand with silt with varying amounts of gravel (SP-SM). Moisture contents within the fill ranged from 8 to 19 percent, with an average of 14 percent. The N-values for this unit ranged from 6 to 14, with an average of 10. The fill is characterized by low shear strength, moderate to high compressibility and moderate permeability.

3.5.2.2 Lake Deposit

Lake deposits were observed in borings B-101 and B-102 underlying the fill and in boring B-103 below the ground surface. The lake deposit extended to depths of 12, 14 and 23 feet bgs in borings B-103, B-101, and B-102, respectively. A two to three foot peat layer was encountered between 12 and 18 feet bgs in B-101 and B-102. The peat deposit consists of very soft to soft, fibrous wood. The remaining lake deposits consist of very loose to loose, sand with silt (SP-SM) and silty sand (SM), and very soft to stiff, sandy silt, silt with sand, and silt (ML). Wood and reeds were typically encountered in this unit. N-values for the lake deposit samples ranged from 0 to 6 with an average value of 2. The natural water content of the samples collected ranged from 15 to 102 percent with an average of 47 percent. The natural water content of the peat samples collected ranged from 350 to 359 percent with an average of 355 percent. A water content greater than 100 percent can occur when the weight of the water in a given sample exceeds the dry weight of that sample. The deposit is characterized by low shear strength, high compressibility, and low to moderate permeability.

3.5.2.3 Mass Wastage Deposit

Mass wastage deposits were observed in all three soil borings below the lake deposits and extended to between 40 and 42 feet bgs in borings B-101 and B-102, respectively. Soil boring B-103 was terminated in this deposit at 31.5 feet bgs. This unit consists of medium dense to very dense, silty sand with varying amounts of gravel (SM) and stiff to hard, sandy silt and silt (ML). Stiff to hard, clay (CL) with some fracturing was encountered in boring B-101. Color mottling and rust staining was typical throughout the unit. N-values for the samples ranged from 3 to 50/6". N-values typically varied between samples and lacked a noticeable trend. The natural water content of the samples collected ranged from 11 to 38 percent with an average of 22 percent. The deposit is characterized by moderate shear strength, moderate compressibility, and low to moderate permeability

3.5.2.4 Pre-Fraser Deposit

Pre-Fraser deposits were observed in borings B-101 and B-102 underlying the mass wastage deposits. These borings were terminated in the pre-Fraser deposit, which consists of very dense silty sand (SM) and hard silt (ML). Hard, elastic silt (MH) was encountered in boring B-101 between 43 and 53 feet bgs. Organic material including wood and charred wood was observed within the unit. N-values for the pre-Fraser deposit ranged from 36 to 73 with an average value of 48. The natural water content of the samples collected ranged from 15 to 34 percent with an average of 26 percent. The deposit is characterized by high shear strength, low compressibility, and low to moderate permeability

3.5.2.5 Groundwater

Groundwater was encountered during our investigation in soil boring B-102. At the time of drilling, groundwater depth was approximately 7 feet bgs with corresponding elevations of approximately 21 feet. Groundwater elevations generally coincide with surface water elevation (19 feet) in Lake Washington.

A monitoring well was installed in boring B-102 and instrumented with a pressure transducer to provide a semi-continuous measurement of the groundwater table (see Appendix B for details). Our monitoring of the pressure transducer between June and September indicates groundwater depth is between 4 to 6feet bgs, or elevation 20 to 22 feet. The groundwater table also fluctuates in response to changes in the lake elevation. We will continue to collect additional groundwater data until May 2011 to observe seasonal fluctuations.

We anticipate that groundwater levels may impact construction of the underground storage tank. Groundwater dewatering considerations for the Triangle Park are discussed in Section 4.4.2.2.

3.6 Seismic Setting

The Puget Sound area is known to be seismically active. The seismic hazard in the area comes primarily from three sources: subduction zone, intraslab or Benioff zone, and shallow crustal earthquakes. Subduction zone earthquakes occur when the interface between the North American tectonic plate and the subducting Juan de Fuca plate ruptures. These events are likely to have magnitudes of up to 9, but the distance to the rupture zone would reduce the intensity of shaking at the project site. Shaking during these events could last over one minute in duration. Intraslab events occur due to tensional rupture within the subducting Juan de Fuca plate at depths of 45 to 60 kilometers. This is the source of our largest historical earthquakes that have affected the project site and has the potential for magnitude 7.5 events.

Shallow crustal earthquakes occur on shallow faults within the Seattle area due to tectonic stresses. Several minor earthquakes occur in the area each year, most of which are not even felt. However, some of the shallow faults are capable of producing significant, damaging earthquakes. Perhaps the most notable of these faults is the Seattle Fault. Recent research indicates that this fault is capable of producing an earthquake with a magnitude 7.5 or higher, which, given the shallow depth and proximity to the Seattle urban area, could produce intense shaking at the project site. Current understanding of the structure of the Seattle Fault Zone (SFZ) indicates that the fault consists of a blind thrust underlying a faulted roof complex. Several subparallel backthrusts are located within the roof complex, and have been considered splays of the Seattle fault. The proposed structures for Basins 38 and 43 are located within the SFZ, as shown in Figure 4.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 General

The main geotechnical design and construction concerns for the proposed structures for Basins 38 and 43 are seismic design considerations, site earthwork, foundation recommendations, and other construction recommendations. For the Triangle Park, additional geotechnical recommendations include site-specific seismic design criteria, temporary and permanent wall recommendations, foundation design values, and uplift forces.

Based on the results of our geotechnical and environmental investigations and analyses, it is our opinion that proposed structures for Basins 38 and 43 are feasible, within the limitations presented below, provided the recommendations of this report are incorporated in design and construction. Further design recommendations are needed for the Basin 43 alternatives. We understand that the general construction sequence for the proposed structures will be:

- Demolition, clearing, and grubbing.
- Dewater the site to lower the groundwater table as needed.
- Install temporary shoring and excavate soil.
- Construct foundations for storage structures.
- Turn off dewatering system.
- Construct utility connections and install pavements.

The above recommendations are presented for the South Alaska Street alternative in Section 4.2, 54th Avenue South in Section 4.3 and Triangle Park in Section 4.4.

4.2 South Alaska Street

4.2.1 Seismic Design Considerations

This section discusses seismic hazards including site response, fault rupture, liquefaction and lateral spreading affecting the South Alaska Street alternative.

4.2.1.1 Surface Fault Rupture

The proposed structures for Basins 38 and 43 are within the SFZ. The USGS has interpreted seismic-reflection data to indicate the SFZ is comprised of at least 3 or 4 splays that generally extend east-west across the Puget Lowland. The SFZ is bounded on the north by fault "A" and the syncline on the southern margin of the Seattle basin, and bounded on the south by fault “C” (Frankel, undated). At the approximate longitude (-122.266°E) of the proposed pipes at the South Alaska Street site, fault “B” is interpreted to be located roughly half way between faults “A” and “C,” as shown in Figure 4. The storage pipes at South Alaska Street are approximately 1 kilometer south of fault “A” and north of fault “B.” In our opinion, the risk of surface fault rupture affecting the alternatives is low and does not need to be considered for design.

4.2.1.2 Liquefaction and Lateral Spreading

As part of our seismic analysis, we analyzed the potential of the soil within the project site to liquefy. Liquefaction is a momentary loss of some portion of soil shear strength during a seismic event. During a seismic event, the loose soil particles tend to densify. This occurs in a short amount of time and the water between the soil grains does not have sufficient time to drain. The result is the water between the soil grains experiences excess pore pressures. This causes a reduction in the effective stress within the soil mass and the result is a reduction, and sometimes total loss, of shear strength. Primary factors controlling the development of liquefaction include intensity and duration of strong ground motion, characteristics of the subsurface soil, in-situ stress conditions and the depth to groundwater. Soil types most prone to liquefaction are loose, saturated and relatively cohesionless, such as wet, clean sands and gravels. Liquefaction is not limited to clean granular soils. Fine grained soils, such as low plasticity silts, can also be susceptible to liquefaction during seismic shaking.

According to the current subsurface investigation for the South Alaska Street alternative, below the proposed minimum foundation elevation for the storage pipes, the site is generally underlain by glacial till deposits of cohesionless and cohesive soils generally too dense/stiff to liquefy during a seismic event. The groundwater data indicates an elevation of 23 feet, roughly 14 feet below an assumed minimum foundation elevation of 37.

The horizontal distance from the site to Lake Washington is roughly 300 feet, but because liquefaction is not likely to occur and the site is roughly 35 feet higher in elevation than Lake Washington, in our opinion, liquefaction and lateral spreading effects do not need to be considered for design of the South Alaska Street alternative.

4.2.2 SITE EARTHWORK

Construction for the proposed storage pipes at the South Alaska Street site will require site preparation and earthwork activities related to construction of structures, utilities, pavement areas and other improvements.

4.2.2.1 Excavation

Based on our interpretation of subsurface conditions at the site, and the proposed grading, it appears that onsite excavations will be made in all of the soil units encountered in our exploration. In general, the contractor should be able to excavate this material using standard construction equipment, however, excavation in the dense glacial till deposit may be difficult and may require the use of special heavy equipment such as rippers and scrapers. Debris within the fill unit was not encountered in our explorations, but should be expected during construction. Groundwater should be anticipated during construction at levels approximately equal to 30 feet bgs, or elevation 23 feet.

4.2.2.2 Dewatering

Based on the permeability of the site soils, and our understanding of the proposed structure depth approximately 15 feet above the groundwater table, it is our opinion the excavation will not require dewatering during construction of the storage pipes. Some dewatering may be necessary to manage storm water entering the excavation if construction takes place during the wet season. The contractor should choose a dewatering method based on the available information and their selected construction techniques.

4.2.3 TEMPORARY SLOPES AND SHORING RECOMMENDATIONS

Construction of the storage pipes will require excavations approximately 15 feet bgs. It is our opinion the proposed excavation depth can be shored using standard passive shoring methods (ie., trench box).

Temporary excavations and protective systems (i.e. shoring or sloping) will be required for this project. They should be implemented in accordance with Section 7-17.3(1)A7 of the City of Seattle *Standard Specifications* (City of Seattle, 2008). All specific design parameters for temporary slopes, trench shields, or other shoring methods should be developed by the Contractor’s competent person. For planning purposes, a 2H:1V inclination can be assumed for temporary sloped excavations in the fill and 1H:1V inclination can be assumed for temporary sloped excavations in all other units. For planning purposes, the soil can be classified as Type C in accordance with WAC 296-155.

The means and methods of shoring the temporary excavations for the protection of workers are the contractor's responsibility. Shoring to protect workers typically consists of passive shoring systems that allow the sides of the trenches to slough and still protect the workers. This type of shoring is acceptable where settlement sensitive structures and/or utilities are not present within the zone of influence of the trench. The size of the wedge depends on the engineering properties of the soil retained. The zone of influence for this site is defined graphically in Figure A.

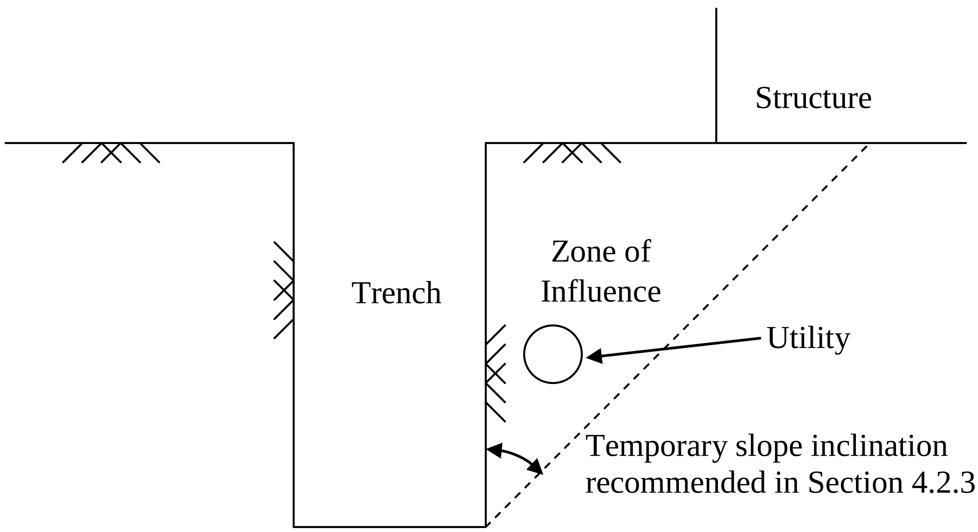

Figure A - Zone of Influence for Excavations

Where settlement sensitive facilities are within the zone of influence, additional analysis should be done to determine both the amount of movement that is expected at the location of the facility, as well as the amount of movement that is acceptable. In the event that the movement anticipated at the location of the facility is unacceptable, the project plans and specifications should require support systems that restrict the movement of the sides of the trenches. Support systems should be designed for the specific situation by a registered professional engineer as defined in Title 18 of the Revised Code of Washington (RCW).

With time and the presence of seepage and/or precipitation, the stability of temporary cuts can be significantly reduced. Therefore, construction should proceed as rapidly as feasible to limit the time the excavations are left open, and runoff water should be prevented from entering excavations. Heavy construction equipment, building materials, and surcharge loads such as excavated or imported soil should not be allowed within one third of the slope height from the top of any excavation.

4.2.4 Foundation Recommendations

Based on our review of the conceptual sketch of the proposed storage pipes provided to us, we understand that 3 storage pipes and lightly loaded facilities vault structures are planned. We anticipate that glacial till deposits will be encountered at the foundation level of the pipes. These soils are generally medium dense to very dense, and should provide adequate support for the anticipated structural loads.

4.2.5 Potential Impacts to Nearby Structures and Utilities From Construction

Some construction methods have the potential to induce ground vibrations which can damage sensitive structures (ie., homes) and utilities west of the site and along South Alaska Street. We recommend developing a vibration and settlement monitoring program prior to the start of construction and implementing it during construction activities. If the recorded movements/vibrations exceed the allowable vibration and settlement thresholds for each structure and utility, alternate construction methods should be used. We can provide acceptable limits of vibration and settlement values if needed during the design phase.

4.2.6 Other Recommendations

Other design recommendations for the South Alaska Street alternative, including subgrade verification, backfill and compaction, construction drainage and erosion considerations, permanent slopes, underground utilities, and pavement design, are included in Chapter 5.

4.3 54TH Avenue South

4.3.1 Seismic Design Considerations

This section discusses seismic hazards including site response, fault rupture, liquefaction and lateral spreading affecting the 54th Avenue South alternative.

4.3.1.1 Surface Fault Rupture

The storage pipe proposed along 54th Avenue South is approximately 1 kilometer south of fault “A” and north of fault “B,” as shown in Figure 4. In our opinion, the risk of surface fault rupture affecting the 54th Avenue South alternative is low and does not need to be considered for design.

4.3.1.2 Liquefaction and Lateral Spreading

Below the proposed storage pipe elevation, the site is generally underlain by recessional lacustrine deposits of cohesionless and cohesive soils generally too dense/stiff to liquefy during a seismic event. Above the proposed storage pipe elevation, localized pockets of silty sand, sandy silt and silt encountered in the fill and recessional lacustrine deposits may be susceptible to localized liquefaction during a seismic event.

The horizontal distance from the site to Lake Washington is about 300 to 700 feet. Because liquefaction is not likely to occur at or below the proposed storage pipe elevation and the site is roughly 42 feet higher in elevation than Lake Washington, in our opinion, liquefaction and lateral spreading effects do not need to be considered for design of the 54th Avenue South alternative.

4.3.2 SITE EARTHWORK

Construction for the proposed storage pipe along 54th Avenue South site will require site preparation and earthwork activities related to construction of structures, utilities, pavement areas and other improvements.

4.3.2.1 Excavation

Based on our interpretation of subsurface conditions at the site, and the proposed grading, it appears that onsite excavations will be made in all of the soil units encountered in our explorations. In general, the contractor should be able to excavate this material using standard construction equipment. Debris within the fill unit was not encountered in our explorations, but should be expected during construction. Groundwater should be anticipated during construction at levels approximately equal to 21 feet bgs, or elevation 38 feet.

4.3.2.2 Dewatering

Based on the assumed permeability of the site soils, and the proposed minimum storage pipe elevation at 32 feet, or 6 feet below the highest recorded groundwater table as of this report (September 2010), the excavation should be dewatered during construction of the storage pipe. Dewatering should be required to maintain groundwater 2 feet below the excavation depth, in accordance with section 7-17.3(1)A3 of the *City of Seattle Standard Specifications*. We recommend performing hydrogeological testing (ie.,a slug or pumping test) to better characterize the hydraulic conductivity at the site and estimate dewatering volumes in the excavation.

We do not recommend significantly lowering the regional groundwater beyond the *City of Seattle Standard Specifications* requirements to reduce the potential for settlement.

The contractor should choose a dewatering method based on the available information and their selected construction techniques. To avoid damage to adjacent utilities and structures due to settlement, the groundwater table should be drawn down no more than necessary for the proposed work. Well points and other external dewatering systems should be designed by a qualified professional engineer or geologist. The dewatering plan should be submitted to SPU Materials Laboratory for review.

4.3.2.3 Tunneling

It is our understanding that tunneling as a construction method for the storage pipe is being considered for this site. Shafts would be required at both ends of the tunnel for construction of the entrance and receiving portals of the tunnel and to allow lowering of the tunneling machine. This would render 54th Avenue South inaccessible to road traffic during the tunneling operation. The variability encountered in the lacustrine deposit at the proposed depth of the pipe would likely require additional support to conserve structural integrity along the length of the tunnel. It is our opinion tunneling is not a viable construction option for the 54th Avenue South alternative due to constructability issues and impacts to the community.

4.3.3 Temporary Slopes and Shoring Recommendations

Construction of the storage pipe will require excavations approximately 26 feet bgs along 54th Avenue South. It is our opinion the proposed excavation depth cannot be shored using standard passive shoring methods (ie., trench box) due to the presence of sensitive structures (ie. homes) and utilities along 54th Avenue South. Alternative shoring methods such as sheet piles or construction methods may be necessary to limit the amount of movement on the existing structures.

Temporary excavations and protective systems (i.e. shoring) will be required for this project. They should be implemented in accordance with Section 7-17.3(1)A7 of the City of Seattle *Standard Specifications* (City of Seattle, 2008). All specific design parameters for shoring methods should be developed by the Contractor's competent person. Because of the roadway width constraints along 54th Avenue South, it is our opinion the excavation cannot be temporarily sloped. For planning purposes, the soil can be classified as Type C in accordance with WAC 296-155.

The means and methods of shoring the temporary excavations for the protection of workers are the contractor's responsibility. Shoring to protect workers typically consists of passive shoring systems that allow the sides of the trenches to slough and still protect the workers. This type of shoring is acceptable where settlement sensitive structures and/or utilities are not present within the zone of influence of the trench. However, additional analysis should be done to determine both the amount of movement that is expected at the location of the facility, as well as the amount of movement that is acceptable for this site. In the event that the movement anticipated at the location of the facility is unacceptable, the project plans and specifications should require support systems that restrict the movement of the sides of the trenches. Support systems should be designed for the specific situation by a registered professional engineer as defined in Title 18 of the Revised Code of Washington (RCW).

With time and the presence of seepage and/or precipitation, the stability of temporary cuts can be significantly reduced. Therefore, construction should proceed as rapidly as feasible to limit the time the excavations are left open, and runoff water should be prevented from entering excavations. Heavy construction equipment, building materials, and surcharge loads such as excavated or imported soil should not be allowed within one third of the slope height from the top of any excavation.

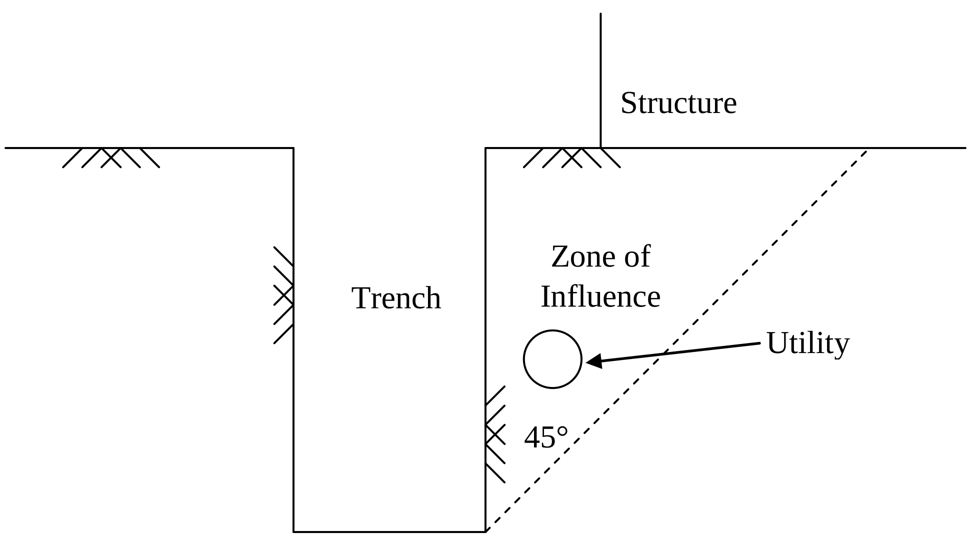

Figure B - Zone of Influence for Excavations

4.3.4 FOUNDATION RECOMMENDATIONS

Based on our review of the conceptual sketch of the proposed storage pipe provided to us, we understand a 10-foot diameter 400-linear foot storage pipe is planned. We anticipate that recessional lacustrine deposits will be encountered at the foundation level of the pipe. These soils are generally medium stiff to very stiff, and should provide adequate support for the anticipated structural loads.

4.3.5 Uplift

The proposed storage pipe minimum elevation is 6 feet below the groundwater level. Depending on the dead load of the storage pipe, uplift pressures due to groundwater may need to be considered for design. We can evaluate uplift for the 54th Avenue South alternative as the design progresses.

4.3.6 Potential Impacts to Nearby Structures and Utilities From Construction

Some construction methods have the potential to induce ground vibrations which can damage sensitive structures (ie., homes) and utilities along 54th Avenue South. We recommend developing a vibration and settlement monitoring program prior to the start of construction and implementing it during construction activities. If the recorded movements/vibrations exceed the allowable vibration and settlement thresholds for each structure and utility, alternate construction methods should be used. We can provide acceptable limits of vibration and settlement values if needed during design.

4.3.7 Other Recommendations

Other design recommendations for the 54th Avenue South alternative, including subgrade verification, backfill and compaction, construction drainage and erosion considerations, permanent slopes, underground utilities, and pavement design, are included in Chapter 5.

4.4 Triangle Park

4.4.1 Seismic Design Considerations

This section discusses seismic hazards including site response, fault rupture, liquefaction and lateral spreading affecting the Triangle Park, and presents the recommended site-specific uniform horizontal design response spectrum for the proposed tank. Discussion of seismic effects on slope stability, wall pressures, allowable bearing pressures, foundation recommendations and uplift pressures are presented later in this chapter.

4.4.1.1 Design Response Spectrum

We understand that the seismic design of the underground storage tank at the Triangle Park will be in accordance with the Seattle Building Code (SBC) 2006. Computation of forces used for seismic design for this code is based on seismological inputs and site soil response factors. Ground motions considered for design using these guidelines have approximately a 2 percent probability of exceedance in 50 years, or a 2,475-year return period (T_R). A uniform horizontal response spectrum incorporating the site-specific ground motions with a T_R of 2,475-years and soil response factors can be constructed for analysis of the tank. The seismological inputs are short-period and 1-second period spectral accelerations, S_s and S_1, respectively, obtained from the USGS National Seismic Hazard Mapping Program spectral acceleration contour map for Site Class B sites (Figure 1613 of the SBC 2006). The mapped S_s and S_1 values are 1.50g and 0.51g, respectively.

Characterization of the soil profile type is required in the SBC 2006 to determine the site class definition. A site classified as Site Class E is defined as soft soil, having an average shear wave velocity less than 600 feet per second (fps), or an average of N-values less than 15, in the top 100 feet. Based on the SPTs and soil classifications derived from the explorations completed at the site, it is our opinion that a Site Class E characterizes the subsurface conditions at the site.

In accordance with the SBC 2006, the site coefficients, Fa and Fv, corresponding to a Site Class E and the appropriate spectral acceleration values are 0.9 and 2.4, respectively. The maximum considered earthquake spectral response accelerations for short-period, S_{MS}, and 1-second period, S_{M1}, are obtained as 1.35g and 1.23g, respectively, by applying the site coefficients to S_s and S_1. Finally, the 5-percent-damped uniform horizontal response spectrum is plotted using the design spectral response accelerations at short-period, S_{DS}, and 1-second period, S_{D1}, obtained by reducing S_{MS} and S_{M1} by a factor of $^2/_3$ to 0.90g and 0.82g, respectively. Figure 5 shows the recommended uniform horizontal design spectrum.

4.4.1.2 Surface Fault Rupture

The proposed structures for Basins 38 and 43 are within the SFZ. The USGS has interpreted seismic-reflection data to indicate the SFZ is comprised of at least 3 or 4 splays that generally extend east-west across the Puget Lowland. The SFZ is bounded on the north by fault "A" and the syncline on the southern margin of the Seattle basin, and bounded on the south by fault “C” (Frankel, undated). The Triangle Park is approximately 0.2 kilometers south of fault “A”, as shown in Figure 4. In our opinion, the risk of surface fault rupture affecting the Triangle Park alternative is moderate but does not need to be considered for design.

4.4.1.3 Liquefaction and Lateral Spreading

According to the current subsurface investigations for the storage tank at the Triangle Park, below the proposed minimum foundation tank elevation, the site is generally underlain by mass wastage deposits of cohesionless and cohesive soils generally too dense/stiff to liquefy during a seismic event. Silty sand, sandy silt and silt encountered in the fill and lake deposits above the proposed minimum foundation elevation may be susceptible to liquefaction during a seismic event. Peat interbedded in the lake deposits is likely to soften during a seismic event. The groundwater data indicates an elevation of 22 feet, roughly 26 feet above the proposed minimum foundation elevation.

Settlement at the site due to liquefaction triggered by a seismic event with T_R of 2,475-years is estimated to be as much as 5 inches, occurring approximately in the upper 20 feet bgs (Figure 6). Because the horizontal distance from the site to Lake Washington is 110 to 130 feet, lateral spreading effects need to be considered for design at the Triangle Park alternative. Available analytical methods estimate a lateral ground displacement, triggered by a seismic event with T_R of 2,475-years, in the order of 5 to 8 feet.

4.4.2 Site Earthwork

Construction for the proposed storage tank will require site preparation and earthwork activities related to construction of structures, utilities, pavement areas and other improvements.

4.4.2.1 Excavation

Based on our interpretation of subsurface conditions at the site, and the proposed grading, it appears that onsite excavations will be made in fill, lake, and mass wastage deposits encountered in our explorations. In general, the contractor should be able to excavate this material using standard construction equipment. Debris within the fill unit was not encountered in our explorations, but should be expected during construction. Groundwater should be anticipated during construction at levels approximately equal to 4 feet bgs, or elevation 22 feet.

4.4.2.2 Dewatering

Based on the assumed permeability of the site soils, and the proposed structure depths below the groundwater table, the excavation should be dewatered during construction of the storage tank and vault. Dewatering will be required to maintain groundwater 2 feet below the excavation depth, in accordance with section 7-17.3(1)A3 of the *City of Seattle Standard Specifications*. We recommend performing hydrogeological testing (ie.,a slug or pumping test) to better characterize the hydraulic conductivity at the site and estimate dewatering volumes in the excavation.

We do not recommend significantly lowering the regional groundwater beyond the *City of Seattle Standard Specifications* requirements to reduce the potential for settlement.

The contractor should choose a dewatering method based on the available information and their selected construction techniques. To avoid damage to adjacent utilities and structures due to settlement, the groundwater table should be drawn down no more than necessary for the proposed work. Well points and other external dewatering systems should be designed by a qualified professional engineer or geologist. The dewatering plan should be submitted to SPU Materials Laboratory for review.

4.4.3 Temporary Slopes and Shoring

Temporary excavations and protective systems (i.e. shoring or sloping) will be required for this project. They should be implemented in accordance with Section 7-17.3(1)A7 of the City of Seattle *Standard Specifications* (City of Seattle, 2008). All specific design parameters for temporary slopes, trench shields, or other shoring methods should be developed by the Contractor's competent person. Because of the high groundwater level at the site, we recommend the excavation be shored, not temporarily sloped back. For planning purposes, the soil can be classified as Type C in accordance with WAC 296-155.

The means and methods of shoring the temporary excavations for the protection of workers are the contractor's responsibility. Shoring to protect workers typically consists of passive shoring systems that allow the sides of the trenches to slough and still protect the workers. This type of shoring is acceptable where settlement sensitive structures and/or utilities are not present within the zone of influence of the trench. The size of the wedge depends on the engineering properties of the soil retained. The zone of influence for this Site is defined graphically in Figure C.

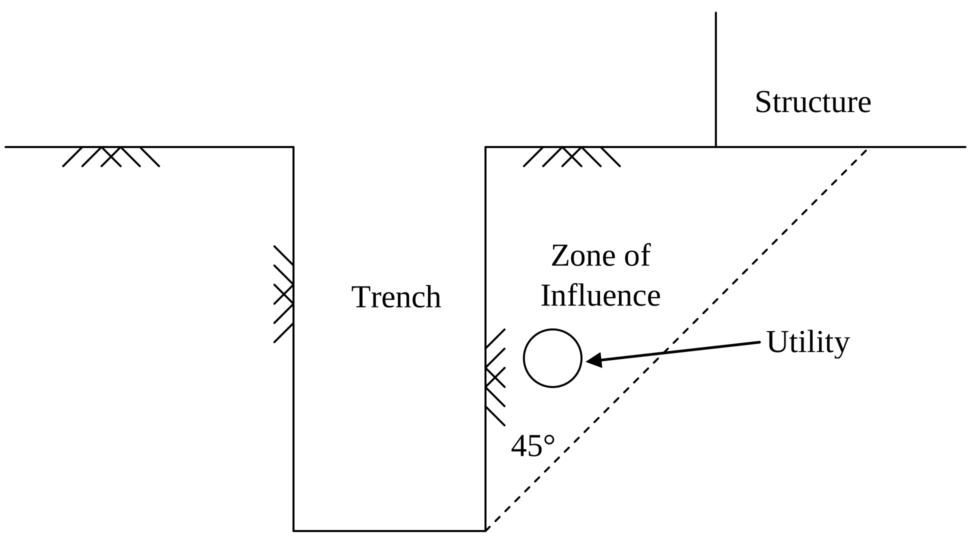

Figure C - Zone of Influence for Excavations

Where settlement sensitive facilities are within the zone of influence, additional analysis should be done to determine both the amount of movement that is expected at the location of the facility, as well as the amount of movement that is acceptable. In the event that the movement anticipated at the location of the facility is unacceptable, the project plans and specifications should require support systems that restrict the movement of the sides of the trenches. Support systems should be designed for the specific situation by a registered professional engineer as defined in Title 18 of the Revised Code of Washington (RCW).

With time and the presence of seepage and/or precipitation, the stability of temporary cuts can be significantly reduced. Therefore, construction should proceed as rapidly as feasible to limit the time the excavations are left open, and runoff water should be prevented from entering excavations. Heavy construction equipment, building materials, and surcharge loads such as excavated or imported soil should not be allowed within one third of the slope height from the top of any excavation.

4.4.4 TEMPORARY SHORING RECOMMENDATIONS

Construction of the storage tank and facilities vault will require excavations approximately 30 feet bgs, which will be approximately 26 feet below the groundwater level. In our opinion, an appropriate temporary shoring for the Triangle Park site would be a groundwater cut-off system that does not lower the groundwater around the excavation, but rather reduces or all together eliminates the ability of the groundwater to enter the excavation. Typical groundwater cut-off systems consist of interlocking steel sheet piles that are driven into the ground around the edges of the proposed excavation, secant pile walls or other methods. Based on the subsurface information and Contractor experience in the Puget Sound region, we recommend an interlocking steel sheet pile system be used for the excavation.

4.4.4.1 Sheet piles

Sheet piles can be driven to a depth that limits the water from infiltrating through the base of the excavation and preferably into a layer with low hydraulic conductivity, and the water that enters the excavation is managed using sump pumps to keep the excavation relatively dry. Sheet piles can also be driven just below the depth of the proposed excavation, the excavation is completed in the wet, and a concrete tremie slab is poured at the base of the excavation of sufficient thickness to resist the uplift pressure of the groundwater. The excavation can then be pumped out and the work proceeds. Based on preliminary estimates of permeability of the soils at the site, it is our opinion the first method may be applicable at this site.

A sheet pile shoring system may require internal bracing during excavation. Recommended earth pressures for use in design of the shoring system with internal bracing are presented on Figure 7. Assuming dewatering will lower the groundwater to 2 feet below the excavation, hydrostatic pressures will act on the shoring system approximately at the elevations shown in Figure 7 during construction only.

Tieback anchors can be used to achieve equilibrium for the temporary shoring wall design. The best option for this project is dependent on what resources are available to the Contractor and therefore we recommend the Contractor be responsible for the design of the system. The Contractor should be required to submit a shoring plan designed by a Washington State licensed Engineer. Tieback recommendations are included in the next section.

4.4.4.2 Tiebacks

Tieback anchors consist of steel strands or a reinforcing bar placed into predrilled holes. The holes are typically drilled at an inclination of about 15 to 45 degrees from horizontal. The strands or bars should be in the center of the borehole, so centralizers are spaced evenly along the tieback anchor length. Anchor holes should be drilled in a manner that minimizes loss of ground and do not endanger previously installed anchors or undermine existing pavement or utilities.

The recommended no-load zone for a single braced soldier pile wall starts at the base of the wall, is horizontal for a distance of H/4, where H is the height of the wall face, and then extends up towards the ground surface at an angle of 60 degrees from horizontal. In the anchor no-load zone, tieback anchor holes could be filled with a material such as a sand pozzolan mixture that will not adhere to the tieback rod but will prevent caving. Alternatively, a bond breaker could be used around the tieback anchor in the no-load zone, and the zone could be filled with concrete or lean concrete backfill. However, a minimum 12-inch buffer zone of sand should be placed in the anchor hole directly behind the soldier pile. We recommend that no-load zone lengths not be left open overnight during construction.

The frictional resistance of an anchor depends on many factors, including the Contractor's means and methods during installation. Consequently, the design of production anchors should be based on a series of test anchors. The following frictional values are only for planning and estimating test anchor lengths. Temporary tieback anchors installed by cased, single-stage, primary pressure grouted methods could be designed for an allowable frictional value of 1 kip per foot (based on a 8-inch-diameter grouted zone). A single-stage, pressure-grouted anchor is defined as an anchor that undergoes high-pressure grouting as the drill casing(s) is removed. Anchors should not be installed within the fill or lake deposits. We recommend a minimum anchor grouted length of 15 feet within the mass wastage deposit.

Load testing for all tieback anchors and acceptability should be as recommended by the Post-Tensioning Institute Manual, Chapter 4, Recommendations for Prestressed Rock and Soil Anchors, 2005. As described in this manual, the following tests should be accomplished.

All anchors should be proof-loaded in 25 percent (0.25P) increments to 133 percent of their design capacity (1.33P), where P is the design capacity. Each load increment should be held until the deformation stabilizes (normally about one minute) and the load and corresponding deformation are recorded. After reaching 1.33P, the load should be held for at least 10 minutes to evaluate creep and then be reduced to the lock-off value.

Prior to installing production anchors within a particular soil stratum, performance tests should be accomplished for each anchor type and/or installation method that will be used. Requirements for installing pre-production test tieback anchors will depend on the location, quantity, and number of tieback anchors. The number of tendons in the selected anchors should be increased as required to complete the performance tests. Approximately 1 percent of production anchors (with a minimum of two anchors), randomly selected, should be performance tested by loading in 25 percent (0.25P) increments to 200 percent of design capacity (2.0P). The 200 percent load should be held constant for a minimum period of at least 10 minutes.

We recommend that all temporary anchors be locked off at 90 percent of the design load. Anchors that do not meet the acceptance criteria should be locked off at one-half the failure load and replaced with additional anchors, as required.

Initial Lift-off Readings: After transferring the load to the stress anchorage and prior to removing the jack, a lift-off reading should be made. The load determined from the lift-off reading should be within 5 percent of the specified lock-off load. If the load is not within 5 percent of the lock-off load, the end anchorage should be reset and another lift-off reading should be made.

Lift-off Test: Lift-off tests may be conducted on selected tiebacks, both during and after construction, to check the magnitude of seating and to transfer load losses and determine whether long-term losses are occurring.

Acceptance Criteria: The results of each anchor test should be evaluated in order to determine anchor acceptability. An anchor would be acceptable provided:

- The total movement obtained from a performance and proof test exceeds 80 percent of the theoretical elastic elongation of the design free stressing length.
- The creep rate during the final test load does not exceed 0.080 inch per log cycle of time and is a linear or decreasing creep rate, regardless of tendon length and load. Otherwise, the anchor should be held for an additional 60 minutes at the required test load.

4.4.5 Seepage and Drainage

We understand that the facilities vault will house an odor control system, and mechanical and electrical rooms. These environments should be designed to remain dry during the life of the structure. Seepage through the shoring should be collected by a drainage composite installed between the shoring and facilities vault walls. This drainage composite could be connected to pipes that drain into a sump. The wall drainage should be continuous over the entire height of the shoring wall. Waterproofing material should be used below the groundwater elevation to prevent water seepage though the structural walls.

For the storage tank, the interior concrete wall could be cast against the shoring walls and seepage could be allowed to seep through the structural walls. Seepage through the structure wall could result in a damp interior wall face. Because the interior of the tank is a moist environment and seepage through structural concrete would occur at a very slow rate, the costs and benefits of collecting seepage between the shoring and tank walls should be reviewed prior to installing a wall drain and waterproofing system.

4.4.6 Foundation Recommendations

Based on our review of the preliminary tank design sketch provided to us, we understand that a heavily loaded storage tank and lightly loaded facilities vault structures are planned. We anticipate that mass wastage deposits will be encountered at the foundation level of the structures. These soils are generally medium dense to very dense and/or very stiff to hard, and should provide adequate support for the anticipated structural loads.

4.4.6.1 Bearing Capacity

We understand that a mat foundation will be used for the tank and vault foundations, consisting of reinforced concrete slabs bearing on the mass wastage deposit. We recommend a maximum allowable bearing pressure of 6,000 pounds per square foot (psf) for designing the slabs bearing on these native deposits. The recommended maximum allowable bearing pressure may be increased by 1/3 for short term transient conditions such as wind and seismic loading.

All excavations for the mat foundation should be observed by a geotechnical engineer to evaluate the adequacy of the bearing stratum and to confirm that subsurface conditions are suitable for the recommended design bearing value.

4.4.6.2 Estimated Settlement

Assuming construction is accomplished as recommended herein, and for the foundation loads anticipated, we estimate total settlement of the slab foundations of less than about ½-inch and differential settlement between the tank and vault supported on competent subgrade of less than about ¼ inch. Differential settlement can be assumed to be across the width/length of the structures. It is anticipated that the majority of the estimated settlement will be primarily elastic and occur during construction, as loads are applied.

The foundation slabs should be designed for a modulus of vertical subgrade reaction, k_1, of 150 pounds per cubic inch. This $k_1$considers a 1-foot x 1-foot load area and should be modified by the following formulae to obtain k for the proposed tank and vault load areas:

$$k_{(BxB)} = k_1 \left(\frac{B+1}{2B}\right)^2$$

where $k_{(BxB)}$ is the coefficient of subgrade reaction of a square foundation measuring B x B (feet), and

$$k = \frac{k_{(BxB)}(1 + 0.5\frac{B}{L})}{1.5}$$

where k is the coefficient of subgrade reaction of a rectangular foundation measuring B x L (feet).

4.4.6.3 Lateral Resistance

Earthquakes and unbalanced earth loads will subject the proposed structures to lateral forces. Lateral loading can be resisted by a combination of passive soil resistance and friction along the base of the structure. Passive soil resistance can be determined using an allowable equivalent fluid weight of 260 pounds per cubic foot, based on submerged conditions. Base friction can be determined using an allowable coefficient of friction of 0.4 for concrete placed directly on the native soils. This coefficient of friction should be used in conjunction with the normal load adjusted for the uplift pressure due to groundwater. The equivalent fluid weight and friction coefficients are ultimate and do not include a factor of safety.

4.4.6.4 Uplift

Based on our understanding of the proposed structure depth of 30 feet bgs and available groundwater observations, approximately 26 feet of the proposed tank will be permanently below the groundwater table. Therefore, an uplift load can be expected on the tank. Preliminary tank design information estimates the total dead weight of the structure to be 4,600 kips. Based on using only dead weight to counteract uplift forces on the tank, we estimate the factor of safety (FS) against uplift pressures to be approximately 1.1. At this time, we do not have preliminary dead weight information on the facilities vault.

