Exhibit 15

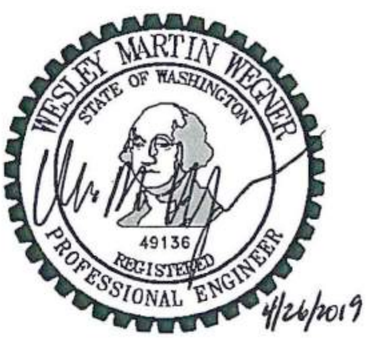
City of Camas WASHINGTON

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENT PROJECT

Final Drainage Report

City of Camas Project # S1000

April 2019



WE Job No. 1460A

wallis engineering

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SECTION A: PROJECT OVERVIEW

A.1 OVERVIEW

This report details the results of a stormwater analysis for the Lacamas Creek Pump Station Improvements project which includes a new sanitary pump station and associated site improvements at the existing Lacamas Creek Trailhead, future park improvements at Lacamas Creek Trailhead, a new sanitary pump station at Baz Park and associated underground utility construction to support both new pump stations. The City has allocated funds to improve the infrastructure in this sewerage basin including two new pump stations and associated site work, demolition of an existing pump station and new underground conveyance systems. Included with this project is the preliminary design and planning for future park improvements at Lacamas Creek Trailhead. Improvements to the park will be undertaken at a later date when additional funding becomes available but is expected to be within the next 5 years. The project sites are owned and maintained by the City of Camas.

This report includes the development of site specific stormwater treatment and detention/infiltration methods to include in the project in accordance with the *Camas Stormwater Design Standards Manual (CSDSM),* Resolution #1193, the *Stormwater Management Manual for Western Washington (SMMWW)*, dated February 2012 and amended in 2014, and the *Low Impact Development Technical Guidance Manual for Puget Sound (LID Manual)*, dated January 2005, as adopted by the City of Camas and Clark County for this project.

A.2 EXISTING SITE CONDITIONS

The project is located in Camas, Washington and consists of 3 separate project areas. See Exhibit A for a Project Location Map. Each project area is described below:

Lacamas Creek Trailhead:

This project area consists of a partially developed City park and is comprised of impervious surfaces, including driveways and parking lots, and pervious surfaces, including landscaping and native vegetation. The site is bounded by NE 3rd Avenue on the south and Lacamas Creek to the east.

See Exhibit B-1 for a Basin Map. The project area has been separated into two sub-areas, Lacamas Creek Pump Station site, located on the southern end of the property, and Lacamas Creek Trailhead future improvements, located on the north end of the existing park. The property has slopes between 0 and 100 percent but the area within the proposed project limits is between 0-10%. Runoff generally drains east towards Lacamas Creek.

The Lacamas Creek Trailhead site is located within the 6-month wellhead protection capture zones which is also known as a Zone 1 Critical Aquifer Recharge Area (CARA). Drywells are prohibited in CARA 1 zones.

Baz Park:

This project area consists of a semi-developed City park and is comprised of impervious parking surfaces and pervious landscaped surfaces. The site is bounded by NE 3rd Loop on the north and Lacamas Creek to the south.

See Exhibit B-2 for a Basin Map. The project area slopes between 0 and 5 percent with steeper slopes existing south of the improvements as the terrain descends towards Lacamas Creek. Runoff generally drains south towards Lacamas Creek.

The Baz Park site is located within the 6-month wellhead protection capture zones which is also known as a Zone 1 Critical Aquifer Recharge Area (CARA). Drywells are prohibited in CARA 1 zones.

Offsite Underground Sewage Conveyance Improvements:

These project areas include portions of NE 3rd Loop, NE 3rd Avenue and E 1st Avenue. Improvements are entirely within existing Right of Way or easements and most of the improvements take place within existing roadways.

A.2.1 EXISTING STORMWATER SYSTEM

No stormwater systems currently exist at Baz Park or the Lacamas Creek Trailhead park. Un-concentrated runoff generally flows across the existing parks and descends towards the Lacamas Creek watershed. Typical municipal stormwater infrastructure exists within the developed roadways and generally consists of collections structures, conveyance piping and outfalls.

A.3 PROPOSED IMPROVEMENTS:

The proposed improvements are divided into three separate project areas and include the Lacamas Creek Pump Station site along with the future park improvements, the Baz Park Pump Station site, and the conveyance system sites (see Exhibit C - Proposed Site and Improvements Plans) which correspond to the different project areas. Preliminary stormwater system improvements for each project area are described below:

> Lacamas Creek Pump Station Site with Future Park Improvements: Runoff from the pump station site improvements will be managed through the use of bioretention BMPs for treatment and an infiltration gallery for flow control. The future park improvements will include additional bioretention facilities for water quality treatment and the same infiltration gallery for flow control.

> Baz Park Pump Station Site: Runoff from the pump station site improvements will be managed through the use of dispersion systems due to its limited footprint and impervious surface creation.

> Conveyance system improvements: No new stormwater management BMPs are proposed with these improvements as all existing surfacings will be replaced as part of the site restoration. Stormwater pollution prevention measures during construction will be implemented.

Minimum Requirements, as defined in the stormwater manual, will be identified for each project site separately as each site is considered a separate Threshold Discharge Area.

SECTION B: MINIMUM REQUIREMENTS

The proposed improvements for both pump station sites result in new or replaced impervious surfacings and are subject to the minimum requirements as determined from Figure 1.3 of the *CSDSM*. The conveyance piping project sites are exempt from all Minimum Requirements except for Construction Stormwater Pollution Prevention in accordance with Section 1.03 of the same manual. Both pump station sites ultimately discharge runoff to Lacamas Creek, but the discharge locations are separated by more than ¼ mile and are considered separate Threshold Discharge Areas when determining the applicable minimum requirements.

Lacamas Creek is classified as a basic treatment receiving water.

This report includes a preliminary analysis of both pump station sites. The conveyance improvement sites are not analyzed due to their exemption from the minimum requirements allowed under Section 1.03 of the *CSDSM*. The details of each site are shown in Exhibit C1 Proposed Improvements Plan. Table 1 below shows the approximate existing and proposed impervious and pervious areas by project site and the corresponding applicable minimum requirements.

Table 1:Basin Area Summary

Project Area	Existing Drainage Area			Proposed Drainage Area			Threshold Discharge Area	Minimum Requirements
	Impervious (acres)	Pervious (acres)	Total (acres)	Impervious (acres)	Pervious (acres)	Total (acres)		
Lacamas Creek PS Site	0.0552	0.2939	0.3491	0.2513	0.0978	0.3491	1	1-9
Lacamas Creek Park	0.2579	0.1417	0.3996	0.2776	0.1313	0.4089	1	1-9
Baz Park PS Site	0	0.062	0.062	0.0528	0.0092	0.062	2	1-5

A WWHM project report detailing the flow conditions of the Lacamas Creek Trailhead site is included in the Technical Appendix. No modeling was completed for Baz Park as the project site is only subject to Minimum Requirements 1-5.

Modeling was conducted for the impervious surfaces of the site only. Pervious surfaces were not evaluated because the existing land cover within the projects is primarily lawn area associated with the park and there will be no conversion of vegetated areas as defined in the Stormwater Manual.

Note that the pathway connecting the future park improvements to NE 3rd Avenue was modeled as pasture in accordance with Washington DOE Stormwater Manual as it will utilize the sheet flow dispersion BMP.

SECTION C: SOILS EVALUATION

C.1 ASSUMPTIONS

Pre-developed conditions for both pump station sites were considered “Forest, Flat”, soil group Soil Group (SG) 3.

C.2 ONSITE HYDROLOGIC SOIL GROUP

The Natural Resources Conservation Service (NRCS) Web Soil Survey (USDA, 2012) classifies the soil within the Lacamas Creek Trailhead site as mainly OmE – Olympic Stoney Clay Loam, corresponding to a hydrologic soil group classification of “B”. According to Clark County WWHM Soil Groups Memorandum (Clark County Memo), dated December 2010, OmE soils fall under “Soils Group (SG) 3” and are suitable for slower infiltrating facilities.

The NRCS classifies the soil within the Baz Park site as mainly SnA – Sauvy Silt Loam, corresponding to a hydrologic soil group classification of “D”. SnA falls under “Soils Group (SG) 3” as described with the Clark County WWHM Soil Groups Memorandum.

The soil maps and Clark County Memo are included in the Technical Appendix.

C.3 SITE SPECIFIC GEOTECHNICAL INVESTIGATIONS

Geotechnical investigations for both sites are included in the Technical Appendix and summarized below.

Preliminary subsurface investigations were completed to aid in the design of the pump station and included deep borings at each pump station site. Subsurface soils at the Lacamas Trailhead site included layers of silty sand and sand at depths approaching 7 feet bgs which appear to be suitable for infiltration. Infiltration testing was completed at the Lacamas Park site near the proposed facility location and at a depth of approximately 12.3 feet deep using the small-scale pilot infiltration testing method. Larger infiltration pits were not feasible due to the surrounding park setting and the need to maintain park access and use. Infiltration results yielded saturated conductivity rates of approximately 32 inches per hour. However, decomposed basalt was discovered less than one foot below the pit after the completion of the testing pit. The presence of the impermeable basalt layer suggests that the infiltration rates observed during testing represent lateral water movement as opposed to vertical. The report recommends using a lateral flow rate of 2.6 ft^3/hr per ft^2 of wetted area.

SECTION D: SOURCE CONTROL

Anticipated BMPs associated with the project include:

S411 – BMPs for Landscaping and Lawn/Vegetation Management

S417 – BMPs for Maintenance of Stormwater Drainage and Treatment Systems

SECTION E: ONSITE STORMWATER MANAGEMENT BMPS

TDA 1: Bioretention facilities were chosen to manage all pollution generating areas to meet the intent of Minimum Requirement 5 and also provide the necessary water quality treatment. A pedestrian pathway is proposed to connect the future park to NE 3rd Avenue and will be managed through dispersion.

The entire TDA will meet the LID Performance Standard as justified through modeling.

TDA 2: Dispersion BMPs are proposed for the Baz Park site improvements due to the limited new impervious surfaces proposed and the geotechnical analysis showing that the site exists on existing fill.

SECTION F: RUNOFF TREATMENT ANALYSIS AND DESIGN

Basic treatment for TDA 1 is provided through the construction of multiple bioretention facilities. All bioretention facilities are assumed to have no native infiltration rate. Stormwater will infiltrate through the BMP media and be conveyed through underdrains and hard piping to the infiltration gallery.

No treatment facilities are proposed or required for TDA 2.

SECTION G: FLOW CONTROL ANALYSIS AND DESIGN

Flow control is required for TDA 1 and will be provided in compliance with Minimum Requirement 7 through the use of an infiltration gallery.

The infiltration rate utilized for sizing and modeling is based on the wetted perimeter of the infiltration gallery and includes the corrections factors recommended by both the Infiltration Report and the Stormwater Manual. The horizontal infiltration rate was assumed along the entire wetted perimeter of the facility to an average height of 2.5 feet. Due to the variability of soils in the area and the potential presence of rock underlying the proposed facility, additional infiltration testing during construction is recommended at the bottom of the facility.

As shown in the WWHM modeling output, the infiltration gallery disposes of 99.9% of the entire runoff profile. It is appropriate to note that the WWHM software has difficulty modeling facilities that achieve full infiltration due to limitations in the software. The proposed size of the facility appears sufficient to manage flows in compliance with the stormwater manual. An overflow is also proposed above the Ordinary High Water mark of Lacamas Creek adjacent to the site.

SECTION H: WETLAND PROTECTION

There are no wetlands in the immediate vicinity of either pump station site, and the proposed stormwater management systems will have no adverse effect on wetlands outside of the immediate site vicinity.

SECTION I: OTHER PERMITS

Permits to be obtained for this project include:

- U.S. Army Corps of Engineers Nationwide Permit
- WDF&W Hydraulic Project Approval
- Shorelines Substantial Development Permit
- Critical Areas Permit
- SEPA Checklist
- Design Review
- Site Plan Review
- Building Permits and Demolition Permit
- Southwest Clean Air Agency Air Discharge Permit

SECTION J: WASHINGTON STATE DOE CONSTRUCTION STORMWATER GENERAL PERMITCONVEYANCE SYSTEMS ANALYSIS AND DESIGN

Conveyance systems proposed for the project include mainly overland flow with collection structures and raingardens, and conveyance piping. No formal modeling was completed for the closed conduit piping systems due the simplicity of the system.

Peak runoff of the 25-year storm for the Lacamas pump station site is approximately 1.32 cfs utilizing the Rational Method where c=0.9, i=4.2 in/hr, and the drainage basin is 0.35 acres. Conveyance piping systems are proposed with a minimum diameter of 10 inches and a slope of 0.01 ft/ft yielding a full capacity of 2.2 cfs.

Conveyance systems for the future Lacamas Park will be evaluated separately at the time of development.

SECTION K: OFFSITE ANALYSIS

A Downstream analysis was not conducted for either TDA. As required by the Minimum Requirements, TDA 1 will be required to match predeveloped flows which will be less than current runoff flows. The proposed improvements within TDA 2 are small in scale and will have an insignificant impact to the natural drainage paths.

SECTION L: APPROVAL CONDITIONS SUMMARY

None

SECTION M: SPECIAL REPORTS AND STUDIES

- U.S. Army Corps of Engineers Nationwide Permit
- Cultural Resources Report
- Critical Areas Report

- Shorelines Substantial Development Permit
- Hydrogeological Report

SECTION N: MAINTENANCE AND OPERATIONS MANUAL

All facilities will be owned and maintained by the City of Camas. M&O procedures are anticipated to be completed in accordance with the CSDSM.

SECTION O: REFERENCES

1. City of Camas' "Camas Stormwater Design Standards Manual," Resolution #1193.
2. United States Department of Agriculture, Natural Resources Conservation Service. "Web Soil Survey." http://websoilsurvey.nrcs.usda.gov/app/
3. Washington State Department of Ecology's "Stormwater Management Manual for Western Washington," 2012 and amended December 2014.
4. Washington State University's "Low Impact Development Technical Guidance Manual for Puget Sound (LID Manual)," January 2005.

