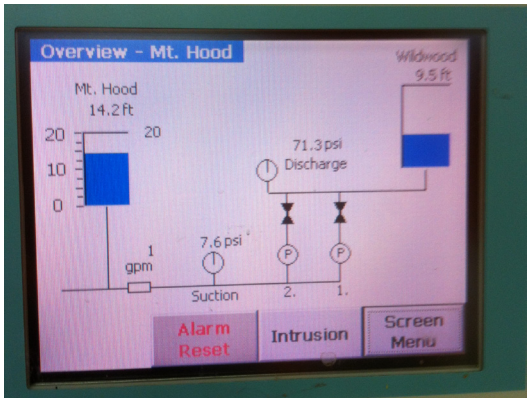

CITY OF ISSAQUAH
Mount Hood Booster Station Predesign Report

G&O #14543
January 2015

Gray & Osborne, Inc.

CITY OF ISSAQUAH

KING COUNTY **WASHINGTON**

CITY OF
ISSAQUAH
WASHINGTON

MOUNT HOOD BOOSTER STATION
PREDESIGN REPORT

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STATE OF WASHINGTON
#6527
REGISTERED
PROFESSIONAL ENGINEER
1-21-15

G&O #14543
JANUARY 2015

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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CHAPTER 1

INTRODUCTION

INTRODUCTION

The City of Issaquah (City) has contracted with Gray & Osborne for design of a new booster station to replace the existing Mount Hood Booster Station. The existing facility is nearing the end of its useful life and is vulnerable to damage from seismic events. The project will include a new building, new pumps, electrical improvements, new site piping, and site improvements.

REFERENCES

The following documents are referenced as part of this analysis:

- *2012 Water System Plan Update*, City of Issaquah.
- *1997 Seismic Vulnerability Assessment,* EQE International.
- *2014 Geotechnical Report,* PanGEO, Inc. (Appendix A).

BACKGROUND

Although the existing Mount Hood Booster Station is in operable condition, the equipment is nearing the end of its expected lifespan. Replacing the pump station with a more earthquake resistant structure was recommended in the *1997 Seismic Vulnerability Assessment*. The project is part of the City's Capital Improvement Plan and is identified in the City's most recent *2012 Water System Plan Update*.

The existing building is located near a steep slope. The Geotechnical Report, attached as Appendix A, discusses the steep slope hazards. The setbacks from the steep slope are also discussed in Chapter 3.

The existing two pumps at the Mount Hood Booster Station have capacities of 475 gpm and 350 gpm. The City has deferred replacement of the pump with diminished capacity in anticipation of replacement of the existing station.

EXISTING FACILITIES

The existing Mount Hood booster pump station is located at 325 Mount Hood Drive Southwest. The current booster pump station facilities include a concrete masonry unit building that houses two pumps, associated site piping, and electrical equipment. There is limited space for working inside and no room for expansion. The foundation for the existing building is a slab on grade with thickened edges. The concrete masonry walls of

the existing building are reinforced; however, it is likely that the reinforcements do not meet current code requirements. The facility will be demolished and replaced with a larger building that will be more resistant to damage from seismic activity.

The existing pumps are controlled by the water level of the Wildwood Reservoir. The original design capacity of both pumps was 450 gpm at a TDH of 195 feet.

The Mount Hood Booster Station pumps water from the Mount Hood Zone to the Wildwood Zone. From the Wildwood Zone, the Wildwood and Highwood booster stations pump water up to the higher zones in the Squak Mountain area (Highwood and Forest Rim Zones). Figure 1-1 presents a map of the pressure zones in the Squak Mountain area of the City's water system.

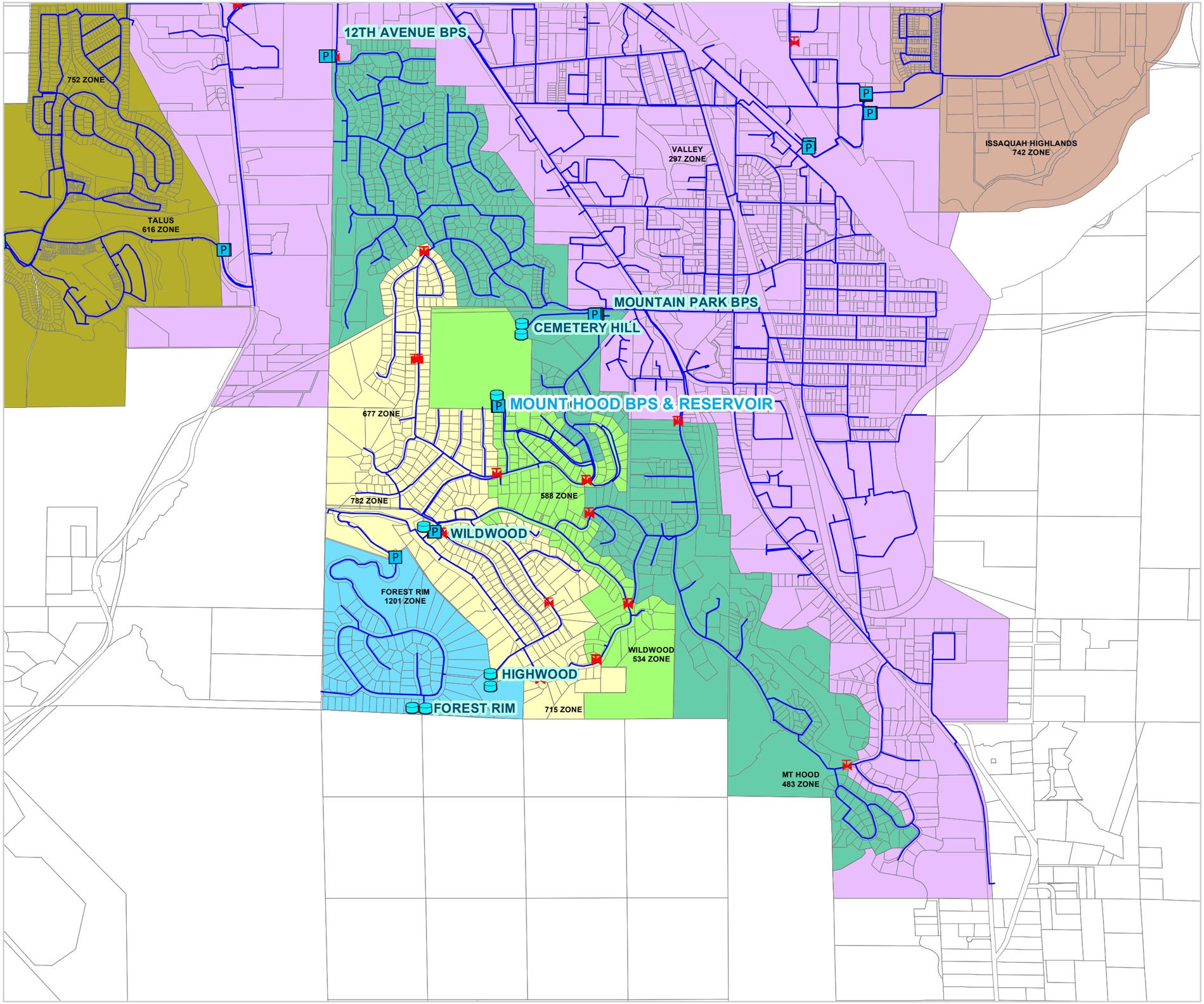
The Valley Zone (297-feet HGL) is the oldest and largest zone in the City which also includes the well supply system. Both the Mountain Park and 12th Avenue Booster Station pump water from the Valley Zone into a transmission main that fills the Mount Hood Reservoir, which serves the Mount Hood Zone (483-feet HGL). The Mount Hood Booster Station then pumps water into the Wildwood Zone (634-feet HGL) and Reservoir. This zone supplies a sub-zone (588-feet HGL) that is fed through PRV 10. If an emergency situation exists, such as a fire in the Mount Hood Zone, the Wildwood Zone will provide flow to the Mount Hood Zone through PRVs 3 and 4. The Wildwood Booster Station sends water to the Highwood Reservoir and Highwood Zone (953-feet HGL) which includes sub-zones with HGL's of 782, 715, and 677. The Highwood Zone has emergency connections to the Wildwood Zone through PRVs 5 and 9 and an emergency connection to Mount Hood through PRV 12. The Forest Rim Booster Station pumps water from Highwood to the Forest Rim Zone (1,201-feet HGL) and Reservoir which is the highest zone on Squak Mountain. There are no emergency connections between the Forest Rim and Highwood Zones.

NEW BOOSTER STATION

The improvements needed at the Mount Hood Booster Station are identified in the *2012 Water System Plan* and are part of the City's Capital Improvement Plan. The purpose of the new booster station is to:

- Improve Reliability – The booster pump station was originally constructed in 1978 and although there are currently no reliability issues, the equipment and site piping are reaching the end of their useful life. The existing building is also vulnerable to damage from seismic events. The new equipment will replace the aging equipment and building and decrease the likelihood of failure.

- Increase capacity – The capacity of one of the existing pumps has diminished over time from 450 gpm to 350 gpm. The City deferred pump



N

0 625 1,250 2,500 Feet

LEGEND:

- RESERVOIR
- BOOSTER PUMP STATION (BPS)
- PRESSURE REDUCING VALVE
- WATERLINES
- PARCELS

PRESSURE ZONES:

- FOREST RIM (HGL - 1201 FT)
- HIGHWOOD (HGL - 715 FT)
- ISSAQUAH HIGHLANDS (HGL - 742 FT)
- MT HOOD (HGL - 483 FT)
- TALUS (HGL - 616 FT)
- VALLEY (HGL - 297 FT)
- WILDWOOD (HGL - 634 FT)

CITY OF ISSAQUAH
MOUNT HOOD BOOSTER STATION

FIGURE 1-1
PRESSURE ZONE MAP

Gray & Osborne, Inc.
CONSULTING ENGINEERS

L:\ISSAQUAH\14543 Mt Hood BPS\GIS\FIGURE 1-1.mxd

replacement in anticipation of the full station replacement. The replacement pumps will restore the original capacity of the station.

The design criteria for these improvements are further discussed in Chapter 2, and the proposed improvements are outlined in Chapter 3.

CHAPTER 2

DESIGN CRITERIA

INTRODUCTION

The new booster station facility will be designed to meet City and Washington State Department of Health (DOH) standards for open system booster stations. This Chapter outlines the basic design criteria for the new facility.

BASIC DESIGN CRITERIA

The Washington State Department of Health (DOH) sets criteria for booster station design in its 2009 Water System Design Manual, Chapter 10. The proposed Mount Hood Booster Station will pump to an open zone served by the Wildwood Reservoir. Booster stations that pump to an open zone must have the capacity to pump maximum day demand with all pumps in service and to meet average day demand with the largest pump out of service.

DOH also recommends that systems meet several reliability criteria in order to promote high levels of water system reliability. It is recommended that the water system have sufficient capacity to replenish depleted fire suppression storage within 72-hours while concurrently supplying maximum day demands. It is also recommended that pump stations have power connections to two independent primary public power sources, or have portable or in-place auxiliary power available.