In our opinion, the mass of generators, pumps, roofing, other live loads, and water/sewage in the tank should not be relied on for uplift resistance. Note that if dewatering activities to lower the pressures below the excavation bottom seal are implemented, they should continue during the project until after construction to resist the permanent long-term uplift pressures.

4.4.6.5 Seepage

Difficulty sealing the shoring-mat foundation contact can result in leakage. We recommend installing a seepage barrier around the perimeter of the mat foundation, at its contact with the shoring, to reduce leakage. Flexible water stops could be installed between the mat foundation and the shoring. We recommend placing a bentonite seal around penetrations through the foundation, e.g., around drainpipe penetrations.

We recommend that an acceptable seepage rate through the mat foundation be specified in the contract documents and that the contract require that remedial measures be implemented if seepage rates are excessive.

4.4.7 Permanent Wall Design

We understand the tank and vault walls will be cast-in place concrete structurally connected to their respective concrete mat foundations. At the time of this report, it is undecided whether the proposed shoring system will be temporary for construction, with forms for concrete walls placed inside the shored excavation perimeter, or if the shoring system will remain in place as part of the permanent wall design. It is also undecided whether the cast-in place walls will be designed as cantilevered elements, supported by internal bracing or be combination thereof.

4.4.7.1 Static Lateral Earth Pressures

The tank and vault structures should be designed to resist the lateral loads from the adjacent retained soil, groundwater pressures, and other surcharge loads including construction traffic and seismic ground motions. Based on our interpretation of the subsurface information, we anticipate the soil retained by the tank and vault foundations could be fill, lake, mass wastage or a combination of these deposits and/or structural fill.

The at-rest condition should be used for the design of restrained walls that limit movement at the top of the wall to less than 0.001 times the wall height. For a cantilever wall and internally-braced wall designed for at-rest conditions, we recommend the permanent wall design criteria shown in Figures 8 and 9, respectively.

Active earth pressures should be used for the design of walls that are unrestrained, or allowed to yield at least 0.001 times the wall height. For a cantilever wall and internally-braced wall designed for active conditions, we recommend the permanent wall design criteria shown in Figures 10 and 11, respectively.

Lateral loads due to surficial surcharge loading (areal fill, traffic, etc.) should be considered. These lateral loads can be determined by multiplying the vertical pressures by earth pressure coefficients of 0.31 and 0.47, for active and at-rest conditions, respectively. An average areal load of about 250 psf to account for construction equipment and materials should be included if the walls will experience loading due to construction activities. This surcharge is equivalent to the horizontal pressures shown in Figures 7 through 11. If construction activities will induce loads greater than 250 psf, these increases should be evaluated by SPU Materials Laboratory and included in the shoring design.

4.4.7.2 Seismic Lateral Earth Pressures

During seismic shaking, inertial effects impose increased lateral earth pressures on subsurface walls. Our recommended seismic surcharge load assumes a uniform distribution along the wall height. The seismic surcharge is based on peak ground accelerations for the 2% probability of exceedance in 50-years seismic design ground motions. The resultant of the seismic surcharge loads should be assumed to act as a horizontal pressure shown in Figures 8 through 11.

4.4.7.3 Liquefied Lateral Earth Pressures

Following seismic shaking, the submerged silty sand, sandy silt and silt encountered in the lake and mass wastage deposits above the proposed minimum foundation elevation may have liquefied. The peat interbedded in the lake deposit is also likely to soften during a seismic event, exhibiting a reduction or loss of shear strength similar to liquefied soil. The reduction or loss of shear strength results in an increase in earth pressures acting on the wall over the depth of the liquefaction. The resultant of the increase in earth pressures due to liquefaction should be assumed to act as shown in Figures 12 through 15.

4.4.8 Construction Vibration, Settlement and Noise Monitoring

Some construction methods have the potential to induce ground vibrations which can damage nearby structures. Excavating and driving sheetpiles may produce significant vibrations to the sensitive structures (ie., homes) and utilities west and up slope of the triangle park.

Prior to starting construction, we recommend establishing a baseline by documenting (ie., survey, photographs, videos) the existing structural conditions, and estimating allowable vibration and settlement levels for each adjacent structure and utility. We recommend each of the structures be monitored for horizontal and vertical movement, including installation of gages in any pre-existing tension cracks. We also recommend developing a vibration monitoring program prior to the start of construction and implementing it during construction activities. If the recorded movements/vibrations exceed the allowable vibration and settlement thresholds for each structure and utility, alternate construction methods should be used. We can provide acceptable limits of vibration and settlement values if needed during design.

Though unlikely to cause structural damage, noise levels from excavating and driving sheetpiles may be unpleasant to people in adjacent homes. The Contractor can reduce noise levels by using dampening techniques.

5.0 ADDITIONAL CONSTRUCTION RECOMMENDATIONS

5.1 General

The following construction recommendations are applicable for both the Basin 43 and 38 alternatives.

5.2 Subgrade Verification

Subgrade preparation for areas where new fills, pavements, and utilities will be built should begin with the removal (stripping) of all deleterious matter, asphalt, and concrete. The exposed subgrade soils should be evaluated by the Geotechnical Engineer-of-Record. For large areas, this evaluation should be performed by proof-rolling the exposed subgrade with a fully loaded dump truck. For smaller areas where access is restricted, the subgrade should be evaluated by probing the soil with a steel probe.

Soft/loose soils identified during subgrade preparation should be compacted to a firm and unyielding condition or over-excavated and replaced with structural fill, as described below. The depth of overexcavation, if required, should be determined by the Geotechnical Engineer-of-Record at the time of construction.

5.3 Backfill and Compaction

Fill material should be onsite or imported material within 3 percent of the optimum moisture content per ASTM D698 (Standard Proctor Test) and does not contain deleterious materials, greater than 5 percent organics, nor material larger than 3-inches in diameter. Any proposed imported common fill should be evaluated by the Geotechnical Engineer-of-Record to determine its suitability. The Contractor is responsible for protecting stockpiled material from becoming unsuitable while it is on site.

We estimate that some of the excavated material may be suitable for re-use as structural fill. Some of the excavated fill and native deposits will be silty and wet of optimum moisture content, and thus will be unsuitable for re-use as structural fill unless it is moisture conditioned to within 3 percent of the optimum moisture content. Depending on the project schedule, area available for farming, and the time of year when construction is planned, moisture conditioning may be very difficult if not impossible. If moisture conditioning is required and not feasible, material that meets the criteria should be imported.

Fill placed in all structural areas (areas that will support slabs, buildings, pavements, and other foundations), and for five feet around such areas, should be compacted to a minimum of 95 percent of the maximum dry density (MDD) as determined by test method ASTM D698. Within a lateral distance of three feet of any retaining wall, smaller, possibly hand-held equipment should be used in conjunction with thinner soil lifts to achieve the required compaction and limit compaction forces on the wall. Fill in unimproved areas such as landscaping areas and swales should be compacted to a minimum of 90 percent of MDD.

Excavated material that is not considered suitable for use as structural fill may be suitable as fill for unimproved areas (i.e. landscaped areas), that would not be adversely impacted by differential settlement over time. Restrictions made on imported material in unimproved areas should be limited, depending on the susceptibility of the area in question to settlement.

The procedure to achieve the specified minimum relative compaction depends on the size and type of compacting equipment, the number of passes, thickness of the layer being compacted, and certain soil properties. When size of the excavation restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough lifts to achieve the required compaction. A sufficient number of in-place density tests should be performed as the fill is placed to verify the required relative compaction is being achieved.

If earthwork is to be performed or fill is to be placed in wet weather or under wet conditions when control of soil moisture content is not possible, the following recommendations should apply:

* Earthwork should be accomplished in small sections to minimize exposure to wet weather. Excavations or the removal of unsuitable soil should be followed immediately by the placement and compaction of a suitable thickness of clean structural fill, as described below. The size of construction equipment used may have to be limited to prevent soil disturbance;

* Material used as trench backfill should consist of clean, granular soil, of which not more than 5 percent by dry weight passes the U.S. Standard No. 200 sieve, based on wet sieving the fraction passing the ¾ inch sieve. The fines should be non-plastic;
* The ground surface in the construction area should be sloped and sealed with a smooth drum roller to promote rapid runoff of precipitation, to prevent surface water from flowing into excavations, and to prevent ponding of water;
* No soil should be left uncompacted so it can absorb water. Soils that become too wet for compaction should be removed and replaced with clean granular materials; and
* Excavation and placement of fill should be observed on a full time basis by a person experienced in wet weather earthwork to verify that all unsuitable materials are removed and suitable compaction and site drainage is achieved.

Recompacted, onsite soils may be assumed as having an in-place moist unit weight of 120 pcf. Imported materials meeting the specifications of Type 2 and Type 17 that have been compacted may be assumed as having a moist unit weight between 125 and 135 pcf, depending on the compaction effort and the source of the material.

5.4 Permanent Slopes

For stability, permanent cut slopes should be no steeper than 3H:1V. To provide uniform compaction, fill slopes should be constructed and compacted beyond their final grade lines and trimmed to grade. Embankment fill material should be a granular material, free of organics, rubbish, and other undesirable material, and should be compacted to a minimum of 90% of its maximum dry density, as determined by ASTM D1557. Constructed in this way, fill slopes should be no steeper than 2H:1V. However, erosion and maintenance issues may require a less steep slope (3H:1V or less). Excavated or fill surfaces should be protected from erosion as soon as possible after exposure. Temporary erosion control measures, such as plastic sheeting or mulching, should be utilized if permanent measures cannot be implemented immediately.

5.5 Construction Drainage and Erosion Considerations

Surface runoff and erosion at the site can be controlled during construction by careful grading practices and observance of best management practices (BMPs). Such practices typically include the construction of shallow, upgrade perimeter ditches or low earthen berms, and the use of temporary sumps to collect runoff. Erosion during construction can be minimized by judicious use of erosion control devices. If used, these devices should be in place prior to construction and remain in place throughout construction.

Erosion and sedimentation of exposed soils can also be reduced by quickly re-vegetating exposed areas of soil, and by staging construction such that large areas of the project site are not denuded and exposed at the same time. Areas of exposed soil requiring immediate and/or temporary protection against exposure should be covered with mulch, erosion control netting and/or blankets.

Permanent erosion control measures should be implemented to reduce the potential for future erosion events. Denuded areas should be mulched and/or planted with approved vegetation.

5.6 Underground Utilities

5.6.1 Trench Subgrades

The native and fill soil encountered throughout the site should generally provide suitable support for underground utilities, provided subgrades remain in an undisturbed condition and the pipes and structures are bedded as described in the following section. A smooth-bladed excavator bucket should be used to excavate to the subgrade elevation and foot traffic on the subgrade minimized to reduce the amount of disturbance to the subgrade. A layer of bedding material or gravel may be used to protect the subgrade once it is exposed.

If unsuitable subgrade conditions are encountered at the time of construction, the subgrade should be evaluated and the course of action determined by the Geotechnical Engineer-of-Record. Typical courses of action may include overexcavation and replacement with structural fill, stabilization with quarry spalls, or use of geosynthetics.

5.6.2 Bedding

Bedding is material placed at the bottom of the trench to provide uniform support along the bottom of a buried utility. Bedding material and placement procedures should meet the appropriate requirements and criteria of the current *City of Seattle Standard Specifications*, depending on the utility in question. In areas where a trench box is used, the bedding material should be placed before the trench box is advanced. Bedding material disturbed by movement of trench boxes should be recompacted prior to final backfilling. Care should be taken not to disturb the utility as the trench box is advanced.

Trench backfill will be placed on top of the bedding. Refer to the backfill recommendations in Section 5.3: *Backfill and Compaction*.

5.7 Pavements

We understand that, when finished, 54th Avenue South and the Triangle Park will be paved with asphalt concrete, and be primarily utilized by light automobiles and pick-up trucks, with occasional use by heavy maintenance or delivery vehicles. At the Triangle Park, pedestrian paths constructed of varying materials may be present around the perimeter of the site.

In our opinion, vehicular parking area and pedestrian pavements may be designed as flexible pavement, assuming an effective subgrade resilient modulus, M_R of 12,000 pounds per square inch (psi) when placed on existing fill. This recommendation is based on our interpretation of surficial ground conditions at the site and the guidelines of the *American Association of State Highway and Transportation Officials Guide for the Design of Pavement Structures* (AASHTO, 1993). The effective resilient modulus takes into account the regional climate of Seattle.

6.0 LIMITATIONS AND ADDITIONAL SERVICES

This geotechnical report was prepared accordance with generally accepted professional principles and practices in the field of geotechnical engineering at the time the report was prepared. This report is intended to provide information and recommendations to support preliminary engineering activities for this project. The conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions.

We recommend that the SPU Materials Laboratory be retained to review the plans and specifications and verify that our recommendations have been interpreted and implemented as intended. Sufficient geotechnical monitoring, testing, and consultation should be provided during construction to confirm that the conditions encountered are consistent with those indicated by explorations and to verify that the geotechnical aspects of construction comply with the contract plans and specifications. Recommendations for design changes can be provided should conditions revealed during construction differ from those anticipated.

We appreciate the opportunity to be of service.

Sincerely,

SPU MATERIALS LABORATORY

Aaron J. Clark
Assistant Engineering Geologist

Juan Carlos Ramirez, P.E.
Senior Geotechnical Engineer

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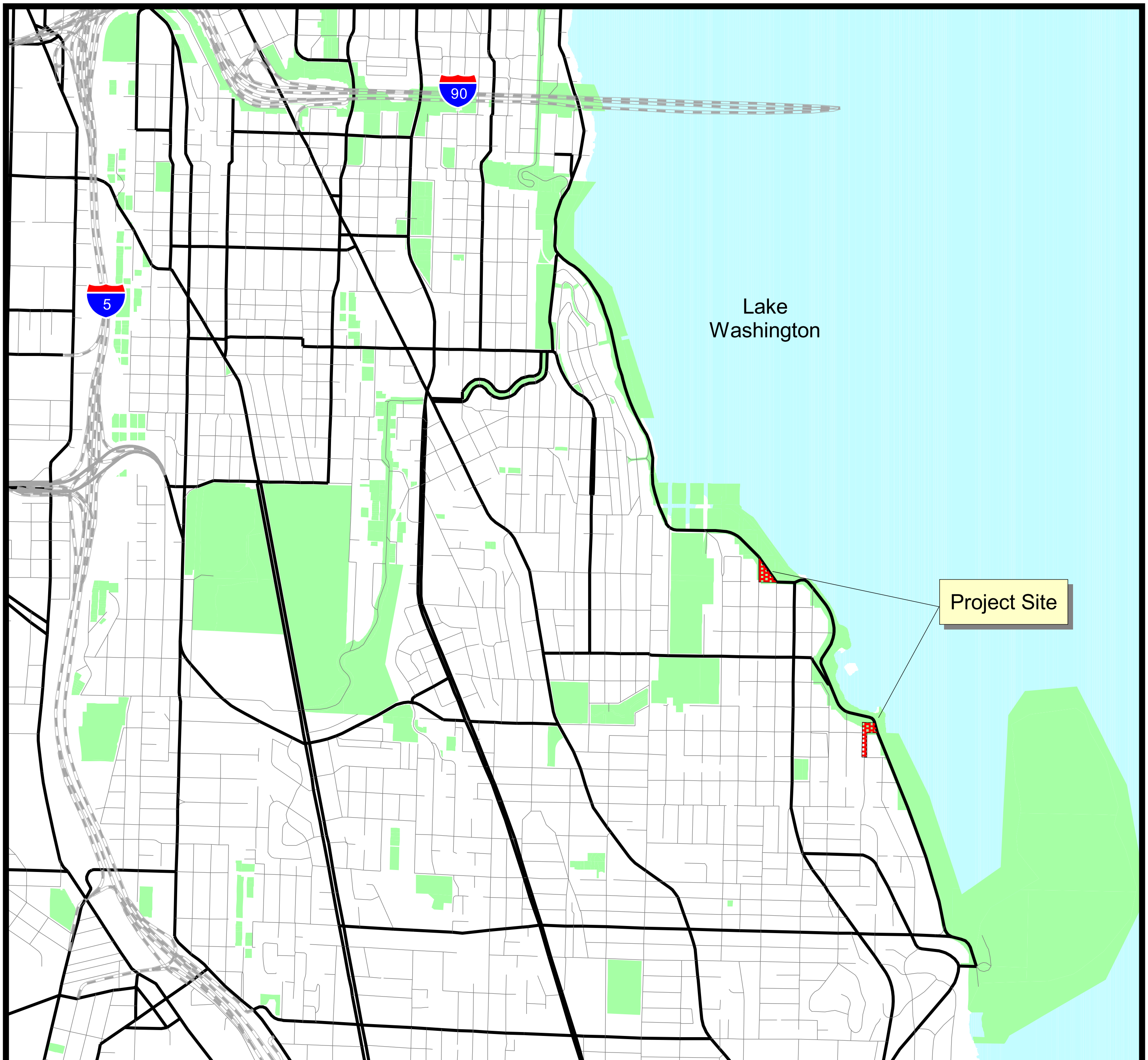

LEGEND

Streets
- Residential
- Arterials
- State Highway
- Interstate Freeway
- Parks
- Water Bodies

N W E S

NAVD88 Datum

0.4 0 0.4 Miles

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GENESEE CSO
SEATTLE, WASHINGTON

VICINITY MAP

AUGUST 2010

FIGURE 1

LEGEND

- SPU Materials Laboratory Boring
- SPU Materials Laboratory Boring with Well
- Previous Boring (SED, 1985)
- Pavement Edge
- 2 foot contours
- LIDAR-derived topography, South (draws at 15000 scale)
- "Environmentally Critical Area, Steep Slope > 40%"
- Possible Construction Impact Area

N
W E
S

NAVD88 Datum

100 0 100 Feet

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SITE & EXPLORATION MAP
ALTERNATIVE OFF-109-43 & ALT IN-103-43

AUGUST 2010

FIGURE 2

LEGEND

- SPU Materials Laboratory Boring
- SPU Materials Laboratory Boring with Well
- Previous Boring (SED, 1985)
- Pavement Edge
- 2 foot contours
- LIDAR-derived topography, South (draws at 15000 scale)
- "Environmentally Critical Area, Steep Slope > 40%"
- Mass Wastage (in review)
- Scarps (in review)
- Possible Construction Impact Area

N
W E
S

NAVD88 Datum

60 0 60 Feet

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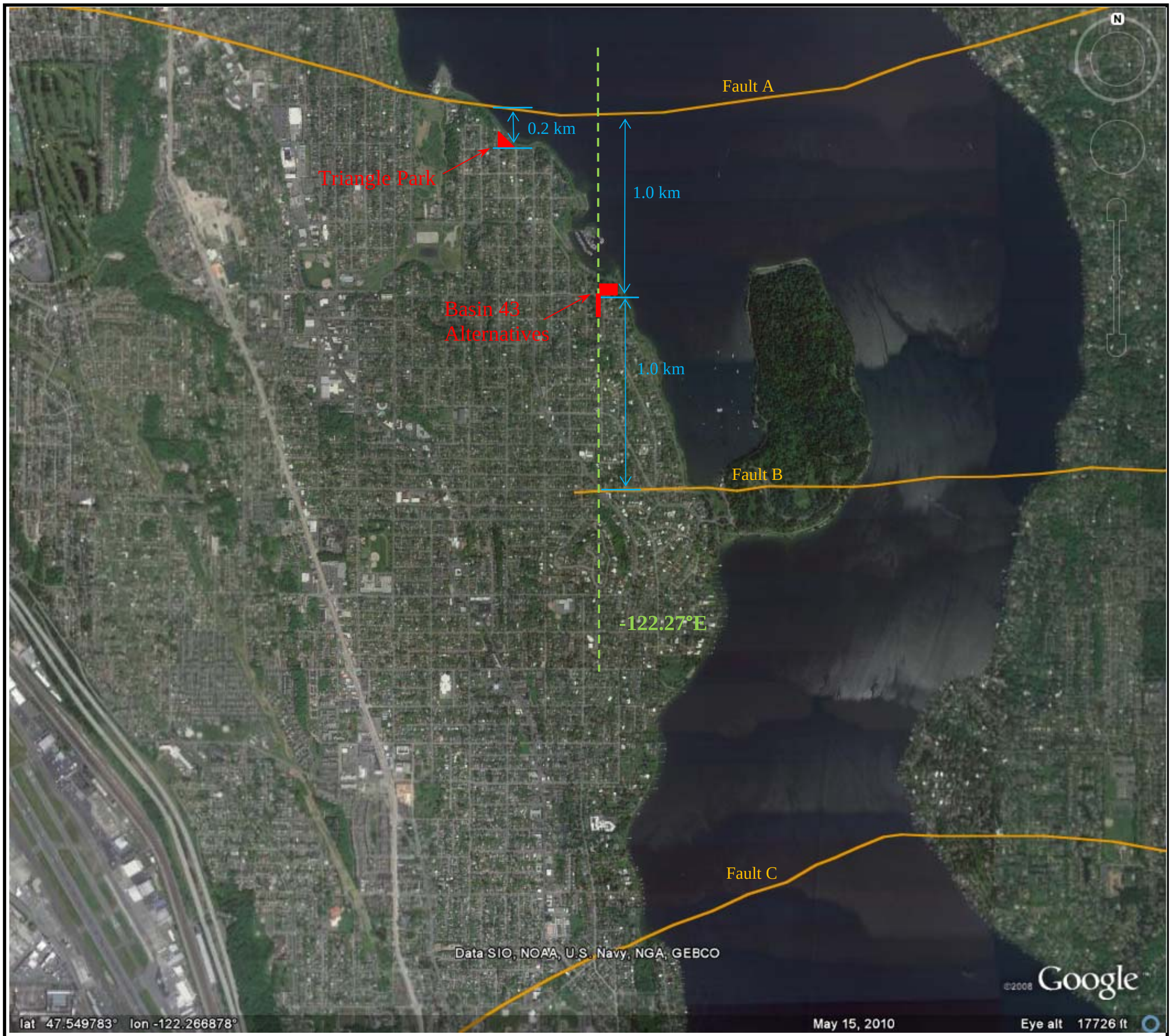
SITE & EXPLORATION MAP

ALTERNATIVE OFF-113-38

AUGUST 2010

FIGURE 3



LEGEND

Approximate Longitude Line

Approximate Distance to Nearest Fault (km)

Locations of CSO Storage Alternatives

Seattle Fault Lines

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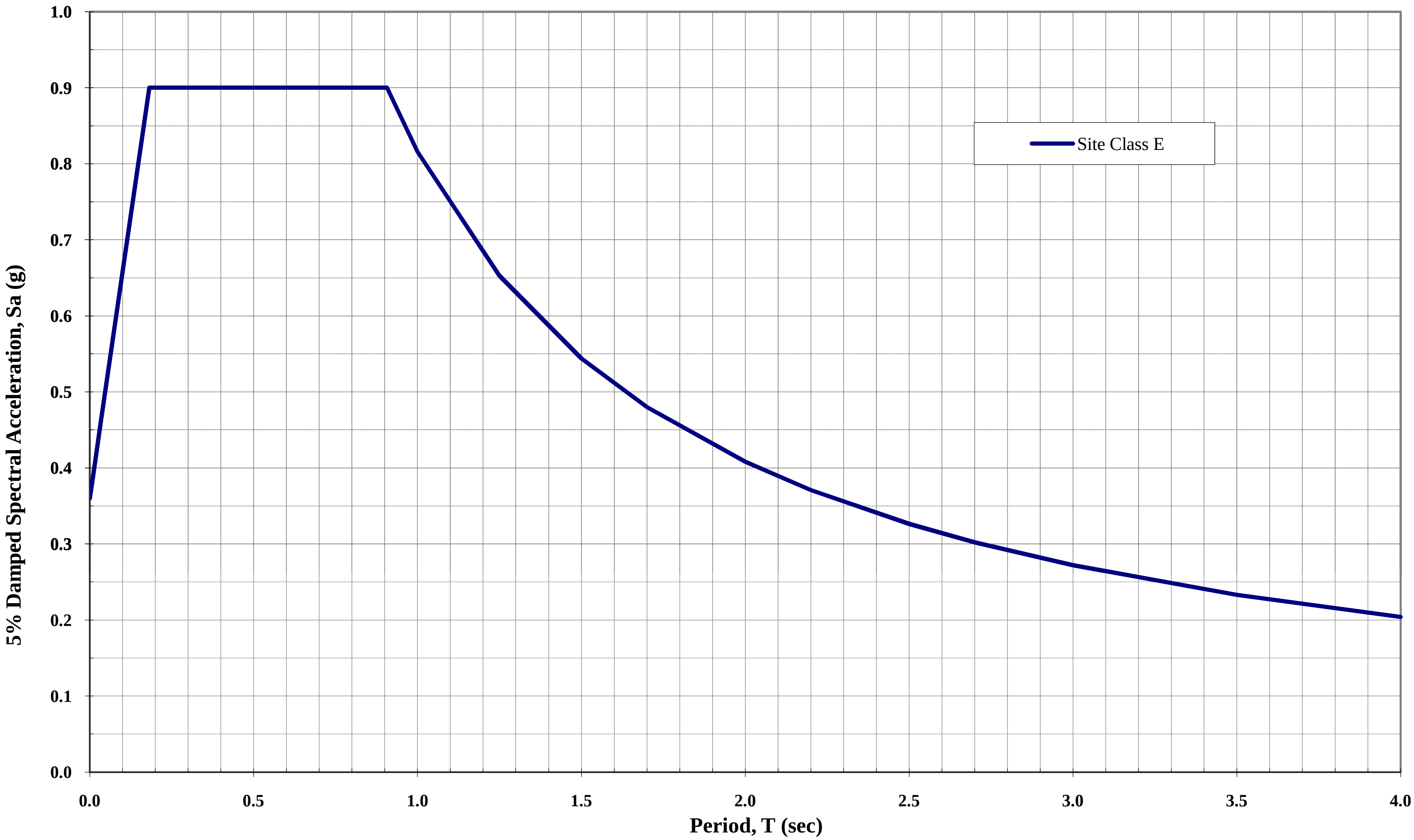
SEATTLE, WASHINGTON

LOCATION OF BASIN 38 & 43 ALTERNATIVES RELATIVE TO FAULTS ON SFZ

AUGUST 2010 **FIGURE 4**



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S_S = 1.50 g
S_1 = 0.51 g
S_{MS} = 1.35 g
S_{M1} = 1.23 g
S_{DS} = 0.90 g
S_{D1} = 0.82 g

F_a = 0.90
F_v = 2.40
T_0 = 0.18 sec.
T_S = 0.91 sec.

Project No: C303103

Horizontal Response Spectrum

Genesee CSO Storage Project

Triangle Park

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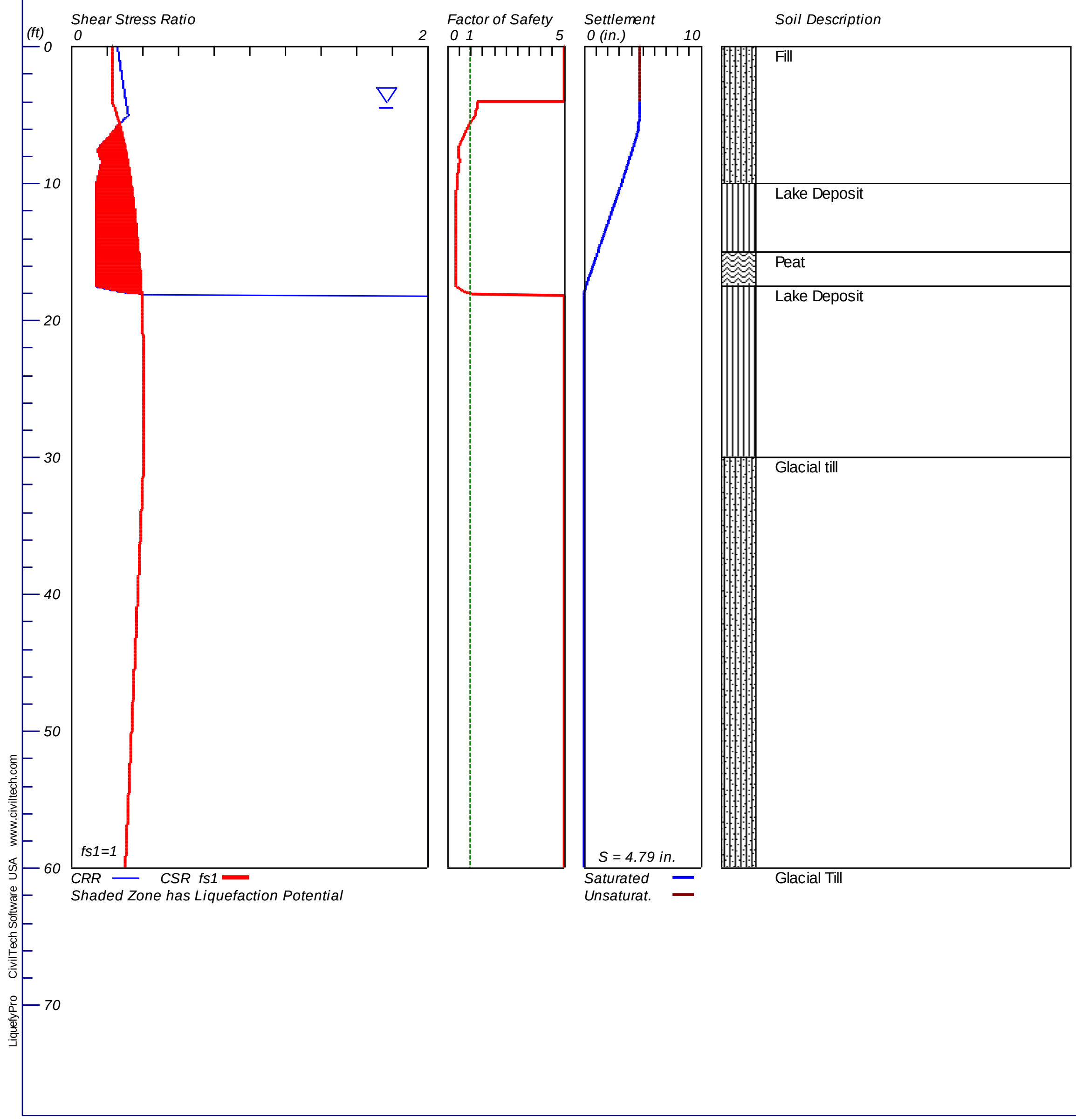
Figure 5

LIQUEFACTION ANALYSIS

Genesee CSO

Hole No.=B-1 Water Depth=4 ft Surface Elev.=28 *Magnitude=7 Acceleration=.36g*



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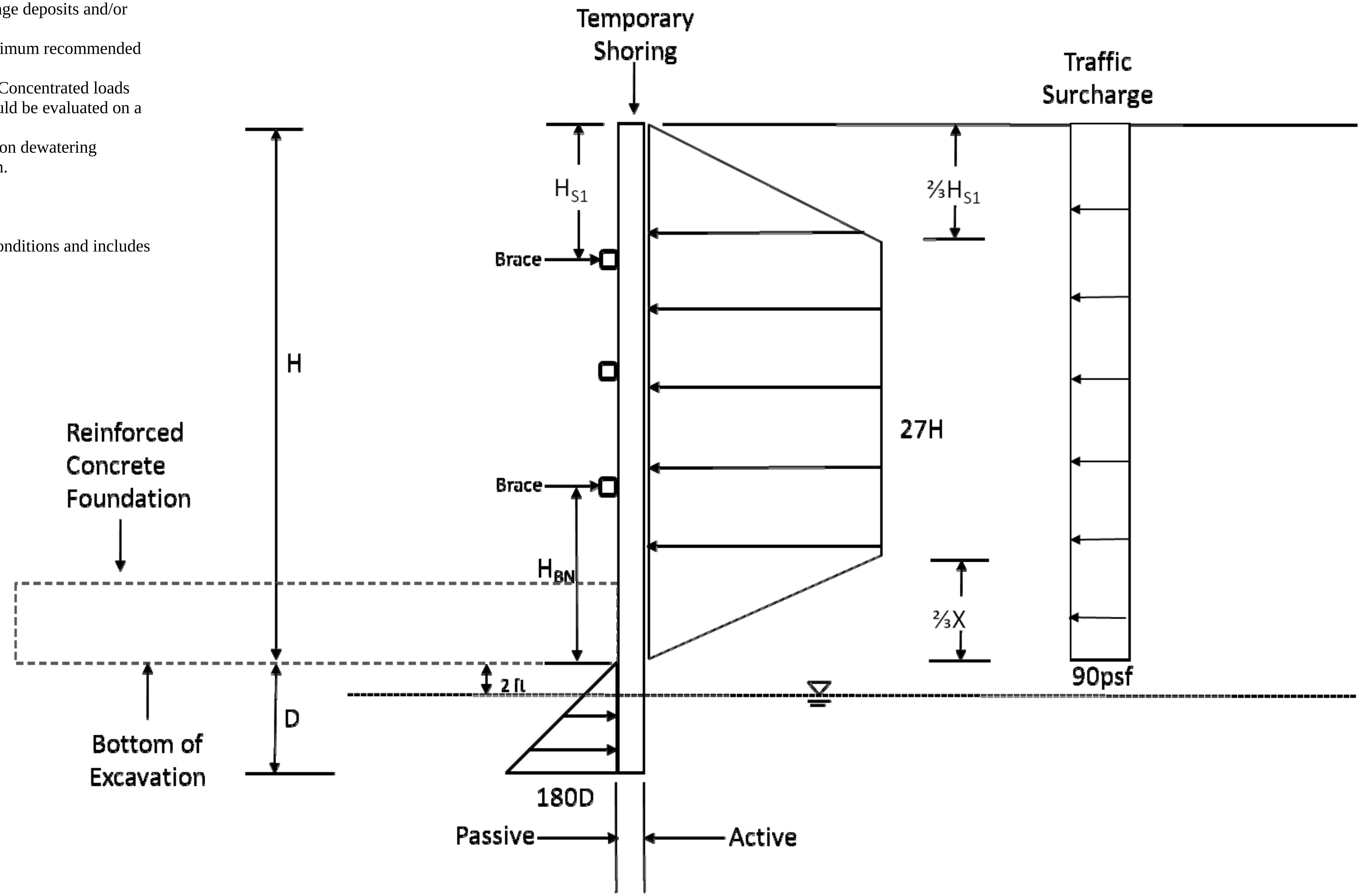
Triangle Park

Figure 6

NOTES:

1) Earth pressures assume an unrestrained internally-braced retaining wall system (active loading condition), which is allowed to yield.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) Wall embedment (D) should consider kickout resistance. Minimum recommended embedment is 5 feet.
5) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
6) Diagram assumes hydrostatic forces as shown, with construction dewatering maintaining groundwater level 2 feet below bottom of excavation.
7) Active pressure shown does not include a factor of safety.
8) $X=H-H_{S1}$ (Single Braced)
9) $X=H_{BN}$ (Multiple Braced)
10) Passive Resistance in front of the wall assumes submerged conditions and includes a factor of safety of 1.5.



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TRIANGLE PARK
GENESEE CSO STORAGE PROJECT
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Not to Scale

RECOMMENDED EARTH PRESSURES FOR TEMPORARY BRACED WALL DESIGN, ACTIVE CONDITION

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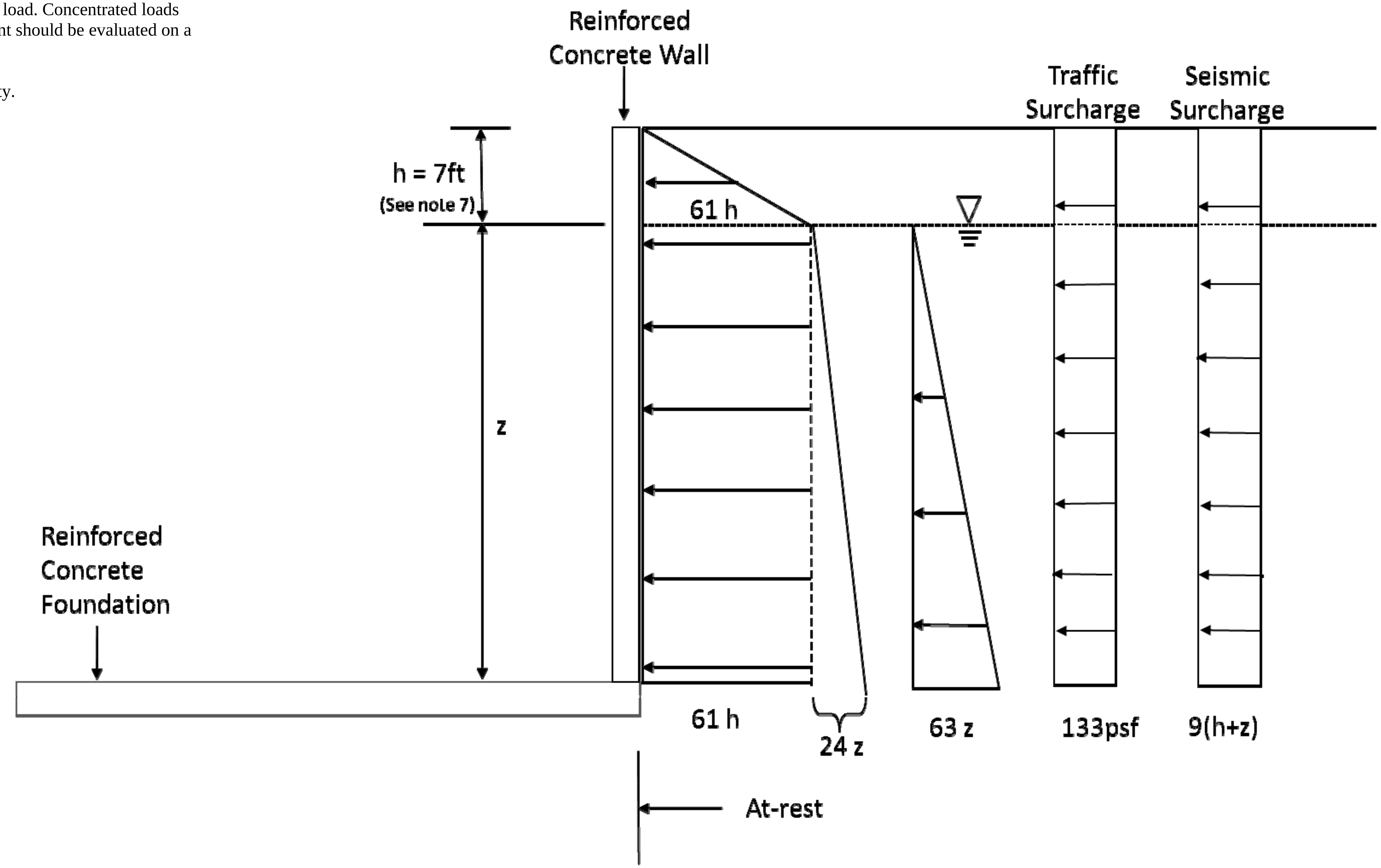
FIGURE 7

NOTES:
1) Earth pressures assume a restrained cantilever retaining wall (at-rest loading condition).
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) h should be measured from existing ground surface.