EXHIBITS

A. Project Location Map

B. Basin Maps

B-1. Lacamas Creek Pump Station Basin Map

B-2. Baz Park Pump Station Basin Map

C. Proposed Improvements Plan

C-1. Lacamas Creek Trailhead Park Improvements

C-2. Lacamas Creek Pump Station Design Plans – Permit Set

D. Geotechnical Reports

D-1. Lacamas Creek Pump Station Infiltration Study

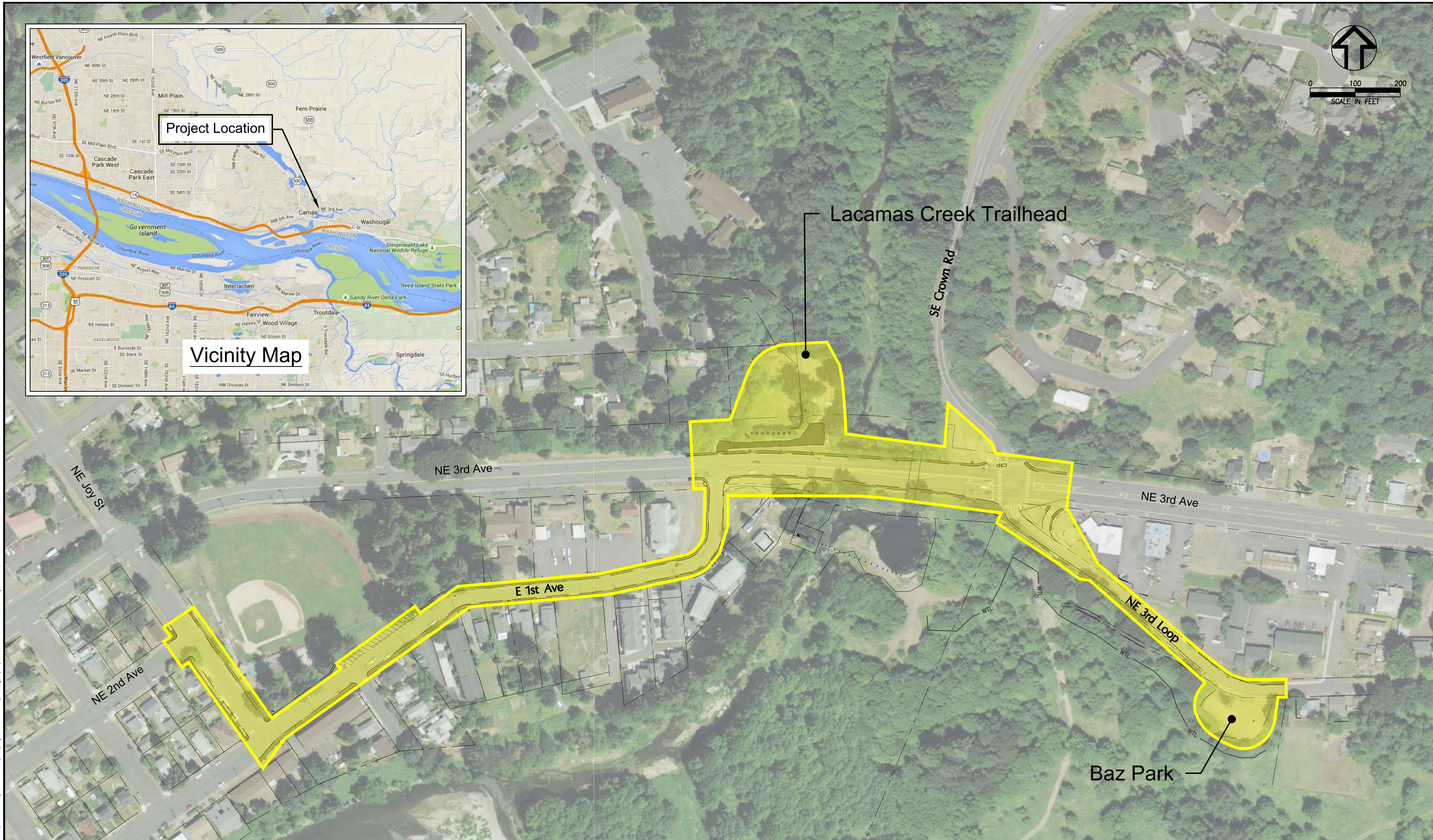

Exhibit A - Project Location Map

City of Camas
Lacamas Creek Pump Station Improvements Stormwater Report

WE:1460A

April 2019

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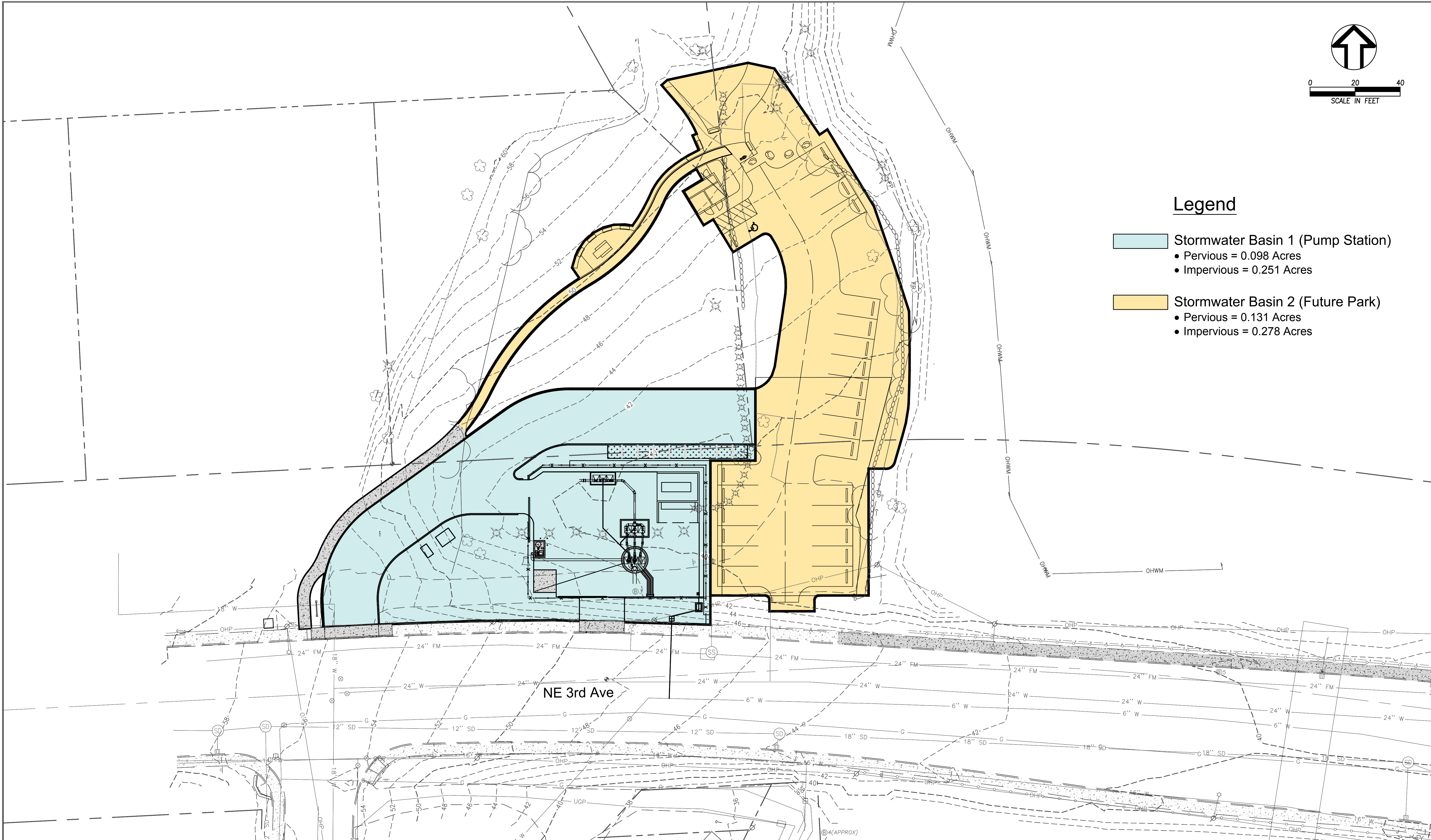

Exhibit B-1 - Lacamas Creek Park Pump Station Basin Map

City of Camas
Lacamas Creek Pump Station Improvements Stormwater Report

WE:1460A

April 2019

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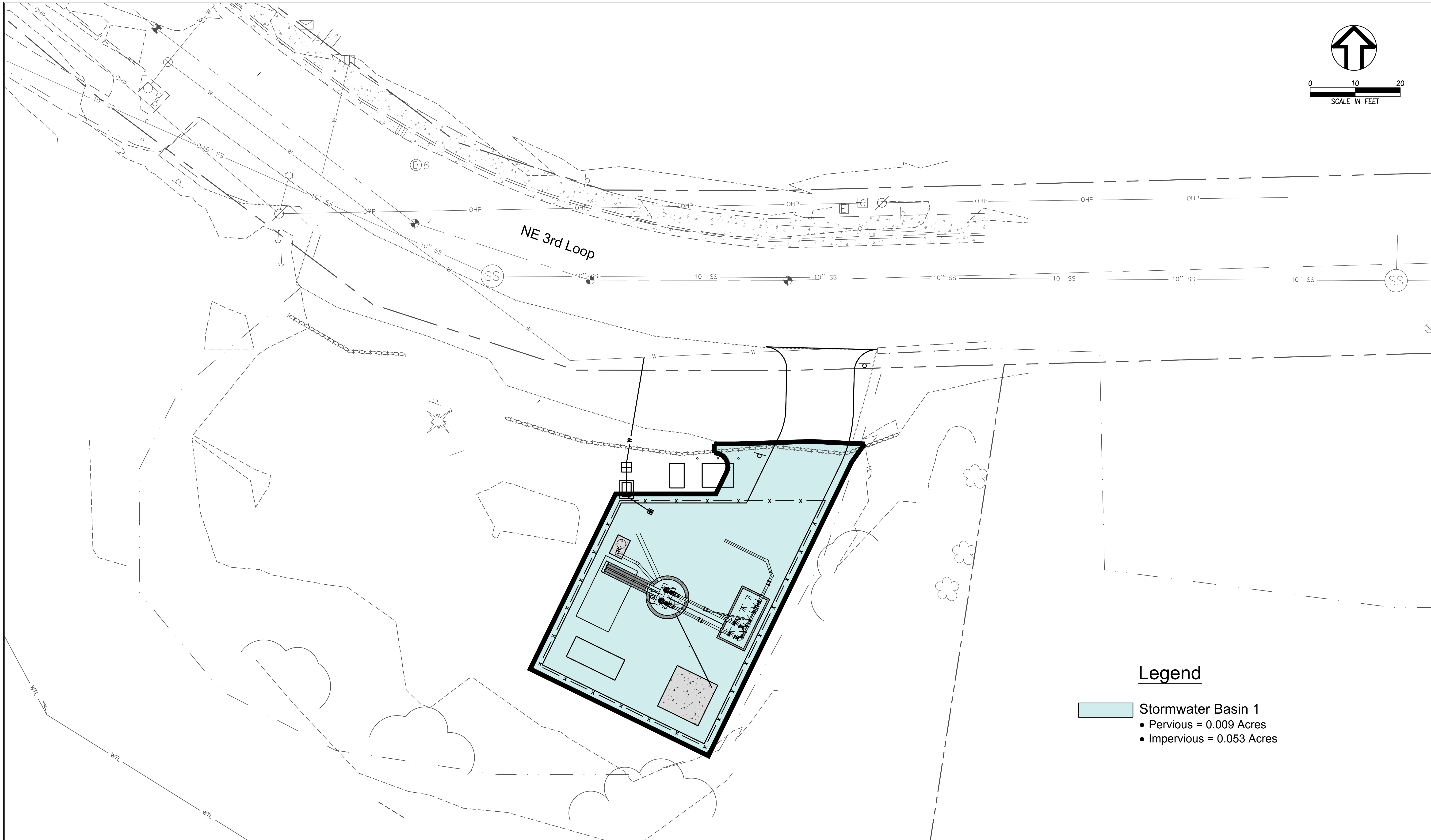

Legend

Stormwater Basin 1
- Pervious = 0.009 Acres
- Impervious = 0.053 Acres

Exhibit B-2 - Baz Park Pump Station Basin Map

City of Camas
Lacamas Creek Pump Station Improvements Stormwater Report

WE:1460A

April 2019

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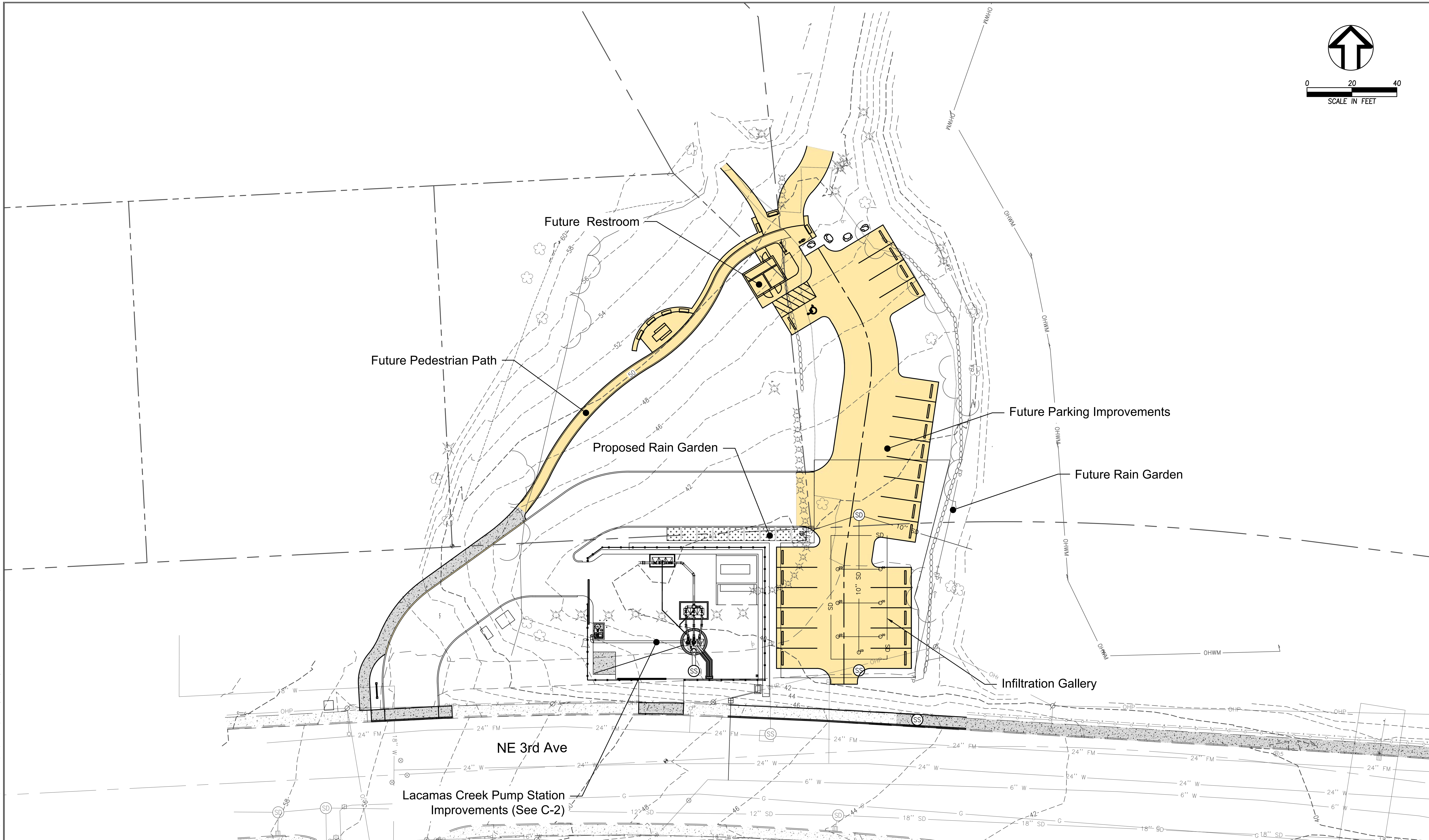


Exhibit C-1 - Lacamas Creek Trailhead Improvements

City of Camas

Lacamas Creek Pump Station Improvements Stormwater Report

WE:1460A

April 2019

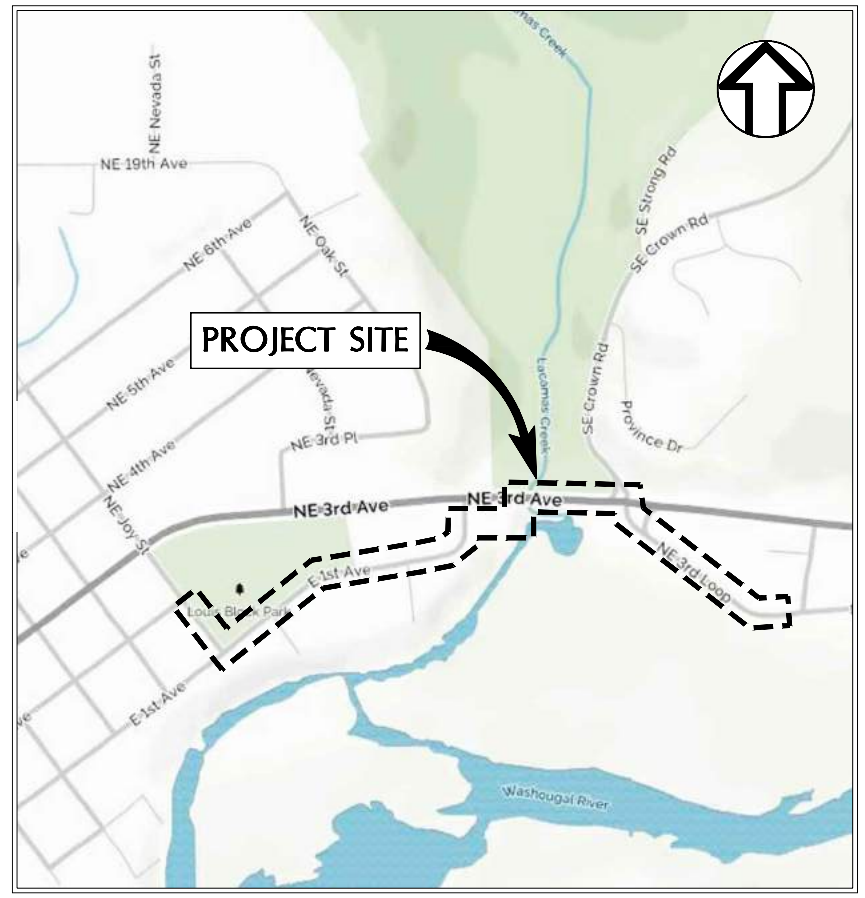
Exhibit C-2: Final Drainage Report

CITY OF CAMAS

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

MARCH 2019

LOCATION MAP
NOT TO SCALE



PROJECT SITE MAP
NOT TO SCALE

Owner: City of Camas
616 NE 4th Ave
Camas, Washington 98607
Camas Public Works Department
Contact: Jim Hodges, Project Manager
(360) 817-7234

Civil Engineer: Wallis Engineering
215 W. 4th Ave., Suite 200
Vancouver, Washington 98660
(360) 695-7041
Contact: Tim Shell, P.E.

FRANCHISE UTILITIES

Clark Public Utilities
Contact: Jon Pilling
Email: jpilling@clarkpud.com
Phone: (360) 992-8814

Frontier Communications
Contact: John Bielec
Email: John.bielec@ftr.com
Phone: (503) 367-5106

Comcast Cable
Contact: Michelle Janson
Email: Michelle Janson@comcast.com
Phone: (360) 518-1851

Northwest Natural
Contact: Gary Nault
Email: gwn@nwnatural.com
Phone: (360) 571-5465 ext: 2046

Wave Broadband
Contact: Derek Larson
Email: dlarson@wavebroadband.com
Phone: (503) 798 8426

NW Pipeline
Contact: Jennifer Tackett
Email: jennifer.1.tackett@williams.com
Phone: (360) 608-7220

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

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COVER

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

CITY PROJECT NO. S1000

DRAWING NO:
G-001
1 OF 71

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Exhibit C-2: Final Drainage Report

SHEET INDEX

*NOT INCLUDED IN PERMIT SET

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER
PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

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SHEET INDEX

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PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
G–002

Exhibit C-2: Final Drainage Report

GENERAL NOTES

1. THE LOCATIONS, DEPTHS, AND DESCRIPTIONS OF EXISTING UTILITIES SHOWN WERE COMPILED FROM UTILITY LOCATE MARKS, UTILITY AS-BUILT MAPS, AVAILABLE RECORDS, AND FIELD SURVEYS. THE ENGINEER/UTILITY COMPANIES DO NOT GUARANTEE THE ACCURACY OR THE COMPLETENESS OF SUCH RECORDS. ADDITIONAL UTILITIES MAY EXIST WITHIN THE WORK AREA. THE CONTRACTOR SHALL POTHOLE ALL UTILITY CROSSINGS A MINIMUM OF 500 FEET IN ADVANCE OF THE PROPOSED UTILITY INSTALLATION AND REPORT ALL CONFLICTS TO THE ENGINEER. THE CONTRACTOR SHALL COORDINATE RELOCATING CONFLICTING UTILITIES WITH THE UTILITY OWNER.
2. THE CONTRACTOR SHALL MAKE PROVISIONS TO KEEP ALL EXISTING UTILITIES IN SERVICE AND PROTECT THEM DURING CONSTRUCTION. IMMEDIATELY REPAIR OR REPLACE ANY DAMAGED UTILITIES IN KIND AND AS APPROVED BY THE UTILITY OWNER AT THE CONTRACTOR'S EXPENSE. IF SERVICE INTERRUPTIONS CANNOT BE PREVENTED TO COMPLETE THE WORK, THE CONTRACTOR SHALL PROVIDE WRITTEN NOTICE TO BUSINESSES A MINIMUM OF TWO WORKING DAYS PRIOR TO THE SERVICE INTERRUPTION. SERVICE INTERRUPTIONS SHALL NOT BE PERMITTED WITHOUT PRIOR WRITTEN AGREEMENT WITH THE UTILITY OWNER.
3. CONTRACTOR SHALL COMPLY WITH ALL PERMIT REQUIREMENTS FOR WORK IN RIGHT-OF-WAY. RESTORE TRENCHES WITH TEMPORARY HOT MIX ASPHALT BY THE END OF EACH WORKING DAY. STEEL SHEETS WITH PINS AND ASPHALT WEDGES MAY BE USED IN COMBINATION WITH TEMPORARY ASPHALT OVER A LIMITED TIME/AREA.
4. THE CONTRACTOR SHALL KEEP AN APPROVED SET OF PLANS AND PERMITS ON THE PROJECT SITE AT ALL TIMES.
5. THE CONTRACTOR SHALL ESTABLISH THE PRINCIPAL LINES AND GRADES IN ACCORDANCE WITH THE SPECIFICATIONS. PROPERTY LINES SHOWN ON ALL PLAN SHEETS ARE APPROXIMATE AND ARE NOT MEANT TO REPRESENT THE ACTUAL BOUNDARIES. A COPY OF THE CAD BASE DRAWING WILL BE PROVIDED TO THE CONTRACTOR UPON REQUEST.
6. PROVIDE TEMPORARY SUPPORT OF TRAFFIC SIGNAL AND UTILITY POLES WHERE NECESSARY. COORDINATE WITH POLE OWNER.
7. SURVEY MONUMENTS SHALL NOT BE DISTURBED. IF THE CONTRACTOR SUSPECTS THAT SURVEY MONUMENT DISRUPTION MAY OCCUR, THE CONTRACTOR SHALL NOTIFY THE PROJECT ENGINEER IMMEDIATELY.