DOMESTIC DEMANDS

The new Mount Hood facility will continue to pump water into the Wildwood Zone and Reservoir which also serves the higher Highwood and Forest Rim Zones via a series of booster stations. The *2012 Water System Plan Update* estimates a future maximum day demand of 260,000 gpd by 2031 based upon water use data through 2010 and future development. Therefore the anticipated maximum day demand in all the zones served by the Mount Hood Booster Station is anticipated to be approximately 180 gpm. The *2012 Water System Plan Update* estimates a future average day demand of 115,000 gpd by 2031 based upon water use data through 2010 and future development. Therefore, the anticipated average day demand in all the zones served by the Mount Hood Booster Station is anticipated to be approximately 80 gpm.

FIRE FLOW STORAGE

The maximum fire flow requirement in the zones downstream of the Mount Hood Booster Station is 1,500 gpm for 2 hours. The maximum fire suppression storage required in these zones is therefore 180,000 gallons. In order to replenish the fire

suppression storage within a 24-hour period, a flow rate of 125 gpm in addition to maximum day demands would be required. Replenishing fire suppression storage within 24 hours exceeds the DOH reliability recommendation of replenishing fire suppression storage within 72 hours.

MINIMUM TOTAL STATION CAPACITY

In order to provide maximum day demands while replenishing fire flow within a 24-hour time period, a total station capacity of 305 gpm is required. In order to meet average day demands with the largest pump out of service, the minimum capacity with the largest pump out of service must be at least 80 gpm. The 305-gpm capacity is the minimum station capacity needed to meet or exceed all DOH requirements and reliability recommendations. However, as further explained in the following section, the downstream pumping facilities exceed the minimum requirements, and matching downstream pumping capacities simplifies operation and minimizes equalizing storage requirements.

EXISTING SYSTEM PERFORMANCE

Historical flow records for the existing Mount Hood Booster Station were analyzed to assess the performance of the existing booster station. From 2009-2012, the average flow from the station was 475 gpm. When the pump with diminished capacity (350 gpm) is the lead pump, then the second pump is typically called on and increases the total output to 800 gpm to meet the demands. When the 475 gpm pump is the lead pump, it is typically able to meet demands without calling the lag pump. This pattern indicates that the pumps are nearly always called on to meet demands when one of the Wildwood pumps is pumping out of the Wildwood Reservoir. The Wildwood pumps each have a capacity of 450 gpm. Installing two pumps in the new station with equal capacity of at least 450 gpm would allow just one pump to be called at a time, which would reduce the frequency that each pump is used and would reduce the typical maximum flow rate in the booster station.

Electrical costs for the existing booster station for the last 3 years have been approximately $3,900 per year. Even with both pumps running, the total power use for the new station is not expected to exceed the Puget Sound Energy demand charge for usage above 50 kW. Therefore, even though two pumps will not typically run simultaneously as they currently do, the power costs for the new station are expected to be similar to the historical costs.

PUMP CRITERIA

As previously discussed, the reliability standards require that the proposed booster station meet average day demands with the largest pump out of service. Therefore, a minimum of two pumps are required. Because the flows required from the station are primarily dependent on flows at the Wildwood Booster Station and are relatively constant, two

equal-sized pumps would be adequate to meet the required demands. A larger number of pumps would require additional building and electrical costs without significant benefit. To exceed the existing capacity and demand from the Wildwood Booster Station and Reservoir, each pump will be designed with a capacity of 500 gpm. The pumps would alternate between being the lead and standby pump.

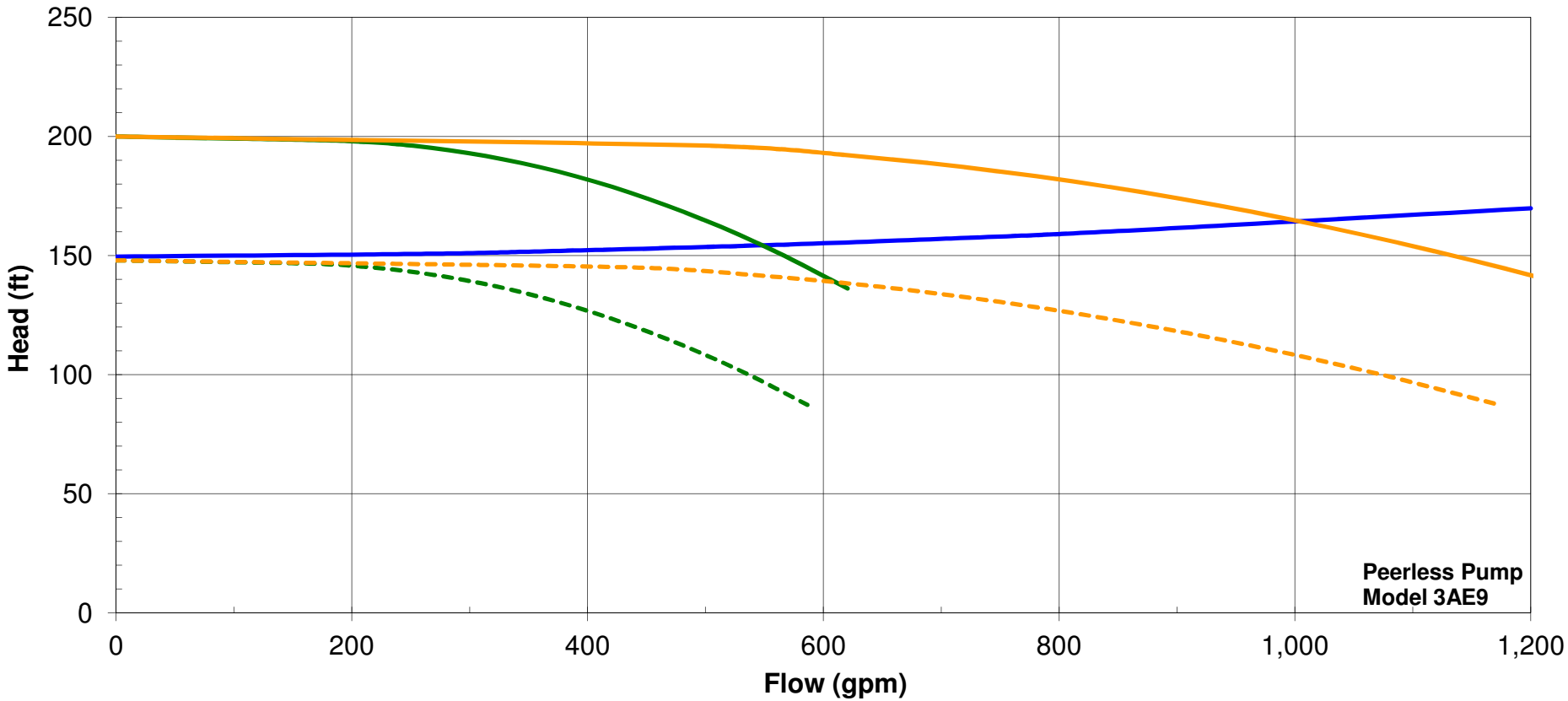
The two typical pump types for this type of pressure boosting application are horizontal split-case pumps and vertical multi-stage pumps. Both of these pump types were considered for installation in the proposed station. Potential pump models were evaluated based on cost, efficiency and O&M considerations. The current pumps at the site are horizontal split-case. Horizontal split-case pumps are also installed at the nearby Mountain Park and Wildwood booster stations. Based on the comparison of potential pump models at the design flow rate and head, and for consistency with the majority of the City's other booster stations, horizontal split case pumps will be installed in the new Mount Hood station.

The City's records and pumping data were used to determine the head required to pump from the Mount Hood Zone (483-feet HGL) to the Wildwood Zone (634-feet HGL). Figure 2-1 shows the system and pump curves for the new station. The pump design criteria for the booster pumps are summarized in Table 2-1.

TABLE 2-1

Booster Pump Design Criteria

Parameter	Value
Pump Type	Horizontal Split-Case
Number of Pumps	2 (1 duty, 1 standby)
Pump Design Flow/Head	500 gpm at 160 ft TDH
Pump and Motor Efficiency	72.1%
Brake Horsepower	28.9 hp
Motor Horsepower	40 hp
Motor Speed	3,600 rpm
Motor Efficiency	94.1%



System Curve

Single Pump Operating Curve

Single Pump Operating Curve at 86% Speed

Two Pump Operating Curve

Two Pump Operating Curve at 86% Speed

CITY OF ISSAQUAH WASHINGTON

FIGURE 2-1
CITY OF ISSAQUAH
Mt. HOOD BOOSTER STATION
PUMP AND SYSTEM CURVES

Gray & Osborne, Inc.

CHAPTER 3

PROPOSED IMPROVEMENTS

GENERAL

The existing Mount Hood Booster Station is located at 325 Mount Hood Drive Southwest as shown in Figure 3-1. The existing facilities include a CMU building housing two pumps, site piping, and electrical equipment. The site also contains the Mount Hood reservoir. The existing building and reservoir are surrounded by a chain link fence. The site will be improved with a new booster station facility, pumps, and new electrical equipment as shown in Figure 3-2. This chapter identifies the proposed improvements to be made as part of the project.

BOOSTER STATION

A new booster station building will be constructed to house the new booster pumps and the electrical equipment for the site. The building will consist of one room housing all of the pumps and electrical equipment.

SITE IMPROVEMENTS

The existing booster station building will remain in service until the new booster station is complete. The existing site has limited space and placement of the building is restricted by required setbacks from the steep slope to the northeast and a residential property line to the south.

The building location must meet minimum setback requirements from a steep slope as given in the Issaquah Municipal Code (IMC). IMC 18.10.390 defines a steep slope hazard area as any ground with an inclination of 40 percent with a vertical rise of at least 10 feet. The slope to the northeast of the existing site matches these criteria. Per IMC 18.10.515.D, a minimum 15-foot building setback area shall be established from the outer edge of the critical area buffer for steep slope hazard areas. IMC 18.10.580.A.1 requires a steep slope hazard area buffer of at least 50 feet. However, there is no building location on the site that would meet the 50-foot buffer requirement. Per IMC 18.10.580.A.2, the steep slope hazard area buffer can be reduced to a minimum of 10 feet from the edge of the hazard area if approved by the Director of the Planning Department. The total building setback with a reduced buffer would be the sum of the buffer setback (15 feet) and the reduced buffer (10 feet), or 25 feet. The Geotechnical Report, attached in Appendix A, also recommends a total setback of 25 feet from the steep slope. The top of the steep slope to the northeast of the site runs approximately along the 460-foot contour as shown on Figure 3-2. As shown on the figure, the preliminary design provides a total setback of 30 feet.