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RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, AT-REST CONDITION

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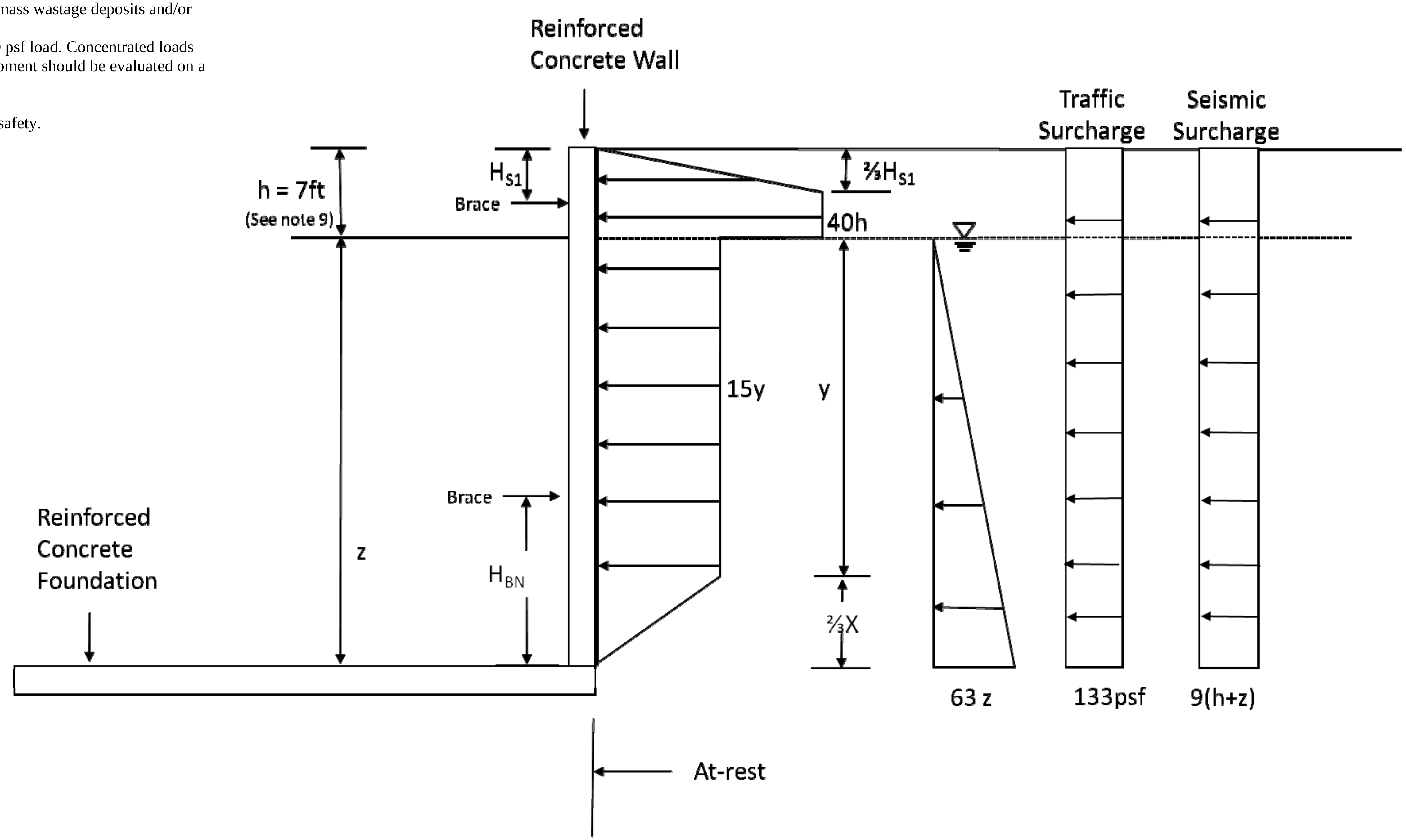
FIGURE 8

NOTES:
1) Earth pressures assume a restrained internally-braced retaining wall system (at-rest loading condition).
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) $X=(h+z)-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) h should be measured from existing ground surface.



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RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, AT-REST CONDITIONS

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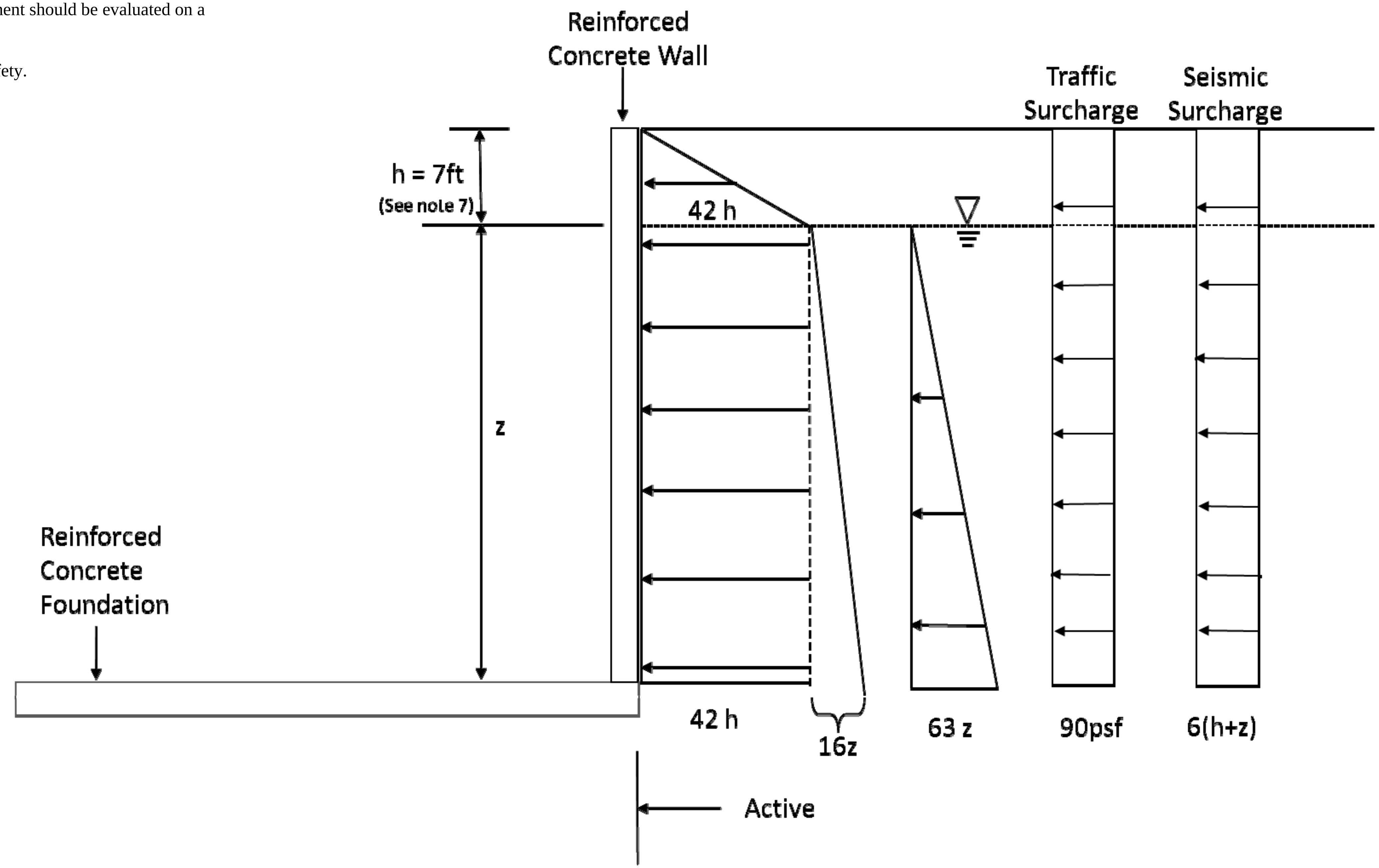
FIGURE 9

NOTES:

1) Earth pressures assume an unrestrained cantilever retaining wall system (active condition), which is allowed to yield.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) h should be measured from existing ground surface.



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RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, ACTIVE CONDITION

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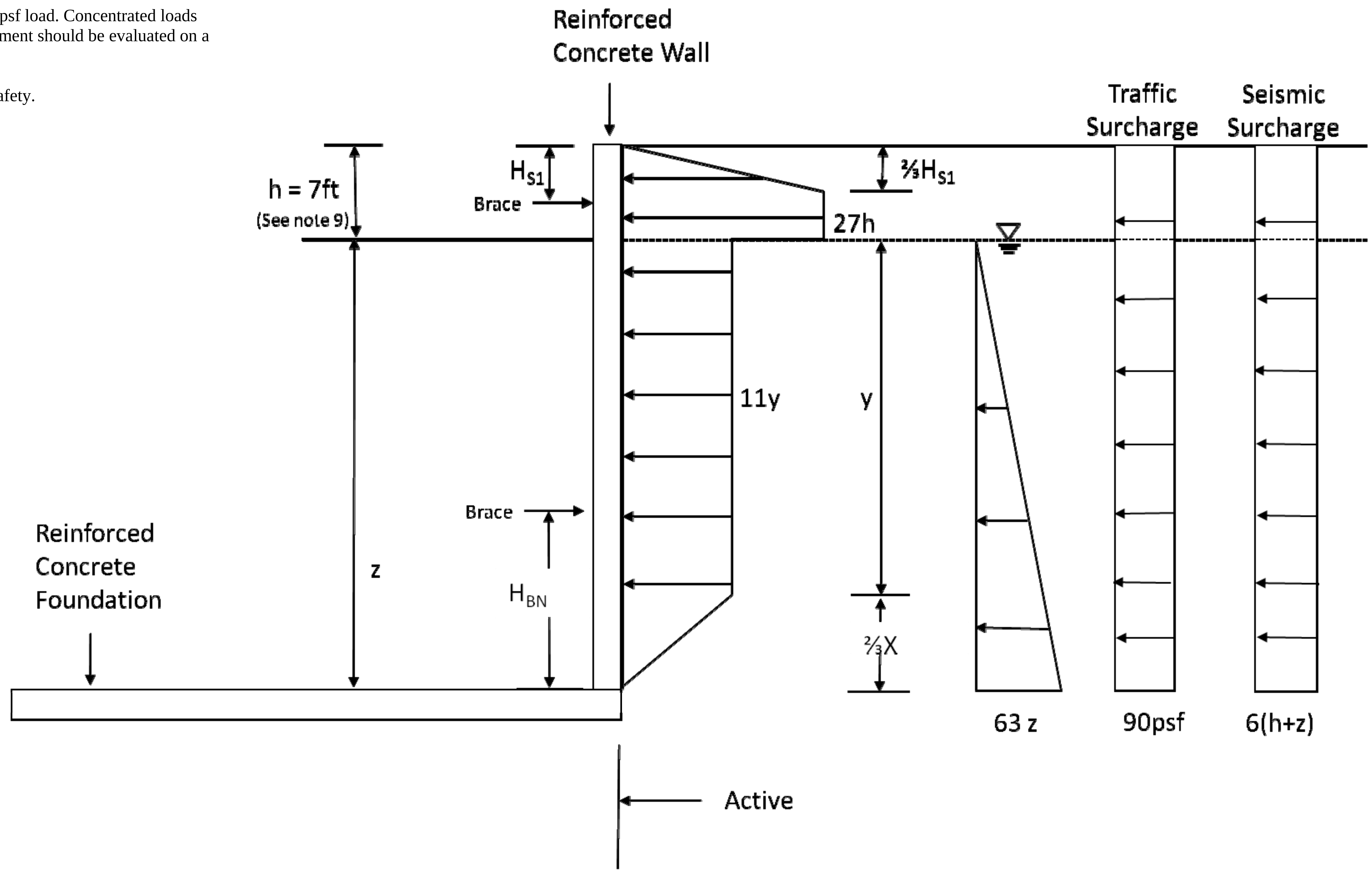
FIGURE 10

NOTES:
1) Earth pressures assume a restrained, internally-braced retaining wall system (active condition), which is allowed to yield.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) $X=(h+z)-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) h should be measured from existing ground surface.



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RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, ACTIVE CONDITION

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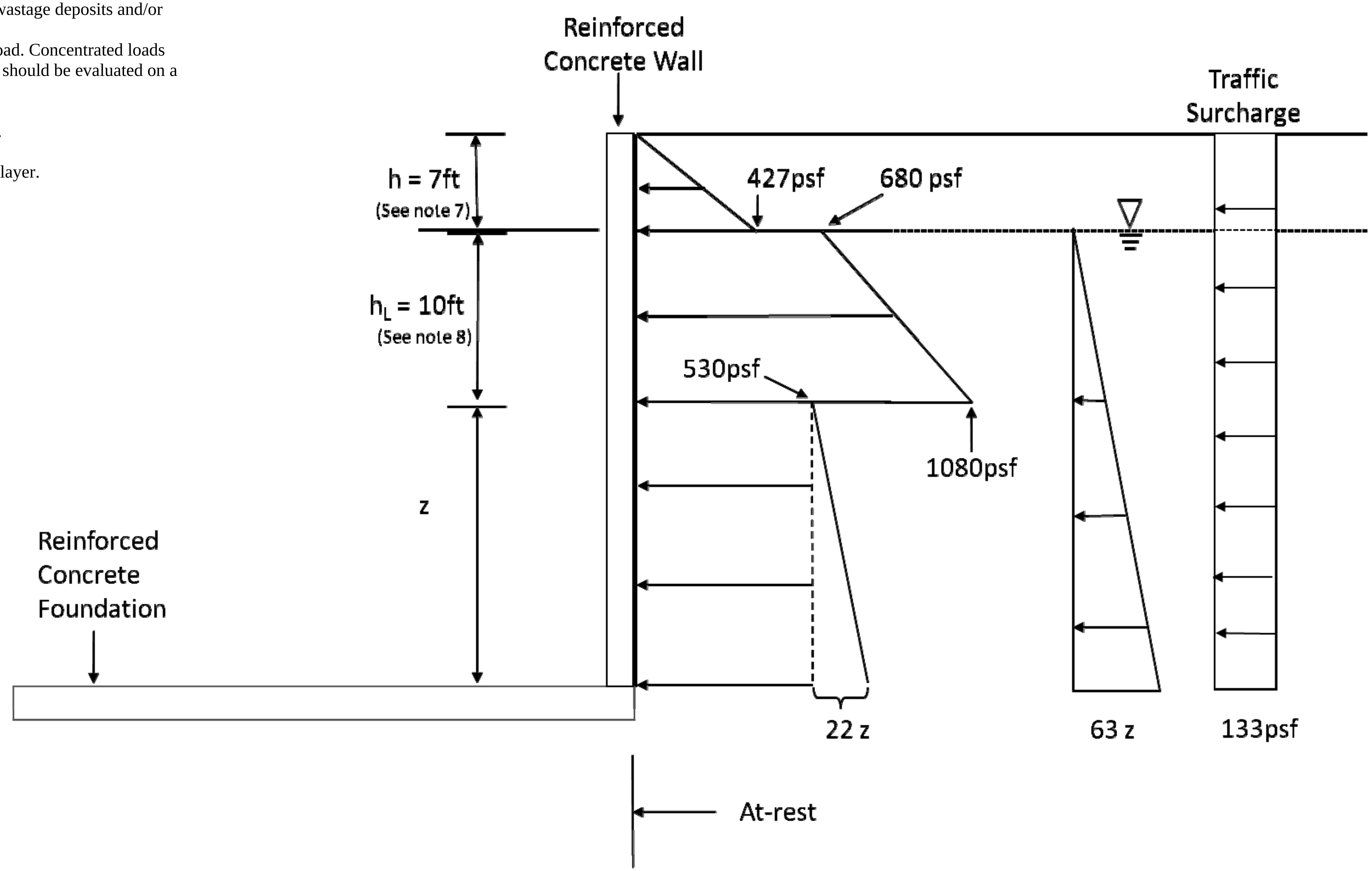
FIGURE 11

NOTES:
1) Earth pressures assume a restrained cantilever retaining wall (at-rest loading condition), under post-seismic (liquefied) conditions.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) h should be measured from existing ground surface.
8) Assumed depth of liquefaction includes softening of Peat layer.



SEATTLE
PUBLIC UTILITIES
MATERIALS LABORATORY

TRIANGLE PARK
GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

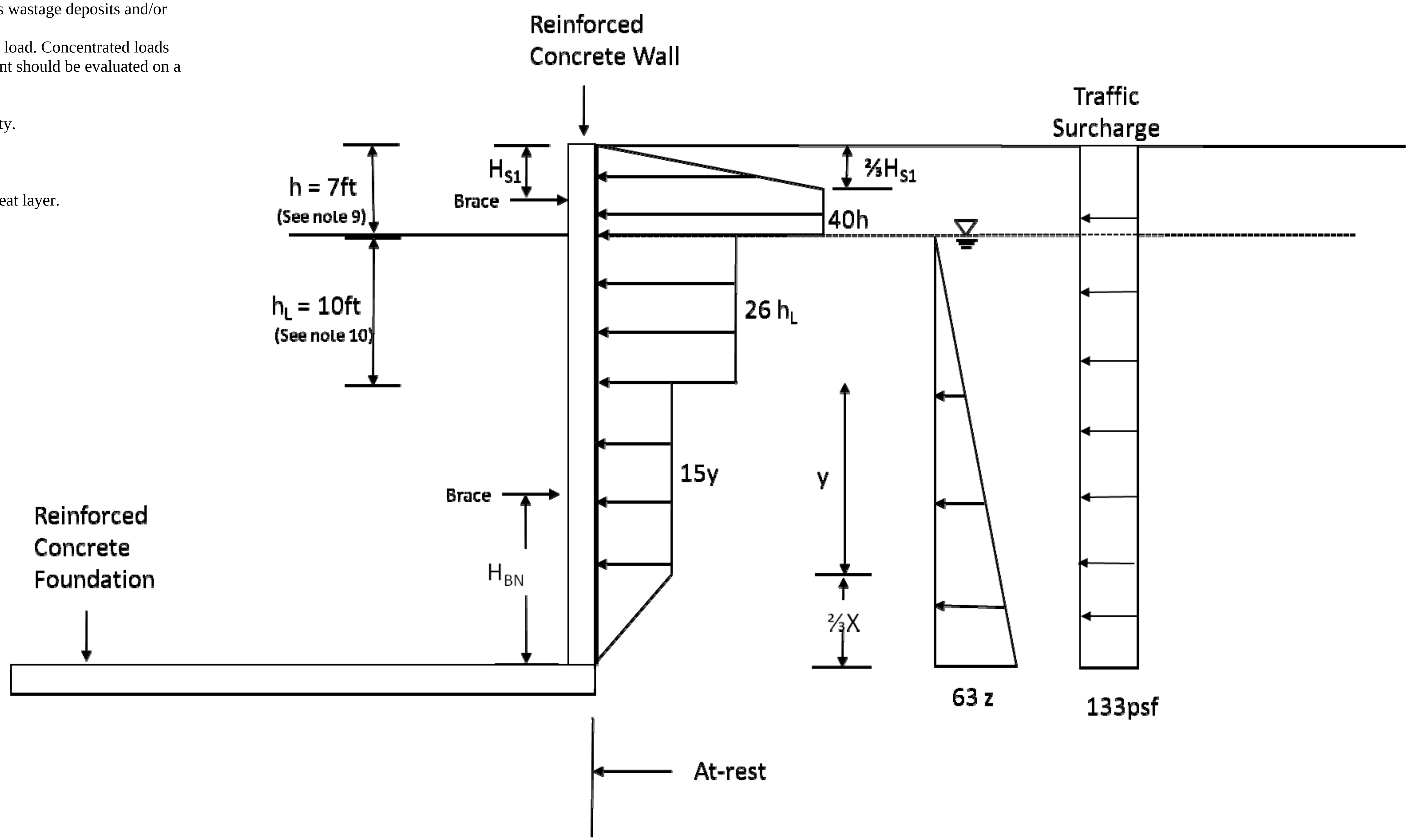
Not to Scale

RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, AT-REST CONDITION, POST-SEISMIC

July 2010

FIGURE 12

NOTES:
1) Earth pressures assume a restrained internally-braced retaining wall system (at-rest loading condition), under post-seismic (liquefied) conditions..
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) $X=(h+h_L+z)-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) h should be measured from existing ground surface.
10) Assumed depth of liquefaction includes softening of Peat layer.



Seattle Public Utilities Materials Laboratory

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GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

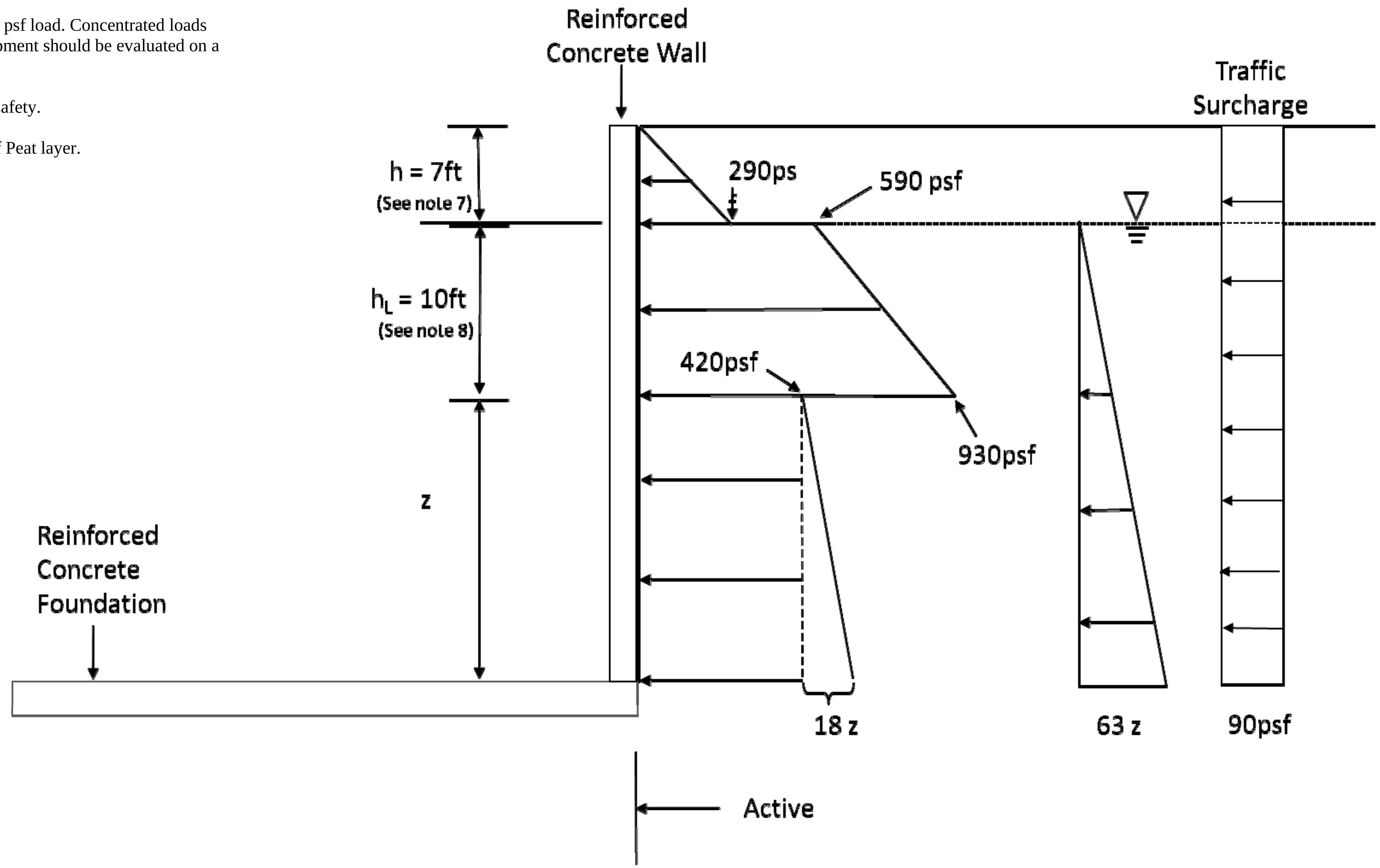
Not to Scale

RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, AT-REST CONDITIONS, POST-SEISMIC

August 2010

FIGURE 13

NOTES:
1) Earth pressures assume an unrestrained cantilever retaining wall system (active condition), which is allowed to yield, under post-seismic (liquefied) conditions.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) h should be measured from existing ground surface.
8) Assumed depth of liquefaction includes softening of Peat layer.



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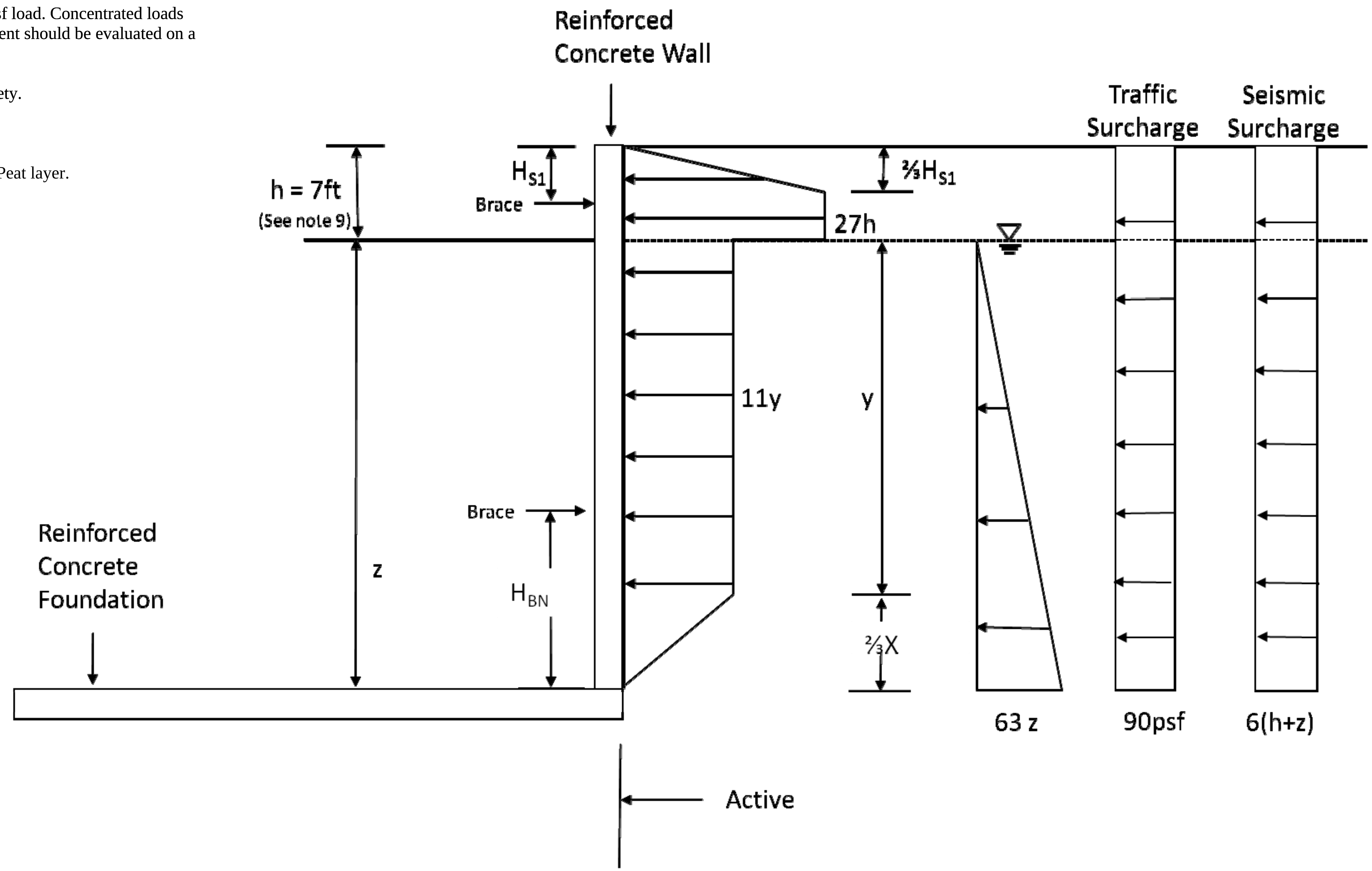
RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, ACTIVE CONDITION, POST-SEISMIC

August 2010

FIGURE 14

NOTES:
1) Earth pressures assume a restrained, internally braced retaining wall system (active condition), which is allowed to yield, under post-seismic (liquefied) conditions.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) $X=(h+z)-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) h should be measured from existing ground surface.
10) Assumed depth of liquefaction includes softening of Peat layer.



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SEATTLE, WASHINGTON

Not to Scale

RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, ACTIVE CONDITION, POST-SEISMIC

August 2010

FIGURE 15

APPENDIX A

PREVIOUS STUDIES

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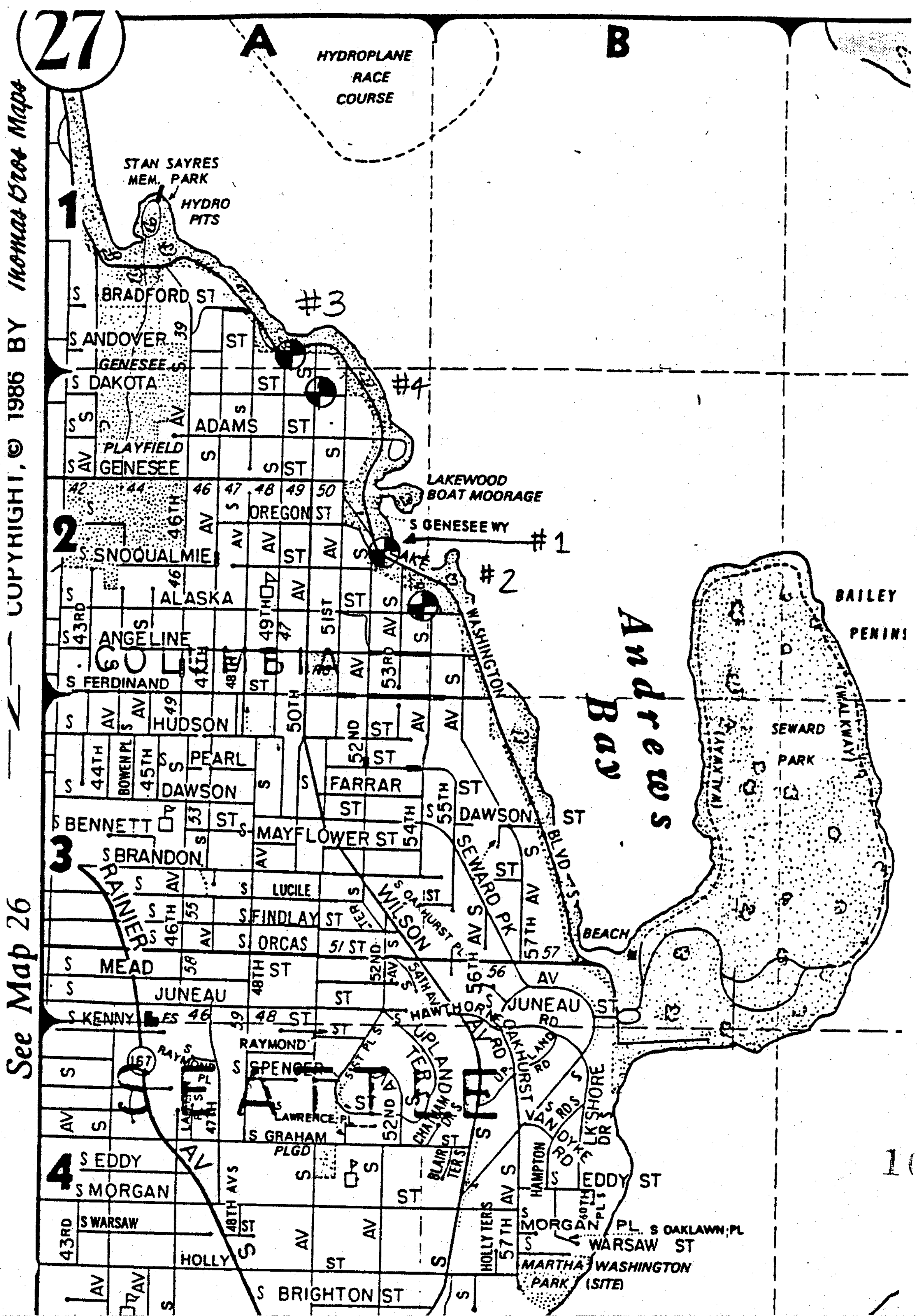
4/4



SEWARD PARK/
MT BAKER
CSO PH I

10656

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE 1-24-85

HOLE NO. 1

PROJECT Seward Pk/MT Baker CSO Ph. I

GRD. ELEV.

LOCATION Lake washington Blvd S. 52nd Ave S. — 25' west ¢ Lk Wash Blvd 125' north ¢ S. Snoqualmie extended

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
							6" ~~Soil~~ 12" top soil				
											3'8" 2-4-85
	5	1	3	5	10	15	mottled very silty sand with some gravel	stiff	Damp	mottled	
~~							Gravels at 8'				WD 8'
	10	2	5	13	20	33	Gravelly silty sand	V. Dense	saturated	Tan	
		3	28	30	33	63	Very silty gravelly sand	"	"	"	
	15	4	17	27	42	69	Same less gravel more sand	"	"	"	
							(Cobbles at 17')				
	20	5	19	53	50/4	100+	Very silty sand with some gravel	V Dense	Damp	Gray	
							(cobbles at 23')				
	25	6	27	33	50	83	slightly silty fine sand	V Dense	wet	Tan	
							interbedded silty gravelly	V Dense	wet	Tan	
	30	7	30	50	/	50+	sand and sandy silt	V stiff	Damp	Gray	
							Bott 29.5'				

(Piezometer installed)

10657

INSPECTOR F Pinney PT Labs

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

CS 7.241

LOG OF TEST BORING

DATE 1-24-85

HOLE NO. 2

PROJECT Seward Pk/Mt Baker CSO Ph I

GRD. ELEV. (50' north ℄ S. Alaska; 40' east ℄ 54th Ave S.)

LOCATION S Alaska & 54th Ave SO

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
							6" Sod 6" top soil				
	5	1	6	9	12	21	Silty clay & clayey silt interbedded with fine sand layers	Stiff	Moist	[illegible]	
	10	2	8	13	50	50+	Interbedded sand and sandy silt	Dense	moist	Tan	
							Gravels at 11'	stiff	moist	Gray	
	15	3	50	—		50+	Gravel, Sand	Dense	Damp	Tan	
			6	—							
							cobbles at 18'				
	20	4	50	—		50+	Rock in end of tube				
			3	—			drilling like cobbles & Gravels				
		5	50	—		50+	Silty Sands & Gravels	V Dense	Damp	Tan	
			3	—							
	25	6	50	—		50+	med grained Sand	V Dense	Damp	Tan	
			6	—							
			36	50		50+	mottled fine & med	V Dense	Damp	Tan &	
	30	7		3			grained Sand			Reddish Br	
							No Free water	Auger left all night no water next day			

10657

INSPECTOR FPinney PTLabs (No piezo Installed)

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE 1-25-85 HOLE NO. 3

PROJECT Seward Park / Mt Baker CSO Ph. I GRD. ELEV.

LOCATION 49th Ave South ; South Andover st. 12' west ℄ 49th Ave S. 60' south ℄ Lk Wash Blvd

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
							8" sod 12" top soil with organics				
	5	1	2	2	4	6	Very silty Sand	[illegible]	[illegible]	Brown	4' 2-4-85
		2	4	3	2	5	Sl. silty, med gr. Sand	loose	wet	Gray	▽ 6' AD
	10	3	4	4	10	14	Sand with wood & silt lenses	[illegible]	[illegible]	[illegible] Brown	
		4	3	4	5	9	Sl. Silty Fine Sand	loose	[illegible]	[illegible]	
	15	5	1	1	1	2	Sandy Silt	soft	wet	[illegible]	
	20	6	1	2	1	3	organic silt, peat	Soft	Damp	Black	
								(piezo Installed)			

10658

INSPECTOR F Rinney
PT Labs

CS 7.241

SEATTLE ENGINEERING DEPARTMENT

MATERIALS LABORATORY

LOG OF TEST BORING

DATE 1-25-85 HOLE NO. 4

PROJECT Seward Park/MT Baker CSO Ph. I GRD. ELEV.

LOCATION S Dakota st & 50th Ave. South. 13' north ¢ S. Dakota 40' west ¢ 50th Ave S.

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
							5" sod, clean sand next 12"				
	5	1	16	40	50/3	50+	Sand, silt or silty	V. Dense	Damp	Gray	
							Sand, some gravel				
							Gravels at 8'				
	10	2	9	25	50/5	50+	same	"	"	"	
							Very hard drilling at 12'				
	15	3	20	35	50/5	50+	Very silty sand or sandy silt (Partially cemented)	"	"	Blue Gray	
							Gravels at 17'				
	20	4	14	29	50	50+	same	"	"	"	
							Gravels at 21'				
	25	5	20	50/4	—	50+	Same	"	"	"	
	30	6	38	50/2	—	50+	same	"	"	"	
				BOH	29'		No Free water				

(No piezo Installed)

INSPECTOR F Pinney PT Labs

10658

APPENDIX B

FIELD EXPLORATION PROGRAM

APPENDIX B

FIELD EXPLORATION PROGRAM

GEOTECHNICAL SOIL BORINGS

Subsurface conditions for the current study were explored using mud rotary and hollow stem auger drilling techniques. Six borings, B-101 through B-106, were completed to depths ranging from 31.5 to 61.5 feet on June 7 through June 10, 2010. The approximate locations of the explorations are illustrated on Figures 2 and 3 in the main body of the text. The explorations were located relative to prominent features in the area. The approximate ground surface elevations at the exploration locations are referenced to the NAVD88 datum.

The borings were drilled by Holocene Drilling, Inc. of Puyallup, Washington, under contract to the SPU Materials Laboratory. A truck-mounted B-59 rig was utilized to drill borings B-101 through B-105. Boring B-106 was drilled using a truck-mounted Diedrich D120. Boring B-101 was drilled using mud rotary drilling techniques. Soils borings B-102 through B-106 utilized 4¼-inch inside diameter (ID) hollow stem augers. The results of the explorations are summarized on the individual summary boring logs, which are included here as Figures B-2 through B-7. A key to the symbols and terms used on the summary logs is presented as Figure B-1.

Soil samples were obtained from all borings at 2.5-foot and 5-foot depth intervals using the Standard Penetration Test (SPT, ASTM D-1586). The 2.0-inch outside diameter (OD) SPT sampler was driven into the soil a distance of 18 inches using a 140-pound auto-trip drive hammer falling a distance of 30 inches. Recorded blows for each 6 inches of sampler penetration (blow counts) are shown on the summary logs in this appendix. The blow counts provide a qualitative measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils. Representative portions of all recovered samples were placed in sealed containers and transported to our laboratory for further observation and testing.

Two-inch diameter Schedule 40 PVC standpipe piezometers were installed in borings B-102, B-104, and B-106 to facilitate measurements of groundwater levels and their fluctuations. The piezometer for boring B-102 was installed with a 15-foot screen section. The piezometers for borings B-104 and B-106 were installed with a 10-foot screen sections. All piezometers were completed with silica sand filter pack, and bentonite seal. Flush mount steel monuments were installed at the surface and secured with concrete. Piezometer construction details are shown on the boring logs. The piezometers were developed by surging and pumping to ensure hydraulic communication between the well screen and the surrounding aquifer. The piezometers should be properly decommissioned in accordance with Washington Administrative Codes (WACs) at the conclusion of the project.

LevelTroll™ pressure transducers were installed in the wells and were programmed to record readings of the groundwater level and associated measurements every hour. Communication with the instruments is achieved via a laptop or Pocket PC and communications cable. The results of our monitoring of these instruments is included in this appendix as Figures B-8 through B-11.

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D2488

MAJOR DIVISION			GROUP SYMBOL	LETTER SYMBOL	GROUP NAME
COARSE GRAINED SOILS CONTAINS LESS THAN 50% FINES	**GRAVEL AND GRAVELLY SOILS** MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVEL WITH ≤ 5% FINES		GW	Well-graded GRAVEL
				GW	Well-graded GRAVEL WITH SAND
				GP	Poorly graded GRAVEL
				GP	Poorly graded GRAVEL WITH SAND
		GRAVEL WITH BETWEEN 5% AND 15% FINES		GW-GM	Well-graded GRAVEL WITH SILT
				GW-GC	Well-graded GRAVEL WITH CLAY
				GP-GM	Poorly graded GRAVEL WITH SILT
				GP-GC	Poorly graded GRAVEL WITH CLAY
		GRAVEL WITH ≥ 15% FINES		GM	SILTY GRAVEL
				GC	CLAYEY GRAVEL
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SAND WITH ≤ 5% FINES		SW	Well-graded SAND
				SW	Well-graded SAND WITH GRAVEL
				SP	Poorly graded SAND
				SP	Poorly graded SAND WITH GRAVEL
		SAND WITH BETWEEN 5% AND 15% FINES		SW-SM	Well-graded SAND WITH SILT
				SW-SC	Well-graded SAND WITH CLAY
				SP-SM	Poorly graded SAND WITH SILT
				SP-SC	Poorly graded SAND WITH CLAY
		SAND WITH ≥ 15% FINES		SM	SILTY SAND
				SC	CLAYEY SAND
FINE GRAINED SOILS CONTAINS MORE THAN 50% FINES	SILT AND CLAY	LIQUID LIMIT LESS THAN 50		ML	Inorganic SILT, low plasticity
				ML	Inorganic SILT WITH SAND, low plasticity
				CL	Lean inorganic CLAY, low plasticity
				CL	Lean inorganic CLAY WITH SAND, low plasticity
				OL	ORGANIC SILT, low plasticity
		LIQUID LIMIT GREATER THAN 50		MH	Elastic inorganic SILT, moderate to high plasticity
				CH	Fat inorganic CLAY, moderate to high plasticity
				OH	ORGANIC SILT or CLAY, moderate to high plasticity
HIGHLY ORGANIC SOILS				PT	PEAT soils with high organic contents
TOPSOIL				TP	TOPSOIL

NOTES:

1) Sample descriptions are based on visual field and laboratory observations using classification methods of ASTM D2488. Where laboratory data are available, classifications are in accordance with ASTM D2487.
2) Solid lines between soil descriptions indicate change in interpreted geologic unit. Dashed lines indicate stratigraphic change within the unit.
3) Fines are material passing the U.S. Std. #200 Sieve.