SURVEY

BASIS OF BEARING:

WASHINGTON STATE PLANE SOUTH ZONE 4602
NAD 83(2011)(EPOCH:2010.0000)
POINT SCALE 1.00006434
COMBINED FACTOR 1.00006578
GRID COORDINATES IN DRAWING

VERTICAL DATUM:

CLARK COUNTY BENCH MARK NUMBER 241, A 2" BRASS DISK IN CURB AT THE NW QUADRANT OF NE 14TH AVENUE AND NE EVERETT STREET INSCRIBED 1400-1992, RECORD ELEVATION 215.34' NGVD 29(47)

ABBREVIATIONS

AC	ASPHALT CONCRETE
ARV	AIR RELEASE VALVE
BPPS	BAZ PARK PUMP STATION
CARV	COMBINATION AIR RELEASE VALVE
CLR	CLEAR
CONC	CEMENT CONCRETE
CONN	CONNECTION, CONNECTING
CSBC	CRUSHED SURFACING BASE COURSE
CSTC	CRUSHED SURFACING TOP COURSE
CY	CUBIC YARD
DI	DUCTILE IRON
DIA	DIAMETER
ES	EACH SIDE
EW	EACH WAY
FA	FOUL AIR
FCA	FLANGE COUPLING ADAPTER
FL	FLANGE
FM	FORCE MAIN
FPT	FEMALE PIPE THREAD
FRP	FIBER REINFORCED PLASTIC
GALV	GALVANIZED
GA	GAUGE
GB	GRADE BREAK
HMA	HOT MIX ASPHALT
HORIZ	HORIZONTAL
ID	INSIDE DIAMETER
IE	INVERT ELEVATION
LCPS	LACAMAS CREEK PUMP STATION
MFR	MANUFACTURER
MH	MANHOLE
MJ	MECHANICAL JOINT
MPT	MALE PIPE THREAD
OC	ON CENTER
OD	OUTSIDE DIAMETER
PVC	POLYVINYL CHLORIDE
PL	PLATE
SAN	SANITARY SEWER
SSMH	SANITARY SEWER MANHOLE
SST	STAINLESS STEEL
STL	STEEL
STM	STORM SEWER
T & B	TOP AND BOTTOM
TEMP	TEMPORARY
VERT	VERTICAL

EXISTING UTILITY CROSSING LEGEND

WITHIN THE PROFILES ON THE PLAN AND PROFILE SHEETS ARE TICK MARKS SHOWN ABOVE THE EXISTING GROUND LEVEL. THESE INDICATE THE CROSSING OF AN EXISTING UTILITY (SEE THE LEGEND BELOW FOR TYPES OF UTILITIES). IF THE SIZE OF THE UTILITY IS KNOWN AND LARGER THAN 4-INCH IN DIAMETER, THE SIZE WILL BE NOTED. IF IN ADDITION TO THE SIZE, THE APPROXIMATE DEPTH OF AN EXISTING UTILITY IS KNOWN, THE UTILITY WILL BE DISPLAYED IN THE PROFILE. NOTE THAT DISPLAYED UTILITY ELEVATIONS ARE APPROXIMATE AND DO NOT RELIEVE THE CONTRACTOR OF PERFORMING POTHOLING.

EXISTING UTILITY CROSSING LEGEND

FM	FORCE MAIN
G	GAS
SD	STORM DRAIN SEWER
SS	SANITARY SEWER
TR	TRAFFIC SIGNAL
UGP	UNDERGROUND POWER
UGT	UNDERGROUND TELECOMMUNICATIONS
W	WATER

TIMOTHY C. ... STATE OF WASHINGTON ... 26182 REGISTERED PROFESSIONAL ENGINEER
PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH
0 — 1"
ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

GENERAL NOTES & ABBREVIATIONS

wallis engineering
215 W 4th Street, Suite 200 Vancouver, WA 98660 360.695.7041

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
G-003

Exhibit C-2: Final Drainage Report

LEGEND

EXISTING

- - 20 - -	EXISTING MAJOR CONTOUR
- - 22 - -	EXISTING MINOR CONTOUR
	EXISTING RIGHT OF WAY
	EXISTING PROPERTY LINE
	EXISTING CENTERLINE
	EXISTING CURB
	EXISTING CONCRETE
	EXISTING GRAVEL
	EXISTING AC PAVEMENT
8" SD	EXISTING STORM, SIZE NOTED IF KNOWN
8" SS	EXISTING SANITARY, SIZE NOTED IF KNOWN
6" FM	EXISTING SANITARY FORCE MAIN, SIZE NOTED IF KNOWN
6" W	EXISTING WATER, SIZE NOTED IF KNOWN
2" G	EXISTING GAS, SIZE NOTED IF KNOWN
OHP	EXISTING OVERHEAD POWER
SS	EXISTING SANITARY MANHOLE
SD	EXISTING STORM MANHOLE
	EXISTING CATCH BASIN
	EXISTING CURB INLET
	EXISTING AREA DRAIN
	EXISTING CLEANOUT
	EXISTING WATER METER
	EXISTING WATER VALVE
	EXISTING FIRE HYDRANT
	EXISTING IRRIGATION VALVE
	EXISTING UTILITY POLE
	EXISTING GUY WIRE
	EXISTING GAS VALVE
	EXISTING GAS METER
	EXISTING SIGN
	EXISTING LUMINAIRE
	EXISTING MONUMENT
	EXISTING MAILBOX
	EXISTING ELECTRICAL BOX
	EXISTING BUILDING
x x x	EXISTING FENCE
	EXISTING GUARDRAIL
FP	EXISTING FLOODPLAIN
OHWM	EXISTING ORDINARY HIGH WATER MARK
WTL	EXISTING WETLAND BOUNDARY
	EXISTING TREES

PROPOSED

SS	PROPOSED SANITARY MANHOLE
SD	PROPOSED STORM MANHOLE
10" FM	PROPOSED SANITARY FORCE MAIN, SIZE NOTED
8" SS	PROPOSED SANITARY GRAVITY SEWER, SIZE NOTED
SD	PROPOSED STORM SEWER, SIZE NOTED
	PROPOSED HMA PAVEMENT
	PROPOSED CONCRETE
	PROPOSED GRAVEL
	PROPOSED BIORETENTION FACILITY

PIPE FITTINGS

DOUBLE LINE	SINGLE LINE	ABBREV	DESCRIPTION
		FL	FLANGED JOINT
		MJ	MECHANICAL JOINT
		WYE	LATERAL/45° WYE
		WYE	LATERAL/45° WYE
		WYE	LATERAL/45° WYE
		ECC RDCR	ECCENTRIC REDUCER
		BEND	BEND, ANGLE AS NOTED
		BEND 90	90° BEND
		BEND DN	TURNED DOWN
		BEND UP	TURNED UP
		TEE	STRAIGHT
		TEE UP	OUTLET UP
		TEE DN	OUTLET DOWN

VALVES

DOUBLE LINE	SINGLE LINE	ABBREV	DESCRIPTION
		SCV	SWING CHECK VALVE
		GV	GATE VALVE
		EPV	ECCENTRIC PLUG VALVE

NOTE:
PIPES 3" AND SMALLER DIAMETER ARE SHOWN AS A SINGLE LINE. 4" AND LARGER DIAMETER ARE SHOWN AS A DOUBLE LINE.

DETAIL AND SECTION DESIGNATIONS

DETAIL REFERENCE NUMBER

SHEET ON WHICH THE DETAIL IS SHOWN, OR "–" IF MULTIPLE SHEETS

SECTION REFERENCE LETTER

SHEET ON WHICH THE SECTION IS SHOWN, OR "–" IF MULTIPLE SHEETS

DETAIL REFERENCE NUMBER OR SECTION REFERENCE LETTER

SHEET ON WHICH THE DETAIL OR SECTION IS SHOWN, OR "–" IF MULTIPLE SHEETS

TITLE

SCALE

PHOTO REFERENCE NUMBER

APPROXIMATE VANTAGE POINT

VIEWING DIRECTION

SHEET ON WHICH PHOTO IS SHOWN

SURFACE RESTORATION TYPE

HORIZONTAL PAYMENT LIMIT ALONG ALIGNMENT

NUMERICAL DESIGNATION FOR TRENCH TYPE, SEE DETAIL 2, SHEET C–501

PERMIT SET

TIMOTHY C. ... STATE OF WASHINGTON ... 26182 REGISTERED PROFESSIONAL ENGINEER

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

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LEGEND

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

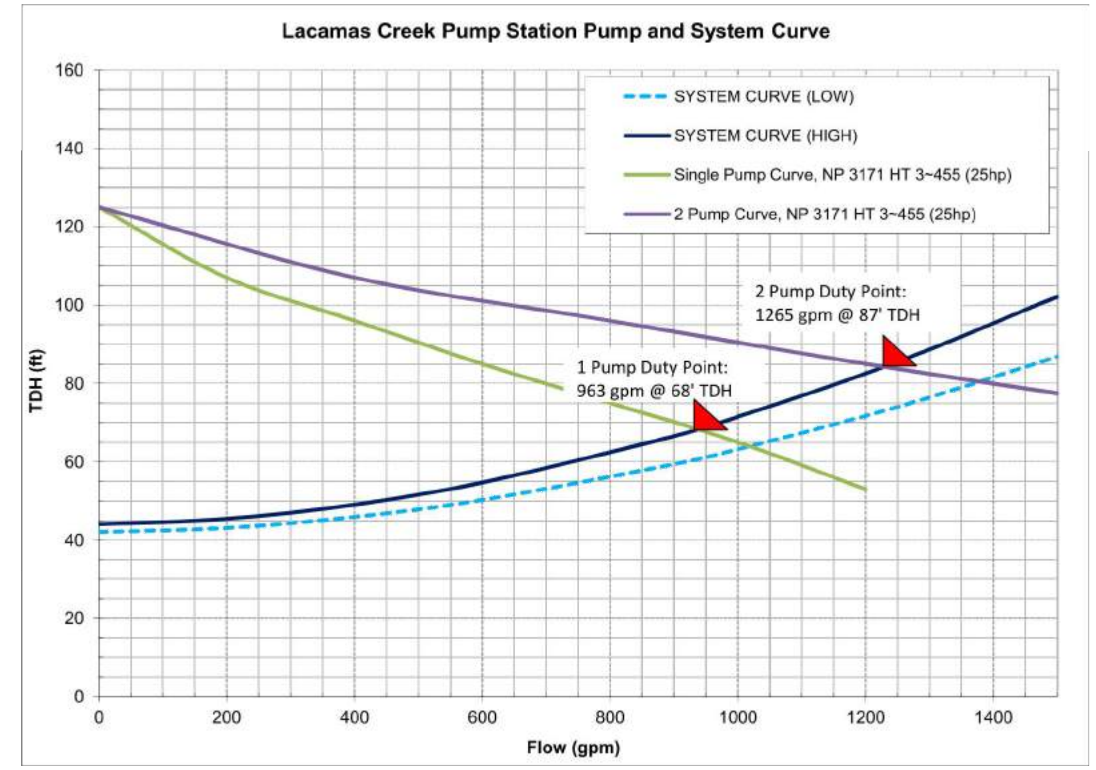
CITY PROJECT NO. S1000

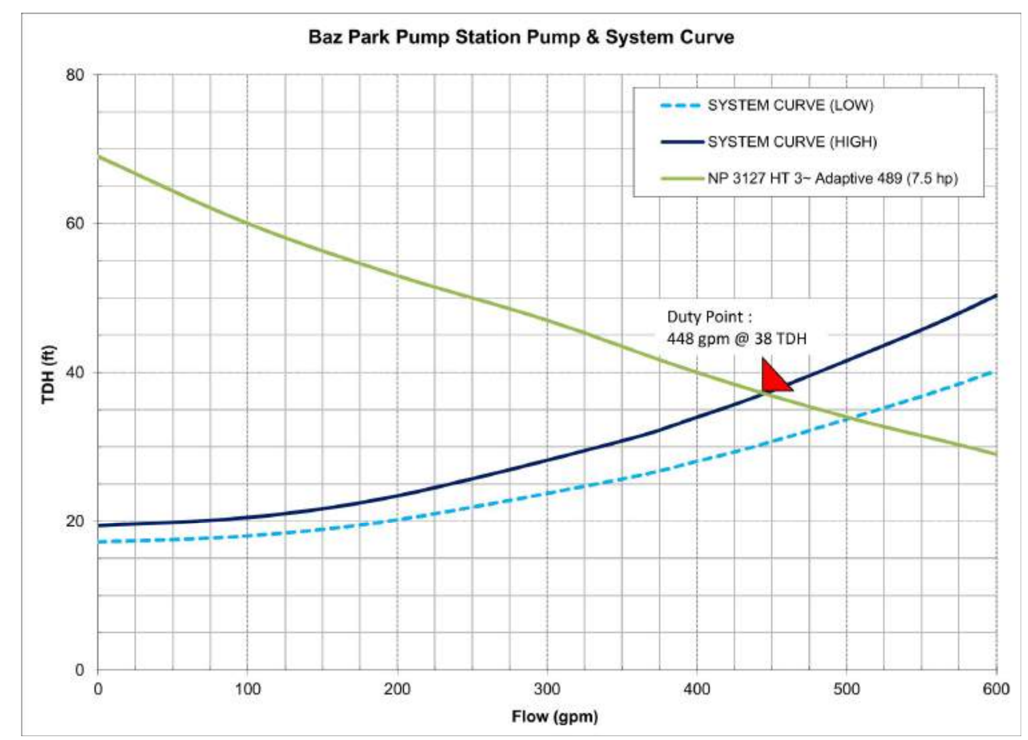
DRAWING NO: G–004

Exhibit C-2: Final Drainage Report

Pump Station Design Criteria

ITEM DESCRIPTION	LACAMAS CREEK PUMP STATION	BAZ PARK PUMP STATION
PUMP STATION TYPE	SUBMERSIBLE	SUBMERSIBLE
PUMP TYPE	FLYGT N IMPELLER	FLYGT N IMPELLER
CAPACITY	984 GPM @ 75' TDH	450 GPM @ 57' TDH
PUMP HP	45 HP	12 hp
ELECTRICAL SERVICE TYPE	480 V, 3 PHASE	480 V, 3 PHASE
LEVEL CONTROL TYPE	ULTRASONIC TRANSDUCER W/ MULTITRODE BACKUP	ULTRASONIC TRANSDUCER W/ MULTITRODE BACKUP
OVERFLOW POINT, ELEVATION	MANHOLE AT ELEVATION	WETWELL AT ELEVATION
OVERFLOW DISCHARGE	OVERLAND FLOW TO LACAMAS CREEK	OVERLAND FLOW TO WASHOUGAL RIVER
AVG TIME TO OVERFLOW @ 20 YR PHF	11 MINUTES	8 MINUTES
AUXILIARY POWER TYPE	DIESEL FUELED GENERATOR	DIESEL FUELED GENERATOR
TRANSFER SWITCH	AUTOMATIC TRANSFER SWITCH	AUTOMATIC TRANSFER SWITCH
EPA RELIABILITY CLASS	CLASS 1	CLASS 1
FORCE MAIN LENGTH/DIAMETER	1850 LF OF 10" DR 17 HDPE	800 LF OF 6" DR 17 HDPE
FORCE MAIN PROFILE	ASCENDING WITH HIGH POINT AT VALVE VAULT	CONTINUOUSLY ASCENDING
DISCHARGE MANHOLE	NE JOY ST AND NE 2ND AVE	NE 3RD AVE AND SE CROWN RD
AIR RELEASE VALVES	AIR RELEASE VALVE AT HIGH POINT (1)	NONE
AVG. DETENTION TIME, BUILDOUT FLOWS	46 MINUTES	18 MINUTES
WETWELL ODOR CONTROL SYSTEM	WETWELL VENTILATION AND CARBON	PASSIVE CARBON FILTER
FORCE MAIN SULFIDE CONTROL SYSTEMS	PROVISIONS FOR FUTURE CHEMICAL INJECTION	PROVISIONS FOR FUTURE CHEMICAL INJECTION
TELEMETRY	GSM MODEM	GSM MODEM





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REV: XX

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PUMP STATION DESIGN CRITERIA

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
G-005

5 OF 71

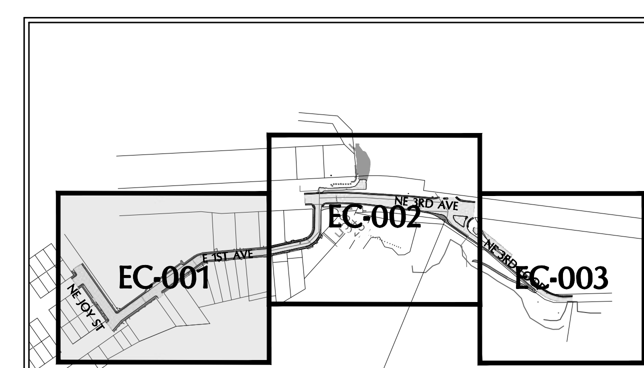
P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\4 PUMP STATION DESIGN CRITERIA.dwg, 4/23/2019 12:27:51 PM, Chad Keys

Exhibit C-2: Final Drainage Report

EROSION CONTROL LEGEND

SF — SILT FENCE

IP — INLET PROTECTION



KEY

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DESIGNED BY: JW/WW

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EROSION CONTROL PLAN I

wallis engineering

PROJECT NO: 1460A

DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:

EC-001

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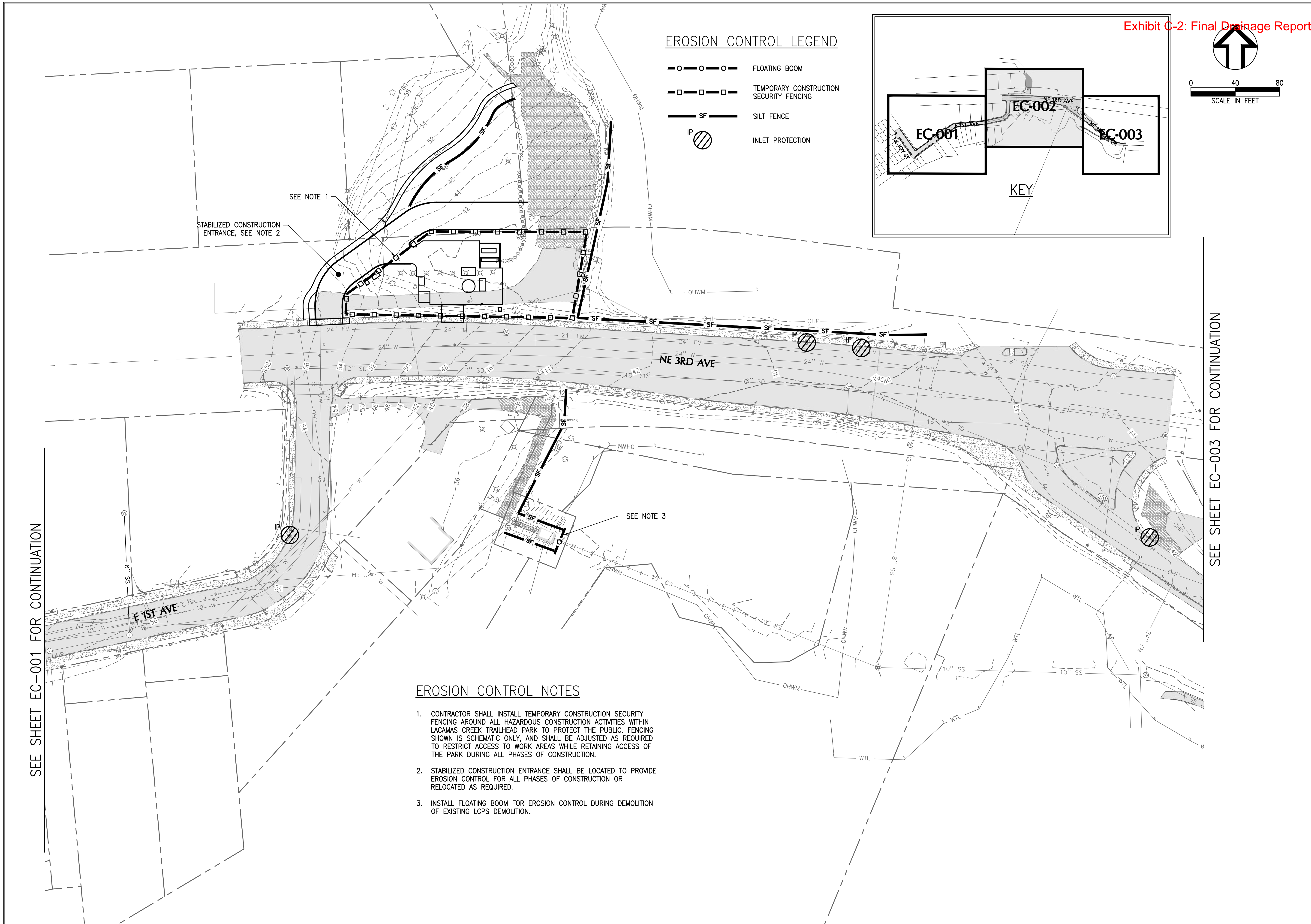

EROSION CONTROL LEGEND

- FLOATING BOOM
- TEMPORARY CONSTRUCTION SECURITY FENCING
- SF — SILT FENCE
- IP — INLET PROTECTION

EROSION CONTROL NOTES

1. CONTRACTOR SHALL INSTALL TEMPORARY CONSTRUCTION SECURITY FENCING AROUND ALL HAZARDOUS CONSTRUCTION ACTIVITIES WITHIN LACAMAS CREEK TRAILHEAD PARK TO PROTECT THE PUBLIC. FENCING SHOWN IS SCHEMATIC ONLY, AND SHALL BE ADJUSTED AS REQUIRED TO RESTRICT ACCESS TO WORK AREAS WHILE RETAINING ACCESS OF THE PARK DURING ALL PHASES OF CONSTRUCTION.
2. STABILIZED CONSTRUCTION ENTRANCE SHALL BE LOCATED TO PROVIDE EROSION CONTROL FOR ALL PHASES OF CONSTRUCTION OR RELOCATED AS REQUIRED.
3. INSTALL FLOATING BOOM FOR EROSION CONTROL DURING DEMOLITION OF EXISTING LCPS DEMOLITION.

PERMIT SET

NO.	REVISION	BY	DATE

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DRAWN BY: CK
REV: XX

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EROSION CONTROL PLANS II

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

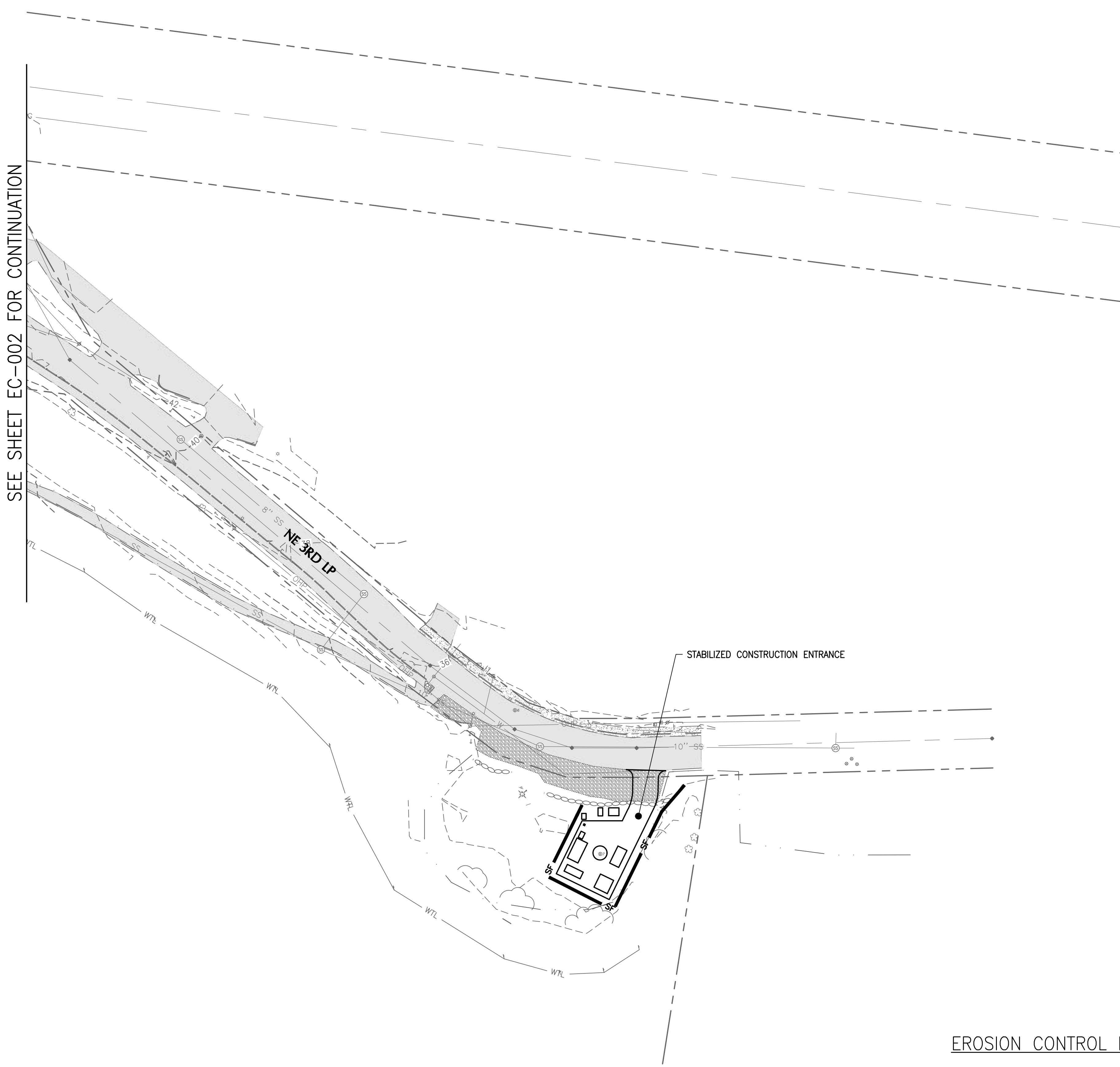
City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:

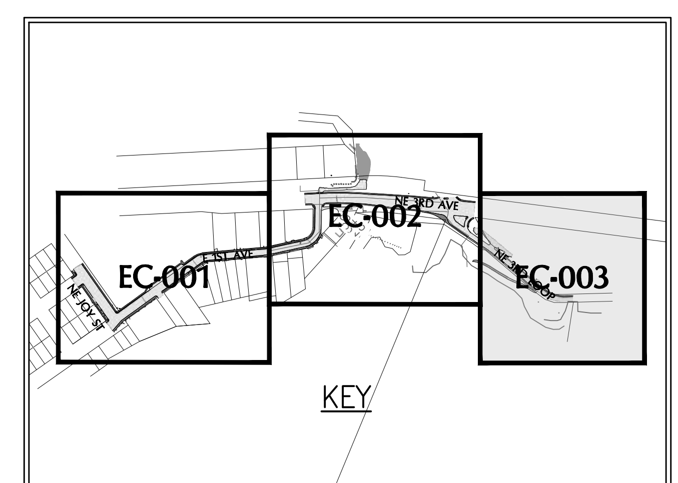
EC–002

Exhibit C-2: Final Drainage Report



EROSION CONTROL LEGEND

SF	SILT FENCE
IP	INLET PROTECTION



KEY

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NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

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EROSION CONTROL PLANS III

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: EC-003

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GRADING NOTES:

1. ALL GRADING SHALL CONFORM TO THE MOST RECENTLY ADOPTED EDITION OF THE W.S.D.O.T. STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION AND THE CITY OF CAMAS DESIGN STANDARDS MANUAL.
2. THE LIMITS OF CLEARING SHALL BE FLAGGED PRIOR TO CLEARING AND GRUBBING OF THE SITE.
3. ANY EXISTING TREES TO REMAIN WITHIN THE CLEARING LIMITS SHALL BE MARKED AND PROTECTED FROM DAMAGE.
4. PRIOR TO ANY FILL PLACEMENT, ALL AREAS WHICH WILL RECEIVE STRUCTURAL FILL SHALL BE EXCAVATED TO FIRM, NON-ORGANIC, UNDISTURBED NATIVE GROUND. THE STRIPPED AREAS SHALL BE OBSERVED AND ACCEPTED BY THE GEOTECHNICAL ENGINEER AND THE CITY OF CAMAS INSPECTOR.
5. ALL LOT FILLS SHALL MEET 95% OF AASHTO T-99 COMPACTION.
6. ALL RIGHT-OF-WAY FILLS SHALL MEET 95% OF AASHTO T-180 COMPACTION.
7. FILLS SHALL BE INSTALLED IN VERTICAL LIFTS NOT EXCEEDING 8 INCHES IN THICKNESS AND SHALL BE COMPACTED AS PREVIOUSLY NOTED.
8. FILLS PLACED ON SLOPES EXCEEDING 5H:1V SHALL BE KEYED AND BENCHED, GEOTECHNICAL APPROVAL REQUIRED PRIOR TO ANY FILL PLACEMENT.
9. ALL SURFACES SHALL BE GRADED SMOOTH AND BE FREE OF IRREGULARITIES THAT MIGHT ACCUMULATE SURFACE WATER.
10. ALL CUT AND FILL SLOPES SHALL NOT EXCEED 2:1 SLOPES.
11. ANY EXCESS MATERIAL NOT REQUIRED TO MEET THE GRADES SHOWN ON THE PLANS SHALL BE HAULED FROM THE SITE TO A CONTRACTOR PROVIDED WASTE SITE. IF WASTE SITE IS WITHIN CITY LIMITS, A GRADING PERMIT MAY BE REQUIRED.
12. ALL EXPOSED AND UNWORKED SOILS SHALL BE STABILIZED BY SUITABLE APPLICATION OF EROSION CONTROL BMP'S.
13. ALL SURFACES REQUIRING VEGETATION SHALL BE ROUGHENED PRIOR TO SEEDING (I.E. WHEEL TRACKED PERPENDICULAR TO SURFACE FLOW TO REDUCE EROSION AND HELP VEGETATION).
14. FINAL GEOTECHNICAL SUMMARY REPORT, INCLUDING ALL COMPACTION TESTING RESULTS, SHALL BE SUBMITTED UPON COMPLETION OF SITE GRADING WORK.

REV. NO.	DATE	BY	APPR.
1	9/18/07	SCD	JC
2	1/1/11	SCD	JC

CITY OF CAMAS - EROSION CONTROL DETAIL
GRADING NOTES
DETAIL APPROVED BY 1-4-11 DATE
NOT TO SCALE
DETAIL NO. EC1
EC-NOTES.DWG

EROSION/SEDIMENT CONTROL NOTES:

1. THE EROSION/SEDIMENT CONTROL (ESC) PLAN AND STORMWATER POLLUTION PREVENTION PLAN (SWPPP) IS TO BE UTILIZED AS A GUIDE TO CONTROL THE TRANSPORT OF LOOSE SOILS TO THE PROPERTY OUTSIDE OF THE CONSTRUCTION AREA AND AROUND THE CONSTRUCTION SITE. THE ESC MEASURES SHALL BE UPGRADED AS NEEDED FOR UNEXPECTED STORM EVENTS AND TO ENSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DOES NOT LEAVE THE SITE.
2. THE IMPLEMENTATION OF THE ESC PLANS AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT AND UPGRADING OF THE ESC MEASURES IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL ALL CONSTRUCTION IS COMPLETED AND APPROVED AND PERMANENT VEGETATION/LANDSCAPING IS ESTABLISHED.
3. IF THE CITY INSPECTOR OR ENGINEER(S) HAS EVIDENCE OF POOR CONSTRUCTION PRACTICES OR EROSION CONTROL TECHNIQUES, A "STOP WORK" ORDER SHALL BE ISSUED UNTIL PROPER MEASURES HAVE BEEN TAKEN AND APPROVED BY THE CITY ENGINEERING STAFF.
4. THE CONTRACTORS SHALL BE RESPONSIBLE TO FAMILIARIZE THEMSELVES WITH THE MOST RECENTLY ADOPTED EDITION OF THE STORMWATER MANAGEMENT MANUAL FOR WESTERN WASHINGTON, VOL. II AND THE CITY OF CAMAS MUNICIPAL CODE 14.06 (2011).
5. ALL EROSION/SEDIMENT CONTROL MEASURES SHALL BE IN PLACE AND IN WORKING CONDITION PRIOR TO DISTURBING AND EXPOSING ANY SOIL SURFACES (I.E. CONSTRUCTION ENTRANCES, FILTER FABRIC SEDIMENT BARRIERS, AND SEDIMENTATION TRAPS) AND MAINTAINED FOR THE DURATION OF THE PROJECT. TRAPPED SEDIMENT IN EXCESS OF 1 FOOT SHALL BE REMOVED OR STABILIZED ON-SITE. DISTURBED SOIL AREAS RESULTING FROM VEGETATION REMOVAL SHALL BE PERMANENTLY STABILIZED. ADDITIONAL MEASURES MAY BE REQUIRED TO ENSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT.
6. TO MINIMIZE EROSION AND SEDIMENTATION TRANSPORTATION, EARTHWORK SHALL NOT BE PERFORMED WHILE SOILS ARE IN AN UNSTABLE STATE DUE TO PRECIPITATION.
7. THE CONTRACTOR SHALL BE RESPONSIBLE TO HAVE CLEARING LIMITS AND/OR ANY EASEMENTS, SENSITIVE OR CRITICAL AREAS, AND THEIR BUFFERS, TREES, AND DRAINAGE COURSES FLAGGED PRIOR TO CONSTRUCTION. DURING THE CONSTRUCTION PERIOD, NO DISTURBANCE BEYOND THE FLAGGED CLEARING LIMITS SHALL BE PERMITTED. FLAGGING LIMITS ARE TO BE MAINTAINED BY THE CONTRACTOR FOR THE DURATION OF CONSTRUCTION.
8. REMOVE ONLY THOSE TREES AND SHRUBS THAT NEED TO BE REMOVED FOR THE CONSTRUCTION OF ROADS, SIDEWALKS, UTILITIES, AND STORMWATER FACILITIES.
9. ALL EXISTING AND NEWLY CONSTRUCTED ROAD CATCH BASINS AND CURB INLETS AFFECTED BY CONSTRUCTION SHALL BE PROTECTED AGAINST SEDIMENT DEPOSITS. AT NO TIME SHALL MORE THAN ONE FOOT OF SEDIMENT BE ALLOWED TO ACCUMULATE WITHIN A TRAPPED CATCH BASIN. ALL CATCH BASINS AND CONVEYANCE LINES SHALL BE CLEANED PRIOR TO PAVING. THE CLEANING OPERATION SHALL NOT FLUSH SEDIMENT LADEN WATER INTO THE DOWNSTREAM SYSTEM.
10. ALL POLLUTANTS THAT OCCUR ON-SITE DURING CONSTRUCTION SHALL BE HANDLED AND DISPOSED OF IN A MANNER THAT DOES NOT CAUSE CONTAMINATION OF STORMWATER SYSTEM.
11. ALL DISTURBED SOIL SURFACES ARE TO BE STABILIZED BY A SUITABLE APPLICATION OF "BEST MANAGEMENT PRACTICES" (BMP'S). DURING THE PERIOD OF OCTOBER 1 THROUGH JULY 5 DISTURBED SOILS MAY REMAIN UNSTABILIZED FOR UP TO TWO DAYS WHEN NOT BEING WORKED. FROM JULY 5 THROUGH OCTOBER 1, DISTURBED SOILS MAY REMAIN UNSTABILIZED FOR UP TO 7 DAYS WHEN NOT BEING WORKED. STABILIZATION OF DISTURBED SOIL AREAS MAY CONSIST OF HYDROSEEDING, HAND-SEEDING AND MULCHING, PLACEMENT OF EROSION CONTROL BLANKETS OR PLASTIC. ALL SEEDED AREAS ARE TO BE FERTILIZED, WATERED, AND MAINTAINED TO ENSURE THAT THE GROWTH OF VEGETATION OCCURS AS SOON AS POSSIBLE.
12. ALL TEMPORARY SEDIMENT AND EROSION CONTROL BMP'S SHALL BE REMOVED WITHIN 30 DAYS AFTER FINAL SITE STABILIZATION IS ACHIEVED OR AFTER THE TEMPORARY BMP'S ARE NO LONGER NEEDED.