The building must also meet minimum setbacks from property lines given in the Issaquah Municipal Code. Per the setback standards given in IMC 18.07.360, Community Facilities must meet the setback standards for the most restrictive contiguous zoning. The only property line within 100 feet of the proposed building lies to the south and is bordered by land zoned Single Family Suburban. Per the setback standards given in IMC 18.07.360, the property line setbacks for Single-Family Suburban areas are 20 feet, 8 feet, and 10 feet for the front, side, and rear yards, respectively.

Locations north and east of the existing building were considered for the new building. However, there is not sufficient space north of the existing building to meet the steep slope setback requirements. The new building will therefore be placed east of the existing building. The existing building will be demolished after service has been transferred to the new booster station building. The proposed Site Plan is shown in Figure 3-2.

The proposed building location allows the current booster pump station to remain in service and meets the setback requirements. Because the booster station site is adjacent to a single-family residential neighborhood, residential building features and landscape improvements are anticipated as part of the project.

Temporary electrical service will need to be provided to the existing station during construction so that the existing electrical service can be removed for excavation of the proposed building footings.

City staff potholed the location of the existing water mains in 2014 to verify their exact location so that the proposed improvements could be designed to be constructed while maintaining service to the existing station.

Drainage Review

According to the City of Issaquah 2011 Addendum to the *2009 King County, Washington Surface Water Design Manual* (Effective October 31, 2011 per Ordinance 2625), a drainage review is required for a project that is subject to a City of Issaquah development permit or approval AND that meets any one of the following conditions:

1. The project adds or will result in 2,000 square feet or more of new impervious surface, replaced impervious surface, or new plus replaced impervious surface.
2. The project proposes 7,000 square feet or more of land disturbing activity.
3. The project is a redevelopment project proposing $100,000 or more of improvements to an existing high-use site.
4. The project proposes to construct or modify a drainage pipe/ditch that is 12 inches or more in size/depth, or receives surface and storm water runoff from a drainage pipe/ditch that is 12 inches or more in size/depth.

This project is not anticipated to create and/or replace over 2,000 square feet of impervious surface area or to involve more than 7,000 square feet of land disturbing activity. The other two conditions do not apply. Therefore, it is not anticipated that a drainage review will be required for this project.

BOOSTER PUMPS

The booster station building will contain two 40-horsepower booster pumps. The booster pump piping will include check valves, isolation valves, and dismantling joints so that each pump can be isolated and removed for repair. A pressure relief bypass will also be provided to prevent excessive surge pressures and to allow the station to be operated with a closed zone if the Wildwood Reservoir is taken offline for maintenance. A proposed mechanical plan is shown in Figure 3-3.

STRUCTURAL

A new building will be constructed to house the new pump and electrical equipment. There are several building material options for the booster station structure, including wood, concrete masonry unit (CMU), and pre-cast concrete.

A wood structure has the lowest capital costs of the three options; however, it has the highest life cycle costs due to continued maintenance. A wood structure has an expected life term of about 35 years. During that period, maintenance would include exterior and interior repainting, frequent inspection to check for rot, and repair of any rotting or otherwise damaged components. If a shingle roof is installed, it will need to be reroofed at least once during the life of the building.

A CMU building with a metal roof has an expected life of about 50 years or more. Although capital costs are higher than for a wood frame building, on-going maintenance costs are far less since it does not require painting and the material is not susceptible to rot or damage like wood is. Another benefit to a CMU building is additional flexibility for installing electrical equipment inside. Equipment can be mounted easily without the limitations of requiring additional bracing between wood studs.

The third option, a pre-cast concrete structure, would have slightly lower capital cost than a CMU building. It would also not require painting or rot repair. However, this type of structure is less flexible in terms of penetrations or changes encountered in the field. In addition, concrete structures have much fewer finish and color options. These buildings are also prone to leaking at the joints and the roof slab.

Based on the existing site and the aesthetic considerations for the residential neighborhood, the City's chosen building material and method is a combination of smooth and split face concrete masonry units (CMU) with a concrete foundation and a standing seam metal roof at a 6:12 pitch. The building will include a double door in front and an emergency exit door in the back. A telescoping monorail hoist will be provided to

lift the booster pumps and extend them out of the door to be deposited in the bed of a truck. Proposed building elevations are shown in Figure 3-4.

HEATING, VENTILATION, AND AIR CONDITIONING

Heating for the new building will be provided by a wall-mounted 5 kW unit heater. Ventilation will be provided by a fan and vent louver. The fan will be located on the north side of the building to minimize the noise and aesthetic impacts to the surrounding residents. A dehumidifier will also be installed to control the humidity in the new building.

ELECTRICAL AND CONTROL IMPROVEMENTS

The electrical and control improvements will include the following new facilities:

- 480 Volt Three Phase Underground Feed to the Site
- Main Breaker – 200 Amp
- Portable Generator Receptacle
- Manual Transfer Switch
- Motor Control Center (MCC)
- Control Panel and Programmable Logic Controller (PLC)
- Variable Frequency Drives (VFDs)

A preliminary feasibility analysis by the electrical service provider, Puget Sound Energy, indicates that a new pad-mounted transformer will be required to provide 480 volt three-phase service to the proposed booster station.

The electrical equipment in the existing building will be removed and replaced with new equipment in the booster station building. The electrical and control equipment associated with the reservoir will remain in place and will be tied in to the new electrical system. A manual transfer switch and portable generator receptacle will be installed to allow the use of a portable generator in emergency situations.

It is anticipated that the pumps will be run with VFDs. The VFD speed may be set by operator enterable flow rates or by increasing flow proportionally as the level in the Wildwood Reservoir decreases. The VFDs will also be used to maintain a constant pressure when the Wildwood Reservoir is offline for maintenance and the Wildwood Zone is operating as a closed zone.

While a chlorine analyzer will not be installed as part of this project, provisions in the plumbing, electrical and telemetry systems will be included for the future installation of an analyzer if desired.

INSTRUMENTATION

Instrumentation that will be provided will include the following:

- Intrusion Alarm
- Smoke Alarm
- Flood Alarm
- Discharge Flow Meter
- Pressure Relief Bypass Flow Meter
- Inlet (483-feet HGL)/Outlet (634-feet HGL) Zone Pressure Transducers
- Chlorine/pH Analyzer (Future)

The PLC will monitor the following:

- Booster Station Discharge Flow
- Pressure Relief Bypass Flow
- Suction Pressure
- Discharge Pressure
- Pump Status – Hand, off, auto (HOA)
- Power Status
- VFD Status
- Chlorine Residual (Future)
- pH (Future)

The PLC will control the following:

- Pump Starts – Based on Wildwood Reservoir Level
- Pump Sequencing
- Pump Stops – Based on Wildwood Reservoir Levels
- VFD Speed

The PLC will relay the following alarms:

- Intrusion
- Smoke
- Flood
- Communication Failure
- Drive Fault
- Pump Fail

- Motor High Temperature
- Power Fail (Control and 480V)
- PLC Fail
- VFD Fail
- Low Suction Pressure
- Low Discharge Pressure
- High Discharge Pressure
- Low Chlorine Residual
- High Chlorine Residual
- Low pH
- High pH

TELEMETRY

The new facilities will be integrated into the City's existing Supervisory Control and Data Acquisition (SCADA) system for full control and alarming at the City's Public Works Operations facility.

The booster pumps will be called based upon the water level in the Wildwood Reservoir. The reservoir levels at which the pumps will be called will also be operator adjustable at the City's Public Works Operations facility. The programming will also include a control scenario for pressure maintenance of a closed system when the Wildwood Reservoir is offline for maintenance.

OPERATION DURING CONSTRUCTION

During construction, the existing booster station will stay in service to meet the demands in the Squak Mountain zones of Wildwood, Highwood, and Forest Rim. The existing booster station can meet the Maximum Day Demands for these zones, so no additional temporary accommodations will need to be made during construction.

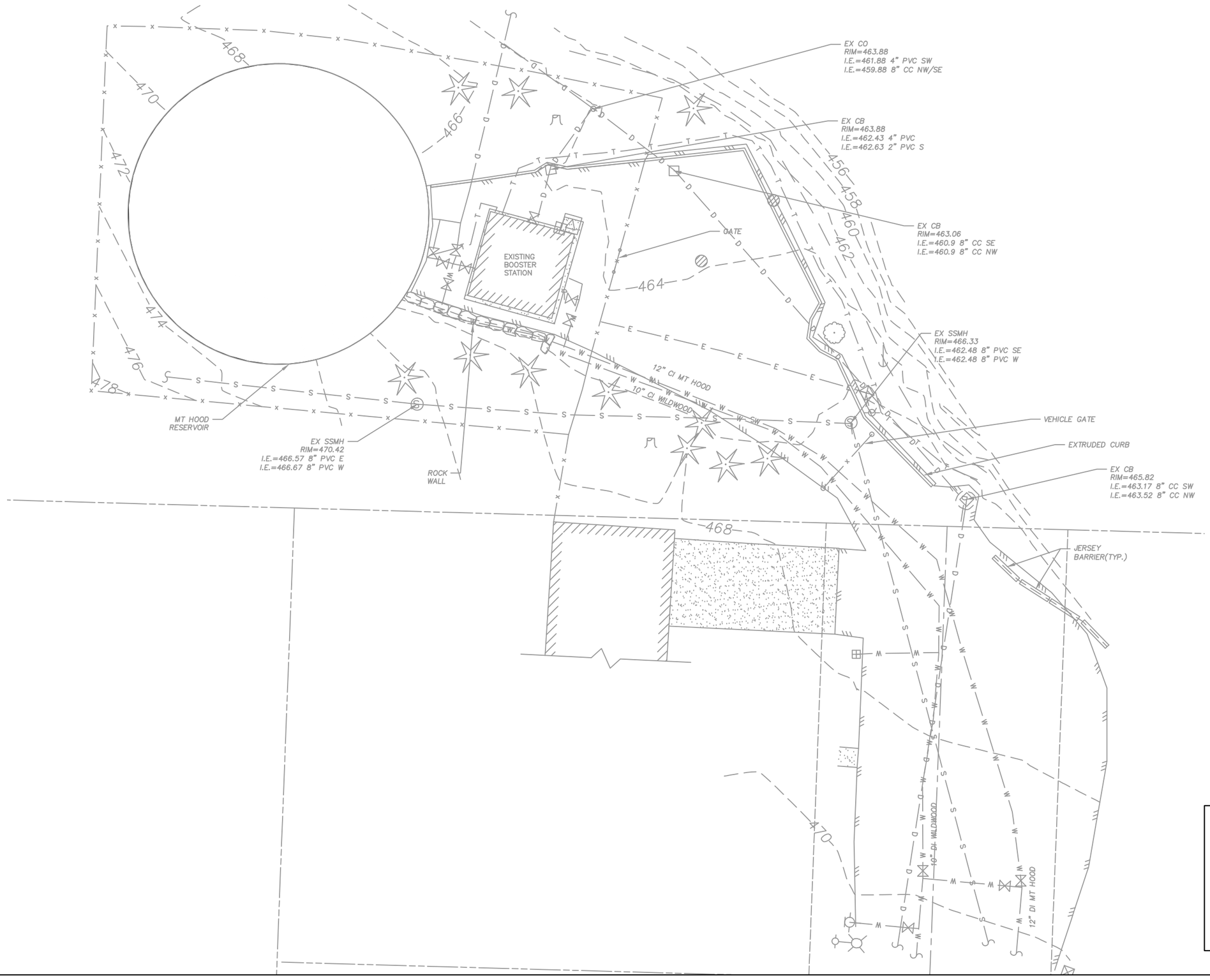
CONSTRUCTION SCHEDULE

A preliminary construction schedule is as follows:

- March 2015 – Complete Design/Advertise
- April 2015 – Award Construction Contract
- October 2015 – Complete Construction on New Booster Station

CONSTRUCTION COST ESTIMATE

Table 3-1 provides the estimated construction costs for the project.