Seattle Public Utilites Materials Laboratory

FIGURE B-1
(Sheet 1 of 2)

KEY :

SAMPLING METHOD

	2-inch OD SPT Split Spoon Sample with 140-lb hammer falling 30 inches (ASTM D1586).
	No Recovery.
	Shelby Tube Sample (ASTM D1587).
	3-inch OD Split Spoon Sample (California Sampler) with 300-lb hammer falling 30-inches.
	Grab Sample.
	Non Standard (As noted on log).
	Core Run.

LABORATORY TEST

AL	Atterberg Limits
FC	Fines Content
GSD	Grain Size Distribution (Sieve and/or Hydrometer)
ENV	Environmental Testing
SG	Specific Gravity
MD	Moisture Density Relationship
C	Consolidation
UCS	Unconfined Compression Strength
	Hydraulic Conductivity Test
Perm	Pocket Penetrometer
PP	Torvane
TV	Direct Shear
DS	Organic
O	

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No. 4 (4.75 mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

COMPONENT PROPORTIONS

DESCRIPTIVE TERMS	RANGE OF PROPORTION
Trace	Less than 5%
Few	5 - 12%
Some	12 - 30%

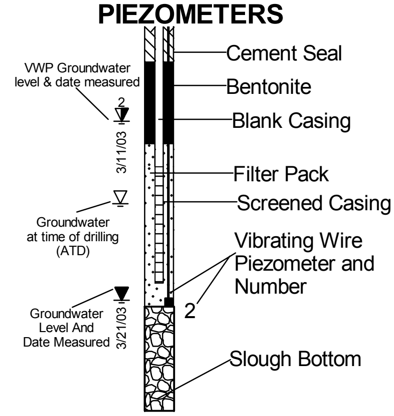
MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch
MOIST	No visible water, near optimum moisture content.
WET	Visible free water,usually soil is below water table.
SATURATED	Water content prevents soil from retaining structure.

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N - VALUE

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

PIEZOMETERS



SOIL STRATIFICATION AND STRUCTURE

STRATA	DESCRIPTION
Parting	Less than 1/16 inch thick
Seam	1/16 to 1/2 inch thick
Layer	1/2 to 12 inch thick
Pockets	Inclusions < 1 inch thick
Occasional	> 1 occurrance per foot
Scattered	> 10 occurrance per foot
Numerous	< 1 per foot

STRUCTURE	DESCRIPTION
Stratified	Alternating layers of varying material or color with layers at least 1/4 inch thick;note thickness
Laminated	Alternating layers of varying material or color with layers less than 1/4 inch thick;note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogenous	Same color throughout
Dilatent	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

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Materials Laboratory

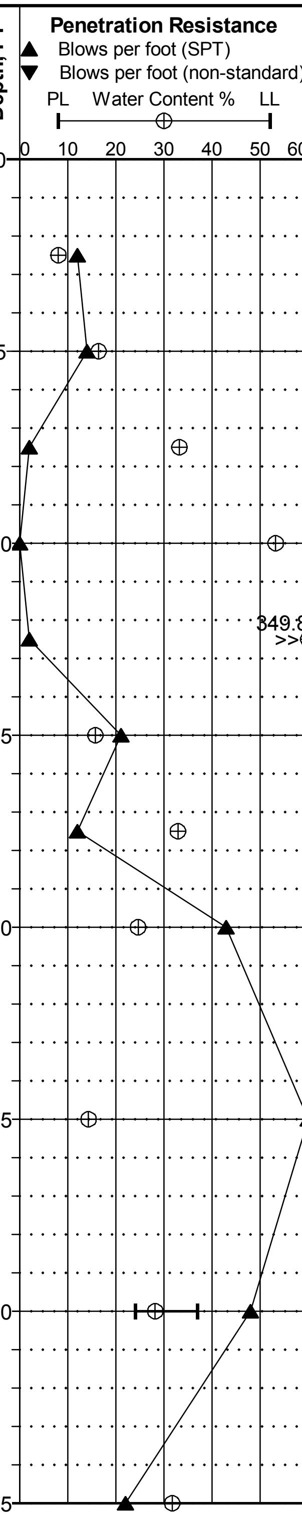
FIGURE B-1
(Sheet 2 of 2)

SOIL DESCRIPTION

Surface Elevation: 28 NAVD88

SOIL DESCRIPTION	USCS	Samples	Blows/6"	Lab tests	Ground Water
Surface is asphalt.					
FILL Medium dense, brown, fine to medium SAND WITH SILT AND GRAVEL, few coarse sand; moist.	SP-SM	1	2,5,7		
Medium dense, brown, fine to medium SAND WITH SILT, trace fine gravel and coarse sand; moist; scattered rust stained pockets, gravels polished.	SP-SM	2	4,6,8		
LAKE DEPOSIT Very soft to soft, gray with tan mottling, SILT, trace fine sand; moist to wet; scattered pockets fine sandy silt and trace gravel, trace brown organics.	ML	3 4	3,1,1 0,0,0		∇
Very soft to soft, brown to dark brown, PEAT; moist; trace wood.	PT	5	1,1,1		
MASS WASTAGE DEPOSIT Medium dense, bluish-gray, SILTY SAND, few gravel; saturated; scattered layers brown silt at top of sample.	SM	6	8,9,12		
Stiff, brown and gray, CLAY, few silt, trace sand; moist; fractured, scattered pockets gray silt with sand.	CL	7	3,4,8		
Hard, gray, SILT, few sand and clay, trace fine gravel; wet; scattered rust stained seams.	ML	8	10,18,25		
Very dense, brown, SILTY fine SAND WITH GRAVEL, few medium to coarse sand; moist; scattered pockets silt.	SM	9	18,25,35	GSD	
Hard, gray, CLAY, few silt, trace sand; moist; numerous red-orange fine sandy silt seams (weathered rock), scattered light gray and rust stained seams. (Driller changes to 4 7/8-inch Mud Rotary bit).	CL	10	9,19,29	AL	
Very stiff, gray, SILT, few clay and sand; moist; numerous rust stained seams, numerous pockets sand.	ML				

Depth, FT: 0, 5, 10, 15, 20, 25, 30, 35



(Continued)

Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 5 7/8 inch Mud Rotary
Hammer System: Automatic

Approximate Location: Triangle Park: 32 feet west of sewer MH, 45 feet south of tree (NE corner of park), 13 feet west of curb. (N: 210549 E: 1285069)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-101

C303103 Z1626 MG1 **FIGURE B-2**

Logged by: AJC Reviewed by: CAN

SOIL DESCRIPTION

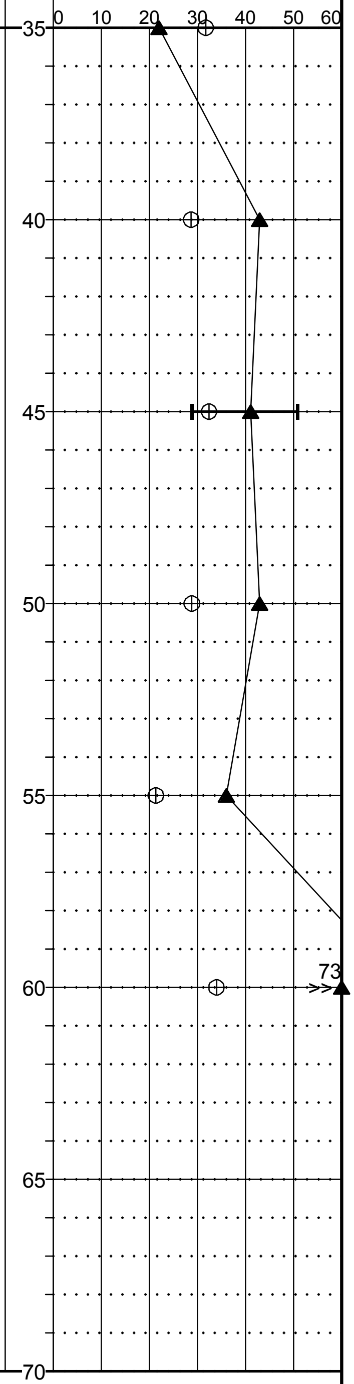
Surface Elevation: 28 NAVD88

Soil Description	USCS	Sample	Blows/6"	Lab tests
(35–38 ft)		11	4,5,17	
PRE-FRASER DEPOSIT Hard, gray, SILT, few clay and sand; moist; scattered partings light gray silt.	ML	12	9,18,25	
Hard, gray, elastic SILT, few clay; moist; scattered pockets fine sand.	MH	13	12,16,25	AL
		14	10,13,30	
Hard, gray, SILT WITH fine to medium SAND, trace coarse sand and fine gravel; moist.	ML	15	12,15,21	
Hard, gray, SILTY fine to medium SAND, trace coarse sand and fine gravel; moist; scattered pockets green silt, few organics (wood, charred wood, matter).	SM	16	20,30,43	GSD

Boring completed at 61.5 feet below ground surface (bgs). Groundwater encountered at 15 feet bgs. Boring backfilled with bentonite chips.

Depth, FT: 35 – 70

Penetration Resistance
▲ Blows per foot (SPT)
▼ Blows per foot (non-standard)
PL Water Content % LL



Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 5 7/8 inch Mud Rotary
Hammer System: Automatic

Approximate Location: Triangle Park: 32 feet west of sewer MH, 45 feet south of tree (NE corner of park), 13 feet west of curb. (N: 210549 E: 1285069)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-101

C303103 Z1626 MG1 **FIGURE B-2**

Logged by: AJC Reviewed by: CAN

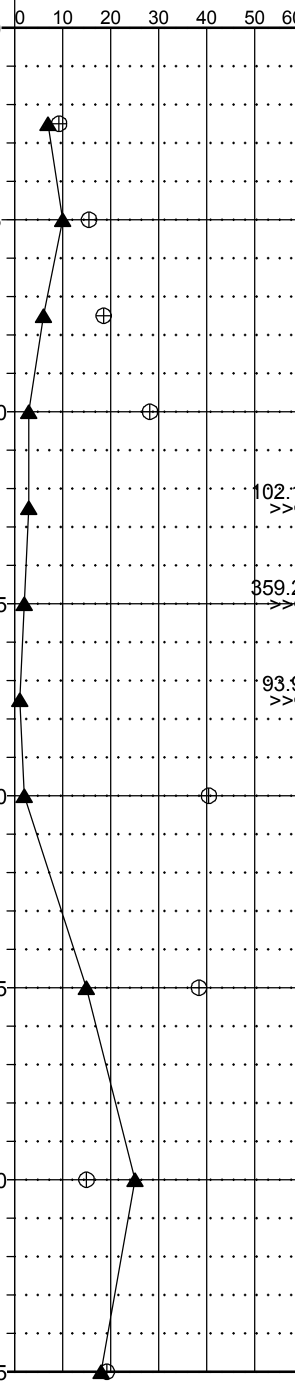
SOIL DESCRIPTION

Surface Elevation: 26 NAVD88

Depth, FT	Soil Description	USCS	Samples	Blows/6"	Lab tests
0	Surface is Asphalt.				
	FILL Loose, brown, fine to medium SAND WITH SILT, trace coarse sand, few fine gravel; moist; scattered pockets silt.	SP-SM	1	3,3,4	
5	Becomes loose to medium dense, no gravel, decreased coarse sand, no pockets silt.		2	3,5,5	
	Numerous pockets brown silt, wet, trace organics (wood, reeds).		3	2,1,5	
10	**LAKE DEPOSIT** Very loose, brown, SILTY fine to medium SAND, trace coarse sand; wet; trace organics.	SM	4	1,2,1	
	Soft, dark brown, SILT WITH fine to medium SAND; moist to wet; few organics (wood).	ML	5	2,1,2	GSD
15	Very soft to soft, brown, PEAT; moist; scattered pockets silt.	PT	6	0,0,2	
	Very soft, tan and dark brown, SILT; moist; few organics (wood, reeds).	ML	7	0,0,1	
20	Very soft to soft, brown and gray, fine SANDY SILT, trace medium to coarse sand and fine gravel; moist to wet; scattered pockets brown silt, trace organics. (Driller notes change in drilling at 23.0 feet below ground surface).	ML	8	0,0,2	
25	**MASS WASTAGE DEPOSIT** Stiff to very stiff, bluish gray and tan, CLAY, few silt; moist; numerous pockets fine sand, occasional rust staining.	CL	9	4,5,10	
30	Medium dense, brown with gray mottling, SILTY fine to medium SAND WITH GRAVEL, few coarse sand; moist; trace organics, numerous rust stained pockets, numerous pockets silt.	SM	10	4,8,17	GSD
35					

Ground Water: ATD

Penetration Resistance
▲ Blows per foot (SPT)
▼ Blows per foot (non-standard)
PL Water Content % LL



(Continued)

Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: Triangle Park: 45 feet north of sewer drain, 64 feet north of light pole, 12 feet west of curb. (N: 210436 E: 1285143)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-102

C303103 Z1626 MG1 **FIGURE B-3**

Logged by: AJC Reviewed by: CAN

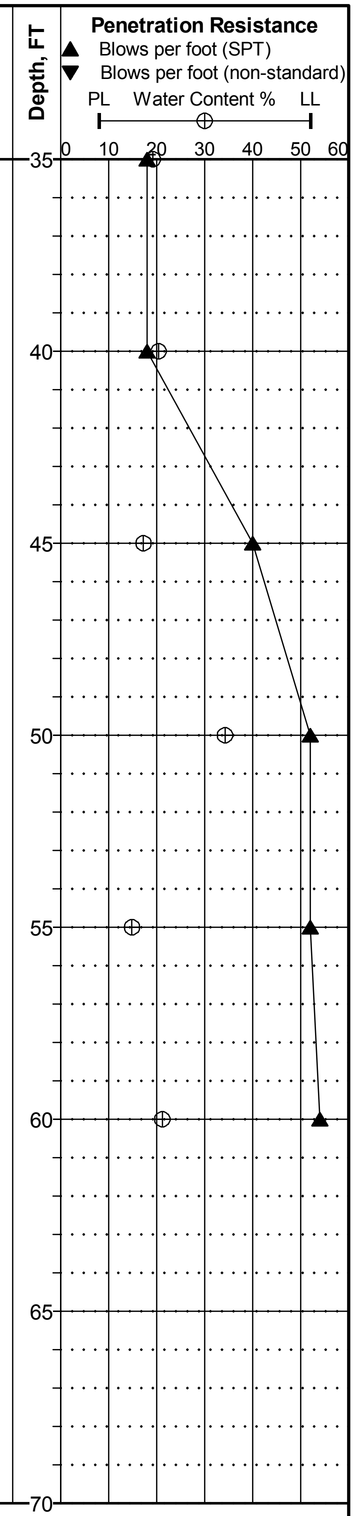
SOIL DESCRIPTION

Surface Elevation: 26 NAVD88

Depth, FT	Soil Description	USCS	Samples	Blows/6"	Lab tests
35	Becomes brown, wet, increased silt, few clay, no rust staining, no organics.		11	5,7,11	
	Very stiff, gray, fine SANDY SILT, trace medium to coarse sand and fine gravel; moist to wet; scattered green stained pockets and wet sand seams. (Driller notes water at 40 feet bgs).	ML	12	7,9,9	
	PRE-FRASER DEPOSIT Hard, gray, SILT, few sand; moist; numerous pockets fine sand, 6-inch layer silty sand with trace fine gravel at 46-46.5 bgs.	ML	13	14,15,25	
50	Becomes brown, numerous gray layers, scattered pockets brown silt, near horizontal bedding, trace organics (wood).	ML	14	12,18,34	GSD
	Very dense, gray, SILTY fine to medium SAND, trace coarse sand and fine gravel; moist; trace organics (wood).	SM	15	17,24,28	
	Hard, gray, SILT, trace sand; moist; numerous wet pockets/layers fine to medium sand, trace organics.	ML	16	17,24,30	

Boring completed at 61.5 feet below ground surface (bgs). Groundwater encountered at 7 feet bgs. Piezometer installed and screened between 10 and 25 feet bgs. Well tag No. BBR390.

Penetration Resistance



Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: Triangle Park: 45 feet north of sewer drain, 64 feet north of light pole, 12 feet west of curb. (N: 210436 E: 1285143)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-102

C303103 Z1626 MG1

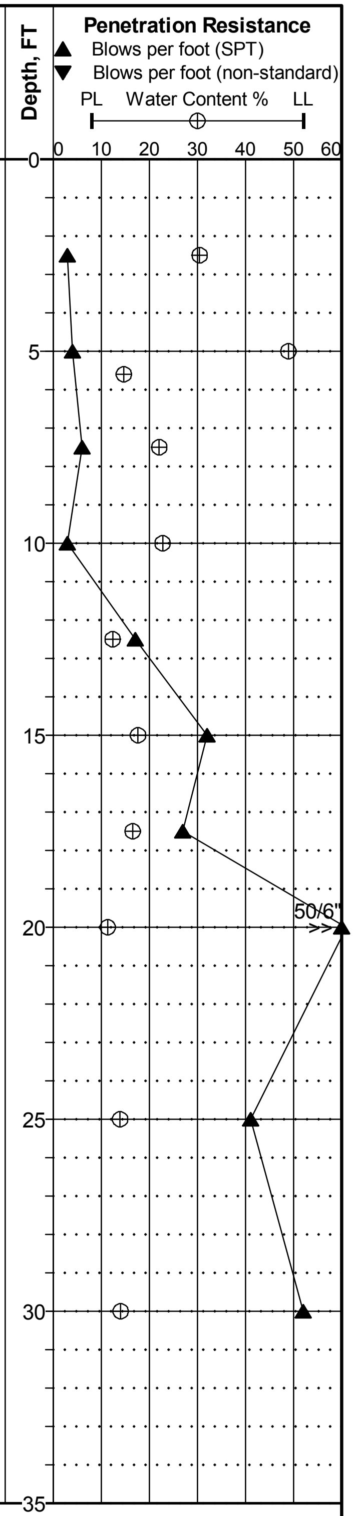
FIGURE B-3

Logged by: AJC Reviewed by: CAN

SOIL DESCRIPTION

Surface Elevation: 29 NAVD88

Soil Description	Depth, FT	USCS	Samples	Blows/6"	Lab tests	Ground Water
Surface is grass. Cuttings are dark brown sandy silt.	0					
LAKE DEPOSIT Soft, tan with dark brown pockets, SILT; moist; trace organics (roots).		ML	1	1,2,1		
Becomes soft to medium stiff, increased organics (roots, matter, charred wood).	5	SP-SM	2a 2b	1,1,3		
Very loose to loose, brown, fine to medium SAND WITH SILT, trace coarse sand and fine gravel; moist. Becomes loose, saturated, no gravel.			3	0,2,4		▽
Increased silt, few coarse sand, trace organics. Dark brown PEAT layer between 10.8 to 11.1.	10		4	1,0,3		
MASS WASTAGE DEPOSIT Medium dense, brown mottled gray, SILTY fine to medium SAND, few coarse sand, trace fine gravel; wet to saturated; scattered rust stained seams.		SM	5	4,5,12		
Dense, brown, SILTY SAND WITH GRAVEL; saturated.	15	SM	6	7,11,21	GSD	
Becomes medium dense, wet, decreased coarse sand and gravel.			7	11,14,13		
Hard, brown, fine to medium SANDY SILT, trace coarse sand and fine gravel; moist; scattered partings light gray silt.	20	ML	8	7,25,50/6"		
With numerous rust stained pockets/seams, grades to silt at tip.	25		9	18,18,23	GSD	
Decreased rust stained pockets/seams, scattered pockets gray sandy silt.	30		10	8,17,35		
Boring completed at 31.5 feet below ground surface (bgs). Groundwater encountered at 7.5 feet bgs. Boring backfilled with bentonite chips.	35					



Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: Triangle Park: 17 feet west of nearest curb, 60 feet east of sewer MH (MH in trees), 27 feet north of tree (SW corner of site). (N: 210412 E: 1285079)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-103

C303103 Z1626 MG1 FIGURE B-4

Logged by: AJC Reviewed by: CAN

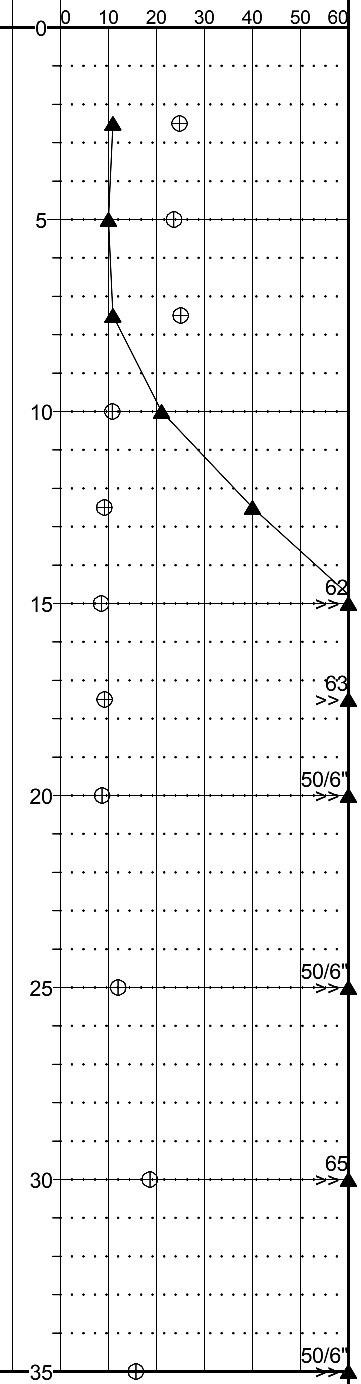
SOIL DESCRIPTION

Surface Elevation: 52 NAVD88

Depth, FT	Soil Description	USCS	Sample	Blows/6"	Lab tests
0	Surface is grass.				
	FILL Stiff, tan, SILT, trace fine to medium sand and clay; moist; numerous rust stained seams.	ML	1	3,4,7	
5			2	3,4,6	
	Stiff, tan, CLAY, few sand, trace fine gravel; moist; scattered rust stained seams, scattered pockets fine sand.	CL	3	2,5,6	
10	**GLACIAL TILL** Medium dense, brown, SILTY fine to medium SAND, trace coarse sand and gravel; dry to moist; scattered pockets medium to coarse sand.	SM	4	5,8,13	
	Becomes dense, moist.		5	13,10,30	
15	Becomes very dense, no pockets sand, no gravel, decreased silt, rust stained.		6	14,25,37	
	Becomes very dense, trace medium sand, dry to moist.		7	20,24,39	GSD
20			8	17,36,50/6"	
25	Becomes moist, increased medium to coarse sand and fine gravel, rust mottled.		9	19,50/6"	
30	Becomes wet, scattered pockets gray silt.		10	17,30,35	GSD
35					

Ground Water: ATD.

Penetration Resistance
▲ Blows per foot (SPT)
▼ Blows per foot (non-standard)
PL Water Content % LL



(Continued)

Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: 54th & Alaska (grass area): 48.5 feet north of curb, 100 feet east of power pole. (N: 207842 E: 1286867)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-104

C303103 Z1626 MG1 **FIGURE B-5**

Logged by: AJC Reviewed by: CAN

SOIL DESCRIPTION

Surface Elevation: 52 NAVD88

SOIL DESCRIPTION	Depth, FT	Symbol	USCS	Samples	Blows/6"	Lab tests	Ground Water	Depth, FT	Penetration Resistance ▲ Blows per foot (SPT) ▼ Blows per foot (non-standard) PL Water Content % LL (0 10 20 30 40 50 60)
With scattered rust stained pockets, trace fine gravel.	35			11	24,50/6"			35	
Boring completed at 36.5 feet below ground surface (bgs). Groundwater encountered at 30 feet bgs. Piezometer installed and screened between 25 and 35 feet bgs. Well tag No. BBR391.	40							40	
	45							45	
	50							50	
	55							55	
	60							60	
	65							65	
	70							70	

Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: 54th & Alaska (grass area): 48.5 feet north of curb, 100 feet east of power pole. (N: 207842 E: 1286867)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-104

C303103 Z1626 MG1 **FIGURE B-5**

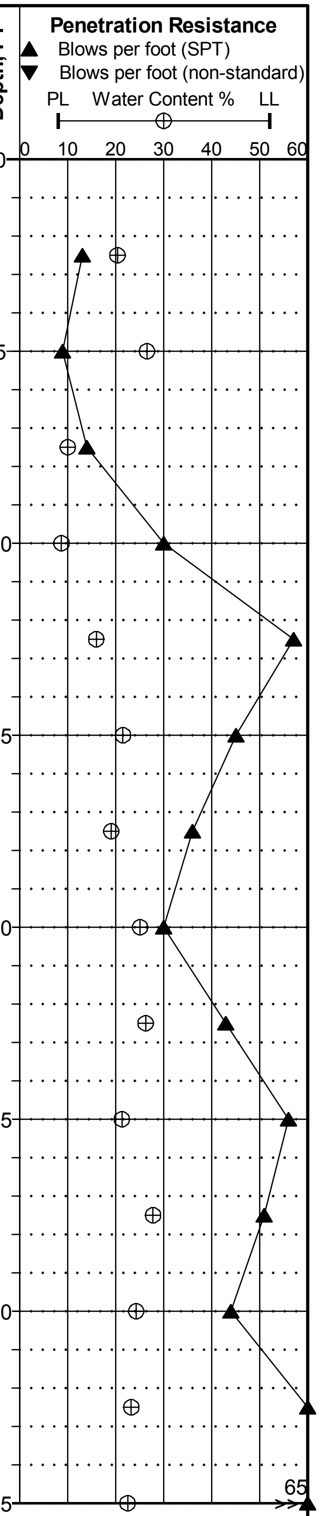
Logged by: AJC Reviewed by: CAN

SOIL DESCRIPTION

Surface Elevation: 59 NAVD88

Depth, FT	Soil Description	USCS	Sample	Blows/6"	Lab tests
0	Surface is concrete (6-inches).				
	FILL Stiff, brown, SILT, few sand, trace fine gravel; moist to wet.	ML	1	5,6,7	
5	Decreased sand, numerous layers of fine sand, scattered rust halos around grains, trace organics, scattered pockets sand (completely weathered gravels).		2	3,3,6	
	RECESSIONAL LACUSTRINE Medium dense, brown, fine SAND, trace medium to coarse sand, silt and fine gravel; dry to moist; scattered pockets brown fractured silt.	SP	3	6,5,9	
10	Becomes medium dense to dense, no coarse sand or gravel, no pockets of silt.		4	5,12,18	
	Very dense, brown, SILTY fine SAND; moist; numerous rust stained seams and pockets, occasional organics.	SM	5	16,21,36	
15	Becomes dense, decreased rust staining, no organics.		6	7,18,27	
			7	12,12,24	
20	Very stiff to hard, tan, SILT, trace fine sand; moist; numerous rust stained seams.	ML	8	9,12,18	GSD
	Becomes hard, scattered pockets of fine sand.		9	9,18,25	
25	Increased rust staining, sand pockets are rust stained, occasional organics.		10	19,24,32	
	Becomes gray, numerous partings light gray fine sand.		11	10,19,32	GSD
	Very dense, brown, SILTY SAND; moist; rust staining throughout, scattered seams and layers of silt.	SM			
30	Becomes dense, increased fine sand, numerous rust stained seams.		12	9,17,27	
	Hard, brown, SILT, few sand; moist; numerous rust stained seams, scattered pockets fine to medium sand, trace organics.	ML	13	12,20,40	
35					

Ground Water



(Continued)

Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: 54th near Alaska: 278 feet north of hydrant (54th & Angeline), 25 feet north of nearest water service, 6.5 feet west of curb. (N: 207686 E: 1286793)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-105

C303103 Z1626 MG1

FIGURE B-6

Logged by: AJC　Reviewed by: CAN

SOIL DESCRIPTION

Surface Elevation: 59 NAVD88

Depth, FT	Soil Description	USCS	Samples	Blows/6"
35	Increased pockets fine to medium sand (rust staining around sand), trace fine gravel.		14	5,18,47
	Scattered rust staining, decreased pockets of sand, few fine sand and mica flecks in silt matrix.		15	13,17,23
40	Dense, brown, SILTY fine SAND, few medium to coarse sand, trace fine gravel; moist; scattered rust stained seams, scattered pockets of gray and tan silt.	SM	16	7,13,23
	Boring completed at 41.5 feet below ground surface (bgs). No groundwater encountered. Boring backfilled with bentonite chips.			

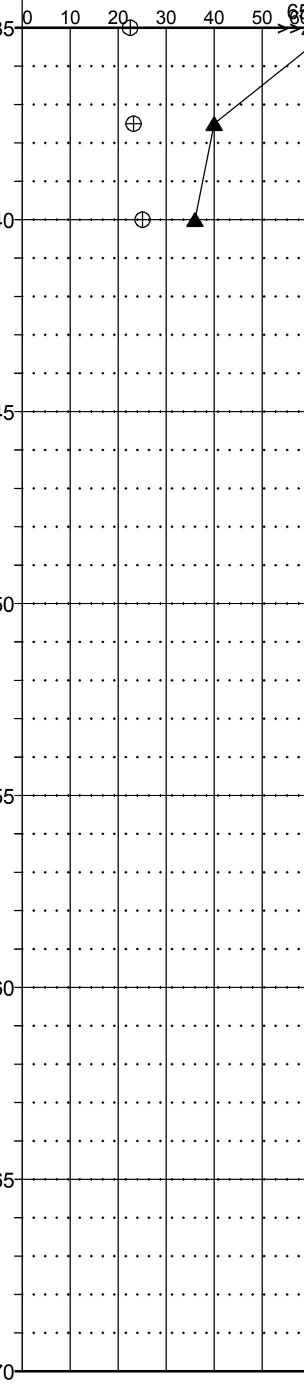
Columns: Depth, FT; Symbol; USCS; Samples; Blows/6"; Lab tests; Ground Water; Depth, FT (35–70)

Penetration Resistance

▲ Blows per foot (SPT)

▼ Blows per foot (non-standard)

PL Water Content % LL



Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted B59
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: 54th near Alaska: 278 feet north of hydrant (54th & Angeline), 25 feet north of nearest water service, 6.5 feet west of curb. (N: 207686 E: 1286793)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-105

C303103 Z1626 MG1 **FIGURE B-6**

Logged by: AJC Reviewed by: CAN

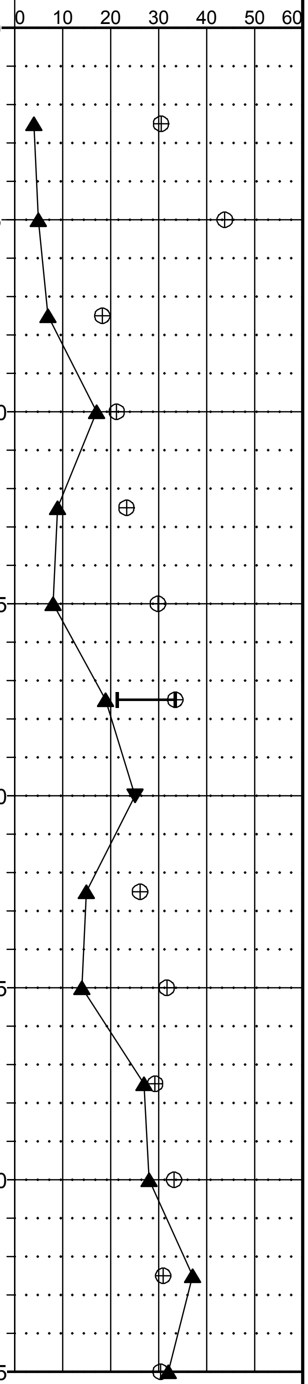
SOIL DESCRIPTION

Surface Elevation: 59 NAVD88

Depth, FT	Soil Description	USCS	Samples	Blows/6"	Lab tests
0	Surface is concrete (6-inches).				
	FILL	CL			
	Soft to medium stiff, gray, CLAY, few silt, trace sand; moist; trace organics, numerous rust stained seams.		1	1,1,3	
5	Becomes medium stiff, decreased rust staining.		2	2,2,3	
			3	2,3,4	
	RECESSIONAL LACUSTRINE	SP-SM			
	Loose, brown, fine SAND WITH SILT, trace medium to coarse sand; moist; occasional pockets gray fine sand.				
10	Medium dense, brown, SILTY fine SAND; moist; scattered layers (<1/2-inch) fine sandy silt, scattered rust stained seams.	SM	4	7,9,8	
	Becomes wet, few medium sand, trace coarse sand, and fine gravel, numerous pockets/layers of silt.		5	4,3,6	
15	Medium stiff, brown, fine SANDY CLAY, trace medium to coarse sand and fine gravel, few silt; moist to wet; numerous pocket/layers sand.	CL	6	2,3,5	GSD
	Becomes very stiff, scattered layers silt and sandy silt trace coarse sand, 6-inch layer fine to medium sand at 18.3 to 18.8 feet bgs.		7	3,7,12	AL
20	Rock in tip of sampler. No recovery.		8	7,9,16	
	Becomes stiff to very stiff, wet, numerous seams/layers silt and sand.		9	6,7,8	
25	Becomes saturated, scattered silt layers, numerous fine sand seams, scattered rust stained seams, horizontal bedding.		10	3,6,8	GSD
	Very stiff, tan, SILT; moist; numerous rust stained seams, scattered pockets rust stained fine to medium sand, trace organics.	ML	11	7,10,17	
30			12	5,11,17	
	Becomes hard.		13	12,17,20	
35					

Ground Water: ATD

Penetration Resistance
▲ Blows per foot (SPT)
▼ Blows per foot (non-standard)
PL Water Content % LL



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Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted Diedrich D120
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: 54th near Angeline: 68 feet north of hydrant, 6 feet west of curb. (N: 207462 E: 1286790)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-106

C303103 Z1626 MG1 FIGURE B-7

Logged by: AJC Reviewed by: CAN

SOIL DESCRIPTION

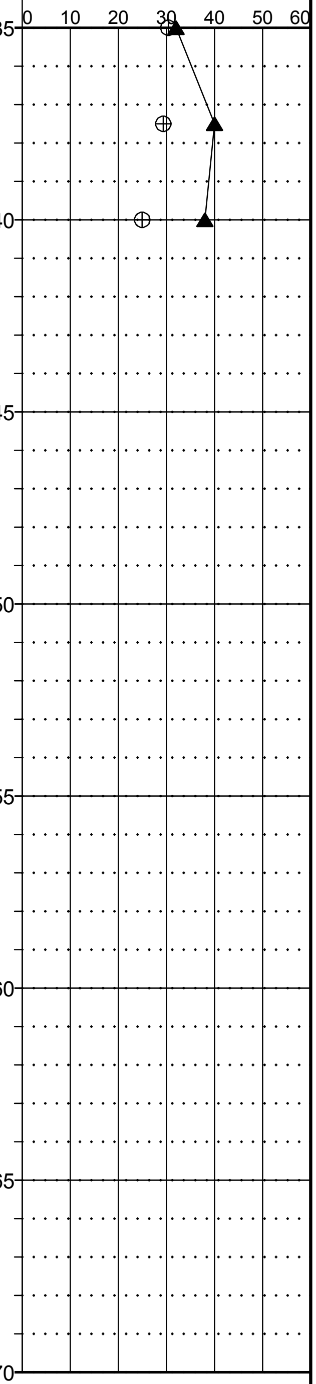
Surface Elevation: 59 NAVD88

Soil Description	Depth, FT	Symbol	USCS	Samples	Blows/6"	Lab tests	Ground Water
No rust staining, numerous partings fine sand.	35			14	7,13,19		
				15	13,17,23		
Hard, gray, fine SANDY SILT; moist; grades to tan rust stained fine sandy silt.	40		ML	16	11,17,21		

Boring completed at 41.5 feet below ground surface (bgs).
Groundwater encountered at 12 feet bgs.
Piezometer installed and screened between 15 and 25 feet bgs.
Well tag No. BBR563.

Depth, FT: 35, 40, 45, 50, 55, 60, 65, 70

Penetration Resistance
▲ Blows per foot (SPT)
▼ Blows per foot (non-standard)
PL Water Content % LL



Date Completed: 6/7/2010
Driller: Holocene Drilling Inc.
Equipment: Truck Mounted Diedrich D120
Drilling Method: 4.25-in. ID HSA
Hammer System: Automatic

Approximate Location: 54th near Angeline: 68 feet north of hydrant, 6 feet west of curb. (N: 207462 E: 1286790)

GENESEE CSO
Seattle, WA

Seattle Public Utilites Materials Laboratory

LOG OF BORING B-106

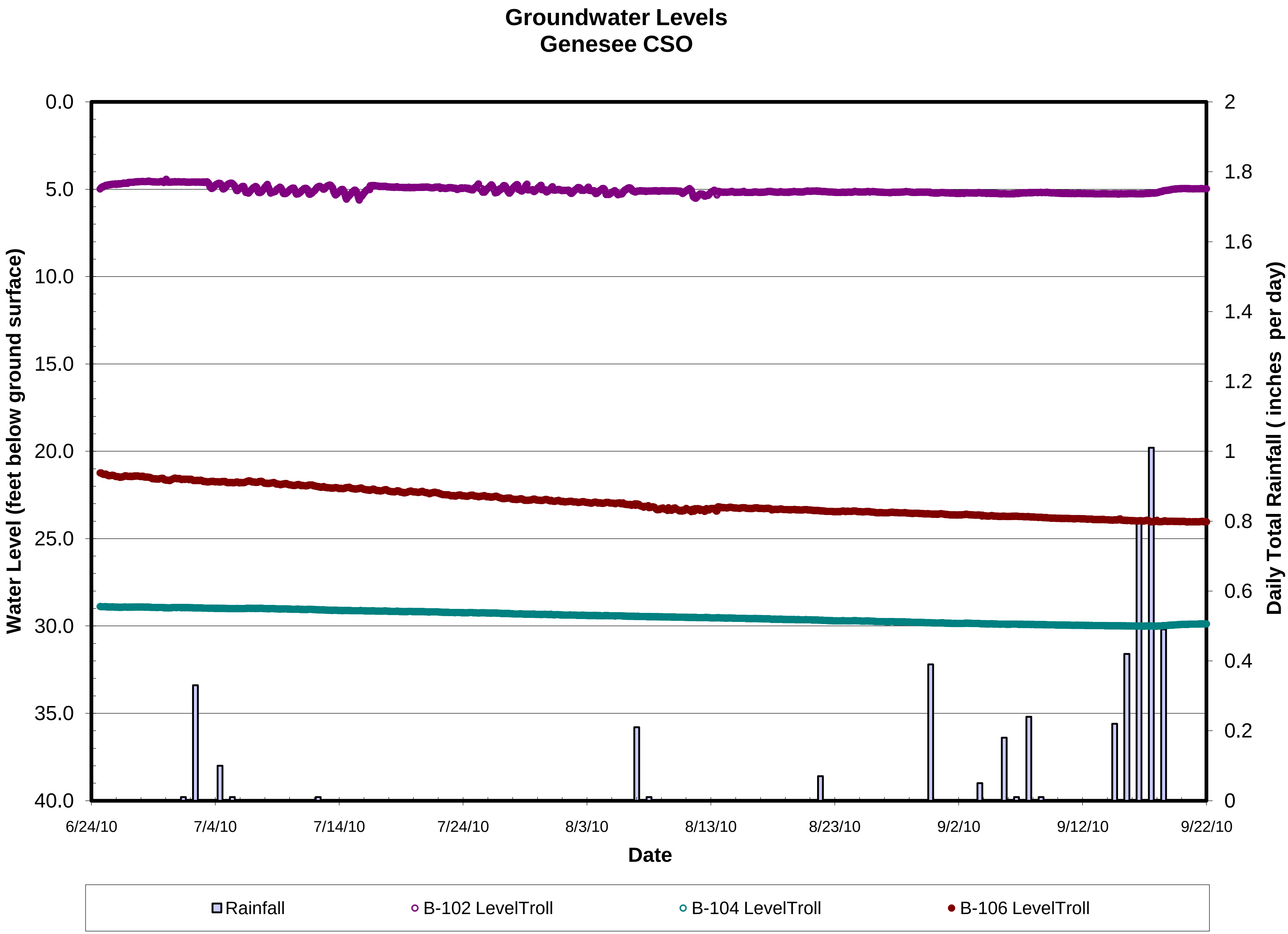
C303103 Z1626 MG1 **FIGURE B-7**

Logged by: AJC Reviewed by: CAN

Groundwater Levels - Genesee CSO

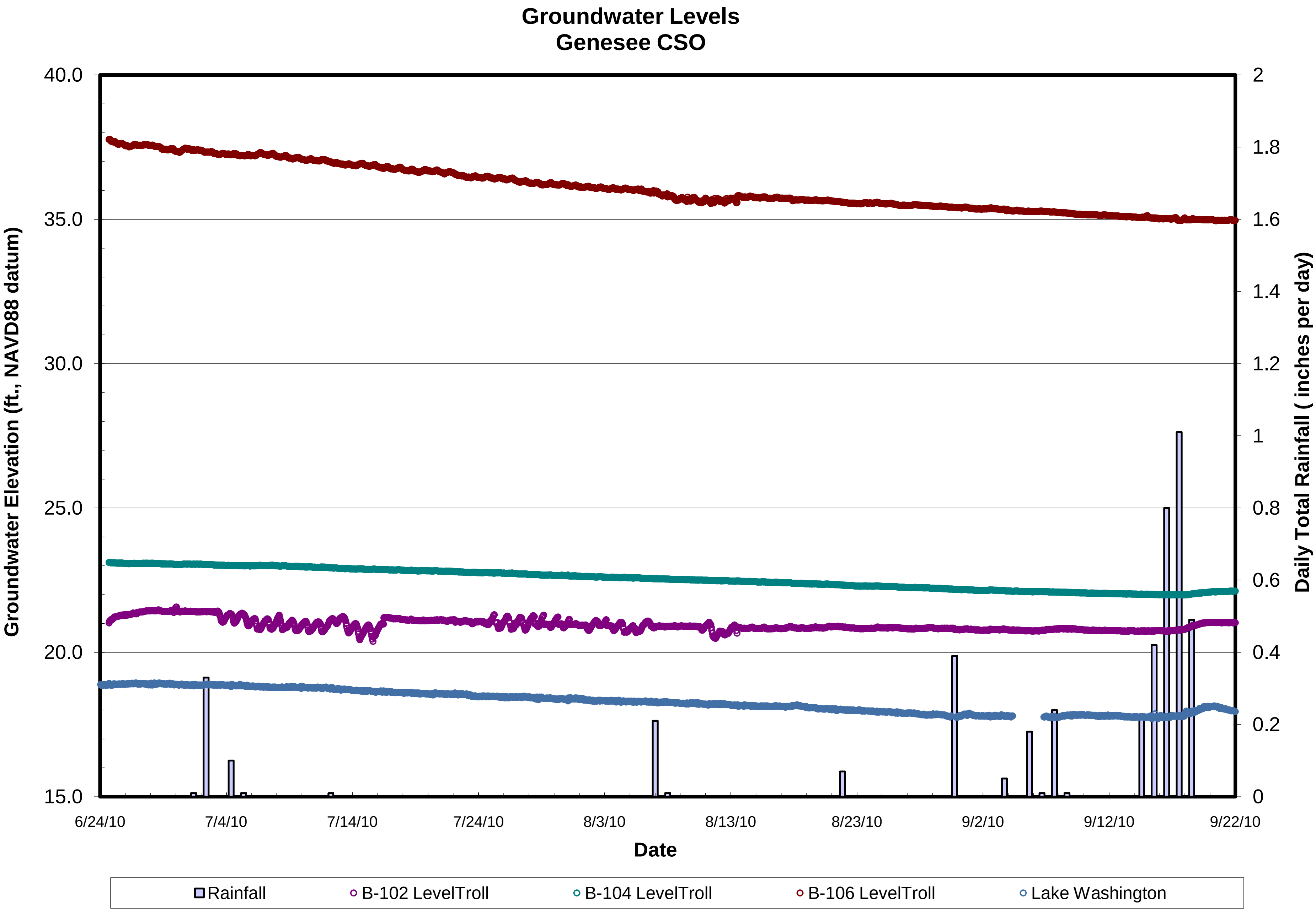
Boring	B-102	B-104	B-106	Comments
Screen Interval Depth (ft.)	10 to 25	25 to 35	15 to 25	
Date	**Depth to Water (ft.)**			
6/24/2010	NM	NM	NM	B-102 Developed, LevelTrolls installed.
7/16/2010	NM	NM	NM	See Water Levels Chart.
8/13/2010	NM	NM	NM	See Water Levels Chart.
9/22/2010	NM	NM	NM	See Water Levels Chart.