REV. NO.	DATE	BY	APPR.
1	9/18/07	SD	JC
2	1/1/11	SCD	JC

CITY OF CAMAS - EROSION CONTROL DETAIL
EROSION/SEDIMENT CONTROL NOTES
DETAIL APPROVED BY 1-4-11 DATE
NOT TO SCALE
DETAIL NO. EC2
EC-NOTES.DWG

EROSION/SEDIMENT CONTROL NOTES (CONTINUED):

13. THE CONTRACTOR SHALL BE RESPONSIBLE FOR POLICING THE JOB SITE DAILY AND MAINTAINING THE EROSION/SEDIMENT CONTROL MEASURES THROUGHOUT ALL PHASES OF CONSTRUCTION. AN INSPECTION LOG SHALL BE KEPT AND MADE AVAILABLE TO THE CITY OF CAMAS. THE POLICING AND MAINTENANCE SHALL INCLUDE, BUT NOT BE LIMITED TO:
    - VERIFYING THAT ALL AREAS ARE GRADED SUCH THAT ALL RUNOFF IS DIRECTED TO A SEDIMENTATION DEVICE BEFORE DISCHARGE TO SURFACE.
    - REMOVAL OF TRAPPED SILT AT SILT BARRIERS, SILT TRAPS, OR POINTS OF ACCUMULATION.
    - ADDITIONAL PROTECTIVE MEASURES DUE TO JOB SITE OR WEATHER CONDITIONS AS REQUIRED BY THE CITY OF CAMAS.
    - MONITORING OF VEHICLES LEAVING THE SITE TO MINIMIZE TRANSMISSION OF LOOSE SOILS TO THE PUBLIC ROADWAYS.
    - VERIFY THAT ALL PROPERTIES ADJACENT TO THE PROJECT SITE ARE PROTECTED FROM SEDIMENTATION DEPOSITION. THIS MAY BE ACCOMPLISHED BY INSTALLING PERIMETER CONTROLS SUCH AS SEDIMENTATION BARRIERS, FILTERS OR DIKES, SEDIMENTATION BASINS/TRAPS, OR BY A COMBINATION OF SUCH MEASURES.
14. CUT AND FILL SLOPES SHALL BE DESIGNED AND CONSTRUCTED IN A MANNER THAT WILL MINIMIZE EROSION. SLOPES SHALL BE STABILIZED IN ACCORDANCE WITH EROSION/SEDIMENT CONTROL NOTE 11. SLOPES FOUND TO BE ERODING EXCESSIVELY WITHIN TWO YEARS OF CONSTRUCTION MUST BE PROVIDED WITH ADDITIONAL SLOPE STABILIZING MEASURES. THESE MEASURES MAY CONSIST OF ROUGHENED SOIL SURFACES, INTERCEPTORS, DIVERSIONS OR TERRACES, TEMPORARY OR PERMANENT CHANNELS, ADDITIONAL VEGETATION, OR PIPE SLOPE DRAINS AS REQUIRED BY THE CITY OF CAMAS UNTIL THE PROBLEM IS CORRECTED.
15. THE ESC MEASURES ON INACTIVE SITES SHALL BE INSPECTED AND MAINTAINED A MINIMUM OF ONCE A MONTH OR WITHIN 24 HOURS FOLLOWING ANY STORM EVENT.
16. THE CONTRACTOR SHALL BE RESPONSIBLE FOR INSTALLING UNDERGROUND UTILITIES AS SPECIFIED BELOW:
    - WHERE FEASIBLE, NO MORE THAN 500 FEET OF TRENCH SHALL BE OPEN AT ONE TIME.
    - WHERE CONSISTENT WITH SAFETY AND SPACE CONSIDERATIONS, EXCAVATED MATERIAL SHALL BE PLACED ON THE UPHILL SIDE OF TRENCHES.
    - TRENCH DE-WATER DEVICES SHALL DISCHARGE INTO A SEDIMENT TRAP OR SEDIMENT POND.
17. PRIOR TO CONSTRUCTION, THE CITY OF CAMAS REQUIRES AN APPROVED FORM OF SECURITY IN THE AMOUNT OF 200% OF THE ENGINEER'S ESTIMATED COST OF THE ESC MEASURES, INCLUDING ASSOCIATED LABOR, AS SHOWN IN THE APPROVED ESC PLAN AND SWPPP.
18. SUGGESTED STANDARD SEED MIXTURE FOR THOSE AREAS WHERE A TEMPORARY VEGETATIVE COVER IS REQUIRED:

TEMPORARY EROSION CONTROL MIX*

SEED VARIETY	% WEIGHT	% PURITY	% GERMINATION
CHEWINGS OR ANNUAL BLUE GRASS *(FESTUCA RUBRA VAR. COMMUTATA OR POA ANNA)*	40	98	90
PERENNIAL RYE *(LOLIUM PERENNE)*	50	98	90
REDTOP OR COLONIAL BENTGRASS *(AGROSTIS ALBA OR AGROSTIS TENUIS)*	5	92	85
WHITE DUTCH CLOVER *(TRIFOLIUM REPENS)*	5	98	90

*APPLICATION RATE OF 120 LBS/ACRE AND COVERED WITH STRAW OR MULCH

19. SUGGESTED TURF SEED MIXTURE FOR DRY SITUATIONS WHERE THERE IS NO NEED FOR MUCH WATER:

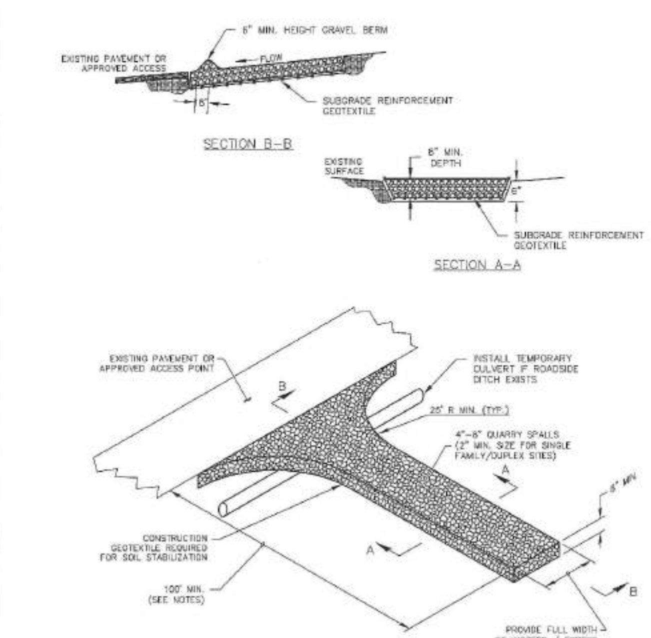
LOW-GROWING TURF SEED MIX*

SEED VARIETY	% WEIGHT	% PURITY	% GERMINATION
DWARF TALL FESCUE (SEVERAL VARIETIES) *(FESTUCA ARUNDINACEA VAR.)*	45	98	90
DWARF PERENNIAL RYE *(LOLIUM PERENNE VAR. BARCLAY)*	30	98	90
RED FESCUE *(FESTUCA RUBRA)*	20	98	90
COLONIAL BENTGRASS *(AGROSTIS TENUIS)*	5	98	90

*APPLICATION RATE OF 120 LBS/ACRE AND COVERED WITH STRAW OR MULCH

REV. NO.	DATE	BY	APPR.
1	9/18/07	SD	JC
2	1/1/11	SCD	JC

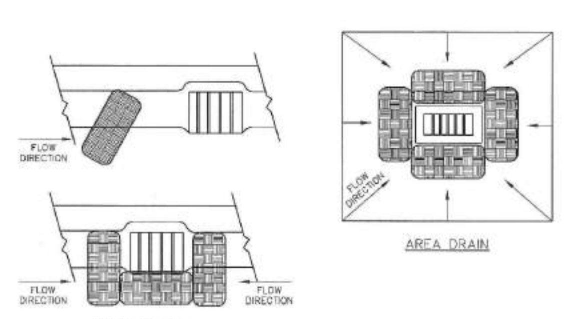
CITY OF CAMAS - EROSION CONTROL DETAIL
EROSION/SEDIMENT CONTROL NOTES
DETAIL APPROVED BY 1-4-11 DATE
NOT TO SCALE
DETAIL NO. EC3
EC-NOTES.DWG



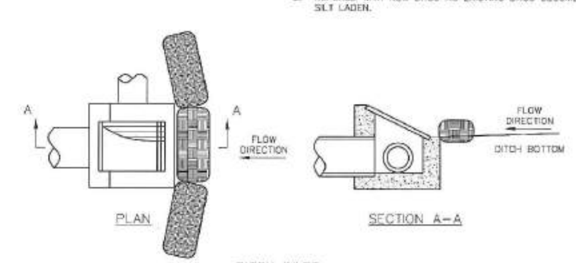
NOTES:
1. 100 FOOT MINIMUM MAY BE REDUCED TO 50 FOOT MINIMUM FOR SITES WITH LESS THAN ONE ACRE OF EXPOSED SOIL, IF APPROVED BY SITE INSPECTOR.
2. 20 FOOT MINIMUM LENGTH FOR SINGLE FAMILY AND DUPLEX RESIDENTIAL.
3. ROCK SHALL BE REMOVED AND REPLACED, OR ADDITIONAL ROCK ADDED IF ENTRANCE FAILS TO FUNCTION AS INTENDED.

REV. NO.	DATE	BY	APPR.
1	8/17/07	SCD	JC
2	1/1/11	SCD	JC
3	3/1/12	SCD	JC

CITY OF CAMAS - EROSION CONTROL DETAIL
STABILIZED CONSTRUCTION ENTRANCE
DETAIL APPROVED BY 3-1-12 DATE
NOT TO SCALE
DETAIL NO. EC6
EC-CONENTRY.DWG

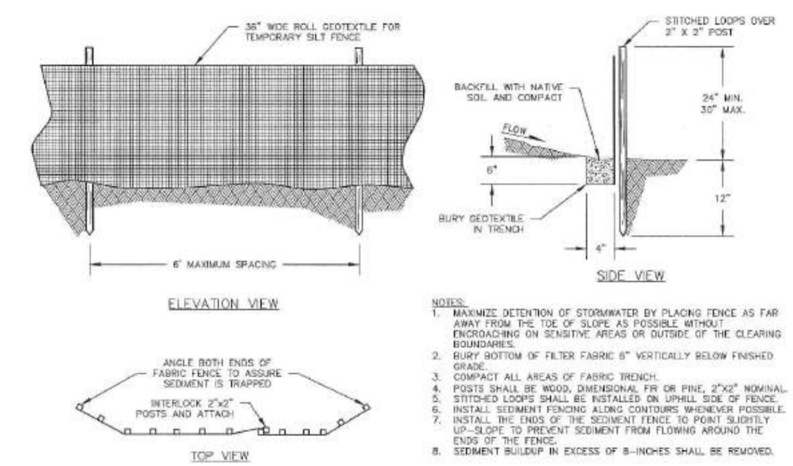


NOTES:
1. MAY BE USED SHORT TERM WITH UTILITY WORK AND WITH PHASING OF DEVELOPMENT (E.G. HOME BUILDERS).
2. REPLACE WITH NEW BAGS AS EXISTING BAGS BECOME SILT LADEN.



REV. NO.	DATE	BY	APPR.
1	9/18/07	SCD	JC
2	1/1/11	SCD	JC

CITY OF CAMAS - EROSION CONTROL DETAIL
INLET PROTECTION - BIOBAGS
DETAIL APPROVED BY 1-4-11 DATE
NOT TO SCALE
DETAIL NO. EC11
EC-INLETS.DWG



NOTES:
1. MAXIMIZE DETENTION OF STORMWATER BY PLACING FENCE AS FAR AWAY FROM THE TOE OF SLOPE AS POSSIBLE WITHOUT ENCROACHING ON SENSITIVE AREAS OR OUTSIDE OF THE CLEARING BOUNDARIES.
2. BURY BOTTOM OF FILTER FABRIC 6" VERTICALLY BELOW FINISHED GRADE.
3. COMPACT ALL AREAS OF FABRIC TRENCH.
4. POSTS SHALL BE WOOD, DIMENSIONAL FIR OR PINE, 2"X2" NOMINAL.
5. STITCHED LOOPS SHALL BE INSTALLED ON UPHILL SIDE OF FENCE.
6. INSTALL SEDIMENT FENCING ALONG CONTOURS WHENEVER POSSIBLE.
7. INSTALL THE ENDS OF THE SEDIMENT FENCE TO POINT SLIGHTLY UP-SLOPE TO PREVENT SEDIMENT FROM FLOWING AROUND THE ENDS OF THE FENCE.
8. SEDIMENT BUILDUP IN EXCESS OF 8-INCHES SHALL BE REMOVED.

REV. NO.	DATE	BY	APPR.
1	9/18/07	SCD	JC
2	1/1/11	SCD	JC
3	3/1/12	SCD	JC

CITY OF CAMAS - EROSION CONTROL DETAIL
SILT FENCE
DETAIL APPROVED BY 3-1-12 DATE
NOT TO SCALE
DETAIL NO. EC12
EC-SEDFENCE.DWG

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER
PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH
0 — 1"
ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

EROSION CONTROL DETAILS

wallis engineering
215 W 4th Street, Suite 200
Vancouver, WA 98660
360.695.7041

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
EC-004

P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\9 EROSION CONTROL DETAILS.dwg, 4/23/2019 12:28:07 PM, Chad Kays

Exhibit C-2: Final Drainage Report

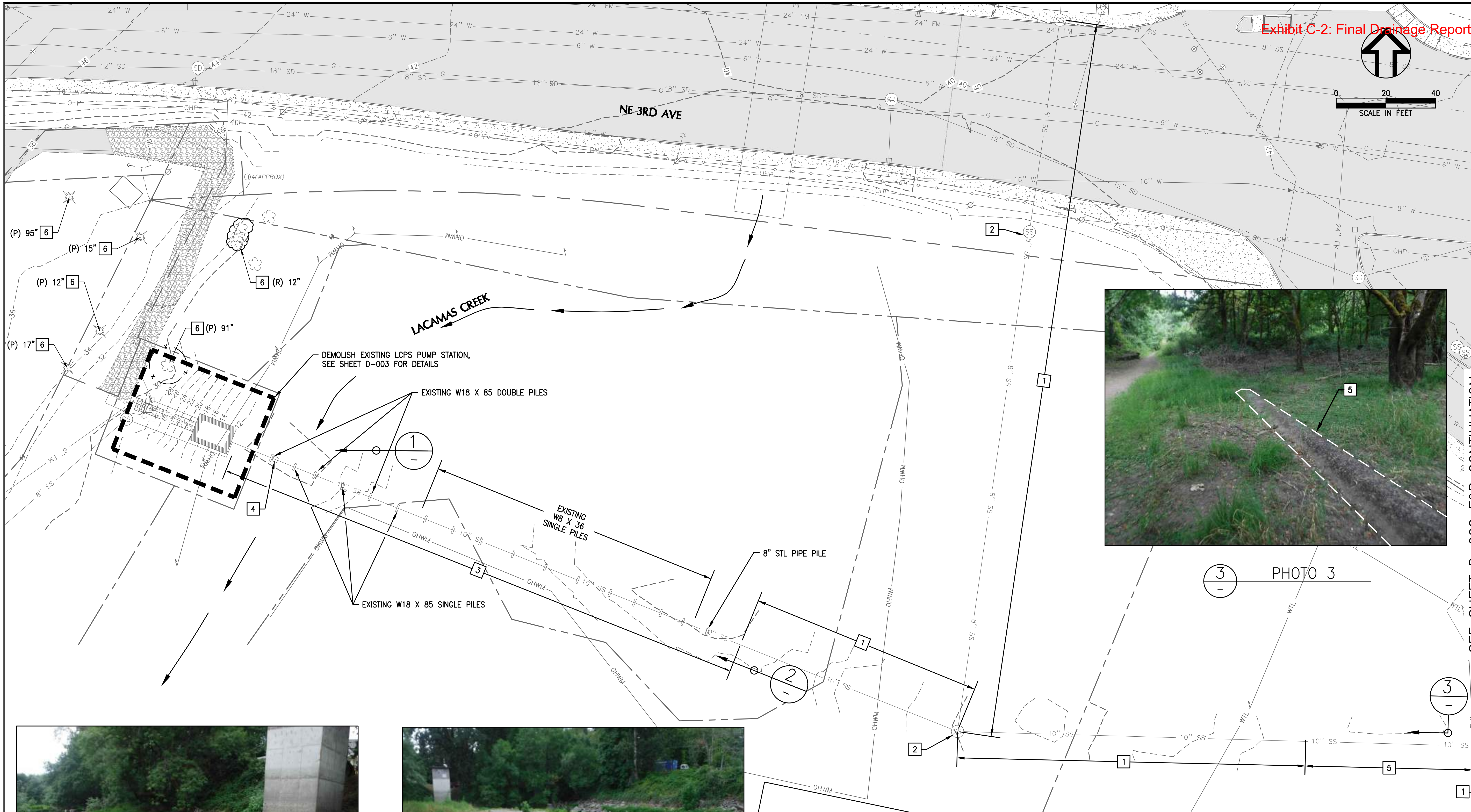


PHOTO 3

PHOTO 1

PHOTO 2

DEMOLITION NOTES

1. ABANDON PIPE IN PLACE AND FILL WITH GROUT.
2. ABANDON MANHOLE. REMOVE TOP CONE. FILL MH WITH GRAVEL AND BACKFILL EXCAVATION WITH TOPSOIL. SEED DISTURBED AREA WITH NATIVE SEED MIX.
3. REMOVE PILES AND PIPE.
4. REMOVE 2' X 2' X 7' CONCRETE PIPE PIER.
5. REMOVE CONCRETE ENCASED EXPOSED PIPE. BACKFILL WITH TOPSOIL. RESTORE SURFACE TO NATIVE EXISTING CONDITION. SEED DISTURBED AREA WITH NATIVE SEED MIX.
6. REMOVE (R) OR PROTECT (P) TREE PER CAMAS STANDARD DETAIL PL5, SHEET SD-503. SIZE AND TYPE NOTED.

CONSTRUCTION NOTES

1. PREVENT ALL DEBRIS, DUST, AND MATERIALS FROM ENTERING LACAMAS CREEK AND WETLAND AREAS.
2. FLUSH PIPE WITH CLEAN WATER PRIOR TO REMOVAL.

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

GRAVITY SEWER DEMOLITION PLAN I

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

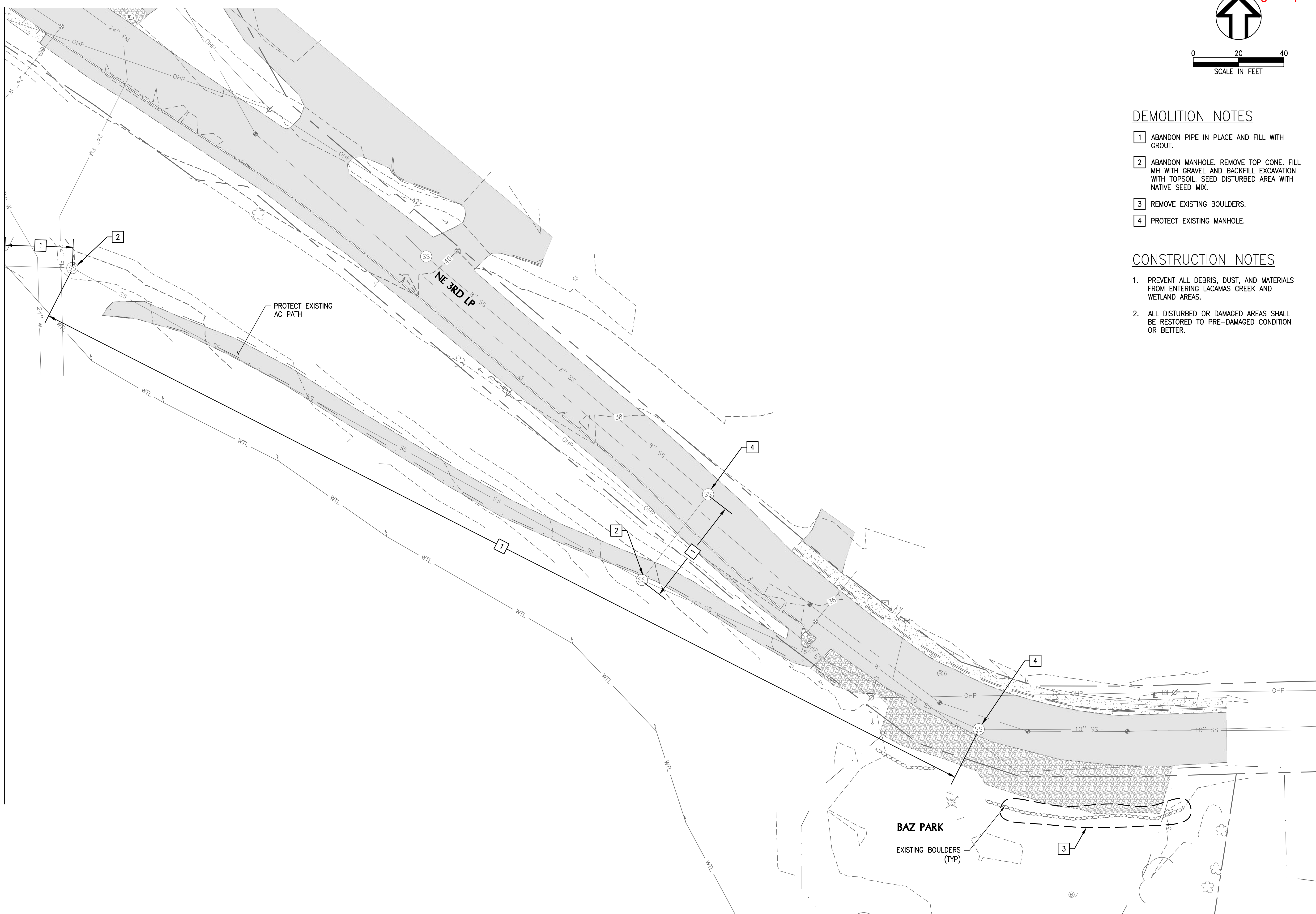
CITY PROJECT NO. S1000

DRAWING NO: D-001

10 OF 71

P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\13 LACAMAS CREEK TRAILHEAD PARK DEMOLITION PLAN.dwg, 4/24/2019 11:37:31 AM, Chad Keys

Exhibit C-2: Final Drainage Report



DEMOLITION NOTES

1. ABANDON PIPE IN PLACE AND FILL WITH GROUT.
2. ABANDON MANHOLE. REMOVE TOP CONE. FILL MH WITH GRAVEL AND BACKFILL EXCAVATION WITH TOPSOIL. SEED DISTURBED AREA WITH NATIVE SEED MIX.
3. REMOVE EXISTING BOULDERS.
4. PROTECT EXISTING MANHOLE.