0 10' 20'

SCALE: 1" = 20'

LEGEND

- = STREET SIGN
- = MANHOLE
- = CATCH BASIN
- = WATER VALVE
- = WATER METER
- = FIRE HYDRANT
- PV = POWER VAULT
- = DECIDUOUS TREE
- = CONIFEROUS TREE
- = STUMP
- —X— = FENCE LINE
- —D— = STORM DRAIN LINE
- —S— = SANITARY SEWER LINE
- —G— = GAS LINE
- —W— = WATER MAIN
- —E— = UNDER GROUND POWER LINE
- —P— = OVERHEAD POWER LINE
- —T— = TELEVISION OR PHONE LINE
- = LANE STRIPING
- = PROPERTY BOUNDARY
- = RIGHT-OF-WAY

CITY OF ISSAQUAH

MOUNTAIN PARK BOOSTER STATION

FIGURE 3-1

EXISTING SITE PLAN

Gray & Osborne, Inc.

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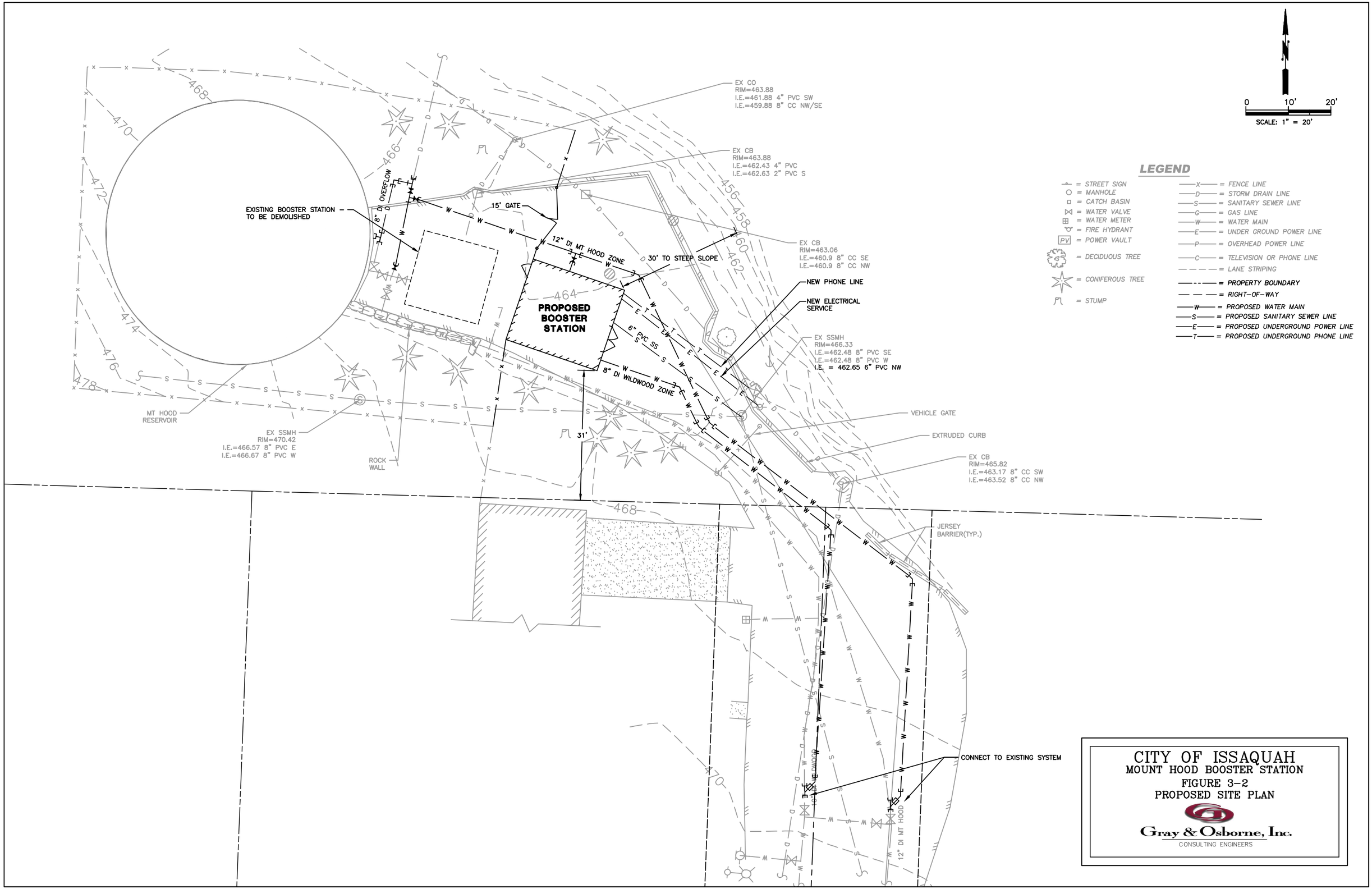

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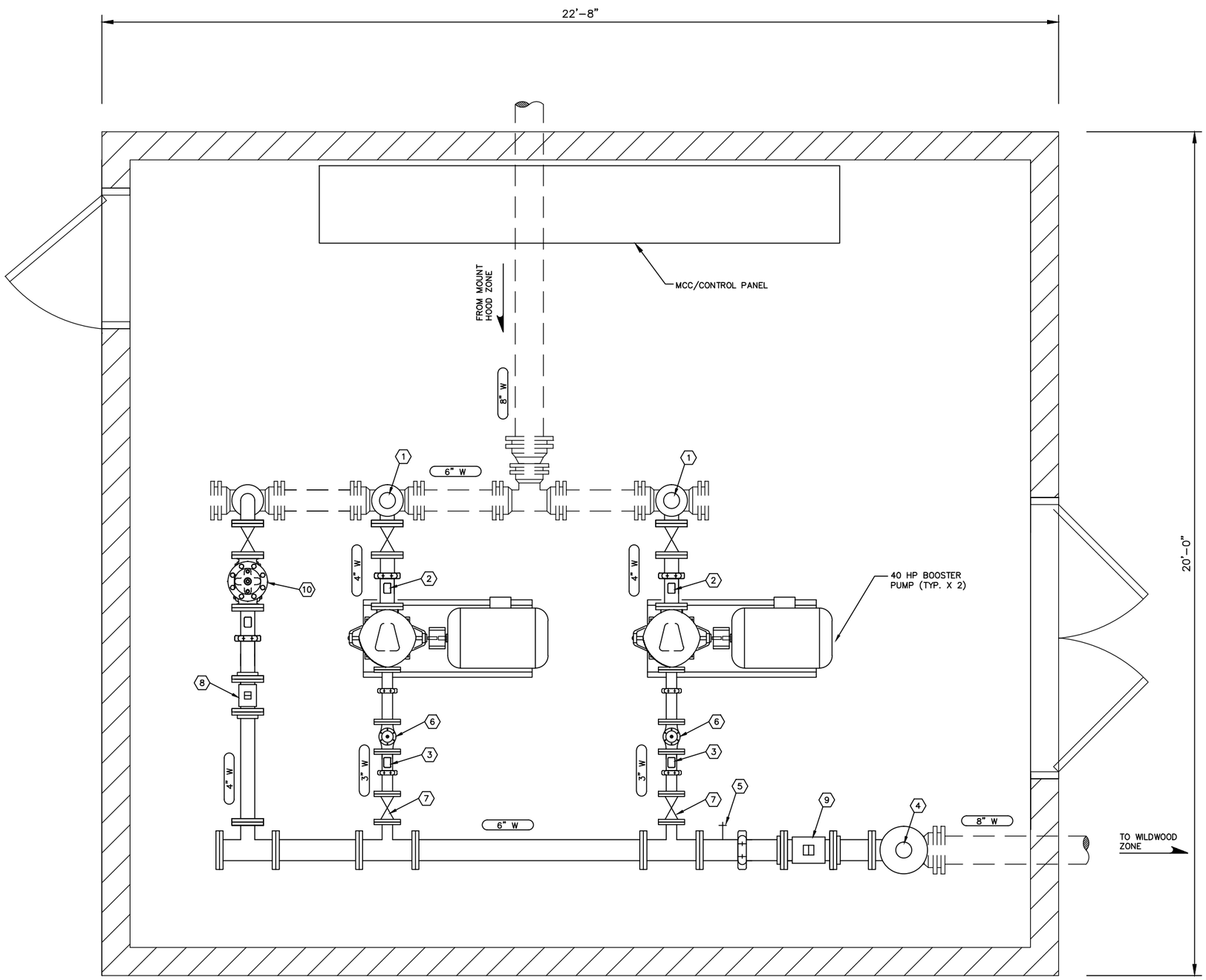


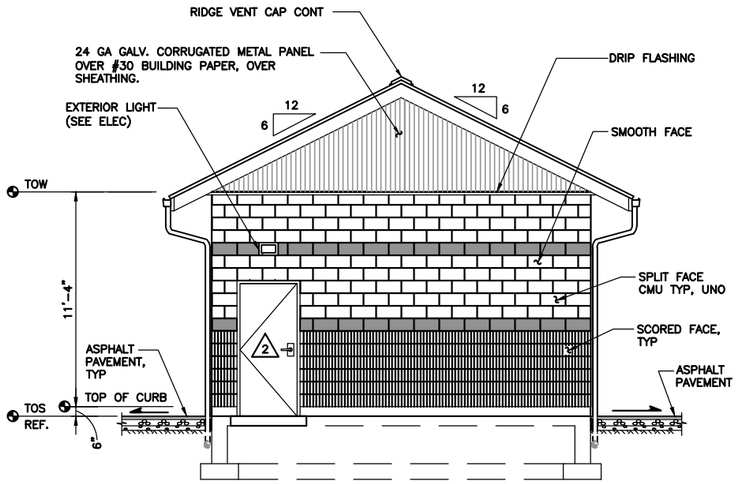
0 1' 2'
SCALE 3/4" = 1'

LEGEND:

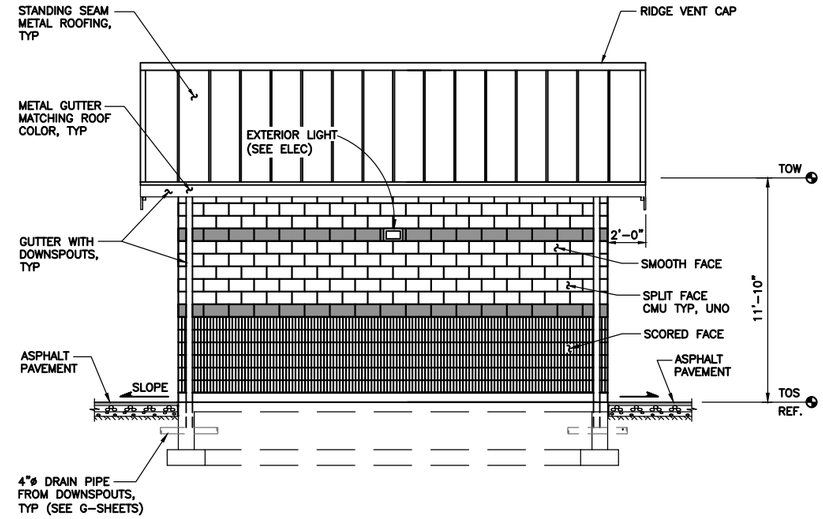
1. 1" COMBINATION AIR VALVE
2. PRESSURE GAUGE, SUCTION SIDE
3. PRESSURE GAUGE, DISCHARGE SIDE
4. 2" COMBINATION AIR VALVE
5. SAMPLE BIBB
6. 3" CHECK VALVE
7. 3" GATE VALVE
8. 4" MAGNETIC FLOW METER, SIEMENS MAGFLO 5100W W/ REMOTE MOUNT 6000 CONVERTER
9. 6" MAGNETIC FLOW METER, SIEMENS MAGFLO 5100W W/ REMOTE MOUNT 6000 CONVERTER
10. 4" PRESSURE RELIEF VALVE

CITY OF ISSAQUAH
MOUNT HOOD BOOSTER STATION
FIGURE 3-3
PROPOSED MECHANICAL PLAN

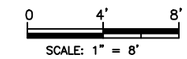
Gray & Osborne, Inc.
CONSULTING ENGINEERS

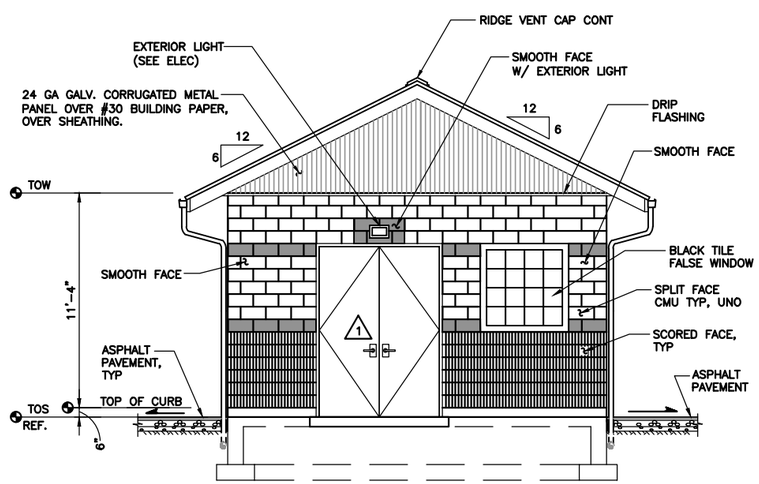


WEST ELEVATION
SCALE: 1/4"=1'-0"

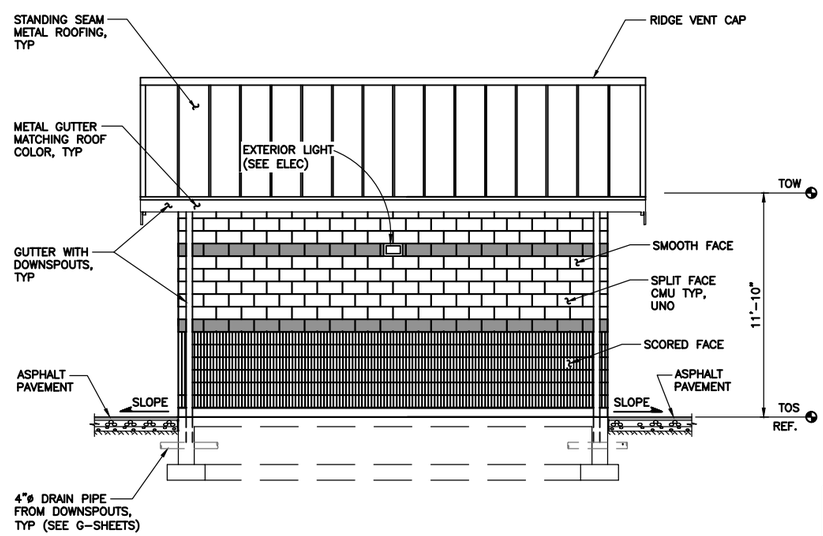


NORTH ELEVATION
SCALE: 1/4"=1'-0"





EAST ELEVATION
SCALE: 1/4"=1'-0"



SOUTH ELEVATION
SCALE: 1/4"=1'-0"

CITY OF ISSAQUAH
MOUNT HOOD BOOSTER STATION
FIGURE 3-4
PROPOSED BUILDING ELEVATIONS

Gray & Osborne, Inc.
CONSULTING ENGINEERS

TABLE 3-1

Project Construction Cost Estimate

No.	Item	Quantity	Unit Price	Amount
1	Mobilization, Cleanup, and Demobilization	1 LS	$35,000	$35,000
2	Removal of Structures and Obstructions	1 LS	$20,000	$20,000
3	Locate Existing Utilities	1 LS	$5,000	$5,000
4	Temporary Erosion Control	1 LS	$5,000	$5,000
5	Excavation Safety Systems	1 LS	$1,000	$1,000
6	Booster Station Building	1 LS	$130,000	$130,000
7	Site Restoration	1 LS	$20,000	$20,000
8	Booster Station Building Piping	1 LS	$60,000	$60,000
9	Booster Station Site Piping	1 LS	$60,000	$60,000
10	Pumps and Motors	2 EA	$20,000	$40,000
11	Electrical and Telemetry	1 LS	$250,000	$250,000
12	Utility Charges	1 LS	$35,000	$35,000

Subtotal $661,000
Contingency (15%) $99,150
Tax (9.5%) $62,795
TOTAL ESTIMATED CONSTRUCTION COST $823,000

APPENDIX A

GEOTECHNICAL REPORT

PanGEO
INCORPORATED
Geotechnical & Earthquake Engineering Consultants

October 13, 2014
PanGEO Project No. 14-196

Mr. Josef Dalaeli, P.E.
Gray & Osborne, Inc.
701 Dexter Avenue North, Suite 400
Seattle, Washington 98109

Subject: **GEOTECHNICAL REPORT**
Proposed Booster Pump Station Building
325 Mt. Hood Drive SW, Issaquah, Washington
Gray & Osborne IPN#14543

Dear Mr. Dalaeli,

PanGEO has completed a geotechnical study to assist the project team with the design and construction of the proposed booster pump station building at 325 Mt. Hood Drive Southwest in Issaquah, Washington. The results of our study and our recommendations are summarized in the attached report.

Based on the results of our subsurface exploration program, the site is generally underlain by medium dense to very dense advance outwash sand and gravel. It is our opinion that the booster pump station building may be supported on conventional shallow foundations, provided the foundations bear on competent native soil or on newly placed structural fill. Additional design recommendations are outlined in the attached report. We appreciate the opportunity to be of service.

Should you have any questions, please do not hesitate to call.

Sincerely,

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

3213 Eastlake Avenue East
Seattle, WA 98102
T. (206) 262-0370

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GEOTECHNICAL REPORT
BOOSTER PUMP STATION BUILDING
325 MT. HOOD DRIVE SOUTHWEST
ISSAQUAH, WASHINGTON

1.0 GENERAL

PanGEO completed a geotechnical engineering study to for the proposed booster pump station building at 325 Mt. Hood Drive Southwest in Issaquah, Washington. Our work was performed in accordance with our proposal dated June 16, 2014, which was subsequently authorized by Gray & Osborne on August 12, 2014. The purpose of our geotechnical study was to evaluate subsurface conditions at the site and, based on the conditions encountered, provide geotechnical engineering recommendations pertinent to the design and construction of the proposed booster pump station building. Our services included conducting a site reconnaissance, reviewing pertinent geologic publications, reviewing a previous geotechnical engineering report prepared for the project site, drilling two test borings, and developing the conclusions and recommendations presented in this report.

2.0 SITE AND PROJECT DESCRIPTION

We understand that the booster pump station building will be constructed at the existing Mount Hood Reservoir site located at 325 Mt. Hood Drive Southwest in Issaquah, Washington (see Figure 1, Vicinity Map). It is our understanding that the reservoir facility was constructed in 1976. The proposed booster pump station building will be located within the relatively level existing asphalt-paved access drive on the east side of the reservoir facility (see Plate 1 and Figure 2). The crest of a steep slope is located just north of the existing pavement.

Plate 1. Existing reservoir facility, facing west.

We understand the proposed booster pump station building will be a relatively small single-story at-grade structure of concrete masonry unit (CMU) construction with an on-grade concrete floor. As such, we anticipate that grading for this project will be minimal. Utility trench excavations associated with the booster station are anticipated to be less than 5 feet deep.

3.0 SUBSURFACE EXPLORATIONS

3.1 CURRENT BORINGS

Two borings (BH-1 and BH-2) were drilled at the site on August 27, 2014. The borings were located in the field by taping from existing site features and are indicated on Figure 2. Borings BH-1 and BH-2 were advanced to depths of approximately 11 and 16½ feet below the existing grade, respectively.

The borings were drilled using a TD 85 trailer mounted drill rig owned and operated by Boretec1, Inc. of Bellevue, Washington. The drill rig was equipped with 6-inch outside diameter hollow stem augers. Soil samples were obtained from the borings at 2½- and 5-foot depth intervals by means of Standard Penetration Test (SPT) sampling methods in general accordance with ASTM test method D1586, in which the samples are obtained using a 2-inch outside diameter split-spoon sampler. The sampler was driven into the soil a distance of 18 inches using a 140-pound weight falling a distance of 30 inches. The number of blows required for each 6-inch increment of sampler penetration was recorded. The number of blows required to achieve the last 12 inches of sample penetration is defined as the SPT N-value. The N-value provides an empirical measure of the relative density of cohesionless soil, or the relative consistency of fine-grained soils.

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

3.2 PREVIOUS BORINGS

In addition to the current borings drilled at the site, we also reviewed the results of previous explorations at the site. Specifically, a geotechnical report was completed for a proposed reservoir to be constructed adjacent to the existing reservoir at the site (GeoEngineers, 2000). The report included four test borings and one of the test borings (B-1) was located in relatively close proximity to the proposed booster pump station building. The approximate location of GeoEngineers test boring B-1 is indicated in Figure 2, and the summary exploration log is included in Appendix B of this report.