NM = Not measured



Transducer Data
Figure B-9

SPU Materials Laboratory



Groundwater Levels
Genesee CSO
Groundwater Elevation (ft., NAVD88 datum)
Daily Total Rainfall (inches per day)
40.0
35.0
30.0
25.0
20.0
15.0
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
6/24/10
7/4/10
7/14/10
7/24/10
8/3/10
8/13/10
8/23/10
9/2/10
9/12/10
9/22/10
Date
Rainfall
B-102 LevelTroll
B-104 LevelTroll
B-106 LevelTroll
Lake Washington

APPENDIX C

LABORATORY TESTING PROGRAM

APPENDIX C

LABORATORY TESTING PROGRAM

SPU Materials Laboratory representatives performed laboratory tests on selected soil samples collected during our field investigation. The laboratory tests were conducted in general accordance with appropriate ASTM test methods. The test procedures and test results are discussed below.

Natural Water Content

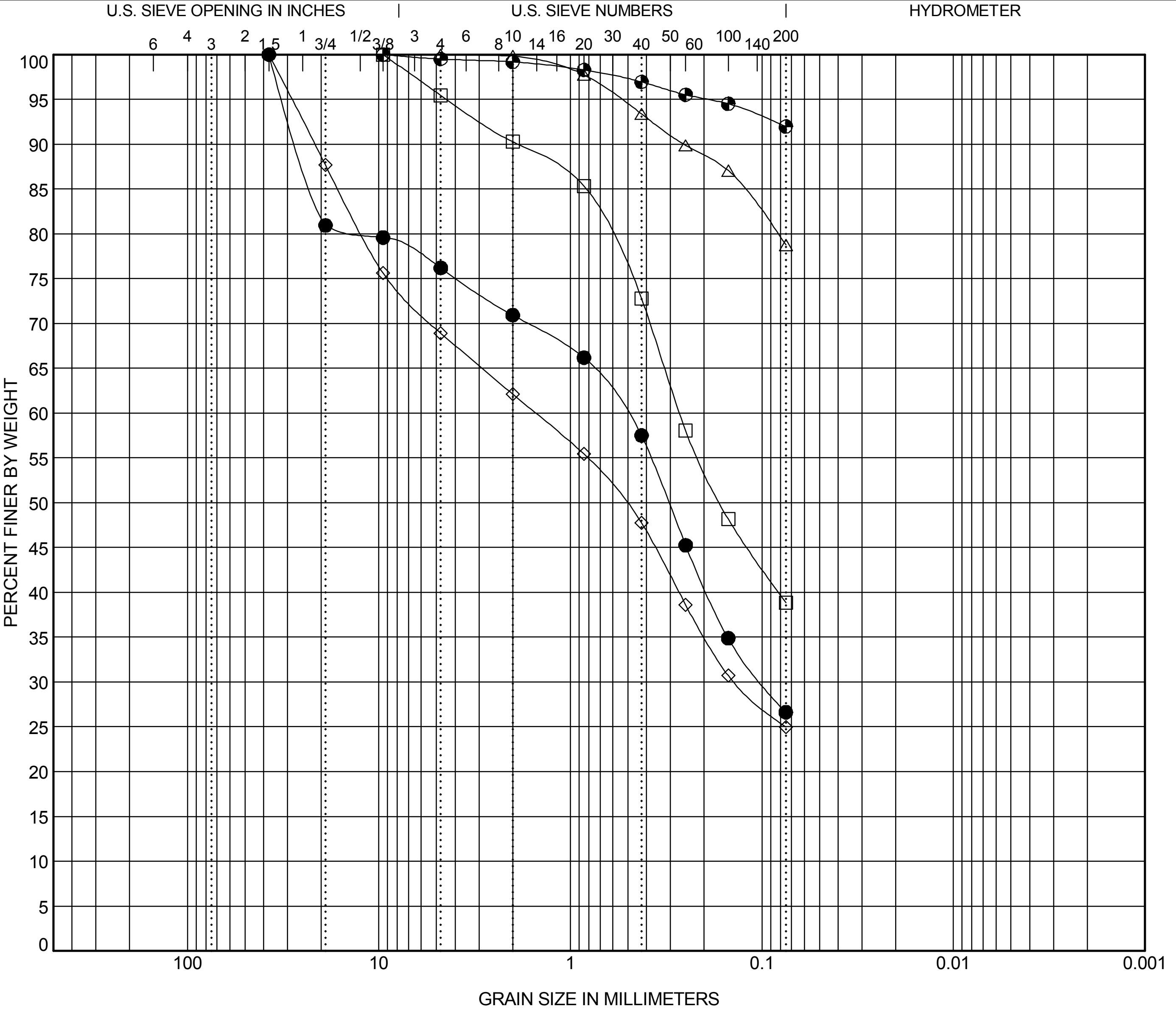
Natural water content determinations were made on selected soil samples in general accordance with ASTM D-2216, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*. Test results are graphically indicated at the appropriate sample depth on the summary logs in Appendix B.

Grain-size Distribution

The grain-size distribution of selected samples was analyzed in general accordance with ASTM D422, *Standard Test Method for Particle-Size Analysis of Soils*. Results of grain size analyses are plotted on Figure C-1 through C-3 of this appendix. The soil samples tested for grain size distribution are indicated on the summary logs in Appendix B.

Atterberg Limit Determination

Atterberg Limits testing of three samples was performed. The testing was conducted in accordance with ASTM D 2487 *Standard Practice for Classification of Soils for Engineering Purposes* (Unified Soil Classification System). The results of the testing are shown on Figure C-4 at the end of this appendix. The soil samples tested are indicated on the summary logs.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample ID	Depth	Classification	LL	PL	PI	Cc	Cu
●	B-101; 9	25.0	Brown, SILTY fine SAND WITH GRAVEL, few medium to coarse sand (SM).					
□	B-101; 16	60.0	Gray, SILTY fine to medium SAND, trace coarse sand and fine gravel (SM).					
△	B-102; 5	12.5	Dark brown, SILT WITH fine to medium SAND (ML).					
◇	B-102; 10	30.0	Brown, SILTY fine to medium SAND WITH GRAVEL, few coarse sand (SM).					
◕	B-102; 14	50.0	Brown, SILT, trace fine to medium sand (ML).					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-101; 9	25.0	37.5	0.52	0.1		23.8	49.6	26.6	
□	B-101; 16	60.0	9.5	0.27			4.5	56.6	38.9	
△	B-102; 5	12.5	4.75				0.0	21.2	78.8	
◇	B-102; 10	30.0	37.5	1.53	0.14		31.1	43.9	25.0	
◕	B-102; 14	50.0	9.5				0.5	7.5	92.0	

Seattle
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Materials Laboratory

WA No.: C303103 Z1626 MG1

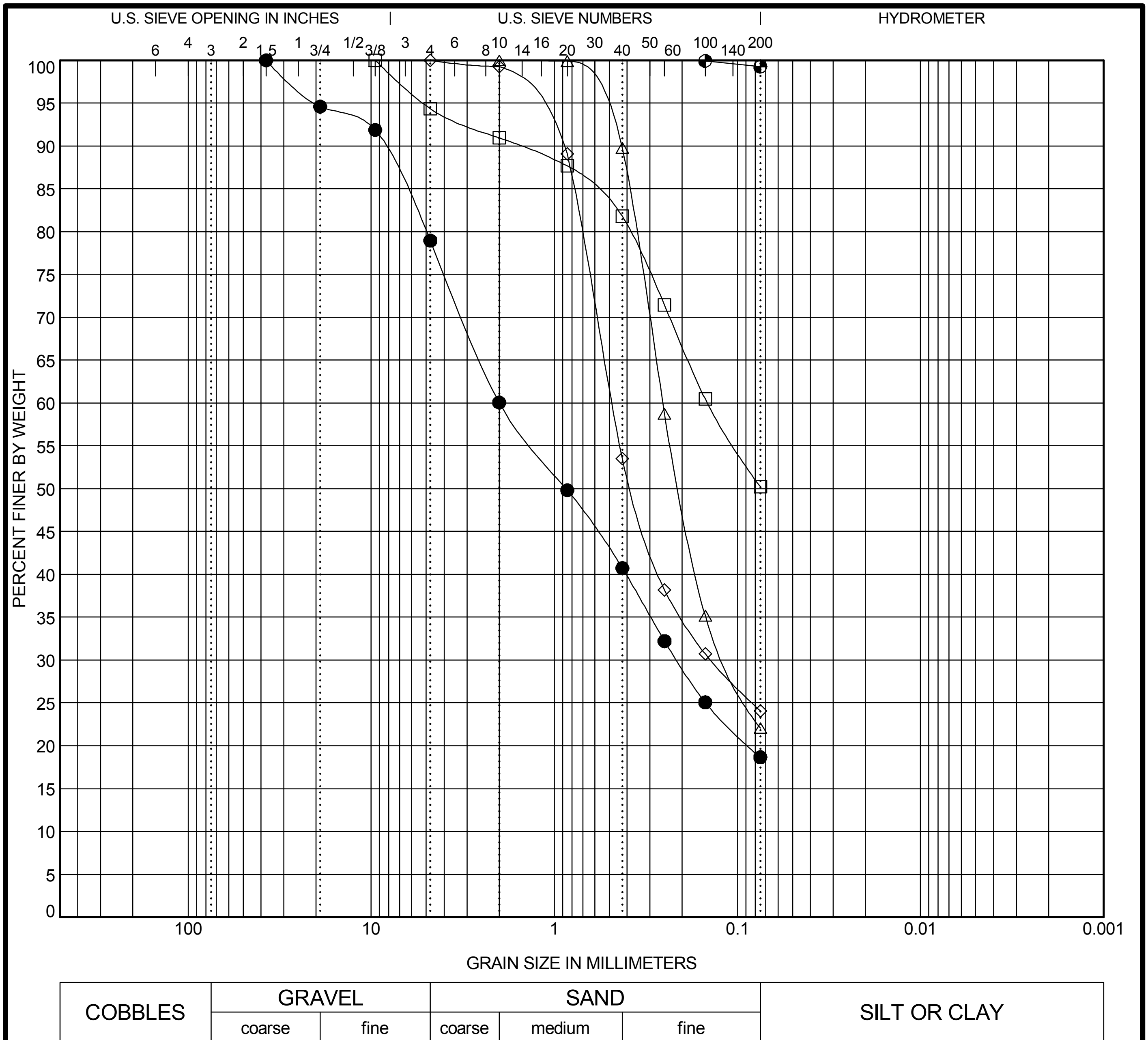
GRAIN SIZE DISTRIBUTION (ASTM D422)

GENESEE CSO
Seattle, WA

August 2010

FIGURE: C-1

US GRAIN SIZE GENESEE CSO.GPJ TEMPL.GDT 8/23/10



	Sample ID	Depth	Classification	LL	PL	PI	Cc	Cu
●	B-103; 6	15.0	Brown, SILTY SAND WITH GRAVEL (SM).					
□	B-103; 9	25.0	Brown, fine to medium SANDY SILT, trace coarse sand and fine gravel (ML).					
△	B-104; 7	17.5	Brown, SILTY fine SAND (SM).					
◇	B-104; 10	30.0	Brown, SILTY fine to medium SAND (SM).					
◕	B-105; 8	20.0	Gray, SILT, trace fine sand (ML).					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-103; 6	15.0	37.5	1.99	0.21		21.0	60.3	18.6	
□	B-103; 9	25.0	9.5	0.15			5.6	44.1	50.2	
△	B-104; 7	17.5	2	0.26	0.11		0.0	77.9	22.1	
◇	B-104; 10	30.0	4.75	0.48	0.14		0.0	75.9	24.1	
◕	B-105; 8	20.0	0.15					0.7	99.3	

Seattle Public Utilites Materials Laboratory

WA No.: C303103 Z1626 MG1

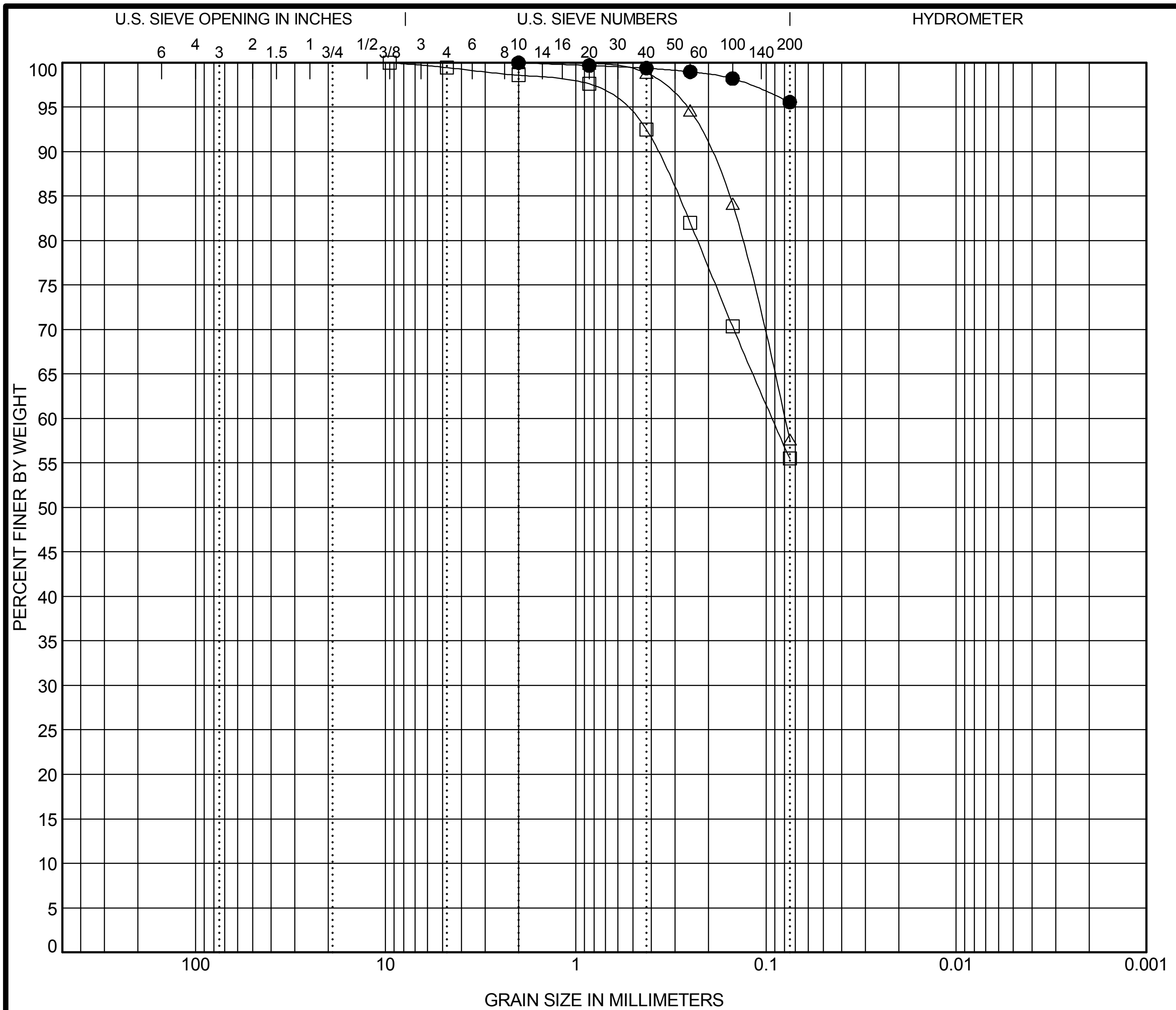
GRAIN SIZE DISTRIBUTION (ASTM D422)

GENESEE CSO
Seattle, WA

August 2010

FIGURE: C-2

US GRAIN SIZE GENESEE CSO.GPJ TEMPL.GDT 8/23/10



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample ID	Depth	Classification	LL	PL	PI	Cc	Cu
●	B-105; 11	27.5	Brown, SILT, trace fine sand (ML).					
□	B-106; 6	15.0	Brown, fine SANDY SILT, trace medium to coarse sand and fine gravel (ML).					
△	B-106; 10	25.0	Brown, fine SANDY SILT (ML).					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-105; 11	27.5	2				0.0	4.4	95.6	
□	B-106; 6	15.0	9.5	0.09			0.6	43.9	55.5	
△	B-106; 10	25.0	2	0.08			0.0	42.4	57.6	

Seattle Public Utilites Materials Laboratory

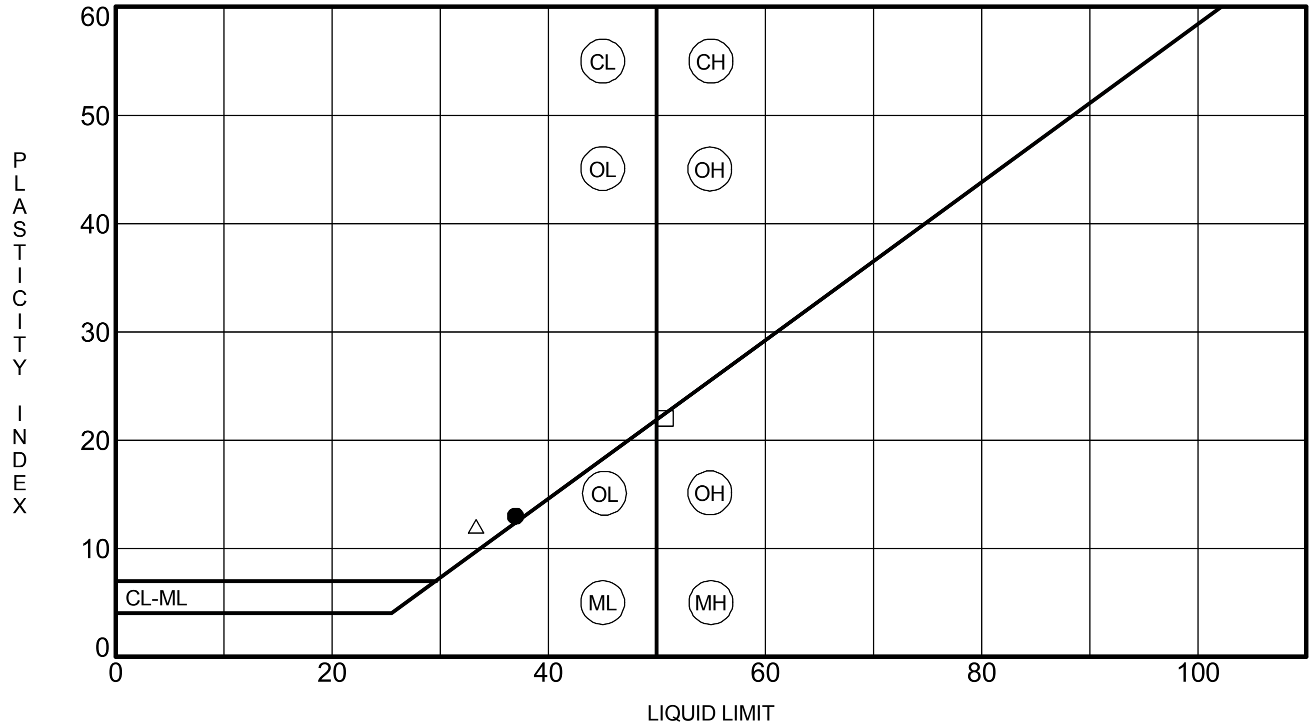
WA No.: C303103 Z1626 MG1

GRAIN SIZE DISTRIBUTION (ASTM D422)

GENESEE CSO
Seattle, WA

August 2010

FIGURE: C-3



	Sample ID	Depth	LL	PL	PI	Fines	Classification
●	B-101, 10	30.0	37	24	13		Gray, CLAY (CL).
□	B-101, 13	45.0	51	29	22		Gray, SILT (MH).
△	B-106, 7	17.5	33	21	12		Brown, SANDY CLAY (CL).

Seattle
Public Utilites
Materials Laboratory

WA No.: C303103 Z1626 MG1

ATTERBERG LIMITS RESULTS

GENESEE CSO
Seattle, WA

August 2010

FIGURE: C-4

US ATTERBERG LIMITS GENESEE CSO.GPJ TEMPL.GDT 8/23/10

GEOTECHNICAL REPORT
GENESEE COMBINED SEWER OVERFLOW BASIN 43
53RD AVENUE SOUTH PARKING LOT STORAGE PROJECT
SEATTLE, WASHINGTON

Work Authorization No.: C303103
May, 2011

Seattle Public Utilities
Geotechnical Engineering

707 South Plummer Street
Seattle, Washington 98134

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GEOTECHNICAL REPORT
GENESEE COMBINED SEWER OVERFLOW BASIN 43
53RD AVENUE SOUTH PARKING LOT STORAGE PROJECT
SEATTLE, WASHINGTON

1.0 INTRODUCTION

1.1 GENERAL

The Seattle Public Utilities (SPU) Geotechnical Engineering Group was retained to complete a geotechnical engineering study for the Genesee Combined Sewer Overflow (CSO) Basin 43 project in the Columbia City neighborhood of Seattle, Washington. The Genesee CSO Basin 43 project involves a new storage tank/conveyance structures within Basins 43.

This geotechnical engineering study focuses on the proposed storage/conveyance structures for the 53rd Avenue South Parking Lot (Site) within Basin 43. The Genesee CSO Project Team requires further geotechnical recommendations to explore design options at the proposed Site. The Site is located within a designated parking area north of Lake Washington Boulevard and 53rd Avenue South. A vicinity map of the project area is shown on Figure 1.

The structures proposed at the Site include astorage tank measuring 29 feet wide, 129 feet long and up to 21 feet deep with an approximate capacity of 0.22 million gallons (MG) and an electrical/mechanical vault measuring 9 feet wide, 40 feet long and 7 feet deep. We understand these dimensions are preliminary and may change as the design is refined.

The Project Team has requested 30% design recommendations for this Basin 43 alternative, which includes:

- Description of subsurface conditions,
- Description of groundwater conditions and impacts to design and construction such as dewatering potential, discharge estimates, and uplift considerations,
- Presence of potential contamination in existing boring logs or borings performed for this study based on drilling notes, observations, and use of a photoionization detector (PID),
- Geologic hazards as applicable to this Site (liquefaction, lateral spread, ground motions, soft soil settlement, landslides, etc),
- Seismic design criteria for the Site,
- Recommended foundation types for structures and/or subgrade considerations for pipes,
- Recommended shoring type(s) and temporary excavation slopes,

- Potential impacts to nearby structures and utilities from construction (i.e. vibrations, settlement from dewatering or tunneling, etc).
- Earth pressure diagrams,
- Foundation design values,
- Uplift design values, and
- Construction considerations (i.e. vibrations, settlement monitoring, etc).

1.2 Authorization and Scope of Work

Our work was requested and authorized by Kathy Robertson, P.E., L.E.G. of the SPU Project Management and Engineering Division. Our scope of work included:

- Reviewing readily available geotechnical/geologic information for the Site and vicinity;
- Conducting a geotechnical exploration program including the completion of two soil borings;
- Installing a groundwater monitoring well instrumented with a pressure transducer to record groundwater data;
- Collecting groundwater monitoring data from field piezometers once a month over a 12 month period;
- Performing laboratory testing and engineering analyses to develop geotechnical recommendations as presented herein; and,
- Preparing this report, which summarizes our investigations, conclusions and recommendations;

2.0 METHODOLOGY

2.1 Document Review and Previous Studies

SPU Geotechnical Engineering conducted a document review of geotechnical reports/explorations performed in the vicinity of the Site. In 1969, Seattle Engineering Department (SED) completed multiple explorations for the Lake Washington Drainage project. One exploration located within the project area was reviewed. The boring log is included in Appendix A. The approximate location of the exploration is shown on Figure 2. This exploration was used in conjunction with onsite data collected for this project for the overall subsurface characterization of the Site. The log of this boring was referenced from the GeoMapNW online database (http://geomapnw.ess.washington.edu/).

We reviewed a preliminary geotechnical evaluation completed by Shannon and Wilson, Inc. in 2009 for the Genesee and Henderson Combined Sewer Overflow project. Their report assessed potential geotechnical issues regarding the conceptual project features in Genesee CSO Basins 43 amongst others.

2.2 FIELD INVESTIGATION

SPU Geotechnical Engineering personnel conducted subsurface explorations on February 24 and 25, 2011 by completing two soil borings (B-201 and B-202). Appendix B describes our investigation in detail. The soil borings were terminated at 60.5 and 61.5 feet deep, respectively. Boring locations are shown on Figure 2. Summary logs of the subsurface explorations are included in Appendix B as Figures B-2 and B-3. Figure B-1 is a key to the terms and symbols used on the logs.

2.3 LABORATORY TESTING

Geotechnical laboratory tests were performed on selected samples to determine index and engineering properties of the soil encountered. Laboratory tests performed included natural moisture content, grain size determination, and Atterberg Limits. A description of the test methods and the results are presented in Appendix C. The natural water content results are graphically indicated at the appropriate sample depth on the summary boring logs.

3.0 SITE DESCRIPTION

3.1 GENERAL GEOLOGY

The general geologic condition of Seattle is a result of glacial and non-glacial activity that occurred in the area over the course of millions of years. The most recent and extensive glacial activity in the Puget Sound area was the Vashon stade of the Fraser glaciation that ended about 10,000 years ago (10 ka). Tertiary bedrock formations in the Seattle area were subsequently overridden by the advancing glaciers and in many areas covered by glacial and non-glacial deposits.

Review of a geologic map (Troost, et al, 2005) indicates that the Site is underlain by lake deposits. Lake deposits are relatively young, are very soft to medium stiff silt and clay with intermittent sand layers, peat and other organics. Other soil units mapped in the area include mass wastage deposits, glacial till and Blakely Formation Tertiary bedrock. Mass wastage deposits result from the downslope movement of colluvium, soil, and landslide debris of indistinct morphology under the direct influence of gravity. Blakely Formation bedrock is primarily composed of weakly to moderately lithified, medium to coarse grained sandstone and minor siltstone. Subsurface borings completed for this study generally agree with the mapped geology.

3.2 Site Surface Conditions

The Site is located north of 53rd Avenue South within an asphalt paved parking lot. Elevations within the parking lot are about 22 feet as identified through the City GIS system[1]. The Site is approximately 50 feet southwest of Lake Washington. The elevation of Lake Washington in the vicinity of the Site is 20 feet. City GIS has identified a landslide scarp approximately 500 feet southwest of the Site. The topography of the study area and scarp location is shown on Figure 2.

3.3 Site Subsurface Conditions

Below are descriptions of the soil deposits encountered in our explorations in borings B-201 and B-202 in order of stratigraphic sequence, with the youngest unit described first, followed by a description of groundwater conditions.

3.3.1 Lake Deposit

Lake deposits were observed in borings B-201 and B-202 below the asphalt pavement. The lake deposit extended to depths of 7 and 4 feet in borings B-201 and B-202, respectively. Lake deposits consisted of very loose, silty sand (SM)[2], soft, silt (ML) and soft to medium stiff, clay (CL). N-values[3] for the lake deposit samples ranged from 2 to 4 with an average value of 3. The natural water contents of the samples collected from boring B-201 are 133 and 65. Water content of the sample collect from boring B-202 is 22. A water content greater than 100 percent can occur when the weight of the water in a given sample exceeds the dry weight of that sample and/or when the sample contains organics, which burn up during the laboratory water content determination. The deposit is characterized by low shear strength, high compressibility, and low to moderate permeability.

[1] NAVD88 elevation datum used throughout this report.

[2] Soil classification in accordance with the Unified Soil Classification System (USCS).

[3] N-values are defined as the number of blows required to drive a 2.0-inch outside diameter sampler one foot, using a 140-pound hammer falling a distance of 30 inches. Refer to ASTM D-1586 (ASTM, 2007).

3.3.2 Mass Wastage Deposit

Mass wastage deposits were observed in both borings below the lake deposits and extended to between 37 and 32 feet below ground surface (bgs) in borings B-201 and B-202, respectively. This unit consists of medium dense, sand with silt and gravel (SP-SM), loose to medium dense, silty sand with varying amounts of gravel (SM), stiff to very stiff, silt and silt with sand (ML) and very stiff clayey sand with gravel (SC). Color mottling and rust staining was typical throughout the unit. The unit generally became increasingly dense with depth. N-values for samples between 5 and 15 feet in depth ranged from 9 to 52 with an average value of 22. N-values for samples between 17.5 and 35 feet in depth ranged from 42 to 62 with an average value of 50. The natural water content of the samples collected ranged from 13 to 30 percent with an average of 19 percent. The deposit is characterized by moderate shear strength, moderate compressibility, and low to moderate permeability

3.3.3 Blakeley Formation

Blakeley formation bedrock was observed in borings B-201 and B-202 underlying the mass wastage deposits. The borings were terminated at 60.5 and 61.5 feet in depth, respectively, in this formation. Blakeley Formation samples consisted of completely weathered fine to coarse grained sandstone. Due to the completely weathered nature of the samples, the samples were classified in accordance with USCS as sand with silt (SP-SM) and sand (SP, SW). N-values for the formation ranged from 29 to 50/6" with an average value greater than 50. The natural water content of the samples collected ranged from 17 to 23 percent with an average of 20 percent. The Blakeley Formation at the depth explored is characterized by high shear strength low compressibility and low to moderate permeability

3.3.4 Groundwater

Groundwater was encountered during our investigation. At the time of drilling, groundwater depth was approximately 5 feet bgs with a corresponding elevation of approximately 17 feet. A monitoring well was installed in boring B-201. Groundwater depth was measured following the development of the well. Groundwater depth was 0.9 feet bgs with a corresponding elevation of 21.1.

The monitoring well was instrumented with a pressure transducer on February 25, 2011 to provide a semi-continuous measurement of the groundwater table. During subsequent monitoring performed on February 28 and March 28, 2011, we observed that groundwater levels had risen to elevation 22 feet, equal with the ground surface. The height of groundwater required that we remove the pressure transducer from the well.

We will continue to collect single monthly groundwater measurements until February 2012 to observed seasonal fluctuations. The groundwater table will likely fluctuate in response to changes in the lake elevation. A pressure transducer can be re-installed within the well if groundwater elevations are measured to be consistently below the top of the well casing.

We anticipate that groundwater levels may impact construction of the underground storage tank. Groundwater dewatering considerations for the Site are discussed in Section 4.3.2.

3.4 Seismic Setting

The Puget Sound area is known to be seismically active. The seismic hazard in the area comes primarily from three sources: subduction zone, intraslab or Benioff zone, and shallow crustal earthquakes. Subduction zone earthquakes occur when the interface between the North American tectonic plate and the subducting Juan de Fuca plate ruptures. These events are likely to have magnitudes of up to 9, but the distance to the rupture zone would reduce the intensity of shaking at the Site. Shaking during these events could last over one minute in duration. Intraslab events occur due to tensional rupture within the subducting Juan de Fuca plate at depths of 45 to 60 kilometers. This is the source of our largest historical earthquakes that have affected the Site and has the potential for magnitude 7.5 events.

Shallow crustal earthquakes occur on shallow faults within the Seattle area due to tectonic stresses. Several minor earthquakes occur in the area each year, most of which are not even felt. However, some of the shallow faults are capable of producing significant, damaging earthquakes. Perhaps the most notable of these faults is the Seattle Fault. Recent research indicates that this fault is capable of producing an earthquake with a magnitude 7.5 or higher, which, given the shallow depth and proximity to the Seattle urban area, could produce intense shaking at the Site. Current understanding of the structure of the Seattle Fault Zone (SFZ) indicates that the fault consists of a blind thrust underlying a faulted roof complex. Several subparallel backthrusts are located within the roof complex, and have been considered splays of the Seattle fault. The Site is located within the SFZ, as shown in Figure 3.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 General

The main geotechnical design and construction concerns for the proposed structures for the Site are site-specific seismic design criteria, temporary and permanent wall recommendations, foundation design values, uplift forces, site earthwork, foundation recommendations, and other construction recommendations.

Based on the results of our geotechnical and environmental investigations and analyses, it is our opinion that proposed structures for Basin 43 are feasible, within the limitations presented below, provided the recommendations of this report are incorporated in design and construction. We understand that the general construction sequence for the proposed structures will be:

- Demolition, clearing, and grubbing.
- Dewater the site to lower the groundwater table as needed.
- Install temporary shoring and excavate soil.
- Construct foundations for storage structures.
- Turn off dewatering system.
- Construct utility connections and install pavements.

4.2 Seismic Design Considerations

This section discusses seismic hazards including site response, fault rupture, liquefaction and lateral spreading affecting the Site, and presents the recommended site-specific uniform horizontal design response spectrum for the proposed tank. Discussion of seismic effects on slope stability, wall pressures, allowable bearing pressures, foundation recommendations and uplift pressures are presented later in this chapter.

4.2.1 Design Response Spectrum

We understand that the seismic design of the underground storage tank at the Site will be in accordance with the Seattle Building Code (SBC) 2006. Computation of forces used for seismic design for this code is based on seismological inputs and site soil response factors. Ground motions considered for design using these guidelines have approximately a 2 percent probability of exceedance in 50 years, or a 2,475-year return period (T_R). A uniform horizontal response spectrum incorporating the site-specific ground motions with a T_R of 2,475-years and soil response factors can be constructed for analysis of the tank. The seismological inputs are short-period and 1-second period spectral accelerations, S_s and S_1, respectively, obtained from the USGS National Seismic Hazard Mapping Program spectral acceleration contour map for Site Class B sites (Figure 1613 of the SBC 2006). The mapped S_s and S_1 values at the Site are 1.51g and 0.52g, respectively.

Characterization of the soil profile type is required in the SBC 2006 to determine the site class definition. A site classified as Site Class D is defined as soft soil, having an average shear wave velocity greater than 600 and less than 2,500 feet per second (fps), or an average of N-values greater than 15 and less than 50, in the top 100 feet. Based on the SPTs and soil classifications derived from the explorations completed at the site, it is our opinion that a Site Class D characterizes the subsurface conditions at the site.

In accordance with the SBC 2006, the site coefficients, Fa and Fv, corresponding to a Site Class D and the appropriate spectral acceleration values are 1.0 and 1.5, respectively. The maximum considered earthquake spectral response accelerations for short-period, S_{MS}, and 1-second period, S_{M1}, are obtained as 1.51g and 0.78g, respectively, by applying the site coefficients to S_s and S_1. Finally, the 5-percent-damped uniform horizontal response spectrum is plotted using the design spectral response accelerations at short-period, S_{DS}, and 1-second period, S_{D1}, obtained by reducing S_{MS} and S_{M1} by a factor of $^2/_3$ to 1.01g and 0.52g, respectively. Figure 4 shows the recommended uniform horizontal design spectrum.

4.2.2 Surface Fault Rupture

The proposed structures for Basin 43 are within the SFZ. The USGS has interpreted seismic-reflection data to indicate the SFZ is comprised of at least 3 or 4 splays that generally extend east-west across the Puget Lowland. The SFZ is bounded on the north by fault "A" and on the south by the syncline on the southern margin of the Seattle basin, (Frankel, undated). The Site is approximately 0.8 kilometers south of fault “A”, as shown in Figure 3. In our opinion, the risk of surface fault rupture affecting the Site is moderate but does not need to be considered for design.

4.2.3 Liquefaction and Lateral Spreading

According to the current subsurface investigations for the storage tank, below the proposed minimum foundation tank elevation, the Site is generally underlain by mass wastage deposits of cohesionless and cohesive soils generally too dense/stiff to liquefy during a seismic event with a T_R of 2,475-years. Silty sand, sandy silt and silt encountered in the lake deposits above the proposed minimum foundation elevation may be susceptible to liquefaction during a seismic event. The groundwater data during dry weather indicates an elevation of 21 feet, roughly 20 feet above the proposed minimum foundation elevation. For design purposes, we recommend the Site be considered fully saturated, as was observed during periods of rain.

Settlement at the site due to liquefaction triggered by a seismic event with T_R of 2,475-years is estimated to be as much as 4 inches, occurring approximately in the upper 12.5

feet bgs (Figure 5). Because the horizontal distance from the Site to Lake Washington is 60 to 70 feet, lateral spreading effects need to be considered for design at the Site alternative. Available analytical methods estimate lateral ground displacements, triggered by a seismic event with T_R of 2,475-years, in the order of 15 to 25 feet.

4.3 Site Earthwork

Construction for the proposed storage tank will require site preparation and earthwork activities related to construction of structures, utilities, pavement areas and other improvements.

4.3.1 Excavation

Based on our interpretation of subsurface conditions at the site, and the proposed grading, it appears that onsite excavations will be made in lake and mass wastage deposits encountered in our explorations. Debris within the lake deposits unit was not encountered in our explorations, but should be expected during construction. Groundwater should be anticipated at ground surface during construction.