CONSTRUCTION NOTES

1. PREVENT ALL DEBRIS, DUST, AND MATERIALS FROM ENTERING LACAMAS CREEK AND WETLAND AREAS.
2. ALL DISTURBED OR DAMAGED AREAS SHALL BE RESTORED TO PRE-DAMAGED CONDITION OR BETTER.

PERMIT SET

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

GRAVITY SEWER DEMOLITION PLAN II

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: D-002

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Exhibit C-2: Final Drainage Report

CONSTRUCTION NOTES

1. PREVENT ALL DEBRIS, DUST, AND MATERIALS FROM ENTERING LACAMAS CREEK AND WETLAND AREAS.
2. ITEMS TO BE SALVAGED TO CITY:
   - GENERATOR
   - PUMPS AND ACCESSORIES
   - STEEL SPIRAL STAIRWAY
   - ELECTRIC HOIST AND BEAM
   - PHASE LOSS MONITOR
3. RESTORE DISTURBED AREA. SEE PLANTING PLAN ON SHEET L-XXX.

DEMOLITION NOTES

1. REMOVE REINFORCED CONCRETE WETWELL/DRYWELL AND CONCRETE BLOCK HOUSING STRUCTURE. FILL WET WELL WITH CLEAN GRAVEL. BACKFILL DISTURBED AREA WITH TOPSOIL AND SEED WITH NATIVE SEED MIX.
2. REMOVE ALL ELECTRICAL, MECHANICAL, AND STRUCTURAL EQUIPMENT WITHIN STRUCTURE. SALVAGE EQUIPMENT TO CITY AS SPECIFIED.
3. REMOVE REINFORCED CONCRETE ELEVATED WALKWAY, STEPS, AND FOOTING.
4. REMOVE GRAVITY SEWER PIPE FROM MANHOLE TO WETWELL.
5. REMOVE 6-INCH AC FORCE MAIN FROM DRYWELL TO THE TOP OF BANK. DISPOSE AC PIPE IN ACCORDANCE WITH APPLICABLE LAWS.
6. COORDINATE WITH NW NATURAL AND CPU FOR ABANDONMENT OF GAS AND ELECTRICAL SERVICE.
7. ABANDON EXISTING 6" AC FORCE MAIN IN-PLACE FROM TOP OF BANK TO DISCHARGE MANHOLE. FILL WITH GROUT.
8. HAZARDOUS BUILDING MATERIALS TO BE HANDLED AND DISPOSED OF IN ACCORDANCE WITH APPLICABLE LAWS. SEE HAZARDOUS BUILDING MATERIALS SURVEY PREPARED BY G2 CONSULTANTS, DATED MARCH, 2019.
9. REMOVE (R) OR PROTECT (P) TREE PER CAMAS STANDARD DETAIL PL5, SHEET SD-503. SIZE AND TYPE NOTED.
10. PROVIDE ORANGE CONSTRUCTION FENCING FOR TREE PROTECTION.
11. WITHIN 75' RADIUS TREE PROTECTION ZONE, PROVIDE 6"-16" DEPTH WOOD CHIPS IN AREAS OF CONSTRUCTION ACTIVITY TO MINIMIZE SOIL COMPACTION

1 PHOTO 1

2 PHOTO 2

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS DEMOLITION PLAN

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: D-003

12 OF 71

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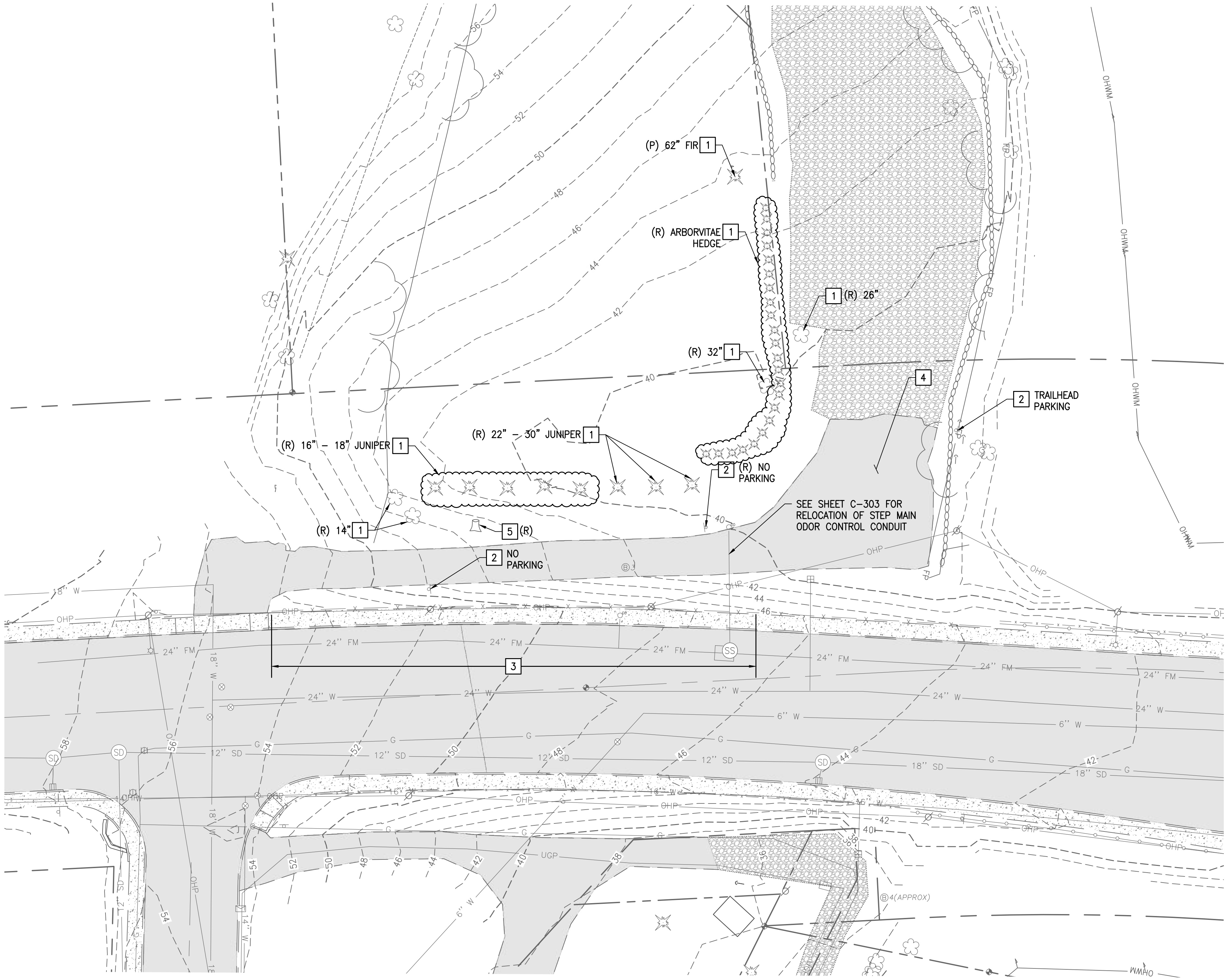
Exhibit C-2: Final Drainage Report



0 20 40
SCALE IN FEET

DEMOLITION NOTES

1. REMOVE (R) OR PROTECT (P) TREE PER CAMAS STANDARD DETAIL PL5, SHEET SD-503. SIZE AND TYPE NOTED.
2. REMOVE SIGN AND RELOCATE PER DRIVEWAY PLAN AND PROFILE, SHEET CX. SIGN TYPE NOTED.
3. REMOVE EXISTING FENCE.
4. REMOVE EXISTING ASPHALT PAVEMENT.
5. REMOVE STUMP.

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LACAMAS CREEK TRAILHEAD PARK DEMOLITION PLAN

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
D-004

13 OF 71

P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\13 LACAMAS CREEK TRAILHEAD PARK DEMOLITION PLAN.dwg, 4/23/2019 12:28:21 PM, Chad Koys

Exhibit C-2: Final Drainage Report

PERMIT SET

TIMOTHY C. ... STATE OF WASHINGTON 26162 REGISTERED PROFESSIONAL ENGINEER

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH
0 — 1"
ONE INCH AT FULL SCALE.
IF NOT ONE INCH ADJUST
SCALE ACCORDINGLY

GRAVITY SEWER KEY MAP

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

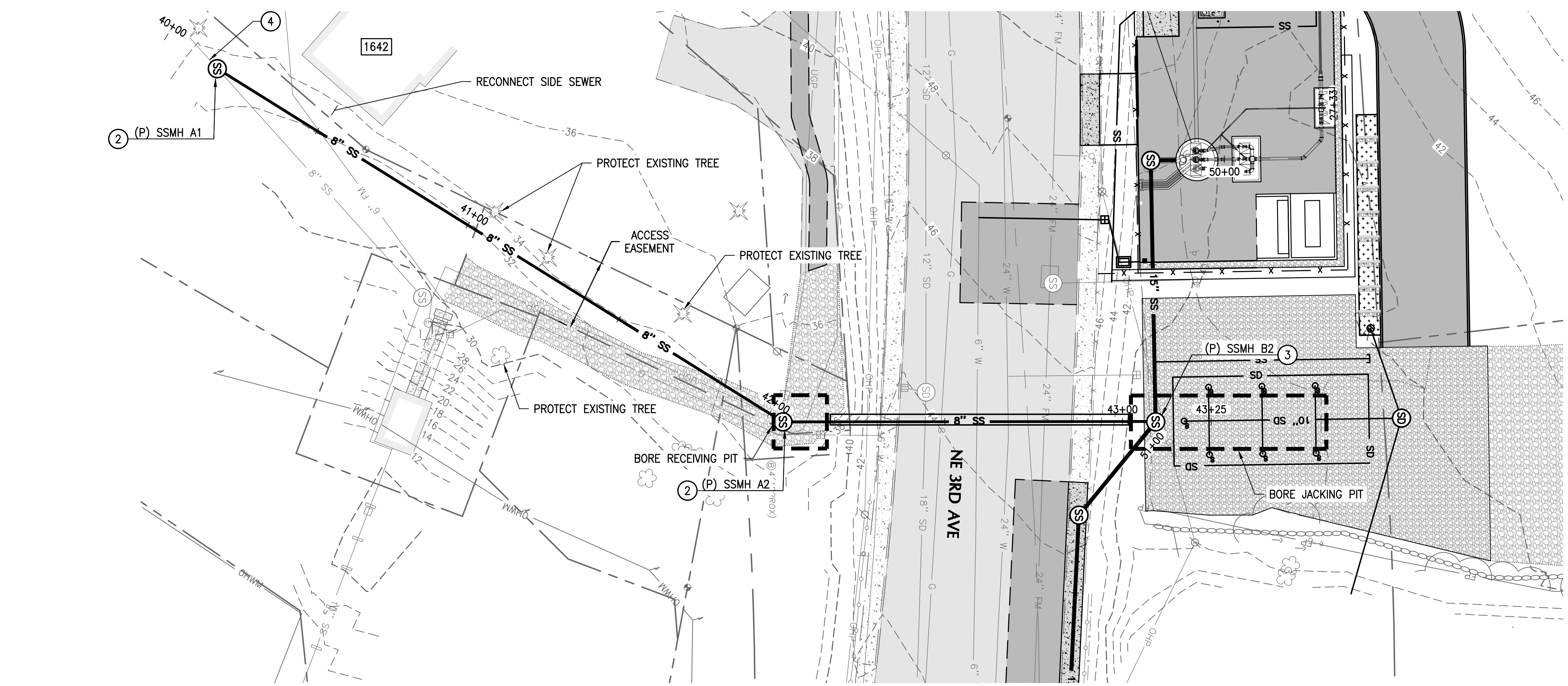
City of Camas WASHINGTON

CITY PROJECT NO. S1000

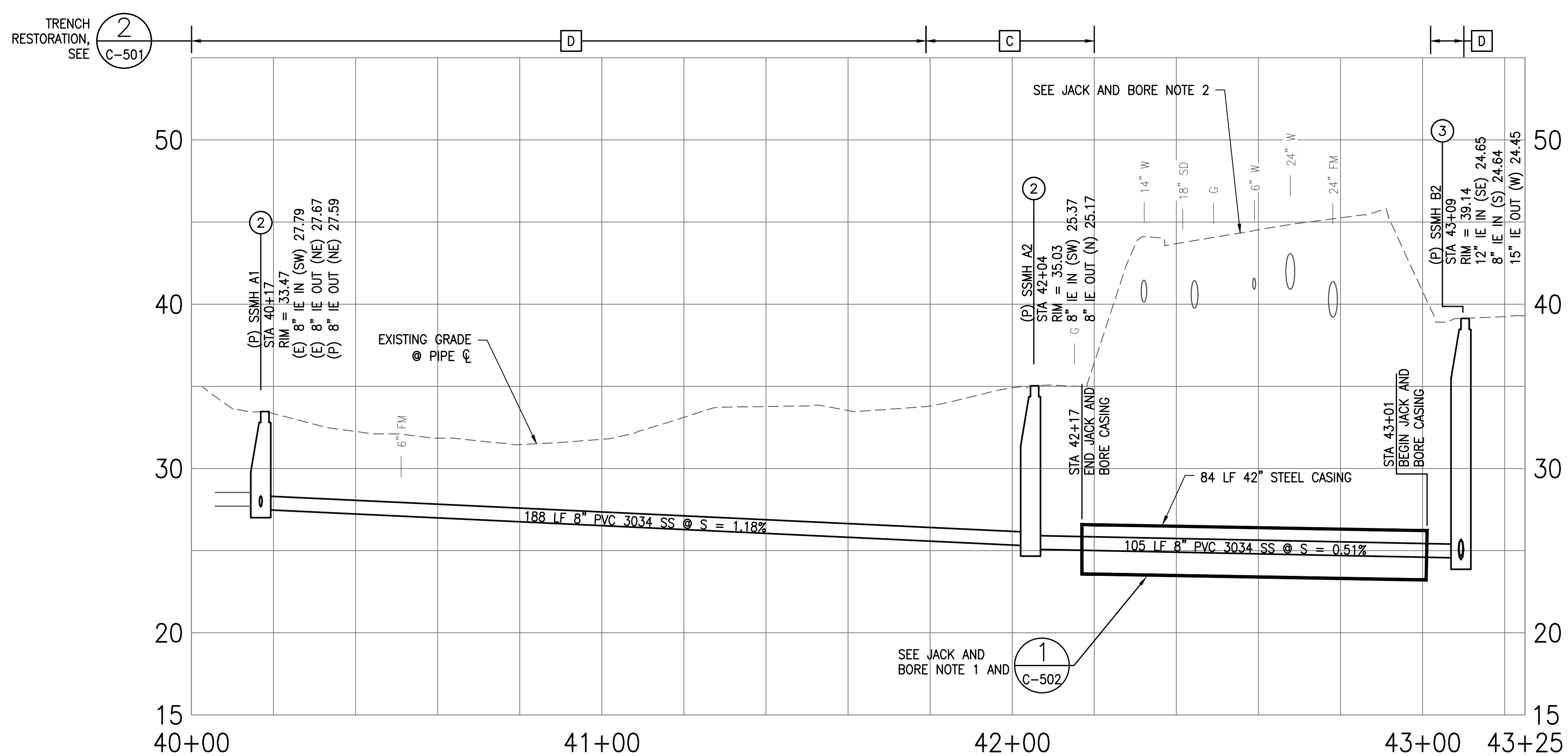
DRAWING NO:
G–101

P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\GRAVITY PLAN & PROFILE.dwg, 4/23/2019 12:28:42 PM, Chad Keys

Exhibit C-2: Final Drainage Report



PLAN



PROFILE

SCALE: 1" = 20' HORIZ
1" = 5' VERT

KEY NOTES

2. CONSTRUCT NEW SSMH. SEE CITY OF CAMAS STANDARD DETAILS S1 AND S4.
3. CONSTRUCT NEW EXTENDED BASE SSMH. SEE CITY OF CAMAS STANDARD DETAILS SI AND S4.
4. CONNECT EXISTING GRAVITY SEWER TO PROPOSED SSMH. SEE CITY OF CAMAS DETAIL S1.

JACK AND BORE NOTES

1. ARRANGEMENT OF JACK AND BORE CASING PIPE AND CARRIER PIPES SHOWN IS SCHEMATIC ONLY. CONTRACTOR IS RESPONSIBLE FOR SETTING CARRIER PIPE I.E. AND ARRANGING CARRIER PIPES TO MAINTAIN SEWER GRADES PER THE SPECIFICATIONS.
2. CONTRACTOR SHALLL MONITOR THE ROAD SURFACE ELEVATION ABOVE JACK AND BORE PER THE SPECIFICATIONS.