4.0 SUBSURFACE CONDITIONS

4.1 GEOLOGY

According to the *Geologic Map of the Issaquah Quadrangle* (Booth, 2006), the surficial geologic unit mapped in the vicinity of the site is advance outwash (Map Unit Qva). Booth describes advance outwash as well-bedded sand and gravel deposited by streams and rivers issuing form the front of the advancing ice sheet. Advance outwash deposits typically have a low fines (i.e. silt and clay) content.

4.2 SOILS

In summary, approximately two feet of loose existing fill consisting of silty sand with gravel was encountered at BH-2, which was drilled near the crest of the steep slope on the north side of the site. The existing fill was characterized by the presence of organics and debris such as Styrofoam. Underlying the existing fill at BH-2 and underlying the pavement at BH-1, medium dense to very dense poorly graded gravel with sand that we interpret to be consistent with the mapped advance outwash deposits were encountered. The upper 3 to 3½ feet of the advance outwash deposits were weathered to a loose to medium dense condition and had a higher silt content. The advance outwash deposits contained large gravels and cobbles and were encountered to the maximum depths explored at PanGEO borings BH-1 and BH-2 as well as GeoEngineer's boring B-1 which extended approximately 11, 16½, and 25½ feet below grade, respectively.

4.3 GROUNDWATER

Groundwater was not encountered in our borings at the time of drilling (August 2014). In addition, groundwater was not encountered in the GeoEngineers boring at the time of drilling (October 1998). It should be noted that groundwater levels may vary depending on the season, local subsurface conditions, and other factors. Groundwater levels are normally highest during the winter and early spring.

5.0 SENSITIVE AREAS

5.1 COAL MINE HAZARDS

Review of Sensitive Areas mapping available on King County's iMAP website indicates the subject site is mapped within a Coal Mine Sensitive Area due to previous mining activity

beneath the site. As part of our study, we reviewed a *Map of Coal Mine Workings in Part of King Co., Washington* (Walsh 1983) and coal mine maps available on the Washington Department of Natural Resources (DNR) website. Specifically, we reviewed maps K-7 Map D (1918) and K-8 Map A (1912) which show the extent of mine workings of the Issaquah & Superior Coal Co., Ltd. Based on the results of our research, the 1,200 foot level of the #4 bed is mapped below the site. Elevation data on map K-7 Map D indicates that the gangway elevation was approximately 328 feet below sea level in the vicinity of the site. As such, the gangway of the 1,200 foot level of the #4 bed is approximately 790 feet below the existing grade at the proposed booster pump station building.

For the purposes of risk assessment, the King County Department of Development and Environmental Services (DDES) considers sites underlain by underground workings that are in excess of 300 feet below the surface as 'Declassified'. 'Declassified' coal mine hazard areas are areas where the risk of catastrophic collapse is not significant and that the hazard assessment report has determined that the site does not require any special engineering or hazard mitigation. Based on the results of our coal mine hazard assessment, the booster pump station building site would be considered 'declassified' and it is our opinion that engineering measures to mitigate collapse or subsidence due to mining activities are not necessary for this project.

5.2 STEEP SLOPE HAZARDS

As previously discussed, the top of a steep slope is located just north of the edge of the existing pavement at the site. The approximate top of the steep slope is shown on Figure 2. During our field work we did not observe evidence of slope movements or instability such as cracks or setdown within the existing pavement area which is approximately 38 years old. Based on the presence of dense to very dense advance outwash sand and gravel in our test borings, considering the relatively light weight of the proposed booster pump station, it is our opinion that construction of the booster pump station building should not impact stability of the steep slope provided the building is constructed at least 25 feet behind the top of the steep slope. The recommended 25 foot horizontal distance from the top of the steep slope includes a 10-foot steep slope buffer and a 15-foot building setback.

6.0 GEOTECHNICAL RECOMMENDATIONS

6.1 SEISMIC DESIGN PARAMETERS

We understand the seismic design of the booster station will be accomplished using the 2012 edition of the International Building Code (IBC), which specifies a design earthquake having a 2% probability of occurrence in 50 years (return interval of 2,475 years). The table below presents the seismic design parameters in accordance with the 2012 IBC, which are consistent with the 2008 USGS seismic hazard maps.

Table 1 - 2012 IBC Summary Seismic Design Parameters

Site Class	Spectral Acceleration at 0.2 sec. (g) S_S	Spectral Acceleration at 1.0 sec. (g) S_1	Site Coefficients		Design Spectral Response Parameters	
			F_a	F_v	S_{DS}	S_{D1}
D	1.317	0.495	1.000	1.505	0.878	0.497

6.2 SOIL LIQUEFACTION

Soil liquefaction is a condition where saturated cohesionless soils undergo a substantial loss of strength due to the build-up of excess pore water pressures resulting from cyclic stress applications induced by earthquakes. Soils most susceptible to liquefaction are loose, uniformly graded sands and loose silts with little cohesion. In our opinion, liquefaction is not a design consideration for this site because of the dense nature of the soils underlying the site and the depressed groundwater level.

6.3 FOUNDATION

Based on the subsurface conditions encountered in our borings drilled at the site, it is our opinion that a conventional spread footings are an appropriate foundation type to support the proposed booster pump station building, provided that the foundation bears on medium dense to very dense advance outwash sand and gravel. Based on the subsurface conditions encountered at BH-1, we anticipate soils suitable for foundation support will be encountered at the design footing

subgrade elevation. The following recommendations should be incorporated into design and construction of the foundation.

Allowable Bearing Pressure – To limit post-construction settlement to about ½ inch or less, we recommend that a maximum allowable bearing pressure of 2,500 pounds per square foot (psf) be used to size foundation elements bearing on competent advance outwash deposits. For allowable stress design, the recommended bearing pressure may be increased by one-third for transient loading, such as wind or seismic forces. Continuous and individual spread footings should have minimum widths of 18 and 24 inches, respectively.

Footing Embedment – For frost heave considerations, exterior footings should be placed at a minimum depth of 18 inches below final exterior grade. Interior spread foundations should be placed at a minimum depth of 12 inches below the top of slab.

Estimated Settlement - Footings designed and constructed in accordance with the above should experience total settlement of less than one inch and differential settlement less than about ½ inch. Most of the anticipated settlement should occur during construction as dead loads are applied.

Lateral Load Resistance - Lateral loads on the structure may be resisted by passive earth pressure developed against the embedded near-vertical faces of the foundation system and by frictional resistance developed between the bottom of the foundation and the supporting subgrade soils. For footings bearing on granular soils, a frictional coefficient of 0.4 may be used to evaluate sliding resistance developed between the concrete and the subgrade soil. Passive soil resistance may be calculated using an equivalent fluid weight of 350 pcf, assuming the footings are backfilled with structural fill. The above values include a factor of safety of 1.5. Unless covered by pavements or slabs, the passive resistance in the upper 12 inches of soil should be neglected.

Footing Excavations - Footings may be founded directly on undisturbed native soils. Prior to placing forms or rebar, the exposed footing subgrades should be compacted to a dense, unyielding condition. If the footing subgrade is still loose or yielding after re-compaction, it should be overexcavated down to competent soil and replaced with properly compacted crushed rock. The overexcavation width should extend at least one-half the overexcavation depth beyond the edge of footing.

6.4 FLOOR SLABS

It is our opinion that conventional concrete slab-on-grade floors are appropriate for this site. The onsite soils, crushed rock or Gravel Borrow are considered suitable to support the floor slab, provided the slab subgrade is compacted to the project requirements for structural fill. In areas where interior space is sensitive to moisture, a 10-mil polyethylene vapor barrier should also be placed directly below the slab.

6.5 NEW UTILITIES

6.5.1 Trench Excavation

Trench excavations may be accomplished using conventional excavation equipment. All excavations in excess of 4 feet in depth should be sloped in accordance with Washington Administrative Code (WAC) 296-155, or be shored. It is contractor's responsibility to maintain safe working conditions, including temporary excavation stability.

6.5.2 Pipe Support and Bedding

Based on our field explorations, we anticipate medium dense to very dense silty gravel with sand and relatively clean gravel with sand will be encountered in utility trench excavations. Utility installation should be conducted in accordance with the 2014 WSDOT Standard Specifications or other applicable specifications for placement and compaction of pipe bedding and backfill. In general, pipe bedding should be placed in loose lifts not exceeding 6 inches in thickness, and compacted to a firm and unyielding condition. Bedding materials and thicknesses provided should be suitable for the utility system and materials installed, and in accordance with any applicable manufacturers' recommendations. Pipe bedding materials should be placed on relatively undisturbed native soil. Soft soils, if present, should be removed from the bottom of the trench and replaced with pipe bedding material.

6.5.3 Trench Backfill

The onsite soils may be utilized for trench backfill provided they can be compacted to the project specifications. If the onsite soils cannot be adequately compacted, trench backfill should consist of select granular material, meeting the requirements for Gravel Borrow as specified in Section 9-03.14(1) of the 2014 WSDOT *Standard Specifications*, or an approved equivalent. The trench backfill should be placed in 8- to 12-inch, loose lifts and compacted using mechanical equipment to at least 90 percent maximum dry density, per ASTM D1557. In paved areas, the upper 2 feet

of the backfill should be compacted to at least 95 percent maximum dry density, per ASTM D1557. Heavy compaction equipment should not be permitted to operate directly over utilities until a minimum of 2 feet of backfill has been placed.

7.0 EARTHWORK CONSIDERATIONS

7.1 SITE PREPARATION

Site preparation for the proposed project includes removing the existing asphalt and excavating to the design subgrade. The asphalt at BH-1 was approximately 3½-inches thick. Following the removal of asphalt and excavation, the exposed subgrade beneath the new structure should be compacted to a dense and unyielding condition. Soil in loose or soft areas, should be over-excavated and replaced with compacted granular structural fill.

7.2 TEMPORARY EXCAVATIONS

We understand utility trenches are anticipated to be less than 5 feet deep. We anticipate that the excavations will largely encounter medium dense to very dense silty gravel with sand and relatively clean gravel with sand.

All temporary excavations should be performed in accordance with Part N of WAC (Washington Administrative Code) 296-155. The contractor is responsible for maintaining safe excavation slopes and/or shoring. For planning purposes, the temporary excavations may be sloped as steep as 1H:1V, but should be re-evaluated in the field during construction based on actual observed soil conditions. During wet weather, the cut slopes may need to be flattened to reduce potential erosion.

7.3 MATERIAL REUSE

It is our opinion that the on-site soils may be considered for use as structural fill or trench backfill provided the soil can be compacted to the project requirements for structural fill. The contractor should be aware that the surficial soils that exist at the site are moisture sensitive, and will become disturbed and soft when exposed to inclement weather conditions and/or construction traffic.