4.3.2 Dewatering

We recommend performing hydrogeological testing (ie.,a slug or pumping test) to better characterize the hydraulic conductivity at the site, assess potential impacts from dewatering to existing structures and utilities, and if applicable, estimate dewatering volumes in the excavation. We do not recommend significantly lowering the regional groundwater beyond the *City of Seattle Standard Specifications* (City of Seattle, 2011). requirements to reduce the potential for settlement.

If further hydrogeologic studies support implementing a dewatering system during construction, the system will be required to maintain groundwater 2 feet below the excavation depth, in accordance with section 2-08 of the *City of Seattle Standard Specifications*. The contractor should choose a dewatering method based on the available information and their selected construction techniques. To avoid damage to adjacent utilities and structures due to settlement, the groundwater table should be drawn down no more than necessary for the proposed work. Well points and other external dewatering systems should be designed by a qualified professional engineer or geologist. The dewatering plan should be submitted to SPU Geotechnical Engineering for review.

4.4 Temporary Slopes and Shoring

Temporary excavations and protective systems (i.e. shoring or sloping) will be required for this project. They should be implemented in accordance with Section 2-07 of the *City* *of Seattle Standard Specifications.* All specific design parameters for temporary slopes, trench shields, or other shoring methods should be developed by the Contractor's competent person. Because of the high groundwater level at the site, we recommend the excavation be shored, not temporarily sloped back. For planning purposes, the soil can be classified as Type C in accordance with WAC 296-155.

The means and methods of shoring the temporary excavations for the protection of workers are the contractor's responsibility. Shoring to protect workers typically consists of passive shoring systems that allow the sides of the trenches to slough and still protect the workers. This type of shoring is acceptable where settlement sensitive structures and/or utilities are not present within the zone of influence of the trench. The size of the wedge depends on the engineering properties of the soil retained. The zone of influence for this Site is defined graphically in Figure A.

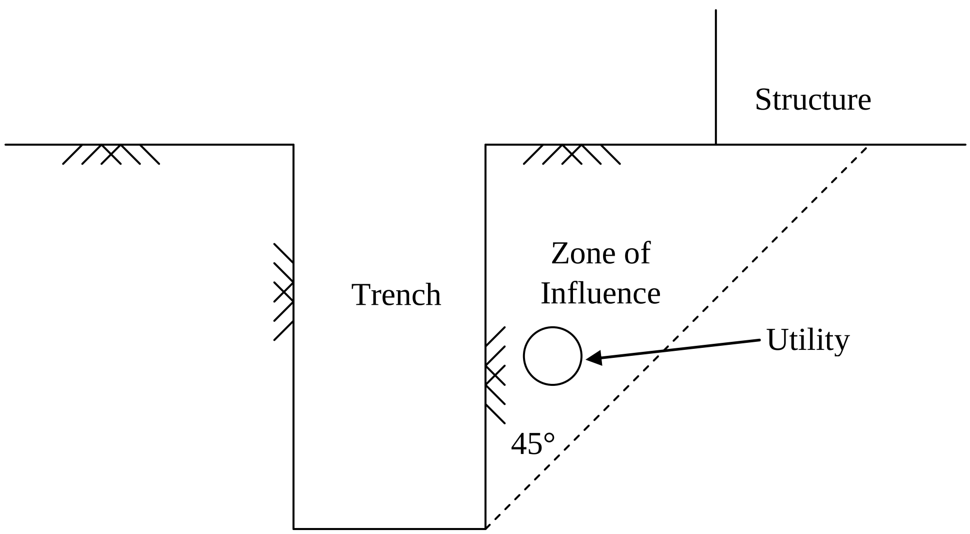

Figure A - Zone of Influence for Excavations

Where settlement sensitive facilities are within the zone of influence, additional analysis should be done to determine both the amount of movement that is expected at the location of the facility, as well as the amount of movement that is acceptable. In the event that the movement anticipated at the location of the facility is unacceptable, the project plans and specifications should require support systems that restrict the movement of the sides of the trenches. Support systems should be designed for the specific situation by a registered professional engineer as defined in Title 18 of the Revised Code of Washington (RCW).

With time and the presence of seepage and/or precipitation, the stability of temporary cuts can be significantly reduced. Therefore, construction should proceed as rapidly as feasible to limit the time the excavations are left open, and runoff water should be prevented from entering excavations. Heavy construction equipment, building materials, and surcharge loads such as excavated or imported soil should not be allowed within one third of the slope height from the top of any excavation.

4.5 TEMPORARY SHORING RECOMMENDATIONS

Construction of the storage tank and facilities vault will require excavations to approximately 22 feet bgs, which will be entirely below the groundwater level. We recommend permeable and impermeable temporary shoring be considered for construction. Permeable shoring systems, such as a soldier pile and lagging, allow the shoring face of the excavation to seep. Impermeable shoring systems, such as concrete-soil mixing (CSM) walls and, sheet piles prevent the shoring face of the excavation to seep. These shoring options are discussed below, however, they are not all-inclusive. Should the design team choose another method of shoring, we should be retained to evaluate the design and make temporary geotechnical recommendations. We also recommend further hydrogeologic evaluations to assess the effectiveness of dewatering systems and the potential impacts to existing structures and utilities in close proximity of the Site.

Assuming that dewatering will lower the groundwater to 2 feet below the excavation, hydrostatic pressures will act on the shoring system approximately at the elevations shown in Figure 6 during construction only. Shoring systems should be designed by a licensed structural engineer in the state of Washington. Tiebacks can be used to restrain the temporary shoring at the Site.

4.5.1 Soldier Piles

Soldier piles generally consist of steel wide-flange sections placed into vertical, pre-drilled holes. They are typically installed on 4- to 8-foot spacings around the perimeter of the proposed excavation. As the excavation proceeds from the top down, timber, precast concrete, or shotcrete lagging is placed to retain the soil between the soldier piles.

The soldier piles should have sufficient penetration below the final excavation level to develop kick-out resistance from passive soil pressure. We recommend that the soldier piles penetrate at least 5 feet into the undisturbed Blakeley Formation beneath the mass wastage deposit.

Soldier piles with center-to-center spacing of less than three pile diameters should not be drilled in sequence. Rather, every other pile should be drilled, and the concrete should be placed and allowed to cure at least 24 hours before adjacent piles are drilled.

We recommend an allowable axial capacity of 10,000 psf for piles bearing on the native deposits.

We recommend a representative from the SPU Geotechnical Engineering group provide special inspection services during soldier pile installations and excavation. Special inspection should include monitoring pile hole drilling, observation of encountered soil units, and inspection of the pile and concrete installation.

4.5.2 Lagging

Lagging should be installed between soldier piles as the excavation proceeds, exposing not more than 4 feet (measured vertically) of unsupported excavation at one time. Voids behind the lagging should be filled with drainage sand and gravel or washed sand backfill. Voids must be backfilled immediately after each section of lagging is installed. Excavation should not exceed a depth of 2 feet below planned bracing elevations to limit deflection of the shoring system.

Due to arching of the retained soils between soldier piles, a reduced lateral earth pressure may be used for design of lagging. At this Site we recommend that the design for lagging be based on 40 percent of the lateral earth pressure recommended for the shoring and underpinning. This reduced soil pressure may be uniformly distributed over the length of the lagging.

Tieback anchors can be used to achieve equilibrium for the temporary shoring wall design. The best option for this project is dependent on what resources are available to the Contractor and therefore we recommend the Contractor be responsible for the design of the system. The Contractor should be required to submit a shoring plan designed by a licensed Washington State Professional Engineer. If tiebacks are included with a soldier pile wall design, we recommend the lagging panels where tiebacks are planned be pre-drilled and fitted with water stops. This measure is suggested to prevent excessive groundwater intrusion to the excavation during tieback installation. Tieback recommendations are included in Section 4.5.5.

The contractor should provide means, such as weep holes, to prevent the buildup of hydrostatic pressures behind shoring walls.

4.5.3 CSM Wall

The CSM process consists of advancing a cutting soil mixing machine at the proposed perimeter of the excavation. The machine mixes cementitious fluid with the soil cuttings as it advances, creating an impermeable concrete-soil wall panel once the mixture cures.

The CSM panels may be used in combination with steel sections to create a soldier pile wall.

If steel sections are used, they should have sufficient penetration below the final excavation level to develop kick-out resistance from passive soil pressure. We recommend that the soldier piles penetrate at least 5 feet into the undisturbed native Blakeley Formation. We recommend a representative from the SPU Geotechnical Engineering group provide special inspection services during soldier pile installations and excavation.

A testing program is necessary to verify the strength and permeability of the CSM wall panels. Compression tests at 28-days should be performed on sample cylinders to evaluate the strength of the CSM wall panels. We recommend a representative from the SPU Geotechnical Engineering group collaborate with the contractor on the testing program.

4.5.4 Sheet Piles

Sheet piles can be driven to a depth that limits the water from infiltrating through the base of the excavation and preferably into a layer with low hydraulic conductivity, and the water that enters the excavation is managed using sump pumps to keep the excavation relatively dry. Sheet piles can also be driven just below the depth of the proposed excavation, the excavation is completed in the wet, and a concrete tremie slab is poured at the base of the excavation of sufficient thickness to resist the uplift pressure of the groundwater. The excavation can then be pumped out and the work proceeds.

A sheet pile shoring system may require internal bracing during excavation. Recommended earth pressures for use in design of the shoring system with internal bracing are presented on Figure 6. Assuming dewatering will lower the groundwater to 2 feet below the excavation, hydrostatic pressures will act on the shoring system approximately at the elevations shown in Figure 6 during construction only.

Tieback anchors can be used to achieve equilibrium for the temporary shoring wall design. Tieback recommendations are included in the next section.

4.5.5 Tiebacks

Tieback anchors consist of steel strands or a reinforcing bar placed into predrilled holes. The holes are typically drilled at an inclination of about 15 to 45 degrees from horizontal. The strands or bars should be in the center of the borehole, so centralizers are spaced evenly along the tieback anchor length. Anchor holes should be drilled in a manner that minimizes loss of ground and do not endanger previously installed anchors or undermine existing pavement or utilities.

The recommended no-load zone for a single braced soldier pile wall starts at the base of the wall, is horizontal for a distance of H/4, where H is the height of the wall face, and then extends up towards the ground surface at an angle of 60 degrees from horizontal. In the anchor no-load zone, tieback anchor holes could be filled with a material such as a sand pozzolan mixture that will not adhere to the tieback rod but will prevent caving. Alternatively, a bond breaker could be used around the tieback anchor in the no-load zone, and the zone could be filled with concrete or lean concrete backfill. However, a minimum 12-inch buffer zone of sand should be placed in the anchor hole directly behind the soldier pile. We recommend that no-load zone lengths not be left open overnight during construction.

The frictional resistance of an anchor depends on many factors, including the Contractor’s means and methods during installation. Consequently, the design of production anchors should be based on a series of test anchors. The following frictional values are only for planning and estimating test anchor lengths. Temporary tieback anchors installed by cased, single-stage, primary pressure grouted methods could be designed for an allowable frictional value of 1 kip per foot (based on an 8-inch-diameter grouted zone). A single-stage, pressure-grouted anchor is defined as an anchor that undergoes high-pressure grouting as the drill casing(s) is removed. Anchors should not be installed within the lake deposits. We recommend a minimum anchor grouted length of 15 feet within the mass wastage deposit.

Load testing for all tieback anchors and acceptability should be as recommended by the Post-Tensioning Institute Manual, Chapter 4, Recommendations for Prestressed Rock and Soil Anchors, 2005. As described in this manual, the following tests should be accomplished.

All anchors should be proof-loaded in 25 percent (0.25P) increments to 133 percent of their design capacity (1.33P), where P is the design capacity. Each load increment should be held until the deformation stabilizes (normally about one minute) and the load and corresponding deformation are recorded. After reaching 1.33P, the load should be held for at least 10 minutes to evaluate creep and then be reduced to the lock-off value.

Prior to installing production anchors within a particular soil stratum, performance tests should be accomplished for each anchor type and/or installation method that will be used. Requirements for installing pre-production test tieback anchors will depend on the location, quantity, and number of tieback anchors. The number of tendons in the selected anchors should be increased as required to complete the performance tests.

Approximately 1 percent of production anchors (with a minimum of two anchors), randomly selected, should be performance tested by loading in 25 percent (0.25P) increments to 200 percent of design capacity (2.0P). The 200 percent load should be held constant for a minimum period of at least 10 minutes.

We recommend that all temporary anchors be locked off at 90 percent of the design load. Anchors that do not meet the acceptance criteria should be locked off at one-half the failure load and replaced with additional anchors, as required.

Initial Lift-off Readings: After transferring the load to the stress anchorage and prior to removing the jack, a lift-off reading should be made. The load determined from the lift-off reading should be within 5 percent of the specified lock-off load. If the load is not within 5 percent of the lock-off load, the end anchorage should be reset and another lift-off reading should be made.

Lift-off Test: Lift-off tests may be conducted on selected tiebacks, both during and after construction, to check the magnitude of seating and to transfer load losses and determine whether long-term losses are occurring.

Acceptance Criteria: The results of each anchor test should be evaluated in order to determine anchor acceptability. An anchor would be acceptable provided:

- The total movement obtained from a performance and proof test exceeds 80 percent of the theoretical elastic elongation of the design free stressing length.
- The creep rate during the final test load does not exceed 0.080 inch per log cycle of time and is a linear or decreasing creep rate, regardless of tendon length and load. Otherwise, the anchor should be held for an additional 60 minutes at the required test load.

4.6 Seepage and Drainage

We understand that the vault will house mechanical and electrical rooms. These environments should be designed to remain dry during the life of the structure. Seepage through the shoring should be collected by a drainage composite installed between the shoring and the vault walls. This drainage composite could be connected to pipes that drain into a sump. The wall drainage should be continuous over the entire height of the shoring wall. Waterproofing material should also be used over the entire height of the vault to prevent water seepage though the structural walls.

For the storage tank, the interior concrete wall could be cast against the shoring walls and seepage could be allowed to seep through the structural walls. Seepage through the structure wall could result in a damp interior wall face. Because the interior of the tank is a moist environment and seepage through structural concrete would occur at a very slow rate, the costs and benefits of collecting seepage between the shoring and tank walls should be reviewed prior to installing a wall drain and waterproofing system.

4.7 Foundation Recommendations

Based on our review of the preliminary tank design sketch provided to us, we understand that a heavily loaded storage tank and lightly loaded facilities vault structures are planned. We anticipate that mass wastage deposits will be encountered at the foundation level of the structures. These soils are generally dense to very dense and/or very stiff to hard, and should provide adequate support for the anticipated structural loads.

4.7.1 Bearing Capacity

We understand that a mat foundation will be used for the tank and vault foundations, consisting of reinforced concrete slabs bearing on the mass wastage deposit. We recommend a maximum allowable bearing pressure of 6,000 pounds per square foot (psf) for designing the slabs bearing on these native deposits. The recommended maximum allowable bearing pressure may be increased by 1/3 for short term transient conditions such as wind and seismic loading.

All excavations for the mat foundation should be observed by a geotechnical engineer to evaluate the adequacy of the bearing stratum and to confirm that subsurface conditions are suitable for the recommended design bearing value.

4.7.2 Estimated Settlement

Assuming construction is accomplished as recommended herein, and for the foundation loads anticipated, we estimate total settlement of the slab foundations of less than about ½-inch and differential settlement between the tank and vault supported on competent subgrade of less than about ¼ inch. Differential settlement can be assumed to be across the width/length of the structures. It is anticipated that the majority of the estimated settlement will be primarily elastic and occur during construction, as loads are applied.

The foundation slabs should be designed for a modulus of vertical subgrade reaction, k_1, of 200 pounds per cubic inch. This $k_1$considers a 1-foot x 1-foot load area and should be modified by the following formulae to obtain k for the proposed tank and vault load areas:

$$k_{(BxB)} = k_1 \left(\frac{B+1}{2B}\right)^2$$

where $k_{(BxB)}$ is the coefficient of subgrade reaction of a square foundation measuring B x B (feet), and

$$k = \frac{k_{(BxB)}(1 + 0.5\frac{B}{L})}{1.5}$$

where k is the coefficient of subgrade reaction of a rectangular foundation measuring B x L (feet).

4.7.3 Lateral Resistance

Earthquakes and unbalanced earth loads will subject the proposed structures to lateral forces. Lateral loading can be resisted by a combination of passive soil resistance and friction along the base of the structure. Passive soil resistance can be determined using an allowable equivalent fluid weight of 150 pounds per cubic foot, based on submerged conditions. Base friction can be determined using an allowable coefficient of friction of 0.4 for concrete placed directly on the native soils. This coefficient of friction should be used in conjunction with the normal load adjusted for the uplift pressure due to groundwater. The friction coefficient does not include a factor of safety.

4.7.4 Uplift

Based on our understanding of the proposed structure depth of 21 feet bgs and available groundwater observations, the proposed tank will be permanently below the groundwater table. Therefore, an uplift load can be expected on the tank. Preliminary tank and vault design information estimates the total dead weights of the structures to be 4,600 and 990 kips, respectively. Based on using only dead weights to counteract uplift forces on the tank and vault, we estimate factors of safety (FS) against uplift pressures to be approximately 1.7 and 12, respectively.

In our opinion, the mass of generators, pumps, roofing, other live loads, and water/sewage in the tank should not be relied on for uplift resistance. Note that if dewatering activities to lower the pressures below the excavation bottom seal are implemented, they should continue during the project until after all dead loads are in place to resist the permanent long-term uplift pressures.

4.7.5 Seepage

Difficulty sealing the shoring-mat foundation contact can result in leakage. We recommend installing a seepage barrier around the perimeter of the mat foundation, at its contact with the shoring, to reduce leakage. Flexible water stops could be installed between the mat foundation and the shoring. We recommend placing a bentonite seal around penetrations through the foundation, e.g., around drainpipe penetrations.

We recommend that an acceptable seepage rate through the mat foundation be specified in the contract documents and that the contract require that remedial measures be implemented if seepage rates are excessive.

4.8 Permanent Wall Design

We understand the tank and vault walls will be cast-in place concrete structurally connected to their respective concrete mat foundations. At the time of this report, it is undecided whether the proposed shoring system will be temporary for construction, with forms for concrete walls placed inside the shored excavation perimeter, or if the shoring system will remain in place as part of the permanent wall design. It is also undecided whether the cast-in place walls will be designed as cantilevered elements, supported by internal bracing or be combination thereof.

We recommend further hydrogeologic studies regarding impacts to regional groundwater flow towards Lake Washington and potential effects to existing structures and utilities in close proximity of the Site.

4.8.1 Static Lateral Earth Pressures

The tank and vault structures should be designed to resist the lateral loads from the adjacent retained soil, groundwater pressures, and other surcharge loads including construction traffic and seismic ground motions. Based on our interpretation of the subsurface information, we anticipate the soil retained by the tank and vault foundations could be lake deposits, mass wastage deposits, or a combination of these soil units and/or structural fill.

The at-rest condition should be used for the design of restrained walls that limit movement at the top of the wall to less than 0.001 times the wall height. For a cantilever wall and internally-braced wall designed for at-rest conditions, we recommend the permanent wall design criteria shown in Figures 7 and 8, respectively.

Active earth pressures should be used for the design of walls that are unrestrained, or allowed to yield at least 0.001 times the wall height. For a cantilever wall and internally-braced wall designed for active conditions, we recommend the permanent wall design criteria shown in Figures 9 and 10, respectively.

Lateral loads due to surficial surcharge loading (areal fill, traffic, etc.) should be considered. These lateral loads can be determined by multiplying the vertical pressures by earth pressure coefficients of 0.36 and 0.53, for active and at-rest conditions, respectively. An average areal load of about 250 psf to account for construction equipment and materials should be included if the walls will experience loading due to construction activities. This surcharge is equivalent to the traffic surcharge horizontal pressures shown in Figures 6 through 14. If construction activities will induce loads greater than 250 psf, these increases should be evaluated by SPU Geotechnical Engineering and included in the shoring design.

4.8.2 Seismic Lateral Earth Pressures

During seismic shaking, inertial effects impose increased lateral earth pressures on subsurface walls. Our recommended seismic surcharge load assumes a uniform distribution along the wall height. The seismic surcharge is based on one half of the peak ground accelerations for the 2% probability of exceedance in 50-years seismic design ground motions. The recommended seismic surcharge loads are shown in Figures 7 through 10.

4.8.3 Liquefied Lateral Earth Pressures (Post-Seismic)

Following seismic shaking, some of the submerged silty sand, sandy silt and silt encountered in the lake and mass wastage deposits above the proposed minimum foundation elevation may have liquefied. The reduction or loss of shear strength results in an increase in earth pressures acting on the wall over the depth of the liquefaction. The recommended earth pressures due to liquefaction are shown in Figures 11 through 14.

4.9 Construction Vibration, Settlement and Noise Monitoring

Some construction methods have the potential to induce ground vibrations which can damage nearby structures. Excavating and driving sheetpiles may produce significant vibrations to the sensitive structures (ie., homes) and utilities west of the Site.

Prior to starting construction, we recommend establishing a baseline by documenting (ie., survey, photographs, videos) the existing structural conditions, and estimating allowable vibration and settlement levels for each adjacent structure and utility. We recommend each of the structures be monitored for horizontal and vertical movement, including installation of gauges in any pre-existing tension cracks. We also recommend developing a vibration monitoring program prior to the start of construction and implementing it during construction activities. If the recorded movements/vibrations exceed the allowable vibration and settlement thresholds for each structure and utility, alternate construction methods should be used. We can provide acceptable limits of vibration and settlement values if needed during design.

Though unlikely to cause structural damage, noise levels from excavating and driving sheetpiles may be unpleasant to people in adjacent homes. The Contractor can reduce noise levels by using dampening techniques.

5.0 ADDITIONAL CONSTRUCTION RECOMMENDATIONS

5.1 General

The following construction recommendations are applicable for both the Basin 43alternatives.

5.2 Subgrade Verification

Subgrade preparation for areas where new fills, pavements, and utilities will be built should begin with the removal (stripping) of all deleterious matter, asphalt, and concrete. The exposed subgrade soils should be evaluated by the Geotechnical Engineer-of-Record. For large areas, this evaluation should be performed by proof-rolling the exposed subgrade with a fully loaded dump truck. For smaller areas where access is restricted, the subgrade should be evaluated by probing the soil with a steel probe.

Soft/loose soils identified during subgrade preparation should be compacted to a firm and unyielding condition or over-excavated and replaced with structural fill, as described below. The depth of overexcavation, if required, should be determined by the Geotechnical Engineer-of-Record at the time of construction.

5.3 Backfill and Compaction

Fill material should be onsite or imported material within 3 percent of the optimum moisture content per ASTM D1557 (Modified Proctor Test) and does not contain deleterious materials, greater than 5 percent organics, nor material larger than 3-inches in diameter. Any proposed imported common fill should be evaluated by the Geotechnical Engineer-of-Record to determine its suitability. The Contractor is responsible for protecting stockpiled material from becoming unsuitable while it is on site.

We estimate that some of the excavated material may be suitable for re-use as structural fill. Some of the excavated fill and native deposits will be silty and wet of optimum moisture content, and thus will be unsuitable for re-use as structural fill unless it is moisture conditioned to within 3 percent of the optimum moisture content. Depending on the project schedule, area available for moisture conditioning, and the time of year when construction is planned, it may be very difficult if not impossible to achieve the required moisture content. If moisture conditioning is required and not feasible, material that meets the criteria should be imported.

Fill placed in all structural areas (areas that will support slabs, buildings, pavements, and other foundations), and for five feet around such areas, should be compacted to a minimum of 95 percent of the maximum dry density (MDD) as determined by test method ASTM D1557. Within a lateral distance of three feet of any retaining wall, smaller, possibly hand-held equipment should be used in conjunction with thinner soil lifts to achieve the required compaction and limit compaction forces on the wall. Fill in unimproved areas such as landscaping areas and swales should be compacted to a minimum of 90 percent of MDD.

Excavated material that is not considered suitable for use as structural fill may be suitable as fill for unimproved areas (i.e. landscaped areas), that would not be adversely impacted by differential settlement over time. Restrictions made on imported material in unimproved areas should be limited, depending on the susceptibility of the area in question to settlement.

The procedure to achieve the specified minimum relative compaction depends on the size and type of compacting equipment, the number of passes, thickness of the layer being compacted, and certain soil properties. When size of the excavation restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough lifts to achieve the required compaction. A sufficient number of in-place density tests should be performed as the fill is placed to verify the required relative compaction is being achieved.

If earthwork is to be performed or fill is to be placed in wet weather or under wet conditions when control of soil moisture content is not possible, the following recommendations should apply:

* Earthwork should be accomplished in small sections to minimize exposure to wet weather. Excavations or the removal of unsuitable soil should be followed immediately by the placement and compaction of a suitable thickness of clean structural fill, as described below. The size of construction equipment used may have to be limited to prevent soil disturbance;

* Material used as trench backfill should consist of clean, granular soil, of which not more than 5 percent by dry weight passes the U.S. Standard No. 200 sieve, based on wet sieving the fraction passing the ¾ inch sieve. The fines should be non-plastic;

* The ground surface in the construction area should be sloped and sealed with a smooth drum roller to promote rapid runoff of precipitation, to prevent surface water from flowing into excavations, and to prevent ponding of water;
* No soil should be left uncompacted so it can absorb water. Soils that become too wet for compaction should be removed and replaced with clean granular materials; and
* Excavation and placement of fill should be observed on a full time basis by a person experienced in wet weather earthwork to verify that all unsuitable materials are removed and suitable compaction and site drainage is achieved.

Recompacted, onsite soils may be assumed as having an in-place moist unit weight of 120 pcf. Imported materials meeting the specifications of Type 2 and Type 17 that have been compacted may be assumed as having a moist unit weight between 125 and 135 pcf, depending on the compaction effort and the source of the material.

5.4 Permanent Slopes

For stability, permanent cut slopes should be no steeper than 3H:1V. To provide uniform compaction, fill slopes should be constructed by benching into native soil and compacted beyond their final grade lines and trimmed to grade. Embankment fill material should be a granular material, free of organics, rubbish, and other undesirable material, and should be compacted to a minimum of 90% of its maximum dry density, as determined by ASTM D1557. Constructed in this way, fill slopes should be no steeper than 2H:1V. However, erosion and maintenance issues may require a less steep slope (3H:1V or less). Excavated or fill surfaces should be protected from erosion as soon as possible after exposure. Temporary erosion control measures, such as plastic sheeting or mulching, should be utilized if permanent measures cannot be implemented immediately.

5.5 Construction Drainage and Erosion Considerations

Surface runoff and erosion at the site can be controlled during construction by careful grading practices and observance of best management practices (BMPs). Such practices typically include the construction of shallow, upgrade perimeter ditches or low earthen berms, and the use of temporary sumps to collect runoff. Erosion during construction can be minimized by judicious use of erosion control devices. If used, these devices should be in place prior to construction and remain in place throughout construction.

Erosion and sedimentation of exposed soils can also be reduced by quickly re-vegetating exposed areas of soil, and by staging construction such that large areas of the Site are not denuded and exposed at the same time. Areas of exposed soil requiring immediate and/or temporary protection against exposure should be covered with mulch, erosion control netting and/or blankets.

Permanent erosion control measures should be implemented to reduce the potential for future erosion events. Denuded areas should be mulched and/or planted with approved vegetation.

5.6 Underground Utilities

5.6.1 Trench Subgrades

The native and fill soil encountered throughout the site should generally provide suitable support for underground utilities, provided subgrades remain in an undisturbed condition and the pipes and structures are bedded as described in the following section. A smooth-bladed excavator bucket should be used to excavate to the subgrade elevation and foot traffic on the subgrade minimized to reduce the amount of disturbance to the subgrade. A layer of bedding material or gravel may be used to protect the subgrade once it is exposed.

If unsuitable subgrade conditions are encountered at the time of construction, the subgrade should be evaluated and the course of action determined by the Geotechnical Engineer-of-Record. Typical courses of action may include overexcavation and replacement with structural fill, stabilization with quarry spalls, or use of geosynthetics.

5.6.2 Bedding

Bedding is material placed at the bottom of the trench to provide uniform support along the bottom of a buried utility. Bedding material and placement procedures should meet the appropriate requirements and criteria of the current *City of Seattle Standard Specifications*, depending on the utility in question. In areas where a trench box is used, the bedding material should be placed before the trench box is advanced. Bedding material disturbed by movement of trench boxes should be recompacted prior to final backfilling. Care should be taken not to disturb the utility as the trench box is advanced.

Trench backfill will be placed on top of the bedding. Refer to the backfill recommendations in Section 5.3: *Backfill and Compaction*.

5.7 Pavements

We understand that, when finished, the Site will be repaved with asphalt concrete, and be primarily utilized by light automobiles and pick-up trucks, with occasional use by heavy maintenance or delivery vehicles. Pedestrian paths constructed of varying materials are currently present around the perimeter of the Site.

In our opinion, vehicular parking area and pedestrian pavements may be designed as flexible pavement, assuming an effective subgrade resilient modulus, M_R of 10,000 pounds per square inch (psi) when placed on existing lake deposits. This recommendation is based on our interpretation of surficial ground conditions at the site and the guidelines of the *American Association of State Highway and Transportation Officials Guide for the Design of Pavement Structures* (AASHTO, 1993). The effective resilient modulus takes into account the regional climate of Seattle.

6.0 LIMITATIONS AND ADDITIONAL SERVICES

This geotechnical report was prepared accordance with generally accepted professional principles and practices in the field of geotechnical engineering at the time the report was prepared. This report is intended to provide information and recommendations to support preliminary engineering activities for this project. The conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions.

We recommend that the SPU Geotechnical Engineering be retained to review the plans and specifications and verify that our recommendations have been interpreted and implemented as intended. Sufficient geotechnical monitoring, testing, and consultation should be provided during construction to confirm that the conditions encountered are consistent with those indicated by explorations and to verify that the geotechnical aspects of construction comply with the contract plans and specifications. Recommendations for design changes can be provided should conditions revealed during construction differ from those anticipated.

We appreciate the opportunity to be of service.

Sincerely,

SPU GEOTECHNICAL ENGINEERING

5/11/2011

5/11/2011

Aaron J. Clark
Assistant Engineering Geologist

Juan Carlos Ramirez, P.E.
Senior Geotechnical Engineer

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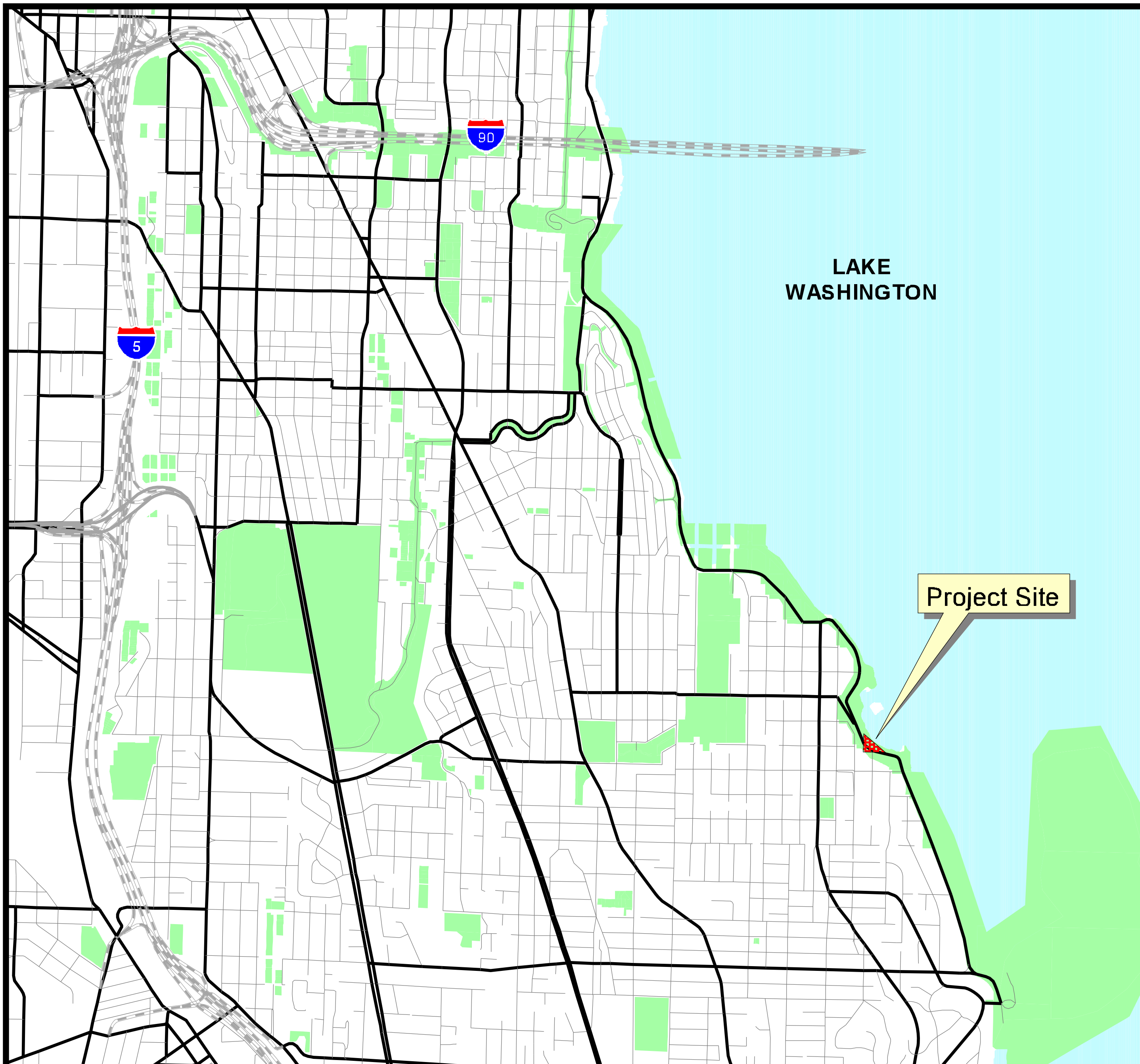

LEGEND

Streets
- Residential
- Arterials
- State Highway
- Interstate Freeway
- Parks
- Water Bodies

N
W E
S

NAVD88 Datum

0.5 0 0.5 1 Miles

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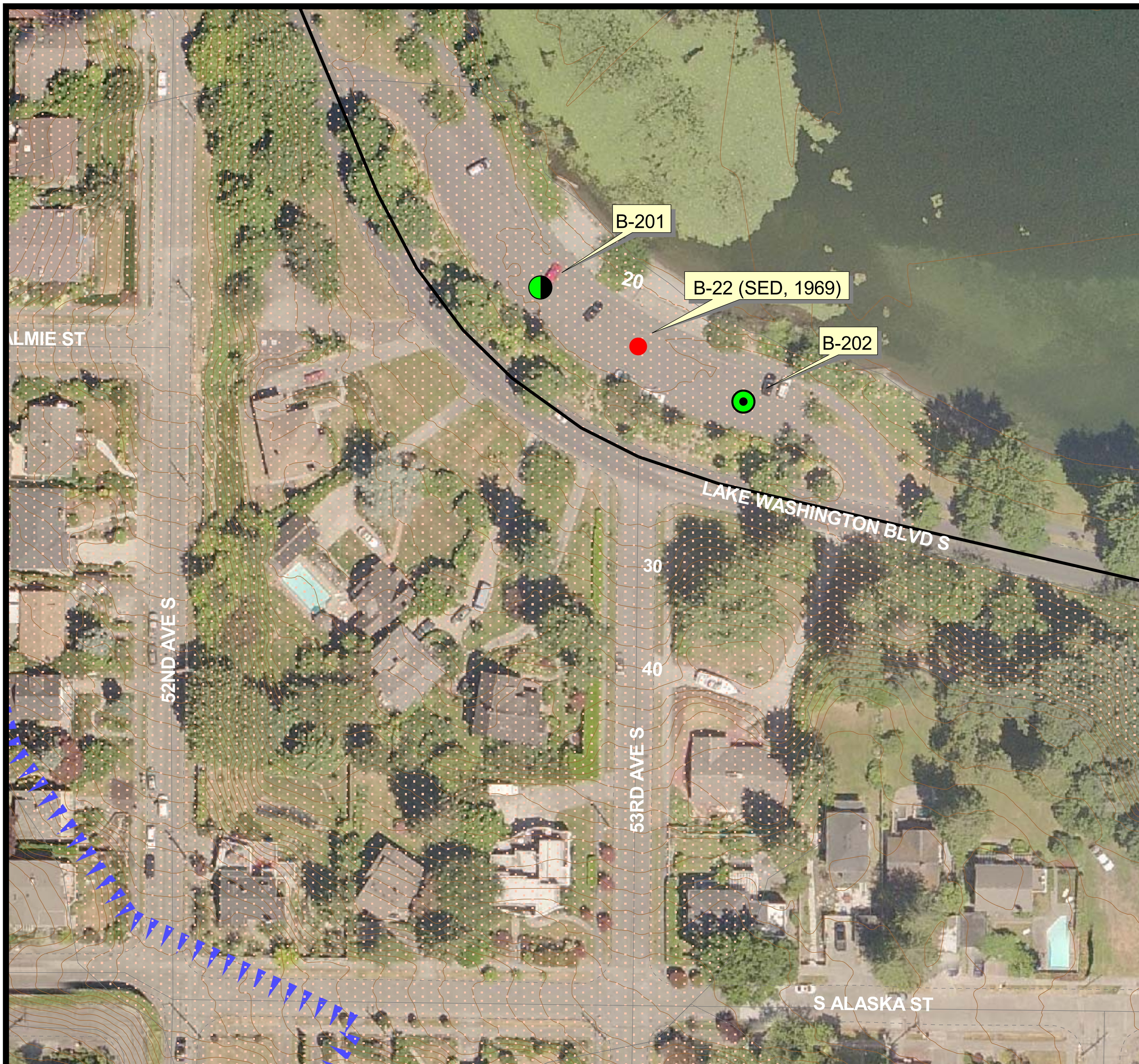
GENESEE CSO AREA 43
53RD AVENUE SOUTH PARKING LOT STORAGE
SEATTLE, WASHINGTON

VICINITY MAP

APRIL 2011

FIGURE 1



LEGEND

- SPU Materials Laboratory Boring
- SPU Materials Laboratory Boring with Well
- Previous Exploration (SED, 1969)
- Residential Streets
- Arterials Streets
- Pavement Edge
- 2 foot contours
- LIDAR-derived topography, South (draws at 15000 scale)
- Mass Wastage (in review)
- Scarps (in review)

N
W E
S

NAVD88 Datum

100 0 100 200 Feet

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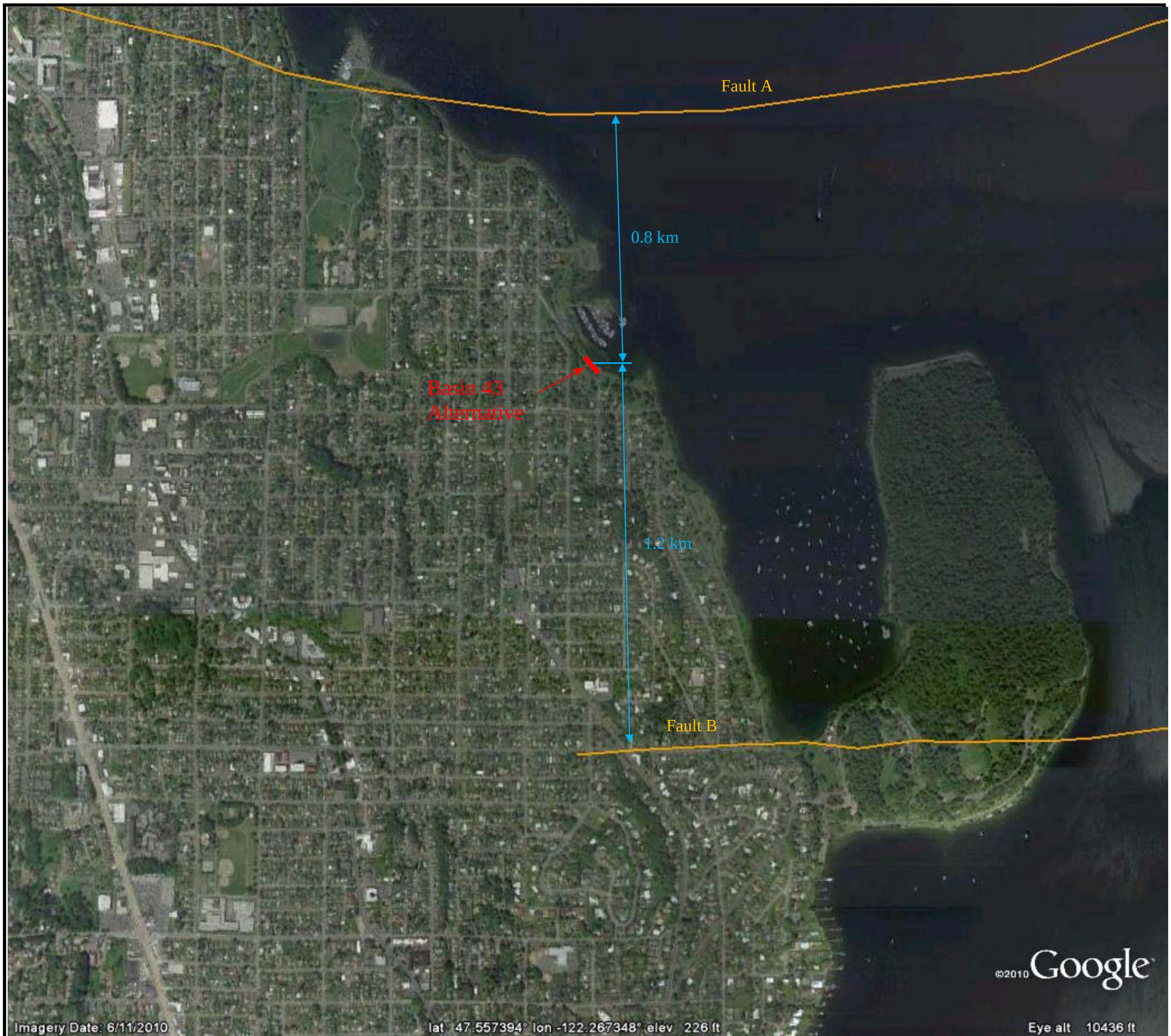
Geotechnical Engineering