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

GRAVITY SEWER A PLAN & PROFILE

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:

C-101

15 OF 71

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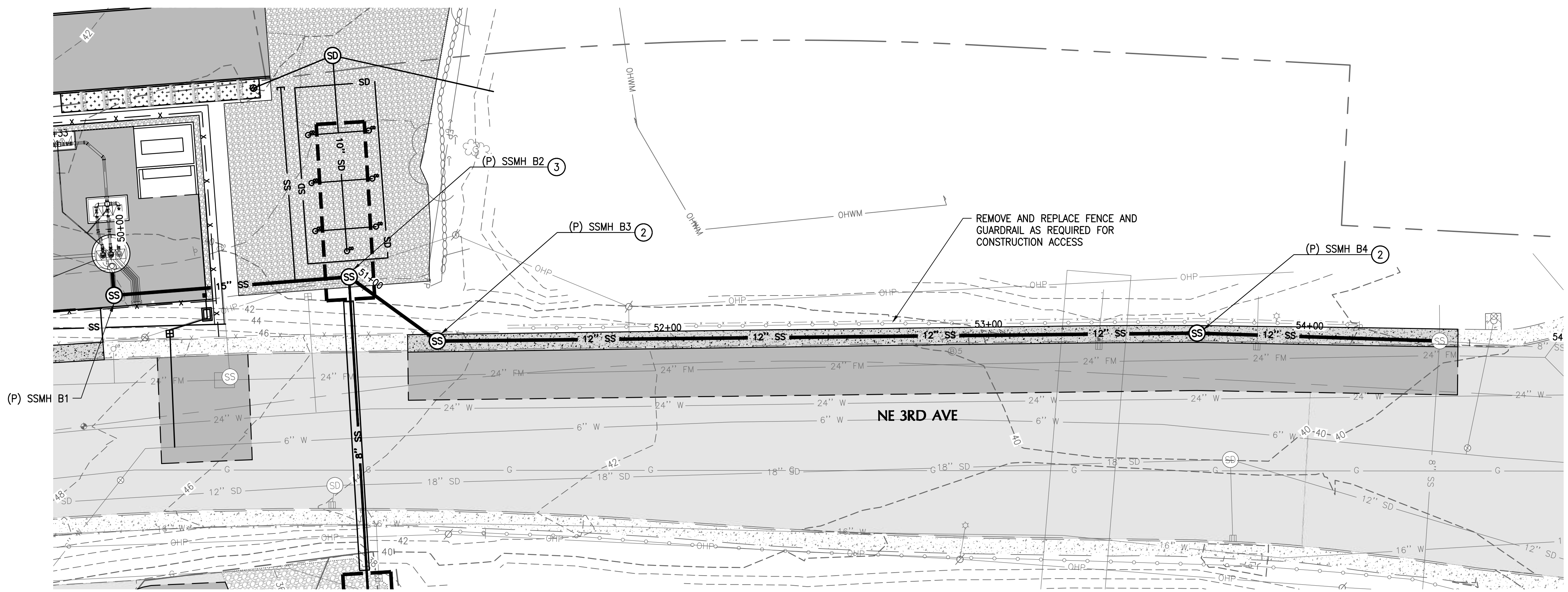
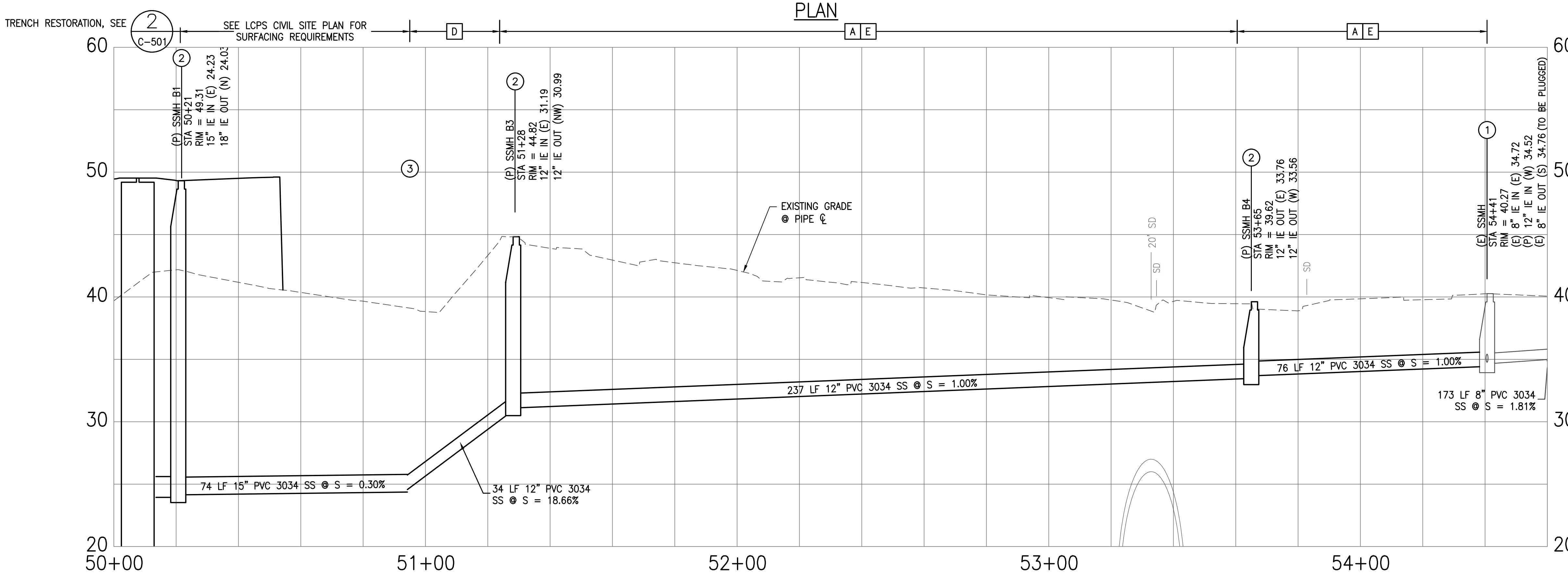
Exhibit C-2: Final Drainage Report



PLAN

KEY NOTES

1. CONNECT PROPOSED GRAVITY SEWER TO EXISTING SSMH AND RECHANNEL BASE. SEE CITY OF CAMAS STANDARD DETAIL S1.
2. CONSTRUCT NEW SSMH. SEE CITY OF CAMAS STANDARD DETAILS S1 AND S4.
3. CONSTRUCT NEW EXTENDED BASE SSMH. SEE CITY OF CAMAS STANDARD DETAILS SI AND S4.



PROFILE

SCALE: 1" = 20' HORIZ
1" = 5' VERT

GRAVITY SEWER B PLAN & PROFILE

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

wallis engineering

PROJECT NO: 1460A

DATE: 3/2019

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

PERMIT SET

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: C-102

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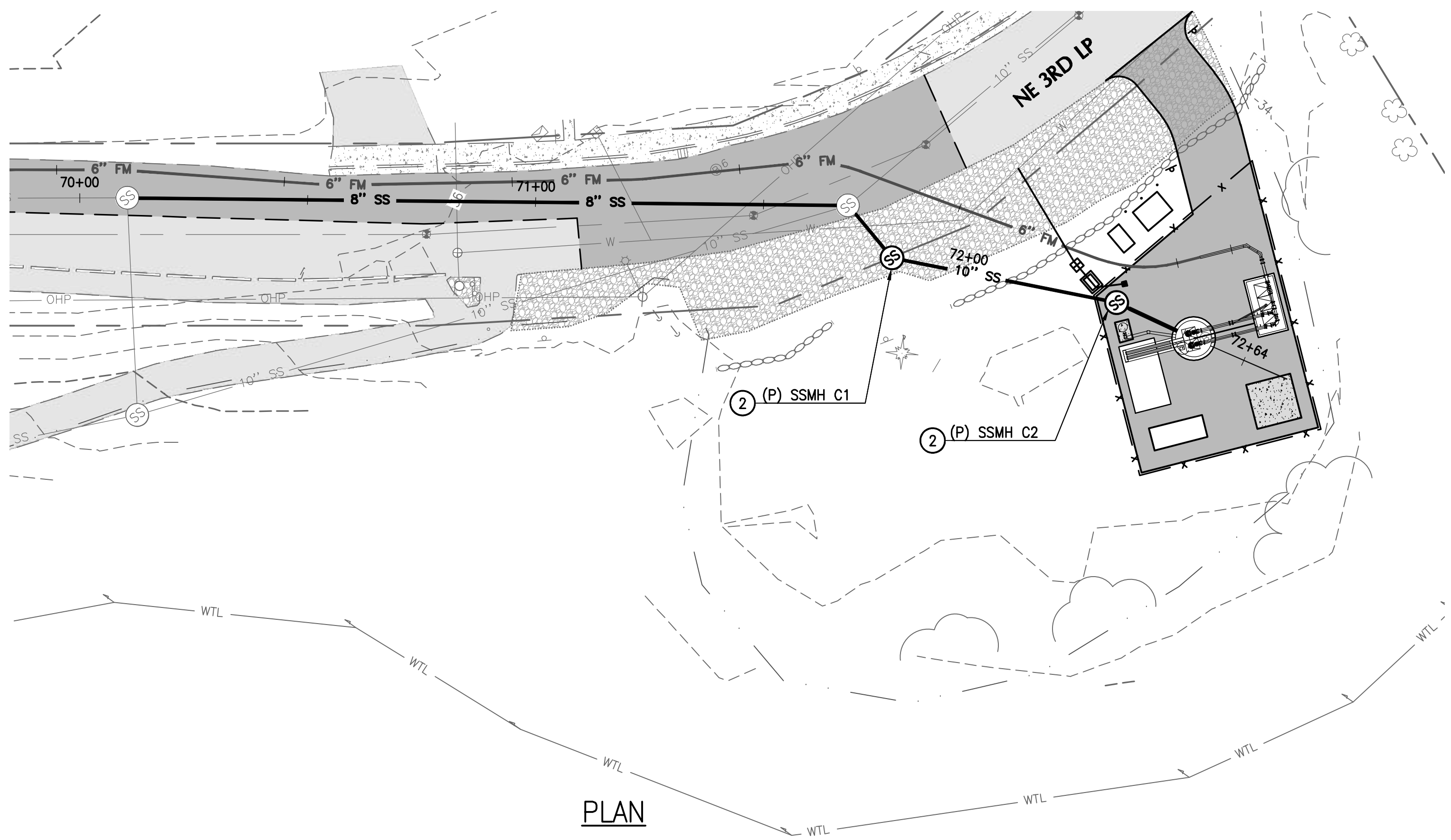
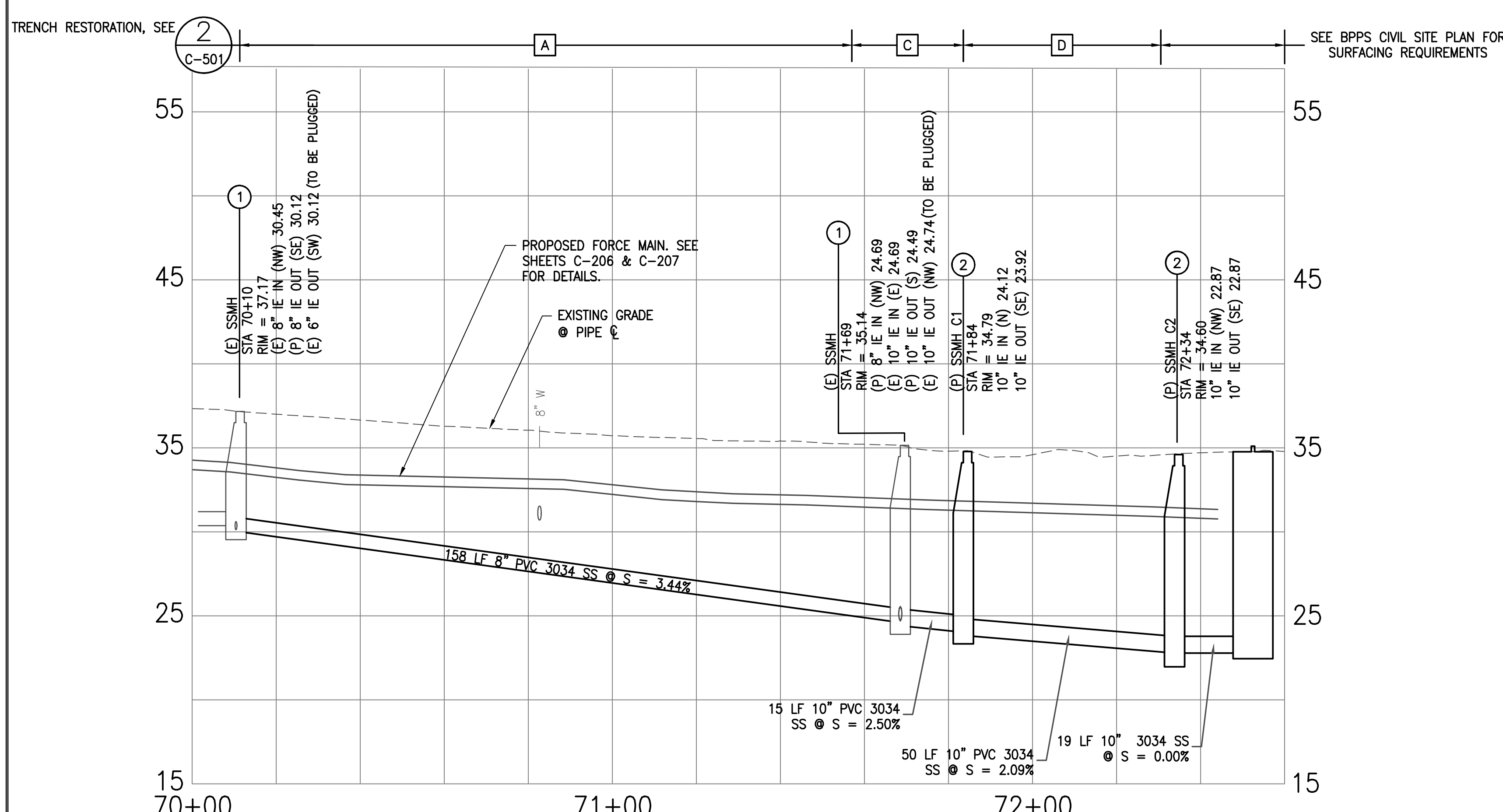
Exhibit C-2: Final Drainage Report



KEY NOTES

1. CONNECT PROPOSED GRAVITY SEWER TO EXISTING SSMH AND RECHANNEL BASE. SEE CITY OF CAMAS STANDARD DETAIL S1.
2. CONSTRUCT NEW SSMH. SEE CITY OF CAMAS STANDARD DETAILS S1 AND S4.



PROFILE
SCALE: 1" = 20' HORIZ
1" = 5' VERT

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TIMOTHY C. ... STATE OF WASHINGTON ... 26182 REGISTERED PROFESSIONAL ENGINEER

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

GRAVITY SEWER C PLAN & PROFILE

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

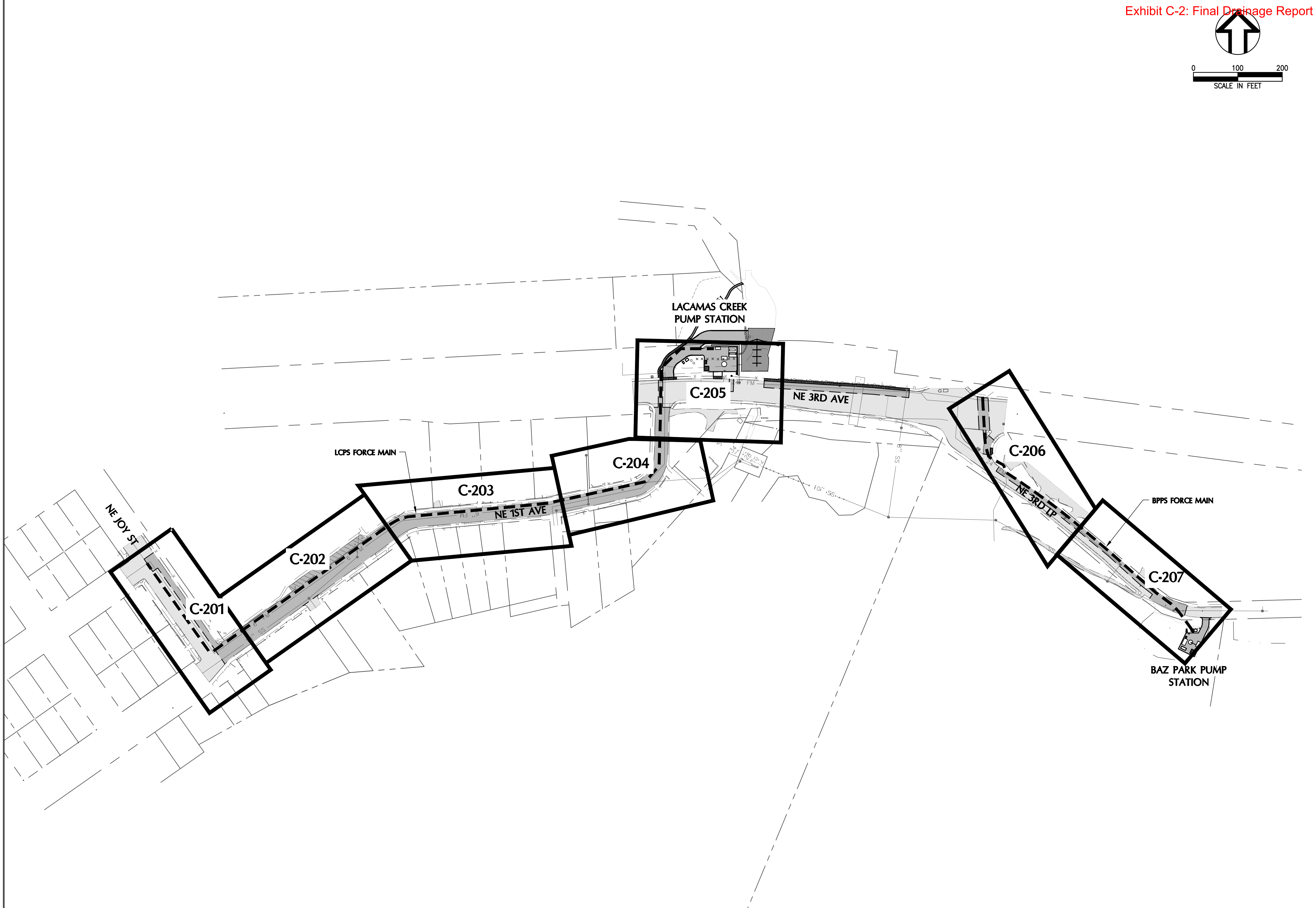
LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
C-103