7.4 STRUCTURAL FILL AND COMPACTION

Imported structural fill, if needed, should consist of clean, free-draining granular soils that are relatively free from organic matter or other deleterious materials. Such materials should be less than 4 inches in maximum dimension, with less than 7 percent fines (portion passing the U. S. Standard No. 200 sieve), as specified for Gravel Borrow in Section 9-03.14(1) of the 2014 WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction*. The fine-grained portion of structural fill soils should be non-plastic. A fines content greater than 7 percent may be acceptable if the earthwork is performed during relatively dry weather and the contractor's methods are conducive to proper compaction of the soil. The use of material with a fines content greater than 7 percent should be approved by the project engineer prior to use.

All structural fill should be moisture conditioned to within about 3 percent of optimum moisture content, placed in loose, horizontal lifts less than 8 inches in thickness, and compacted to at least 95 percent maximum density, determined using ASTM D 1557 (Modified Proctor). The procedure to achieve proper density of a compacted fill depends on the size and type of compacting equipment, the number of passes, thickness of the layer being compacted, and certain soil properties. In areas where the size of the excavation restricts the use of heavy equipment, smaller equipment can be used, but the soil must be placed in thin enough layers to achieve the required relative compaction.

Generally, loosely compacted soils are a result of poor construction technique or improper moisture content. Soils with high fines contents are particularly susceptible to becoming too wet, and coarse-grained materials easily become too dry, for proper compaction. Silty or clayey soils with a moisture content too high for adequate compaction should be dried as necessary, or moisture conditioned by mixing with drier materials, or other methods.

7.5 WET WEATHER CONSTRUCTION

General recommendations relative to earthwork performed in wet weather or in wet conditions are presented below. The following procedures are best management practices recommended for use in wet weather construction:

- Earthwork should be performed in small areas to minimize subgrade exposure to wet weather. Excavation or the removal of unsuitable soil should be followed promptly by the placement and compaction of clean structural fill. The size and type of construction equipment used may have to be limited to prevent soil disturbance.

- During wet weather, the allowable fines content of the structural fill should be reduced to no more than 5 percent by weight based on the portion passing ¾-inch sieve. The fines should be non-plastic.
- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water.
- Bales of straw and/or geotextile silt fences should be strategically located to control surface water and to limit erosion.
- Excavation slopes and soils stockpiled on-site should be covered with plastic sheets during periods of wet weather.

7.6 SURFACE DRAINAGE

Surface runoff can be controlled during construction by careful grading practices. Typically, this includes the construction of shallow, upgrade perimeter ditches or low earthen berms in conjunction with silt fences to collect runoff and prevent water from entering excavations or to prevent runoff from the construction area from leaving the immediate work site. All collected water should be directed under control to a positive and permanent discharge system.

Permanent control of surface water should be incorporated in the final grading design. Adequate surface gradients and drainage systems should be incorporated into the design such that surface runoff is directed away from the structures and away from the top of the steep slope.

8.0 UNCERTAINTY AND LIMITATIONS

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

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

The scope of our work does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractors' methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design. Additionally, the scope of our work specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances. We are not mold consultants nor are our recommendations to be interpreted as being preventative of mold development. A mold specialist should be consulted for all mold-related issues.

This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

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

Within the limitation of scope, schedule and budget, PanGEO engages in the practice of geotechnical engineering and endeavors to perform its services in accordance with generally accepted professional principles and practices at the time the Report or its contents were prepared. No warranty, express or implied, is made.

We appreciate the opportunity to be of service to you on this project. Please feel free to contact our office with any questions you have regarding our study, this report, or any geotechnical engineering related project issues.

Sincerely,

Steven T. Swenson, L.G.
Project Geologist

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

9.0 REFERENCES

International Building Code (IBC), 2012, International Code Council.

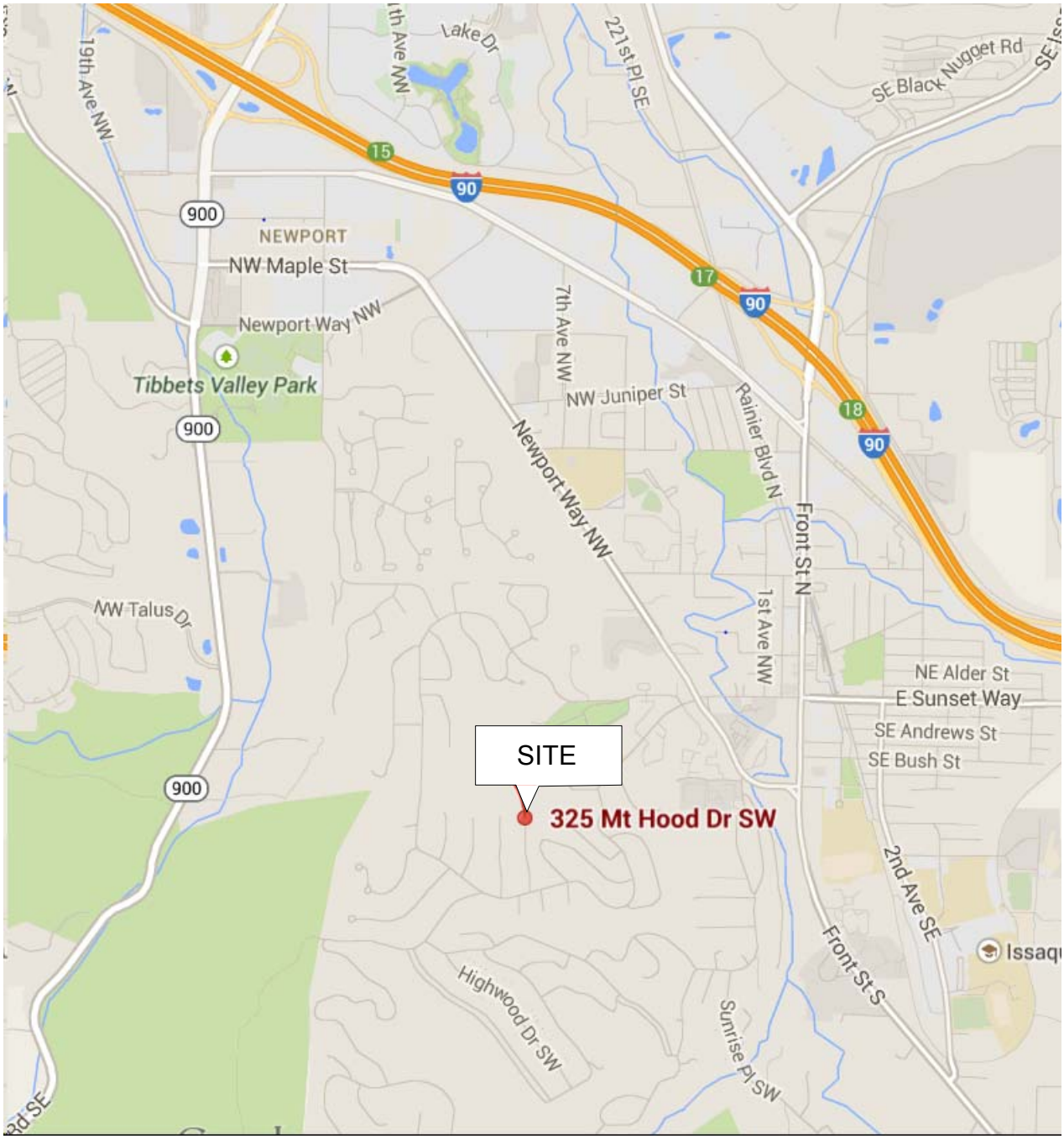
Booth, D.B., Walsh, T.J., Troost, K. G., Shimel, S. A., 2006, Geologic Map of the Issaquah 7.5' Quadrangle, King County, Washington, scale 1:24,000, U.S.G.S. Scientific Investigations Map.

GeoEngineers, Inc,, 2000, *Geotechnical Engineering Report, Proposed 480 Zone Reservoir, Issaquah, Washington.* Consultant report prepared by GeoEngineers for the City of Issaquah, dated March 24.

Walsh, T.J., Map of coal mine working in part of King County, Washington, Open-File Report 83-17, Washington State Department of Natural Resources Division of Geology and Earth Resources.

Washington State Coal Mine Map Collection, Maps K-7 and K-8, Washington State Department of Natural Resources Division of Geology and Earth Resources, downloaded from an FTP site provided for the project by the Division of Geology and Earth Resources.

WSDOT, 2014, *Standard Specifications for Road, Bridges, and Municipal Construction*.



N

PanGEO INCORPORATED	**Proposed Booster Pump Station Building 325 Mt Hood Drive SW Issaquah, WA**	**VICINITY MAP**	
		Project No. **14-196**	Figure No. **1**

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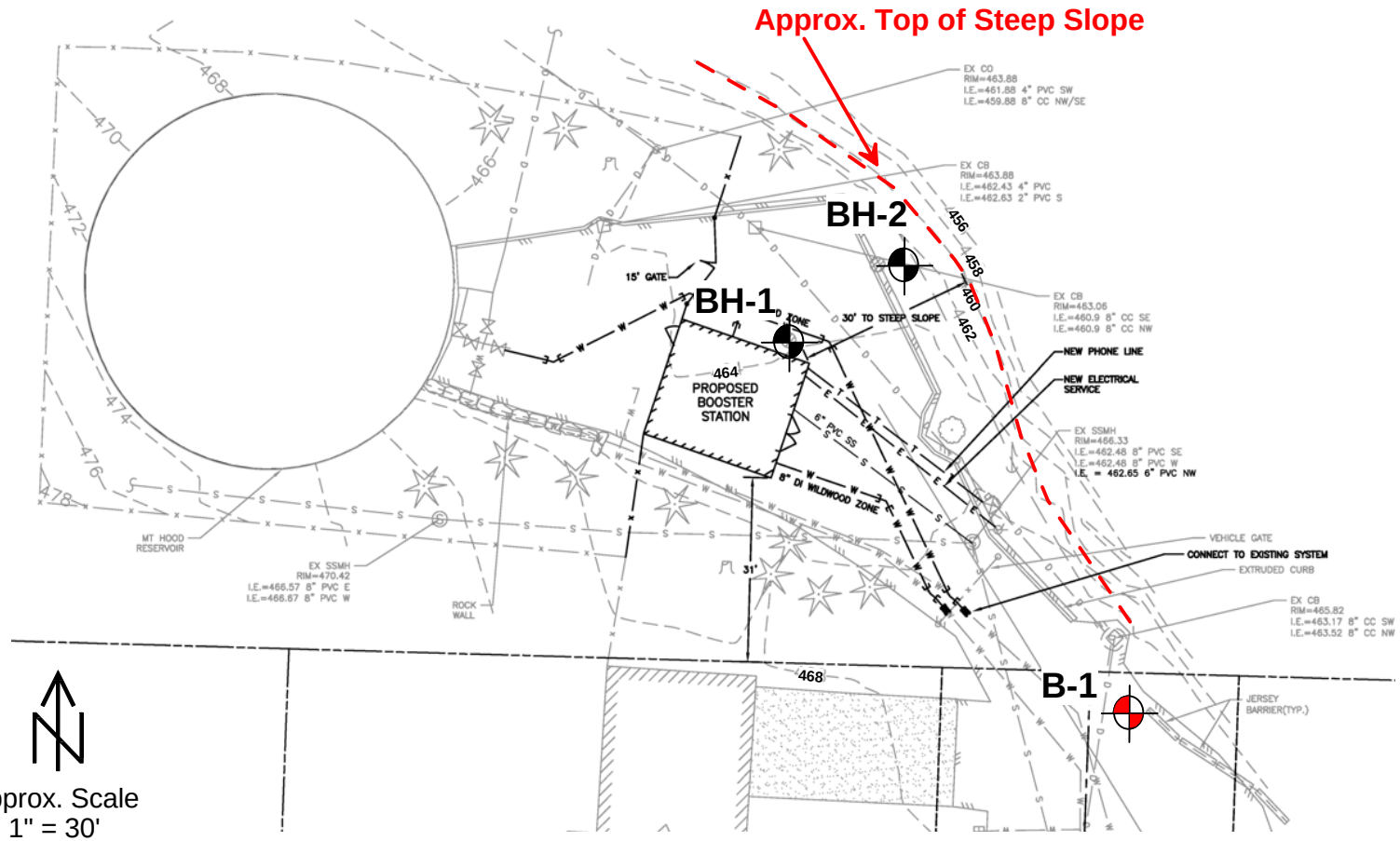

Approx. Scale
1" = 30'

0' 15' 30'

Note: Base map modified from preliminary plan sheet G-1 provided by Gray & Osborne.
Elevation contours are based on the NAVD88 Datum.