GENESEE CSO AREA 43
53RD AVENUE SOUTH PARKING LOT STORAGE
SEATTLE, WASHINGTON

SITE & EXPLORATION MAP

APRIL 2011

FIGURE 2



LEGEND

Approximate Distance to Nearest Fault (km)

Location of CSO Storage Alternative

Seattle Fault Splays

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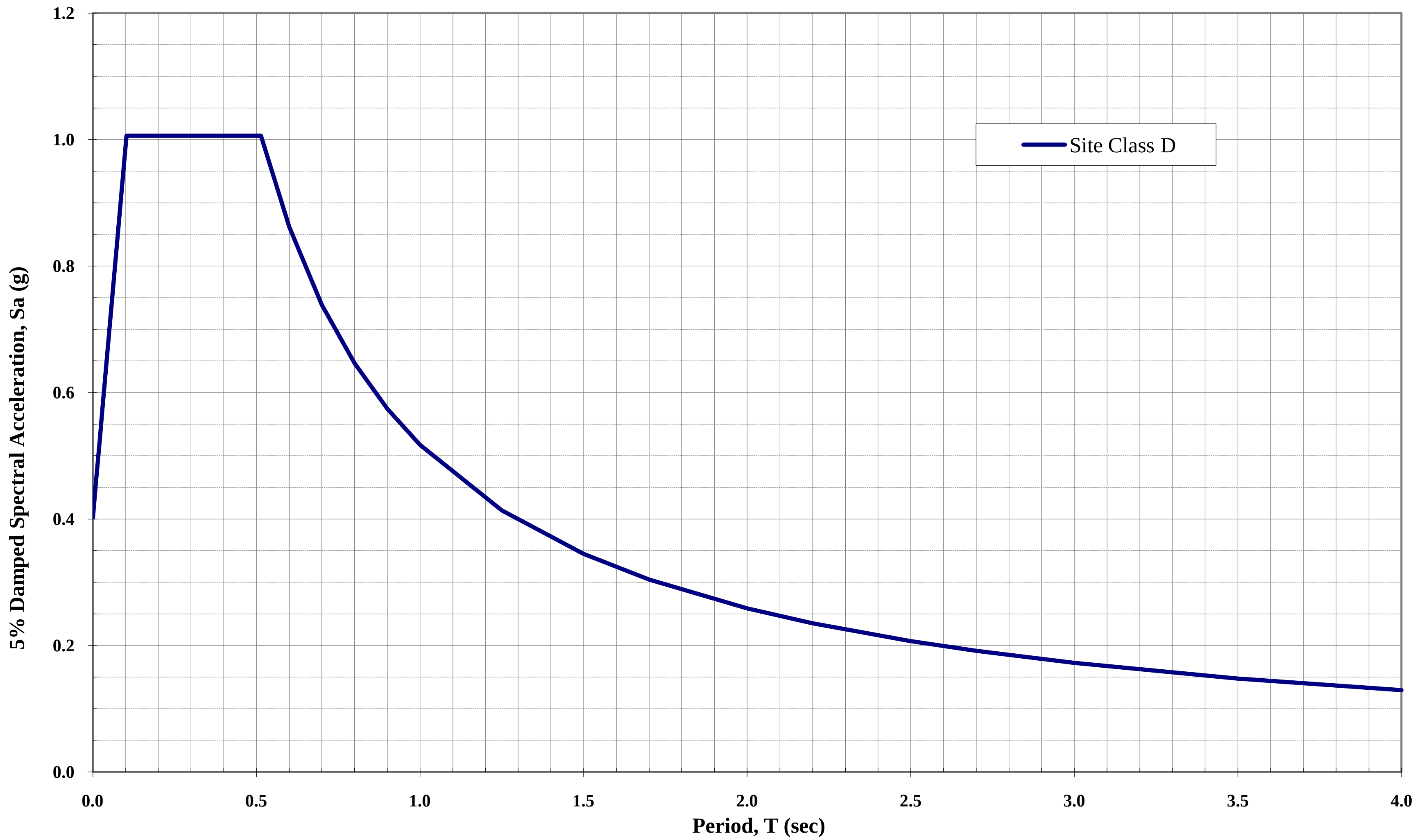
GENESEE CSO AREA 43
53RD AVENUE SOUTH PARKING LOT STORAGE
SEATTLE, WASHINGTON

LOCATION OF BASIN 43 ALTERNATIVE RELATIVE TO FAULT SPLAYS ON SFZ

APRIL 2011 **FIGURE 3**



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S_S = 1.51 g
S_1 = 0.52 g
S_{MS} = 1.51 g
S_{M1} = 0.78 g
S_{DS} = 1.01 g
S_{D1} = 0.52 g

F_a = 1.00
F_v = 1.50
T_0 = 0.10 sec.
T_S = 0.51 sec.

Project No: C303103

Horizontal Response Spectrum

Genesee CSO Storage Project

53rd Ave South Parking Lot

April, 2011

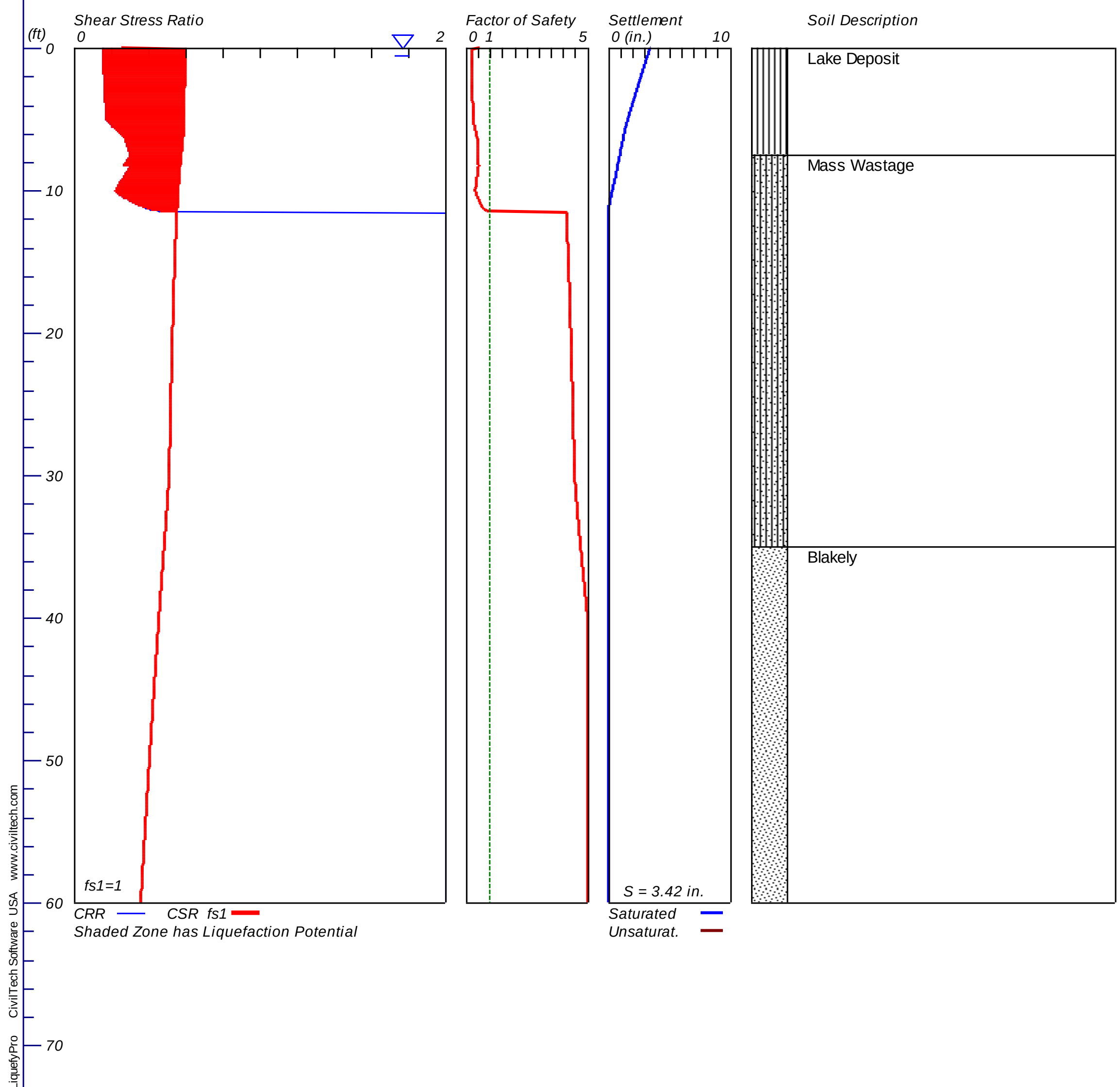
Figure 4

LIQUEFACTION ANALYSIS

Genesee CSO

Hole No.=B-201 Water Depth=0 ft Surface Elev.=22

Magnitude=7.1
Acceleration=0.4g



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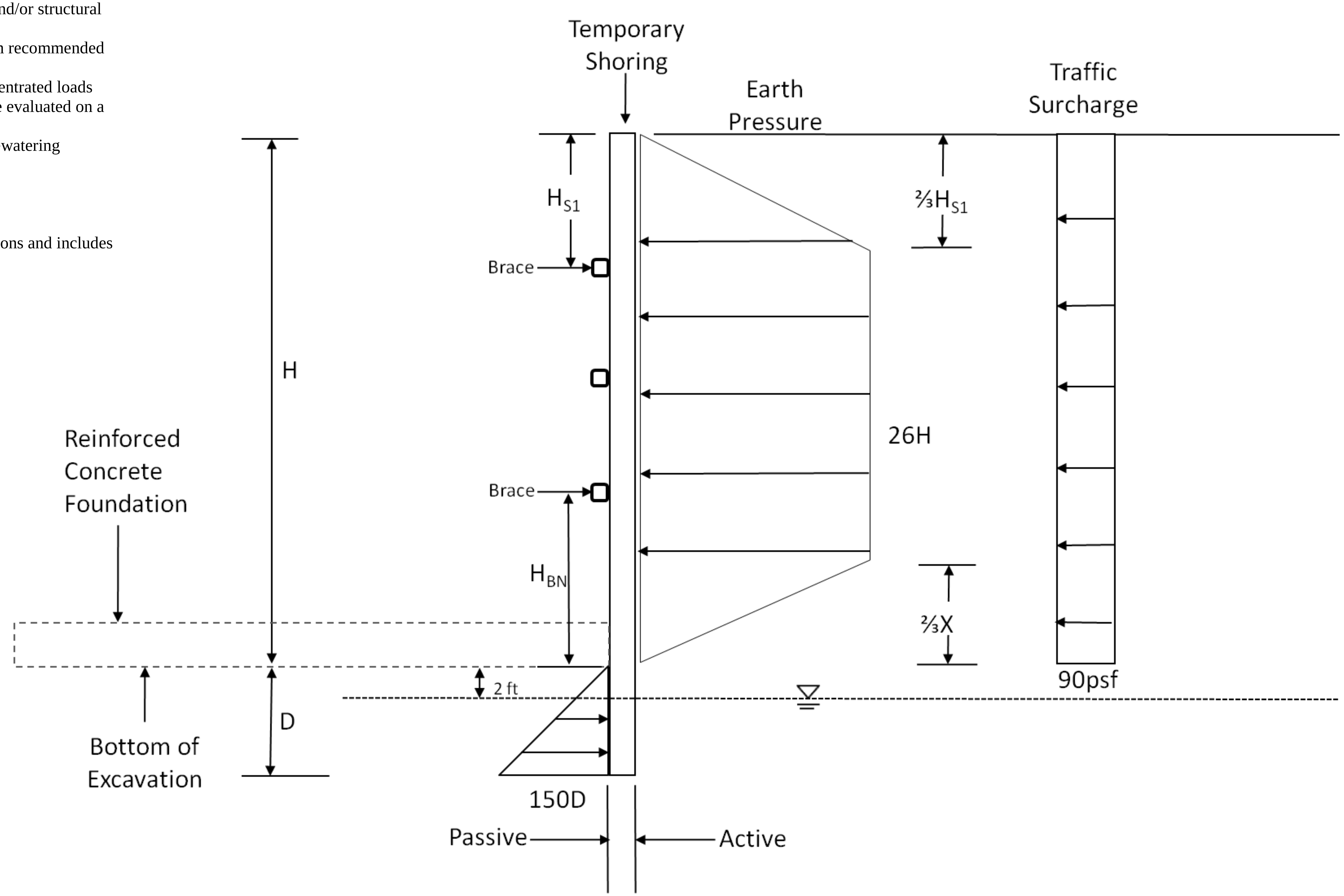
Alternative 43-53rd Ave S Park

Figure 5

NOTES:

1) Earth pressures assume an unrestrained internally-braced retaining wall system (active loading condition), which is allowed to yield.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake, mass wastage deposits and/or structural fill.
4) Wall embedment (D) should consider kickout resistance. Minimum recommended embedment is 5 feet.
5) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
6) Diagram assumes hydrostatic forces as shown, with construction dewatering maintaining groundwater level 2 feet below bottom of excavation.
7) Active pressure shown does not include a factor of safety.
8) $X=H-H_{S1}$ (Single Braced)
9) $X=H_{BN}$ (Multiple Braced)
10) Passive Resistance in front of the wall assumes submerged conditions and includes a factor of safety of 1.5.



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53RD AVE SOUTH PARKING LOT
GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

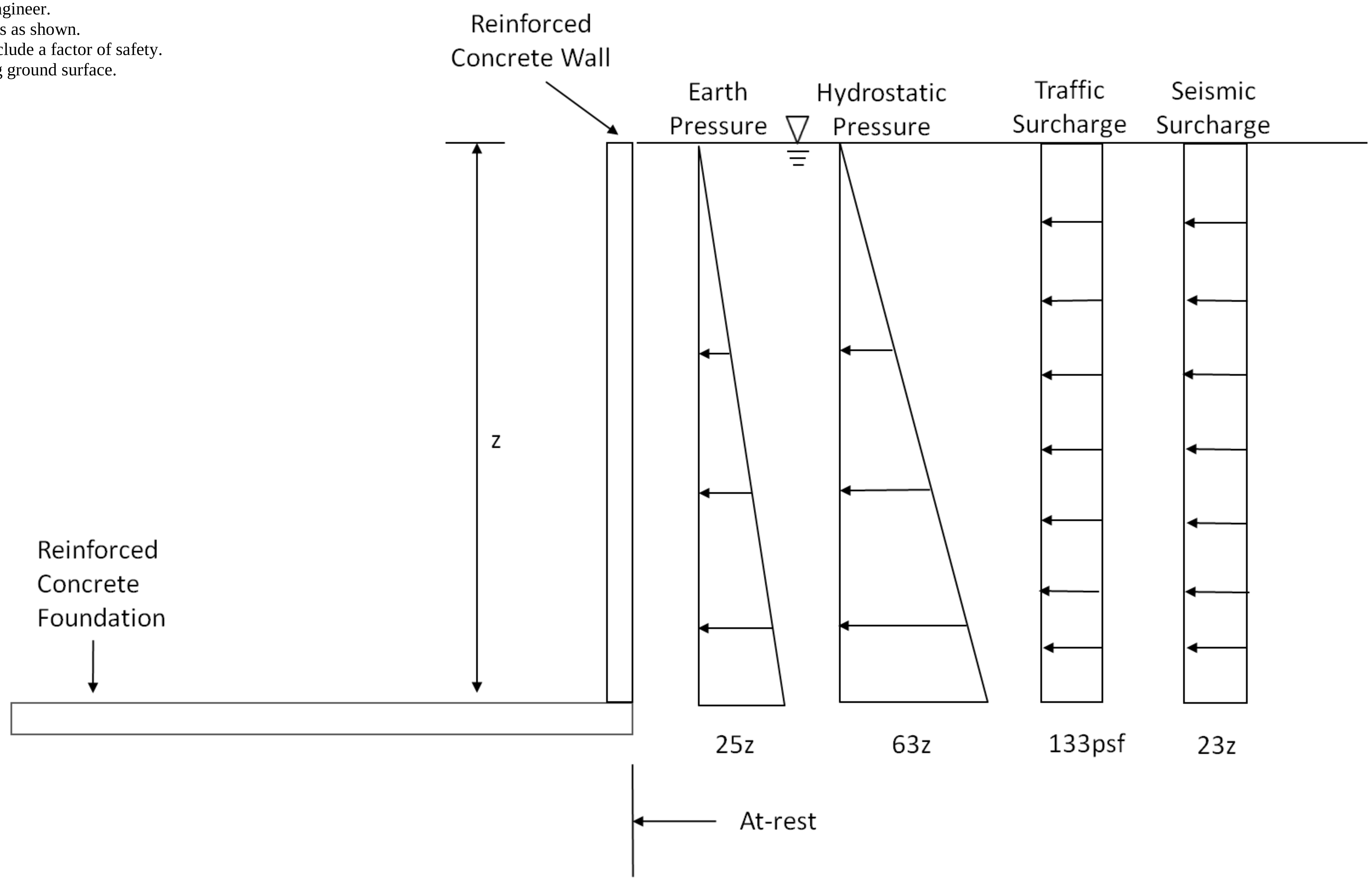
Not to Scale

RECOMMENDED EARTH PRESSURES FOR TEMPORARY BRACED WALL DESIGN, ACTIVE CONDITION

April 2011

FIGURE 6

NOTES:
1) Earth pressures assume a restrained cantilever retaining wall (at-rest loading condition).
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake, mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) z should be measured from existing ground surface.



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GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

Not to Scale

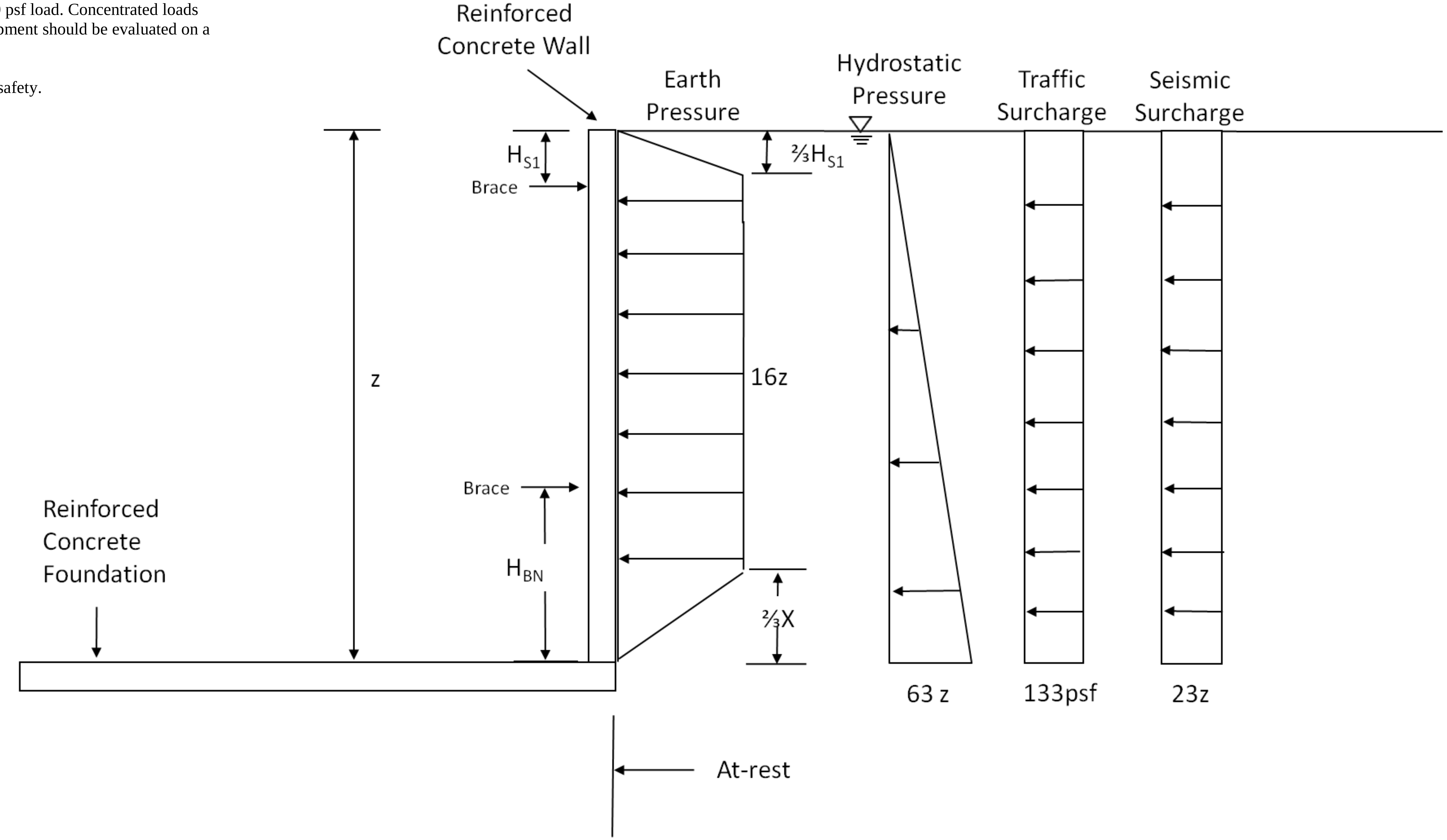
RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, AT-REST CONDITION

April 2011

FIGURE 7

NOTES:

1) Earth pressures assume a restrained internally-braced retaining wall system (at-rest loading condition).
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) $X=z-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) z should be measured from existing ground surface.



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GEOTECHNICAL ENGINEERING

53RD AVE SOUTH PARKING LOT
GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

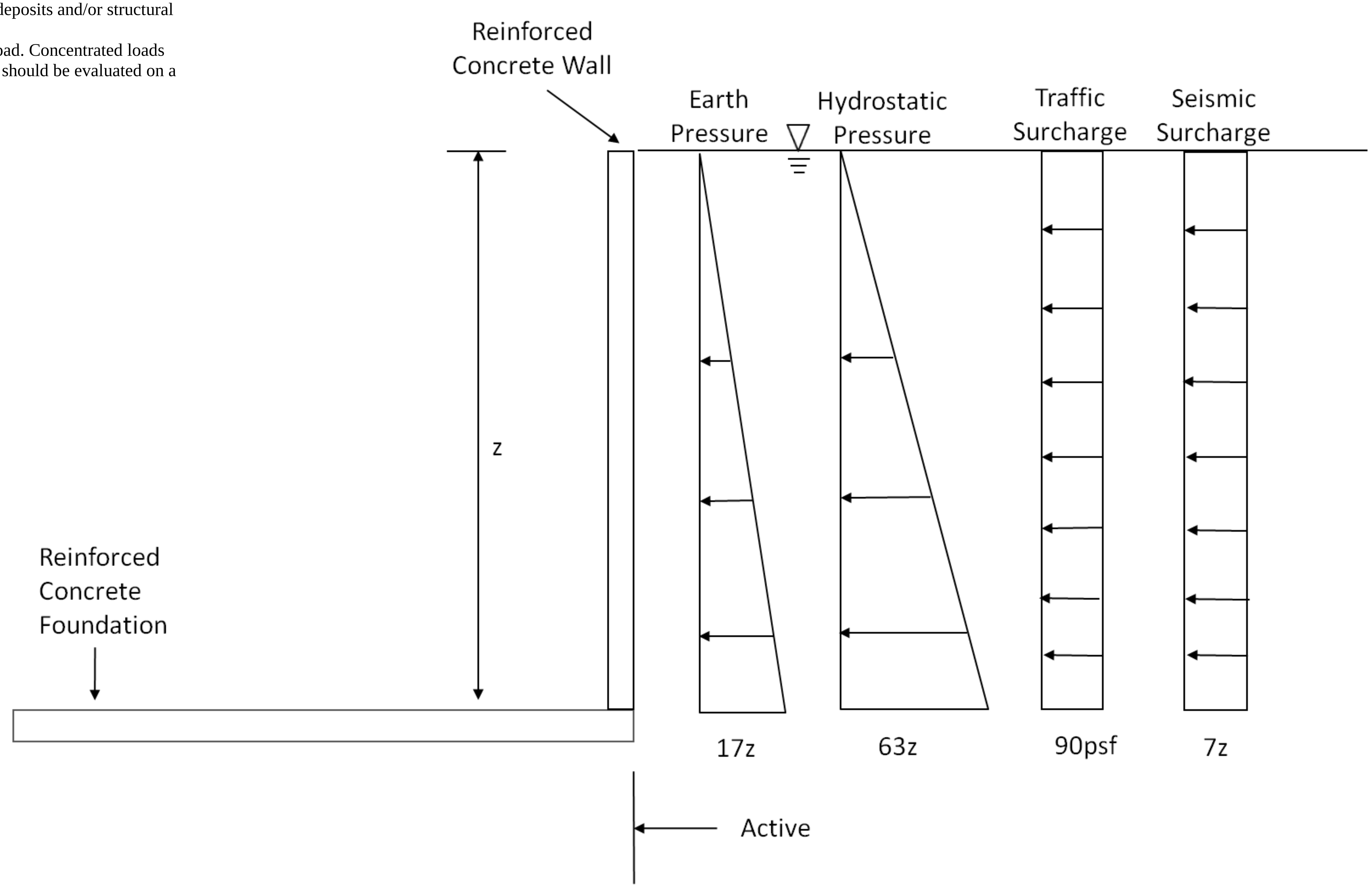
Not to Scale

RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, AT-REST CONDITIONS

April 2011

FIGURE 8

NOTES:
1) Earth pressures assume an unrestrained cantilever retaining wall system (active condition), which is allowed to yield.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake, mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) z should be measured from existing ground surface.



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GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

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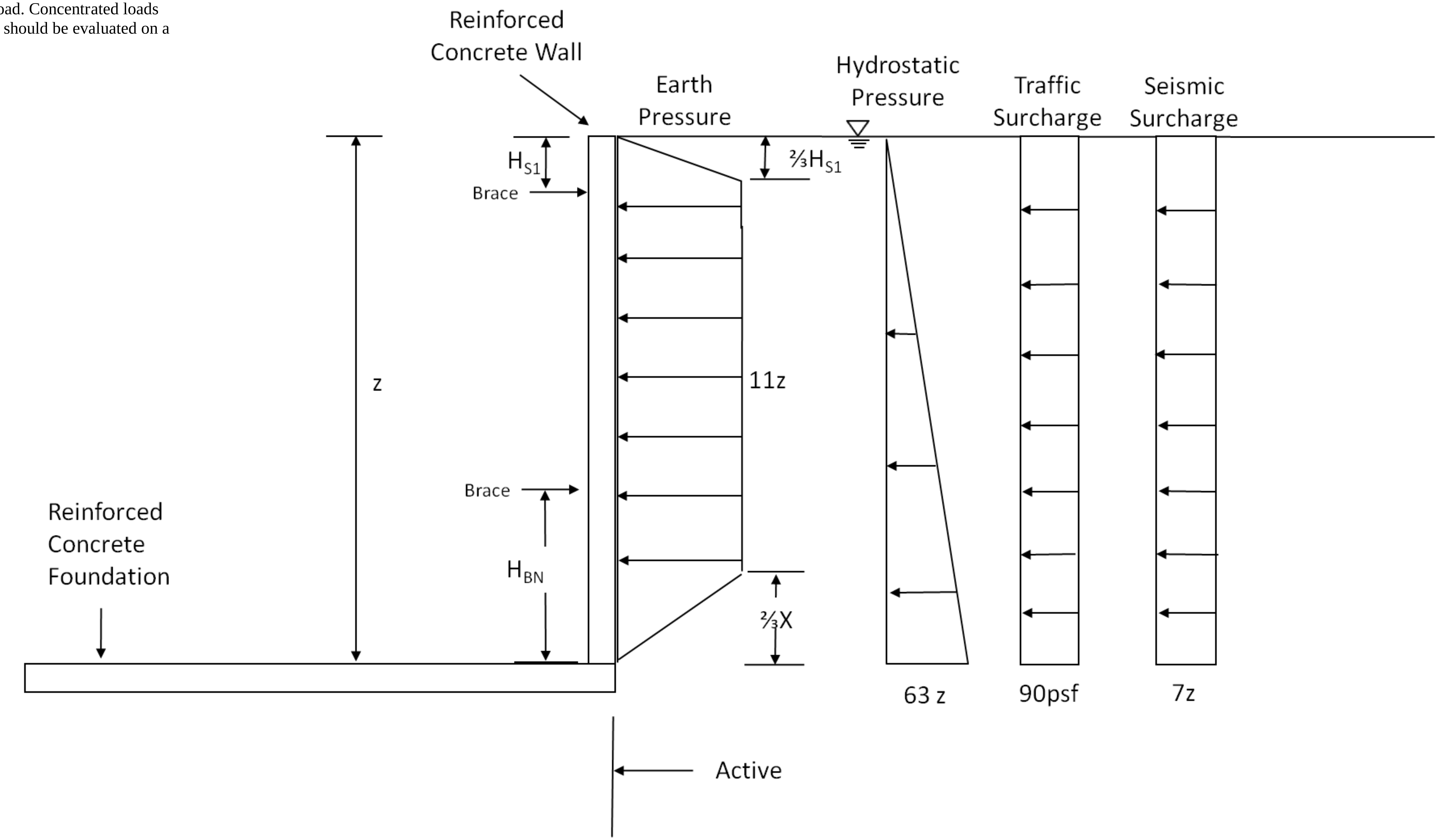
RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, ACTIVE CONDITION

August 2010

FIGURE 9

NOTES:

1) Earth pressures assume a restrained, internally-braced retaining wall system (active condition), which is allowed to yield.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake, mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) $X=z-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) z should be measured from existing ground surface.



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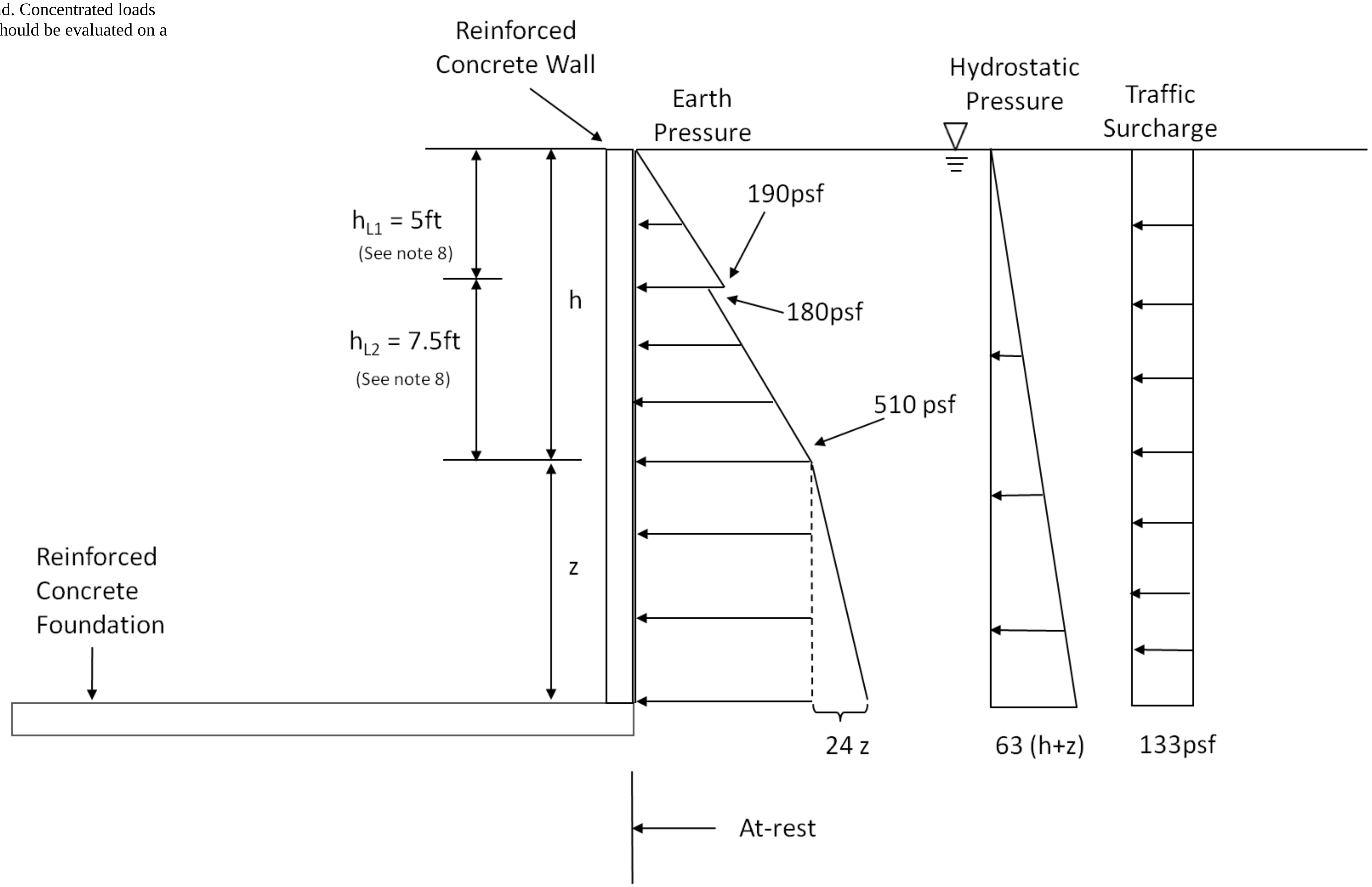
RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, ACTIVE CONDITION

April 2011

FIGURE 10

NOTES:
1) Earth pressures assume a restrained cantilever retaining wall (at-rest loading condition), under post-seismic (liquefied) conditions.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake, mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) (h+z) should be measured from existing ground surface.
8) (h_{L1}+h_{L2}) = height of liquefaction.



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GEOTECHNICAL ENGINEERING

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SEATTLE, WASHINGTON

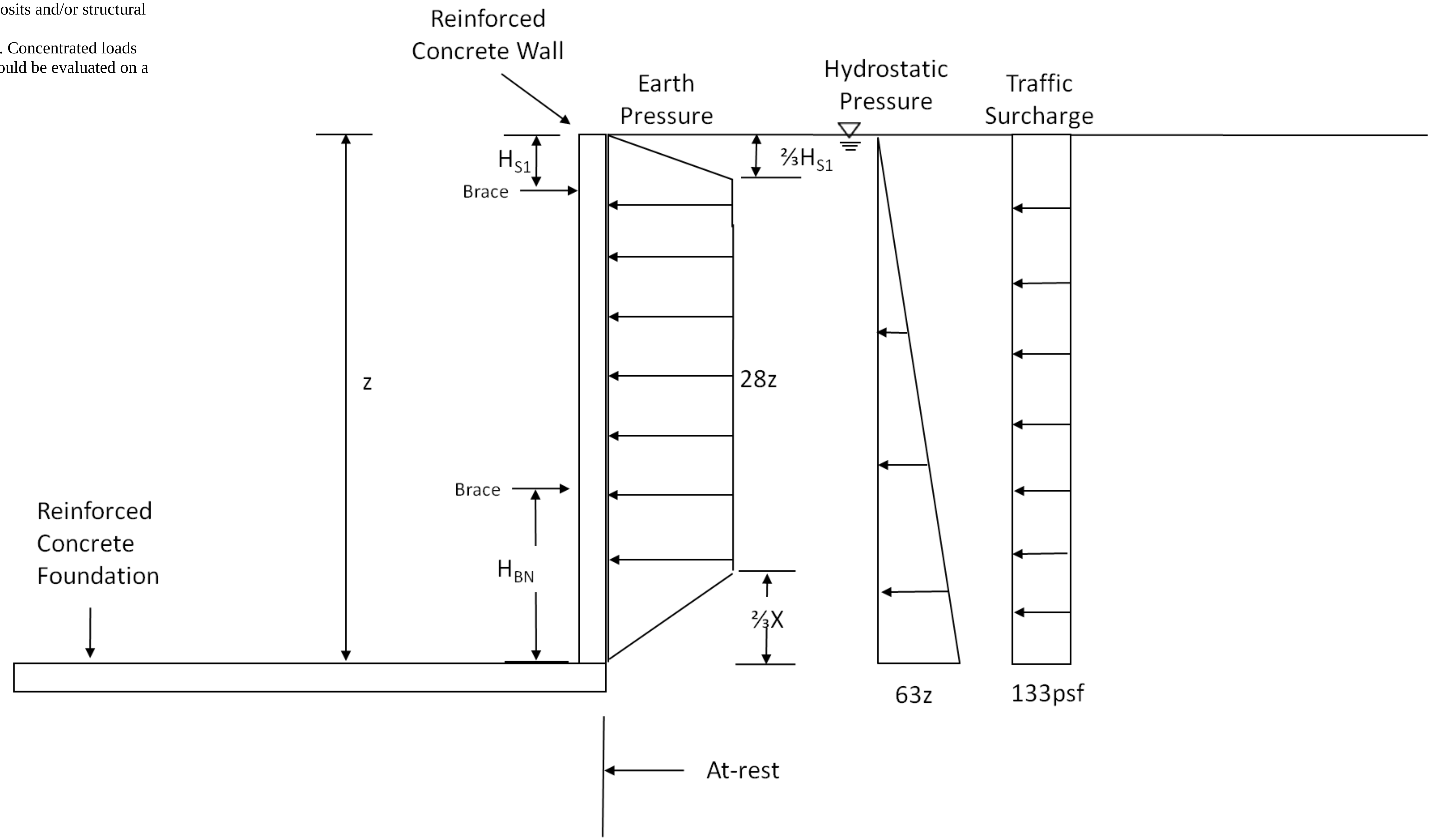
Not to Scale

RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, AT-REST CONDITION, POST-SEISMIC

April 2011

FIGURE 11

NOTES:
1) Earth pressures assume a restrained internally-braced retaining wall system (at-rest loading condition), under post-seismic (liquefied) conditions..
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake, mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) At-rest pressure shown does not include a factor of safety.
7) $X=z-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) z should be measured from existing ground surface.