Legend:

BH-1 Approx. Borehole Location (PanGEO 2014)

B-1 Approx. Borehole Location (GeoEngineers 2000)

PanGEO INCORPORATED

Booster Pump Station Building
325 Mt. Hood Drive SW
Issaquah, WA

SITE AND EXPLORATION PLAN

Project No.	Figure No.
14-196	**2**

APPENDIX A

SUMMARY BORING LOGS

RELATIVE DENSITY / CONSISTENCY

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

UNIFIED SOIL CLASSIFICATION SYSTEM

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

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

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

DESCRIPTIONS OF SOIL STRUCTURES

Layered: Units of material distinguished by color and/or composition from material units above and below

Laminated: Layers of soil typically 0.05 to 1mm thick, max. 1 cm

Lens: Layer of soil that pinches out laterally

Interlayered: Alternating layers of differing soil material

Pocket: Erratic, discontinuous deposit of limited extent

Homogeneous: Soil with uniform color and composition throughout

Fissured: Breaks along defined planes

Slickensided: Fracture planes that are polished or glossy

Blocky: Angular soil lumps that resist breakdown

Disrupted: Soil that is broken and mixed

Scattered: Less than one per foot

Numerous: More than one per foot

BCN: Angle between bedding plane and a plane normal to core axis

COMPONENT DEFINITIONS

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

TEST SYMBOLS

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

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

SYMBOLS

Sample/In Situ test types and intervals

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

MONITORING WELL

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

MOISTURE CONTENT

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

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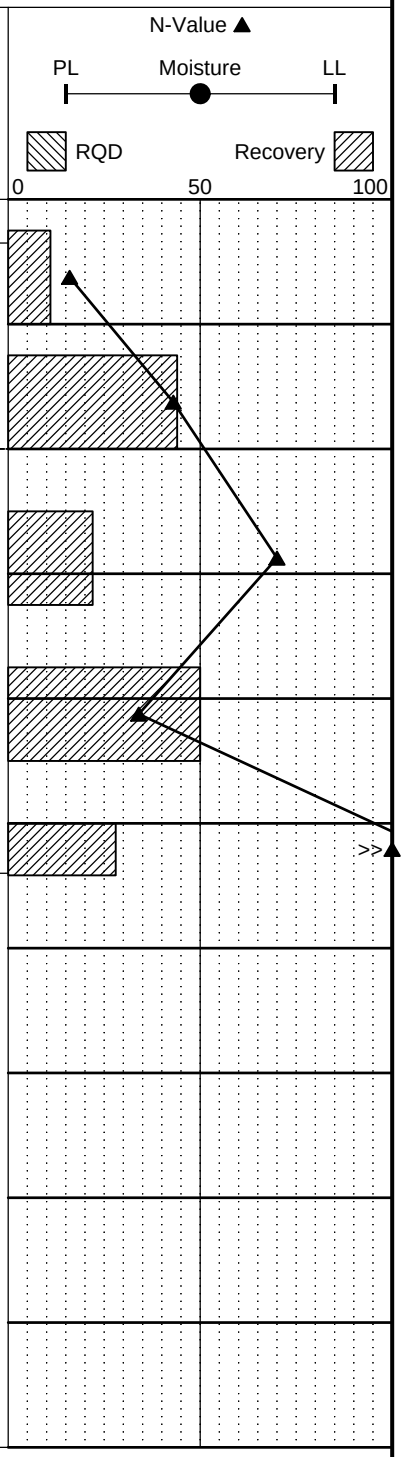
Terms and Symbols for Boring and Test Pit Logs

Figure A-1

Project:	Booster Pump Station Building	Surface Elevation:	464.0ft
Job Number:	14-196	Top of Casing Elev.:	N/A
Location:	325 Mt. Hood Drive SW, Issaquah, WA	Drilling Method:	Hollow Stem Auger
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						3.5-inches ASPHALT over 5 inches crushed rock.
	S-1		12 6 10			Medium dense, orangish-brown, silty GRAVEL with sand to silty SAND with gravel, moist. Weathered. **(Advance Outwash).**
2	S-2		10 17 26			
4						Dense to very dense, brown, poorly graded GRAVEL with sand, moist. Cobbles likely based on drill action. **(Advance Outwash).**
6	S-3		3 41 29			
8	S-4		15 17 17			
10	S-5		19 50/4			-Blowcounts likely elevated due to large gravel and/or cobbles.
						Boring terminated approximately 10.8 feet below grade. No groundwater encountered at the time of drilling.
12						
14						
16						
18						
20						



Completion Depth:	10.8ft
Date Borehole Started:	8/27/14
Date Borehole Completed:	8/27/14
Logged By:	STS
Drilling Company:	Boretec1, Inc.

Remarks: Boring drilled with an EC-85 trailer-mounted drill rig equipped with safety hammer (cathead mechanism) for SPT. Surface elevation (NAVD88) estimated based on a topographic survey prepared by Gray & Osborne.

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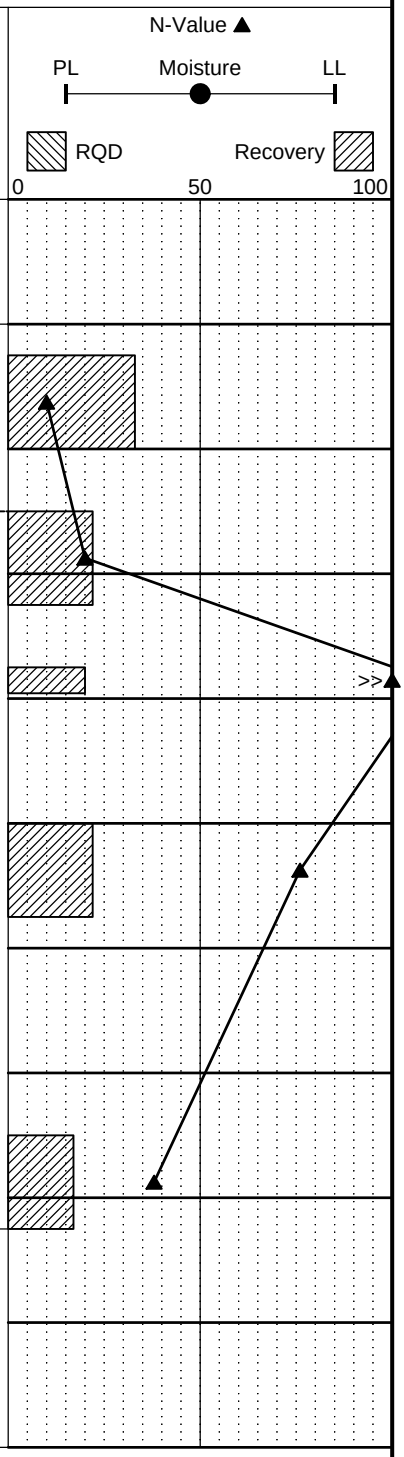
LOG OF TEST BORING BH-1

Figure A-2

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

Project:	Booster Pump Station Building	Surface Elevation:	462.0ft
Job Number:	14-196	Top of Casing Elev.:	N/A
Location:	325 Mt. Hood Drive SW, Issaquah, WA	Drilling Method:	Hollow Stem Auger
Coordinates:	Northing: , Easting:	Sampling Method:	SPT

Depth, (ft)	Sample No.	Sample Type	Blows / 6 in.	Other Tests	Symbol	MATERIAL DESCRIPTION
0						Loose, dark brown, silty SAND with gravel, moist. Organics and styrofoam observed in cuttings. **(Fill).**
2	S-1		5 3 7			Loose to medium dense, orangish-brown, silty GRAVEL with sand to silty SAND with gravel, moist. Weathered. **(Advance Outwash).**
4						
6	S-2		24 7 13			Medium dense to very dense, brown, poorly graded GRAVEL with sand, moist. **(Advance Outwash).**
8	S-3		50/5			-Sampler bouncing on a rock, blowcounts elevated. Low recovery.
10	S-4		24 39 37			
12						-Rough drilling, cobbles likely.
14						
16	S-5		17 22 16			
18						Boring terminated approximately 16.5 feet below grade. No groundwater encountered at the time of drilling.
20						



Completion Depth:	16.5ft
Date Borehole Started:	8/27/14
Date Borehole Completed:	8/27/14
Logged By:	STS
Drilling Company:	Boretec1, Inc.

Remarks: Boring drilled with an EC-85 trailer-mounted drill rig equipped with safety hammer (cathead mechanism) for SPT. Surface elevation (NAVD88) estimated based on a topographic survey prepared by Gray & Osborne.

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LOG OF TEST BORING BH-2

Figure A-3

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

APPENDIX B

PREVIOUS BORING LOG (GEOENGINEERS 2000)

TEST DATA

BORING B-1

DESCRIPTION

Surface Elevation (ft.): 467.0

Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
					SM	Light brown silty fine to coarse sand with fine to coarse organic matter (burnt particles) (medium dense, moist) (fill)
MD	14	99	17	■		
					SP-SM	Light brown fine to medium sand with silt, coarse sand, fine to coarse gravel and occasional cobbles (medium dense, moist)
MC, %F	3		20	■		
MD, %F	5	116	30	■		
MD	3	126	27	■		
MC	2		45	■		Grades to dense Boring completed at 25.5 feet on 10/06/98 No ground water encountered during drilling

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

DEPTH IN METERS: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

Note: See Figure A-2 for explanation of symbols

JRG:ja 12/3/98

0252-024-00a

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LOG OF BORING

FIGURE A-3