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SEATTLE, WASHINGTON

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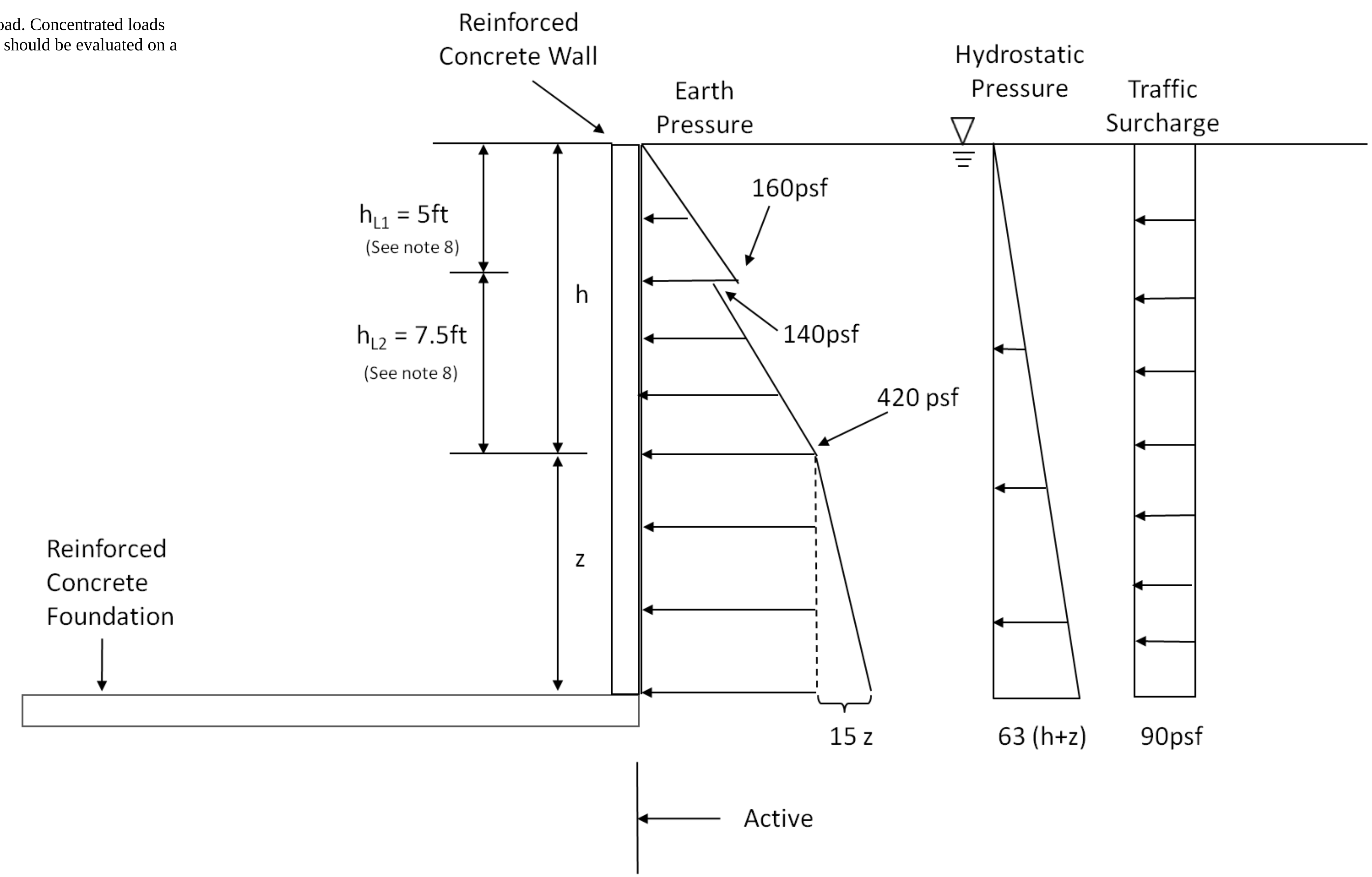
RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, AT-REST CONDITIONS, POST-SEISMIC

April 2011

FIGURE 12

NOTES:
1) Earth pressures assume an unrestrained cantilever retaining wall system (active condition), which is allowed to yield, under post-seismic (liquefied) conditions.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are lake, mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) (h+z) should be measured from existing ground surface.
8) (h_{L1}+h_{L2}) = height of liquefaction.



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GEOTECHNICAL ENGINEERING

53RD AVE SOUTH PARKING LOT
GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

Not to Scale

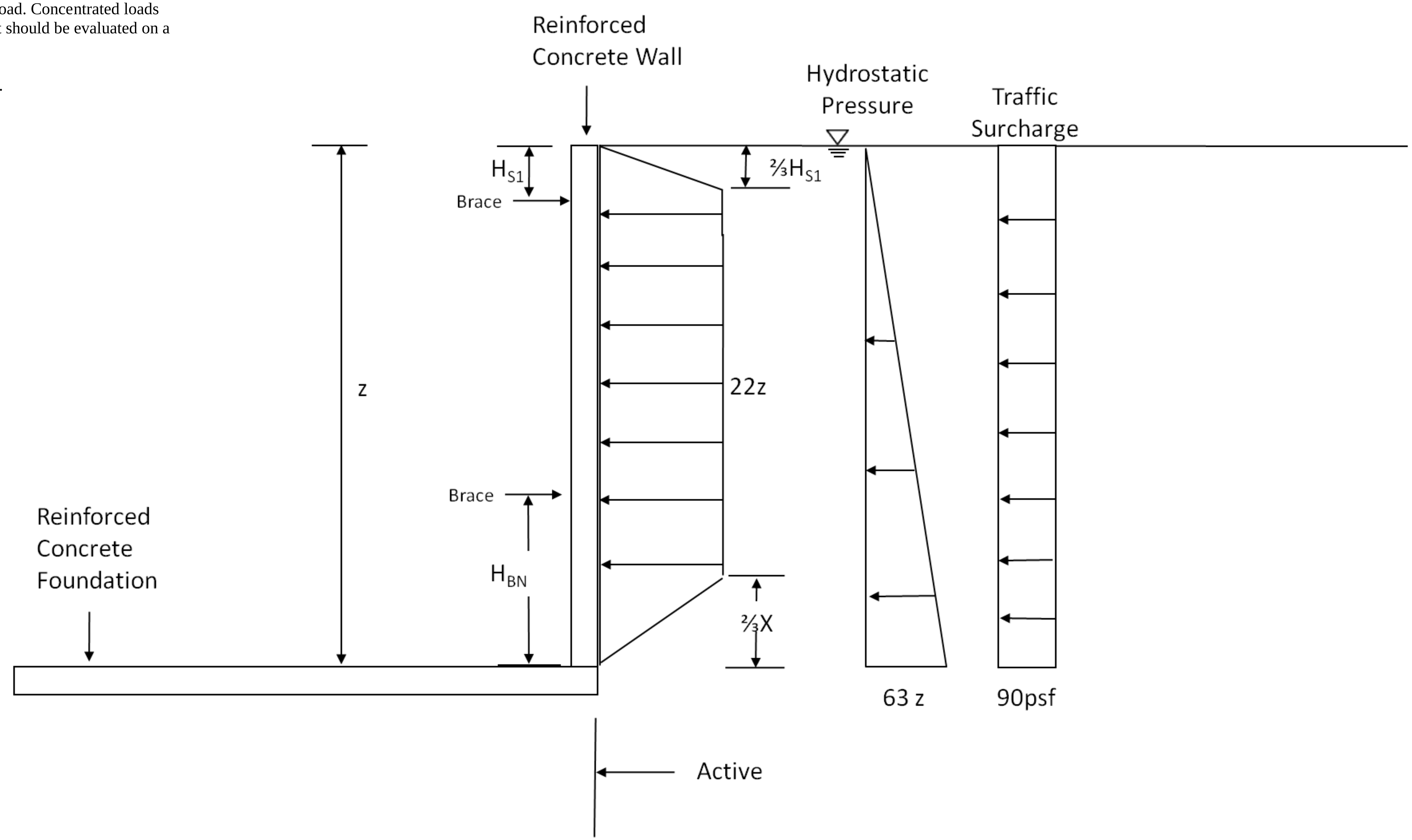
RECOMMENDED EARTH PRESSURES FOR PERMANENT CANTILEVER WALL DESIGN, ACTIVE CONDITION, POST-SEISMIC

April 2011

FIGURE 13

NOTES:

1) Earth pressures assume a restrained, internally-braced retaining wall system (active condition), which is allowed to yield.
2) Magnitude of earth pressures can be calculated by formulas shown. All earth pressures shown are in units of pounds per square foot (psf).
3) Assumed retained soil conditions are fill, lake, and mass wastage deposits and/or structural fill.
4) The traffic surcharge pressures shown assume a 250 psf load. Concentrated loads other than those imposed by general construction equipment should be evaluated on a case-by-case basis by the structural engineer.
5) Diagram assumes hydrostatic forces as shown.
6) Active pressure shown does not include a factor of safety.
7) $X=z-H_{S1}$ (Single Braced)
8) $X=H_{BN}$ (Multiple Braced)
9) z should be measured from existing ground surface.



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GEOTECHNICAL ENGINEERING

53RD AVE SOUTH PARKING LOT
GENESEE CSO STORAGE PROJECT
SEATTLE, WASHINGTON

Not to Scale

RECOMMENDED EARTH PRESSURES FOR PERMANENT BRACED WALL DESIGN, ACTIVE CONDITION, POST-SEISMIC

April 2011

FIGURE 14

APPENDIX A

PREVIOUS STUDIES

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 2-6-69 HOLE NO. 22

PROJECT Lake Wash. Drainage #1 WEATHER

LOCATION 53RD & Snoqualmie ℄ Low cong - thus [illegible]

WATER TABLE: 2-13-69

GRD. EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
5	A	1	1		1	12" Sand	Silt Clay	Soft	Wet	Gray
	A1					8" Silt	Clay Organic		Moist	Brn
						MH-CH				
10	B	3	6	11	17	Clay	Silt	Stiff	Moist	Bl.
						CL				
15	C	3	3	16	19	Sand	Silt	Firm	Sat	Brn
						SP-SM				

INSPECTOR:

NO WATER 2-13-69

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 2-5-69 HOLE NO. 23

PROJECT Lake Wash Drainage #1 WEATHER

LOCATION 52ND & Snoqualmie 32' N. & 14' W. of ℄

GRD. EL.	SAMPLE NO.	BLOW COUNT			STD. PEN.	BASE MAT'L.	AUXILIARY MATERIAL	CONSISTENCY	MOISTURE	COLOR
5	A	1	1	1	2	Silt	Sand-Clay		Wet	Brn
						1" Silt-Clay				B.L.
						ML				
							Harder Drilling (Gravel)			
10	B	1	10	19	29	Silt	Sand, Clay		Wet	Brn
						SM	Layer of Gravel			
	C	32	62	80	142	6" Silt	Clay Sand		Sat.	Brn
	C1					12" Clay	Silt Sand		Moist	Gray
						CL				
15										

INSPECTOR:

05980

APPENDIX B

FIELD EXPLORATION PROGRAM

APPENDIX B

FIELD EXPLORATION PROGRAM

GEOTECHNICAL SOIL BORINGS

Subsurface conditions for the current study were explored using mud rotary drilling techniques. Two borings, B-201 and B-202, were completed to depths of 60.5 and 61.5 feet on February 24 and February 25, 2011, respectively. The approximate locations of the explorations are illustrated on Figures 2 in the main body of the text. The explorations were located relative to prominent features in the area. The approximate ground surface elevations at the exploration locations are referenced to the NAVD88 datum.

The borings were drilled by Gregory Drilling, Inc. of Redmond, Washington, under contract to the SPU Geotechnical Engineering. A truck-mounted CME 85 rig was utilized to drill the borings. The results of the explorations are summarized on the individual summary boring logs, which are included here as Figures B-2 and B-3. A key to the symbols and terms used on the summary logs is presented as Figure B-1.

Soil samples were obtained from both borings at 2.5-foot and 5-foot depth intervals using the Standard Penetration Test (SPT, ASTM D-1586). The 2.0-inch outside diameter (OD) SPT sampler was driven into the soil a distance of 18 inches using a 140-pound auto-trip drive hammer falling a distance of 30 inches. Recorded blows for each 6 inches of sampler penetration (blow counts) are shown on the summary logs in this appendix. The blow counts provide a qualitative measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils. Representative portions of all recovered samples were placed in sealed containers and transported to our laboratory for further observation and testing.

A two-inch diameter Schedule 40 PVC standpipe piezometer was installed in borings B-201 to facilitate measurements of groundwater levels and their fluctuations. The piezometer was installed with a 10-foot screen section. The piezometer was completed with silica sand filter pack, and bentonite seal. An 8-inch diameter flush mount steel monument was installed at the surface and secured with concrete. Piezometer construction details are shown on the boring B-201 summary log. The piezometer was developed by surging and pumping to ensure hydraulic communication between the well screen and the surrounding aquifer. The piezometers should be properly decommissioned in accordance with Washington Administrative Codes (WACs) at the conclusion of the project.

Table B-1: Static Water Level Measurements, B-201

Date	Depth to Water (ft)
2/25/2011	0.86
2/28/2011	0

UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D2488

MAJOR DIVISION			GROUP SYMBOL	LETTER SYMBOL	GROUP NAME
COARSE GRAINED SOILS CONTAINS LESS THAN 50% FINES	**GRAVEL AND GRAVELLY SOILS** MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVEL WITH ≤ 5% FINES		GW	Well-graded GRAVEL
				GW	Well-graded GRAVEL WITH SAND
				GP	Poorly graded GRAVEL
				GP	Poorly graded GRAVEL WITH SAND
		GRAVEL WITH BETWEEN 5% AND 15% FINES		GW-GM	Well-graded GRAVEL WITH SILT
				GW-GC	Well-graded GRAVEL WITH CLAY
				GP-GM	Poorly graded GRAVEL WITH SILT
				GP-GC	Poorly graded GRAVEL WITH CLAY
		GRAVEL WITH ≥ 15% FINES		GM	SILTY GRAVEL
				GC	CLAYEY GRAVEL
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SAND WITH ≤ 5% FINES		SW	Well-graded SAND
				SW	Well-graded SAND WITH GRAVEL
				SP	Poorly graded SAND
				SP	Poorly graded SAND WITH GRAVEL
		SAND WITH BETWEEN 5% AND 15% FINES		SW-SM	Well-graded SAND WITH SILT
				SW-SC	Well-graded SAND WITH CLAY
				SP-SM	Poorly graded SAND WITH SILT
				SP-SC	Poorly graded SAND WITH CLAY
		SAND WITH ≥ 15% FINES		SM	SILTY SAND
				SC	CLAYEY SAND
FINE GRAINED SOILS CONTAINS MORE THAN 50% FINES	SILT AND CLAY	LIQUID LIMIT LESS THAN 50		ML	Inorganic SILT, low plasticity
				ML	Inorganic SILT WITH SAND, low plasticity
				CL	Lean inorganic CLAY, low plasticity
				CL	Lean inorganic CLAY WITH SAND, low plasticity
				OL	ORGANIC SILT, low plasticity
		LIQUID LIMIT GREATER THAN 50		MH	Elastic inorganic SILT, moderate to high plasticity
				CH	Fat inorganic CLAY, moderate to high plasticity
				OH	ORGANIC SILT or CLAY, moderate to high plasticity
HIGHLY ORGANIC SOILS				PT	PEAT soils with high organic contents
TOPSOIL				TP	TOPSOIL

NOTES:
1) Sample descriptions are based on visual field and laboratory observations using classification methods of ASTM D2488. Where laboratory data are available, classifications are in accordance with ASTM D2487.
2) Solid lines between soil descriptions indicate change in interpreted geologic unit. Dashed lines indicate stratigraphic change within the unit.
3) Fines are material passing the U.S. Std. #200 Sieve.

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FIGURE B-1
(Sheet 1 of 2)

KEY :

SAMPLING METHOD

Symbol	Description
◪	2-inch OD SPT Split Spoon Sample with 140-lb hammer falling 30 inches (ASTM D1586).
◫	No Recovery.
⧄	Shelby Tube Sample (ASTM D1587).
■	3-inch OD Split Spoon Sample (California Sampler) with 300-lb hammer falling 30-inches.
⧅	Grab Sample.
◨	Non Standard (As noted on log).
⊠	Core Run.

LABORATORY TEST

AL	Atterberg Limits
FC	Fines Content
GSD	Grain Size Distribution (Sieve
	and/or Hydrometer)
ENV	Environmental Testing
SG	Specific Gravity
MD	Moisture Density Relationship
C	Consolidation
UCS	Unconfined Compression Strength
	Hydraulic Conductivity Test
Perm	Pocket Penetrometer
PP	Torvane
TV	Direct Shear
DS	Organic
O	

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No. 4 (4.75 mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

COMPONENT PROPORTIONS

DESCRIPTIVE TERMS	RANGE OF PROPORTION
Trace	Less than 5%
Few	5 - 12%
Some	12 - 30%

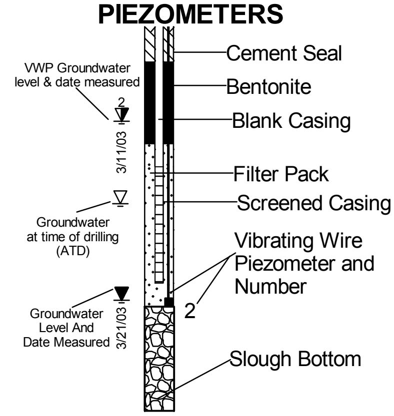
MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch
MOIST	No visible water, near optimum moisture content.
WET	Visible free water,usually soil is below water table.
SATURATED	Water content prevents soil from retaining structure.

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N - VALUE

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

PIEZOMETERS



SOIL STRATIFICATION AND STRUCTURE

STRATA	DESCRIPTION
Parting	Less than 1/16 inch thick
Seam	1/16 to 1/2 inch thick
Layer	1/2 to 12 inch thick
Pockets	Inclusions < 1 inch thick
Occasional	> 1 occurrance per foot
Scattered	> 10 occurrance per foot
Numerous	< 1 per foot

STRUCTURE	DESCRIPTION
Stratified	Alternating layers of varying material or color with layers at least 1/4 inch thick;note thickness
Laminated	Alternating layers of varying material or color with layers less than 1/4 inch thick;note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogenous	Same color throughout
Dilatent	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

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Materials Laboratory

FIGURE B-1
(Sheet 2 of 2)

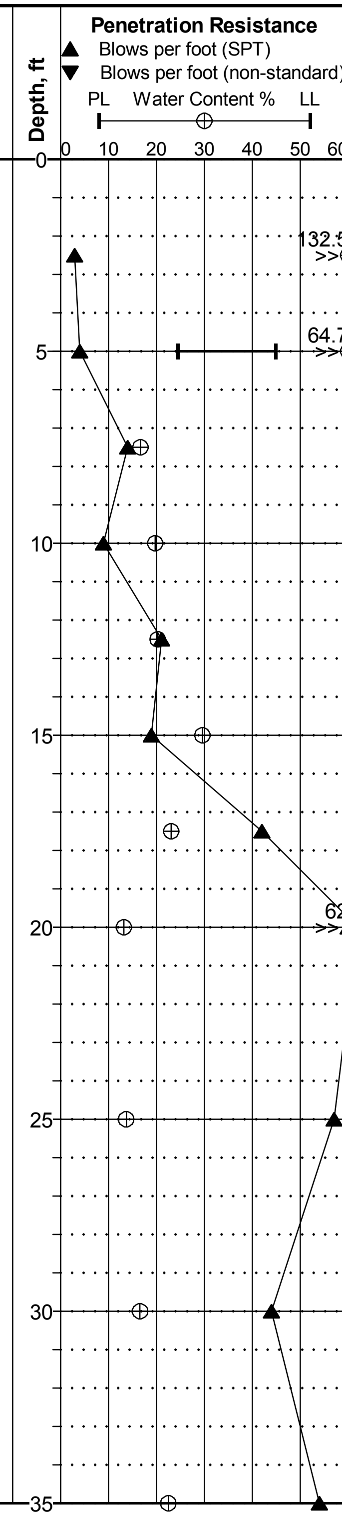
SOIL DESCRIPTION

Surface Elevation: 22 NAVD88

Soil Description	USCS	Sample	Blows/6"	Recovery, %	Lab tests	PID
Surface is asphalt.						
LAKE DEPOSITS Soft, gray, SILT, trace sand; moist; scattered layers of sandy silt and organic silt, trace organics (grass).	ML	1	1,2,1	100		0
Soft to medium stiff, dark brown, CLAY; moist; scattered pockets of gray fine sand and brown sandy silt, few organics.	CL	2	0,0,4	100	AL	0
MASS WASTAGE Medium dense, brown, SILTY SAND, trace gravel and clay; wet; scattered pockets of gray sand and silt.	SM	3	3,7,7	100		0
Stiff, brown mottled gray, SILT WITH SAND, few clay; moist; scattered rust stained seams.	ML	4	4,5,4	100		0
Medium dense, brown, fine to medium SAND WITH SILT and fine GRAVEL, few coarse sand and clay; wet; trace pockets of sandy silt.	SP-SM	5	7,8,13	100	GSD	0
Very stiff, gray and brown, SILT, few sand and clay, trace fine gravel; moist; numerous rust stained seams.	ML	6	5,8,11	100		0
Dense, brown, CLAYEY fine SAND WITH GRAVEL, few medium coarse sand and silt; wet.	SC	7	9,21,21	33	GSD	
Very dense, gray and brown, SILTY SAND WITH GRAVEL, few clay; moist; numerous rust stained seams, scattered pockets of sand.	SM	8	11,25,37	80		
Becomes moist to wet.		9	11,26,31	67		
Dense, gray, SILTY fine SAND, few medium to coarse sand and fine gravel, trace clay; moist; gravel is sub-rounded to rounded.	SM	10	12,26,18	100	GSD	

Ground Water: ATD; 2/28/2011

Depth, ft: 0–35



(Continued)

Date Completed: 2/24/2011
Driller: Gregory Drilling, Inc.
Equipment: Truck Mounted CME 85
Drilling Method: 3-7/8 inch Mud Rotary
Hammer System: Automatic

Approximate Location: 120 feet S of NE parking lot curb corner, 20 feet W of E curb, 67 feet west of shoreline (estimated high tide). (N: 208260 E: 1286415)

GENESEE CSO AREA 43
53RD AVENUE PARKING LOT STORAGE
SEATTLE, WA

Seattle Public Utilites
Geotechnical Engineering

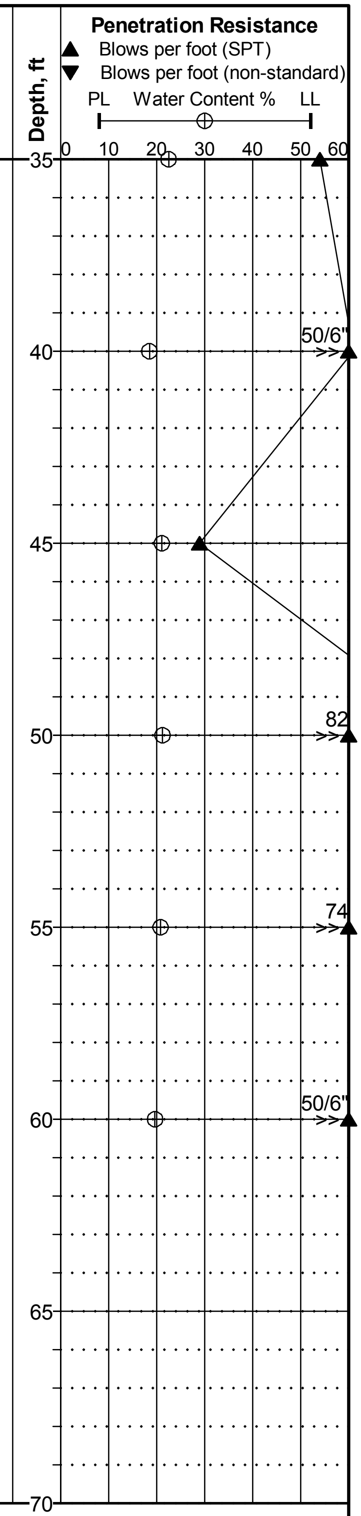
LOG OF BORING B-201

C303103 Z1626 MG2 FIGURE B-2

LOG OF BORING 2/1/11 GENESEE CSO MG2.GPJ UPDATE_DATA_TEMPLATE_(7-20-09).GDT 3/18/11

Logged by: AJC Reviewed by: TS

SOIL DESCRIPTION Surface Elevation: 22 NAVD88	Depth, ft	Symbol	USCS	Samples	Blows/6"	Recovery, %	Lab tests	PID	Ground Water
	35			11	10,12,42	100			
BLAKELEY FORMATION Very dense, gray, SAND WITH SILT, trace gravel; wet. (rock in tip - blows may be overstated)			SP-SM						
	40			12	19,50/6"	50			
Medium dense, brown, SAND; wet; scattered rust stained pockets.			SW						
	45			13	13,13,16	87			
Becomes very dense, scattered mica flecks.	50			14	29,40,42	100			
	55			15	28,32,42	100			
	60			16	50/6"	100			
Boring completed at 60.5 feet below ground surface (bgs). Groundwater encountered at 5 feet bgs. Piezometer installed and screened between 8 and 18 feet bgs. Well tag No. BBT725.									
	65								
	70								



Date Completed: 2/24/2011
Driller: Gregory Drilling, Inc.
Equipment: Truck Mounted CME 85
Drilling Method: 3-7/8 inch Mud Rotary
Hammer System: Automatic

Approximate Location: 120 feet S of NE parking lot curb corner, 20 feet W of E curb, 67 feet west of shoreline (estimated high tide). (N: 208260 E: 1286415)

GENESEE CSO AREA 43
53RD AVENUE PARKING LOT STORAGE
SEATTLE, WA

Seattle Public Utilites
Geotechnical Engineering

LOG OF BORING B-201

C303103 Z1626 MG2 **FIGURE B-2**

Logged by: AJC Reviewed by: TS

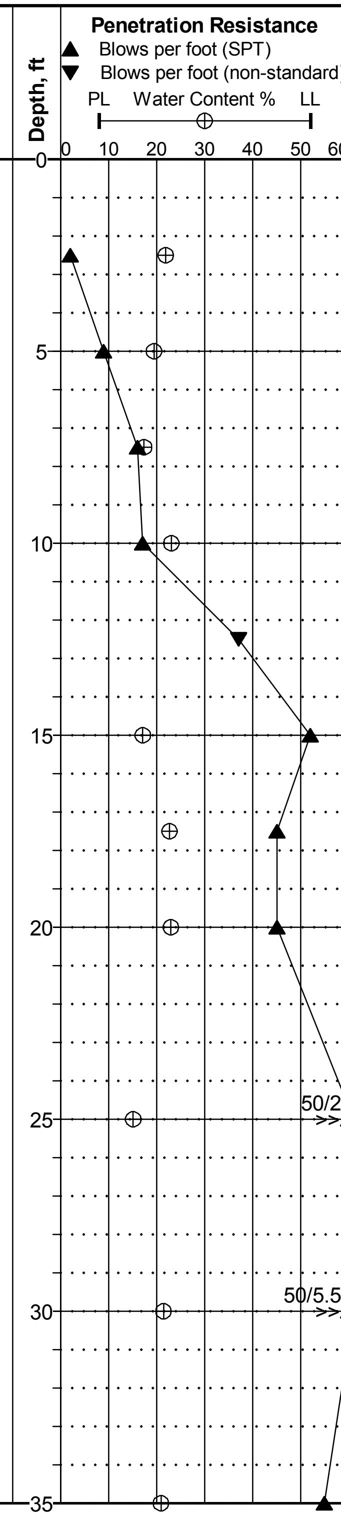
SOIL DESCRIPTION

Surface Elevation: 23 NAVD88

Depth, ft	Soil Description	USCS	Sample	Blows/6"	Recovery, %	Lab tests	PID
0	Surface is asphalt						
	LAKE DEPOSITS Very loose, blue gray, SILTY fine to medium SAND, few clay; moist; scattered pockets of silt, trace organics (grass).	SM	1	1,1,1	100		0
5	**MASS WASTAGE** Loose, brown, SILTY fine to medium SAND, few clay; moist.	SM	2	3,5,4	100		0
	Becomes medium dense, trace gravel and organics, scattered layers of sandy silt.		3	7,6,10	100		0
10	No gravel.		4	6,6,11	100		0
			5	16,18,19	0		0
15	Becomes very dense, few gravel, gravel is sub-rounded to rounded.		6	17,23,29	100		0
	Dense, brown, SILTY SAND WITH GRAVEL; moist; scattered rust stained seams, trace organics.	SM	7	20,21,24	100		0
20	Becomes few clay, scattered pockets of fine to medium sand.		8	11,17,28	100		0
25	With numerous rust stained pockets and seams, few medium to coarse sand. (rock in tip - blows may be overstated)		9	26,38,50/2"	100	GSD	
30	Increased gravel, gravels are fractured, scattered pockets of organic silt. (Blow counts may be overstated due to gravels).		10	31,50/5.5"	100		
35	**BLAKELEY FORMATION** Very dense, brown, fine to medium SAND WITH SILT; wet.	SP-SM					

Ground Water: ∇ (at 35 ft)

Penetration Resistance



(Continued)

Date Completed: 2/25/2011
Driller: Gregory Drilling, Inc.
Equipment: Truck Mounted CME 85
Drilling Method: 3-7/8 inch Mud Rotary
Hammer System: Automatic

Approximate Location: 30 feet N of SE curb corner, 18 feet W of E curb, 62 feet W of shoreline (estimated high tide). (N: 208185 E: 1286550)

GENESEE CSO AREA 43
53RD AVENUE PARKING LOT STORAGE
SEATTLE, WA

LOG OF BORING B-202

Seattle Public Utilites
Geotechnical Engineering

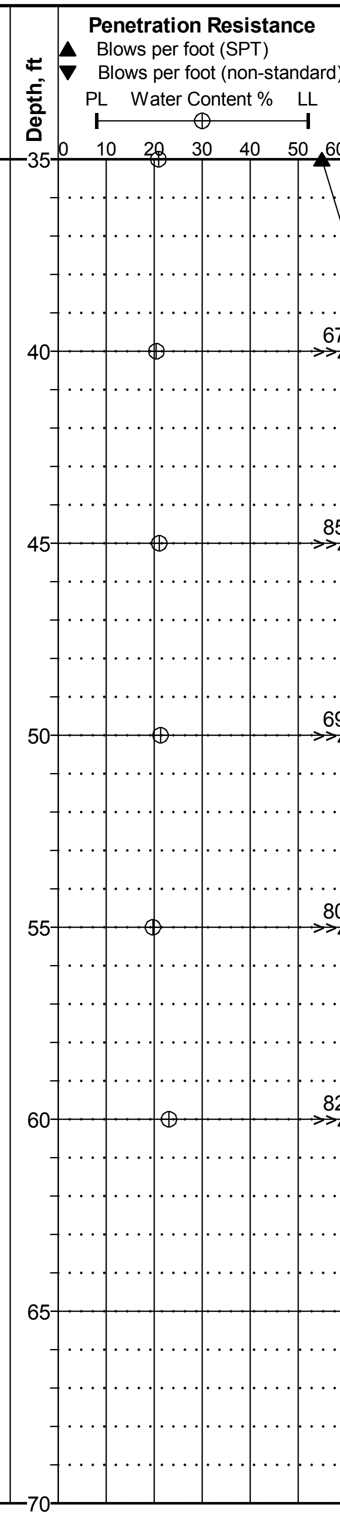
C303103 Z1626 MG2 FIGURE B-3

Logged by: AJC Reviewed by: TS

SOIL DESCRIPTION

Surface Elevation: 23 NAVD88

Depth, ft	Soil Description	USCS	Samples	Blows/6"	Recovery, %	Lab tests	PID	Ground Water
35			11	17,23,32	100			
	Very dense, brown, fine to medium SAND, trace silt; wet.	SP						
40			12	22,34,33	100			
45	Becomes wet to saturated, scattered pockets of gray sandy silt and rusty silt seams.		13	21,37,48	100			
50	Becomes gray, wet, no sandy silt or rust staining, scattered mica flecks.		14	23,34,35	100			
55	No silt, homogeneous.		15	26,38,42	100			
60	With scattered pockets of gray fine sandy silt.		16	31,39,43	100			
	Boring completed at 61.5 feet below ground surface (bgs). Groundwater encountered at 35.0 feet bgs. Boring backfilled with cuttings and bentonite chips.							
65								
70								



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LOG OF BORING B-202

Seattle Public Utilites
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C303103 Z1626 MG2 FIGURE B-3

APPENDIX C

LABORATORY TESTING PROGRAM

APPENDIX C

LABORATORY TESTING PROGRAM

SPU Geotechnical Engineering representatives performed laboratory tests on selected soil samples collected during our field investigation. The laboratory tests were conducted in general accordance with appropriate ASTM test methods. The test procedures and test results are discussed below.

Natural Water Content

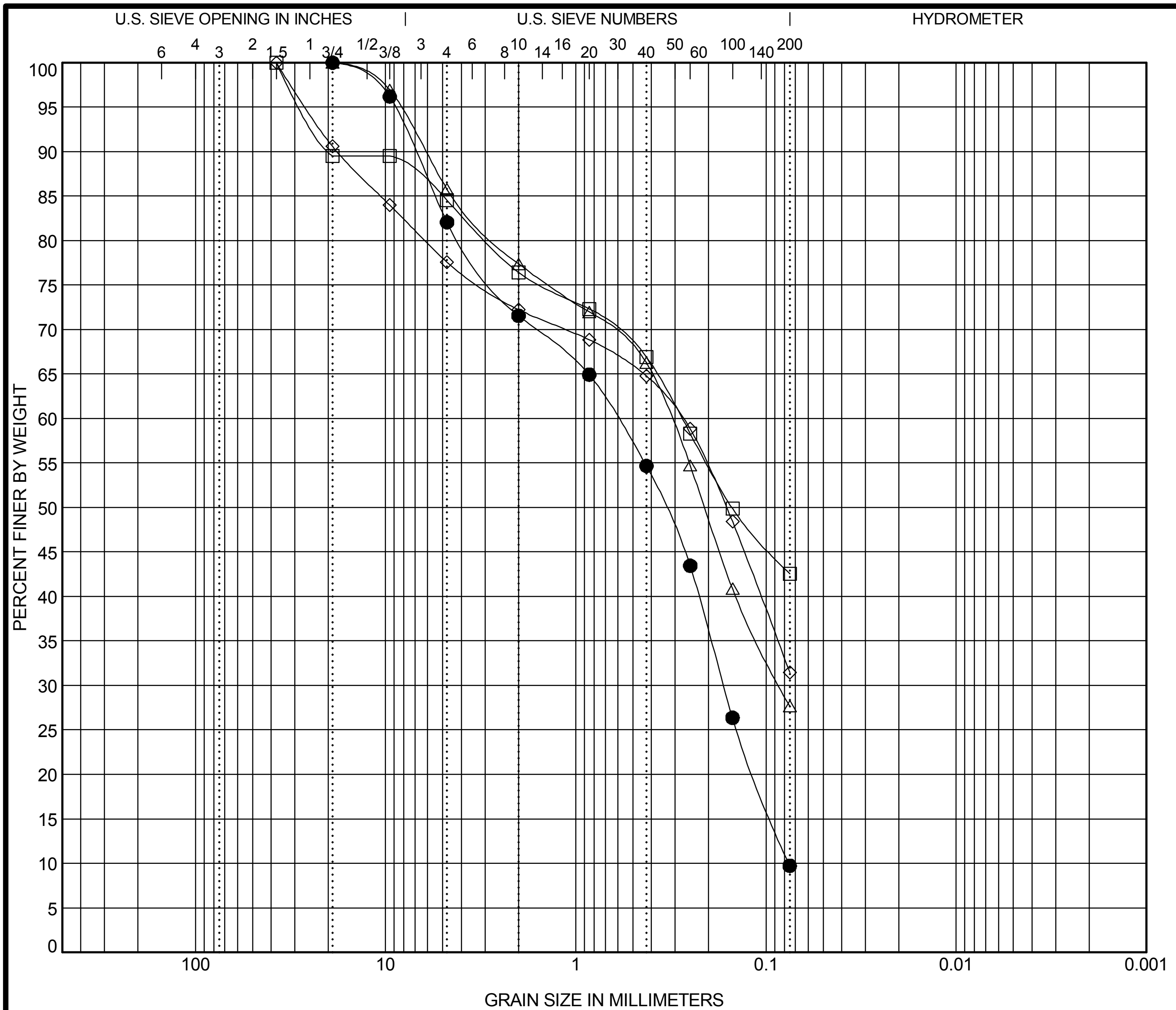
Natural water content determinations were made on selected soil samples in general accordance with ASTM D-2216, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*. Test results are graphically indicated at the appropriate sample depth on the summary logs in Appendix B.

Grain-size Distribution

The grain-size distribution of selected samples was analyzed in general accordance with ASTM D422, *Standard Test Method for Particle-Size Analysis of Soils*. Results of grain size analyses are plotted on Figure C-1 of this appendix. The soil samples tested for grain size distribution are indicated on the summary logs in Appendix B.

Atterberg Limit Determination

Atterberg Limits testing of one sample was performed. The testing was conducted in accordance with ASTM D 2487 *Standard Practice for Classification of Soils for Engineering Purposes* (Unified Soil Classification System). The result of the testing is shown on Figure C-2 at the end of this appendix. The soil sample tested is indicated on the summary logs.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample ID	Depth	Classification	LL	PL	PI	Cc	Cu
●	B-201; 5	12.5	Brown, fine to medium SAND WITH SILT AND fine GRAVEL, few coarse sand (SP-SM)				0.6	8.0
□	B-201; 7	17.5	Brown, CLAYEY fine SAND WITH GRAVEL, few medium to coarse sand (SC)					
△	B-201; 10	30.0	Gray, SILTY fine SAND, few medium to coarse sand and fine gravel (SM)					
◇	B-202; 9	25.0	Brown, SILTY fine SAND WITH GRAVEL, few medium to coarse sand (SM)					

	Sample ID	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-201; 5	12.5	19	0.61	0.17	0.076	17.9	72.3	9.7	
□	B-201; 7	17.5	37.5	0.28			15.4	42.0	42.6	
△	B-201; 10	30.0	19	0.32	0.08		14.2	58.1	27.7	
◇	B-202; 9	25.0	37.5	0.28			22.4	46.1	31.5	

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GRAIN SIZE DISTRIBUTION (ASTM D422)

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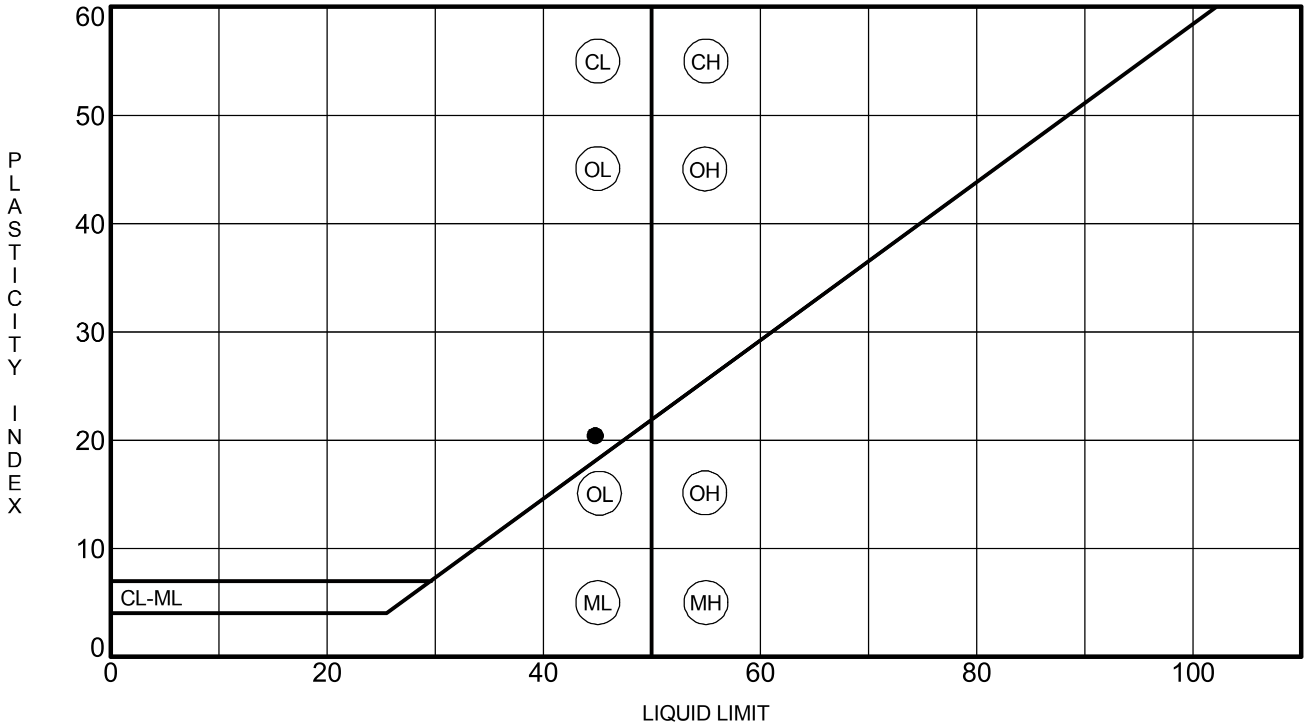
APRIL 2011

FIGURE: C-1

US GRAIN SIZE GENESEE CSO MG2.GPJ TEMPL.GDT 3/18/11



	Sample ID	Depth	LL	PL	PI	Fines	Classification
●	B-201, 2	5.0	45	24	21		Dark brown, CLAY (CL)

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WA No.: C303103 Z1626 MG2

ATTERBERG LIMITS RESULTS

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53RD AVENUE PARKING LOT STORAGE
SEATTLE, WA

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FIGURE: C-2

US ATTERBERG LIMITS GENESEE CSO MG2.GPJ TEMPL.GDT 3/18/11