Exhibit C-2: Final Drainage Report



PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

FORCE MAIN SEWER KEY MAP

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
G-201

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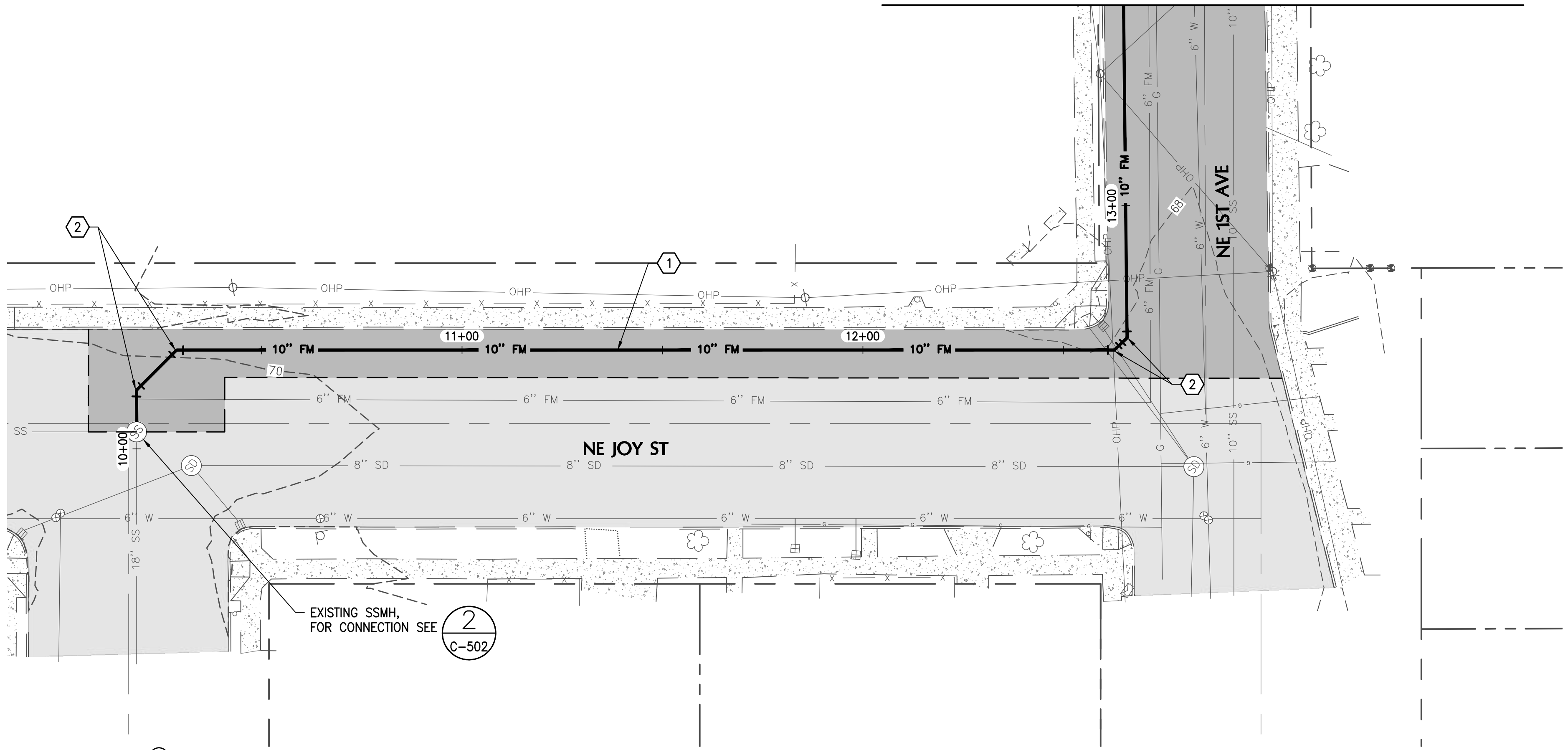
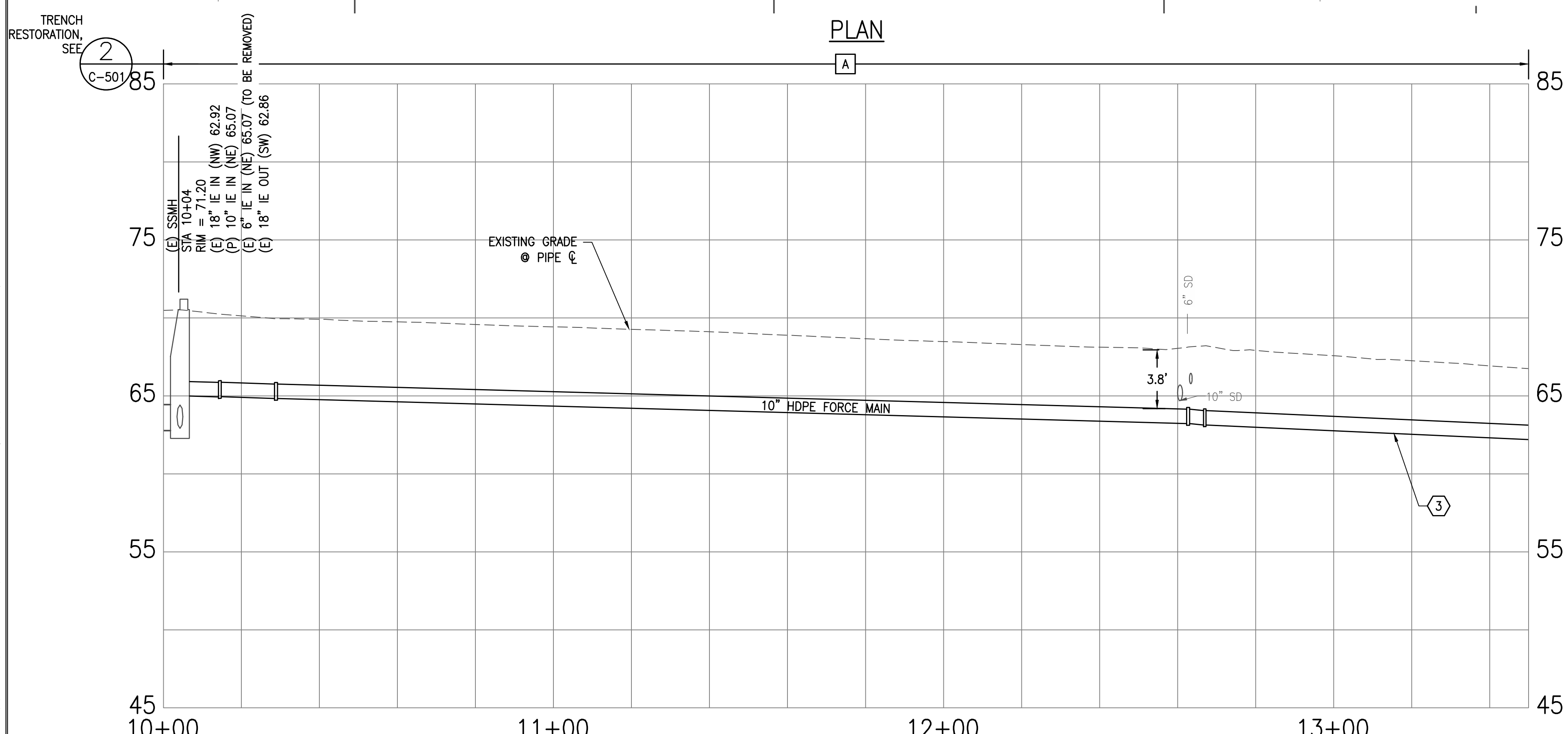
Exhibit C-2: Final Drainage Report

MATCHLINE STA 13+50
SEE SHEET C-202 FOR CONTINUATION



PLAN



PROFILE
SCALE: 1" = 20' HORIZ
1" = 5' VERT

0 20 40
SCALE IN FEET

KEY NOTES

1. CONSTRUCT 10" HDPE FORCE MAIN.
2. INSTALL 10" HDPE 45° BEND.
3. MAINTAIN POSITIVE SLOPE FROM LOW POINTS TO HIGH POINTS, AND NEGATIVE SLOPE FROM LOW POINTS TO HIGH POINTS. DEPTH OF PIPE AS SHOWN ON PROFILE.

PERMIT SET

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS FORCE MAIN PLAN & PROFILE STA 10+00 TO 13+50

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
C-201

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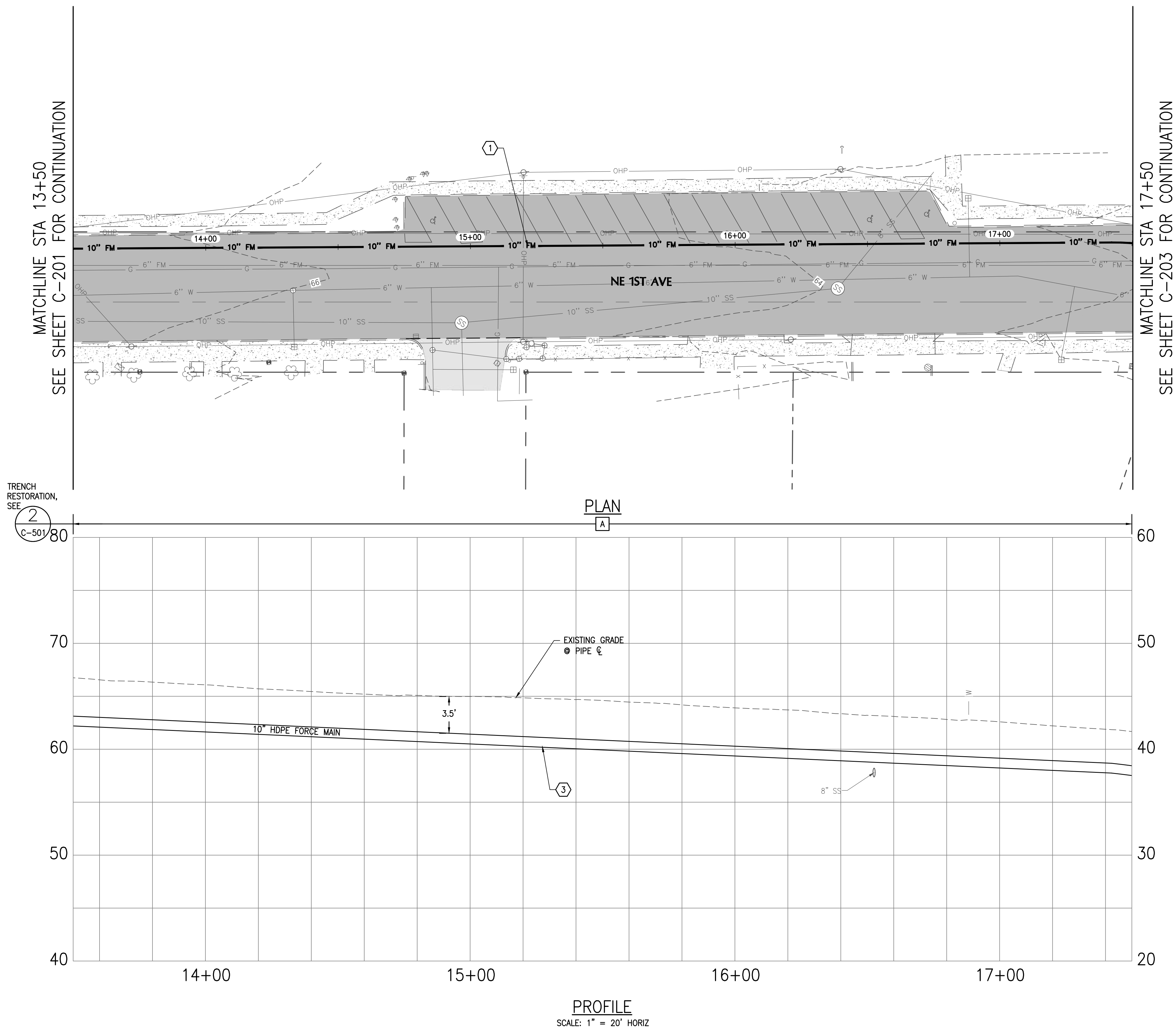
Exhibit C-2: Final Drainage Report



SCALE IN FEET 0 20 40

KEY NOTES

1. CONSTRUCT 10" HDPE FORCE MAIN.
3. MAINTAIN POSITIVE SLOPE FROM LOW POINTS TO HIGH POINTS, AND NEGATIVE SLOPE FROM LOW POINTS TO HIGH POINTS. DEPTH OF PIPE AS SHOWN ON PROFILE.

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS FORCE MAIN PLAN & PROFILE STA 13+50 TO 17+50

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

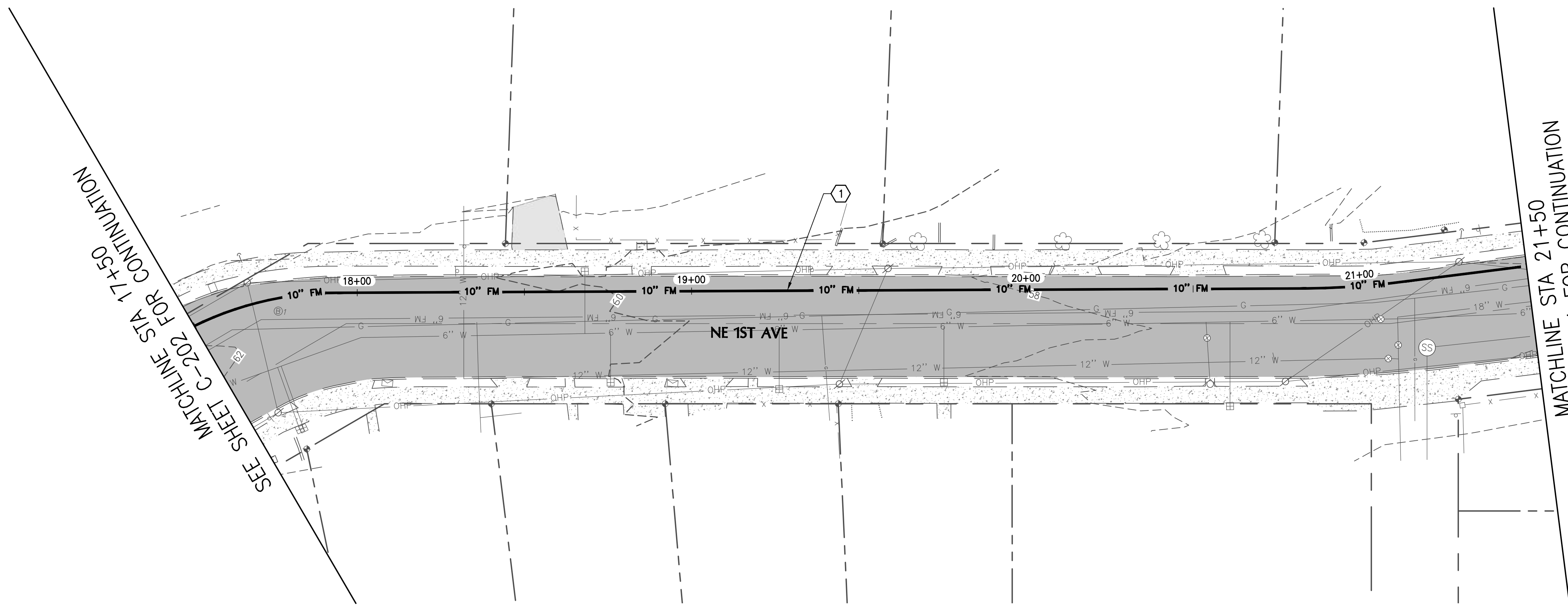
City of Camas WASHINGTON

CITY PROJECT NO. S1000

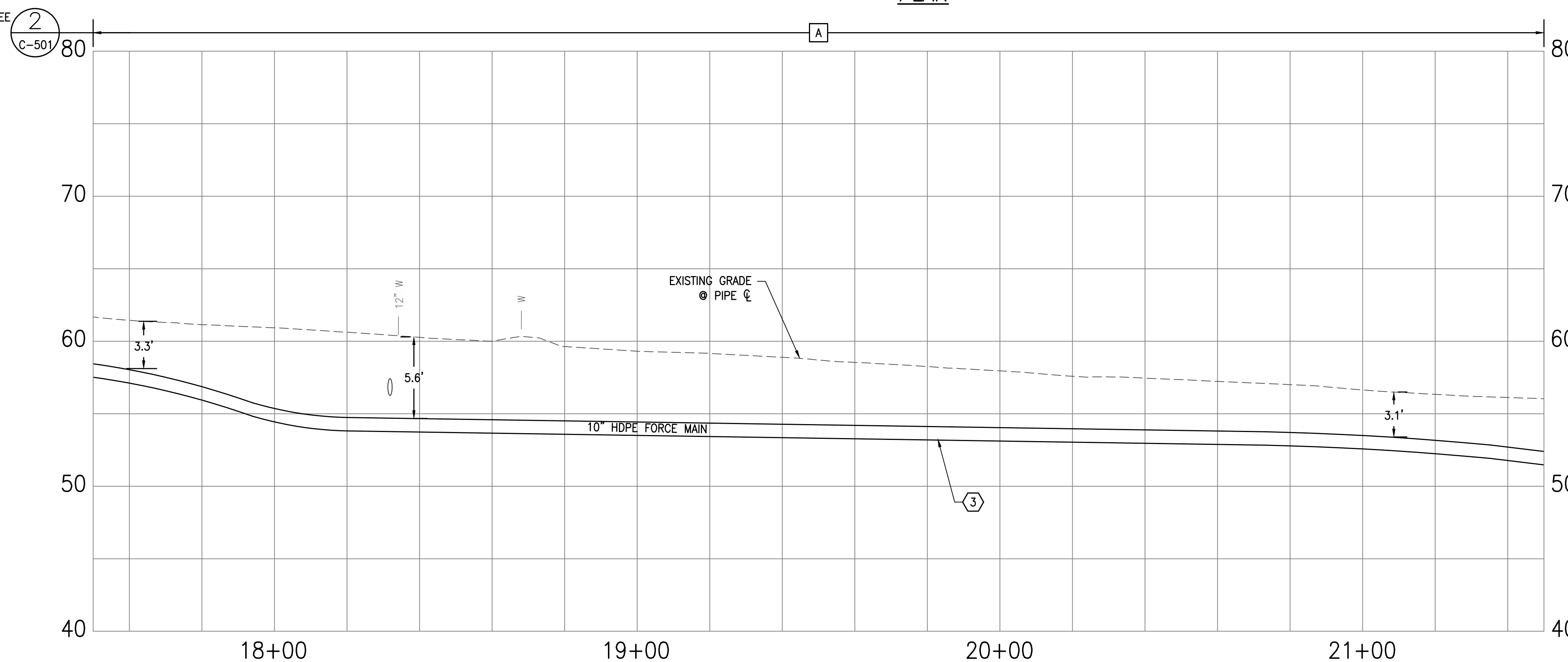
DRAWING NO:

C-202

Exhibit C-2: Final Drainage Report



PLAN



PROFILE

SCALE: 1" = 20' HORIZ
1" = 5' VERT

SCALE IN FEET 0 20 40

KEY NOTES

1. CONSTRUCT 10" HDPE FORCE MAIN.
3. MAINTAIN POSITIVE SLOPE FROM LOW POINTS TO HIGH POINTS, AND NEGATIVE SLOPE FROM LOW POINTS TO HIGH POINTS. DEPTH OF PIPE AS SHOWN ON PROFILE.

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS FORCE MAIN PLAN & PROFILE STA 17+50 TO STA 21+50

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: C-203

21 OF 71

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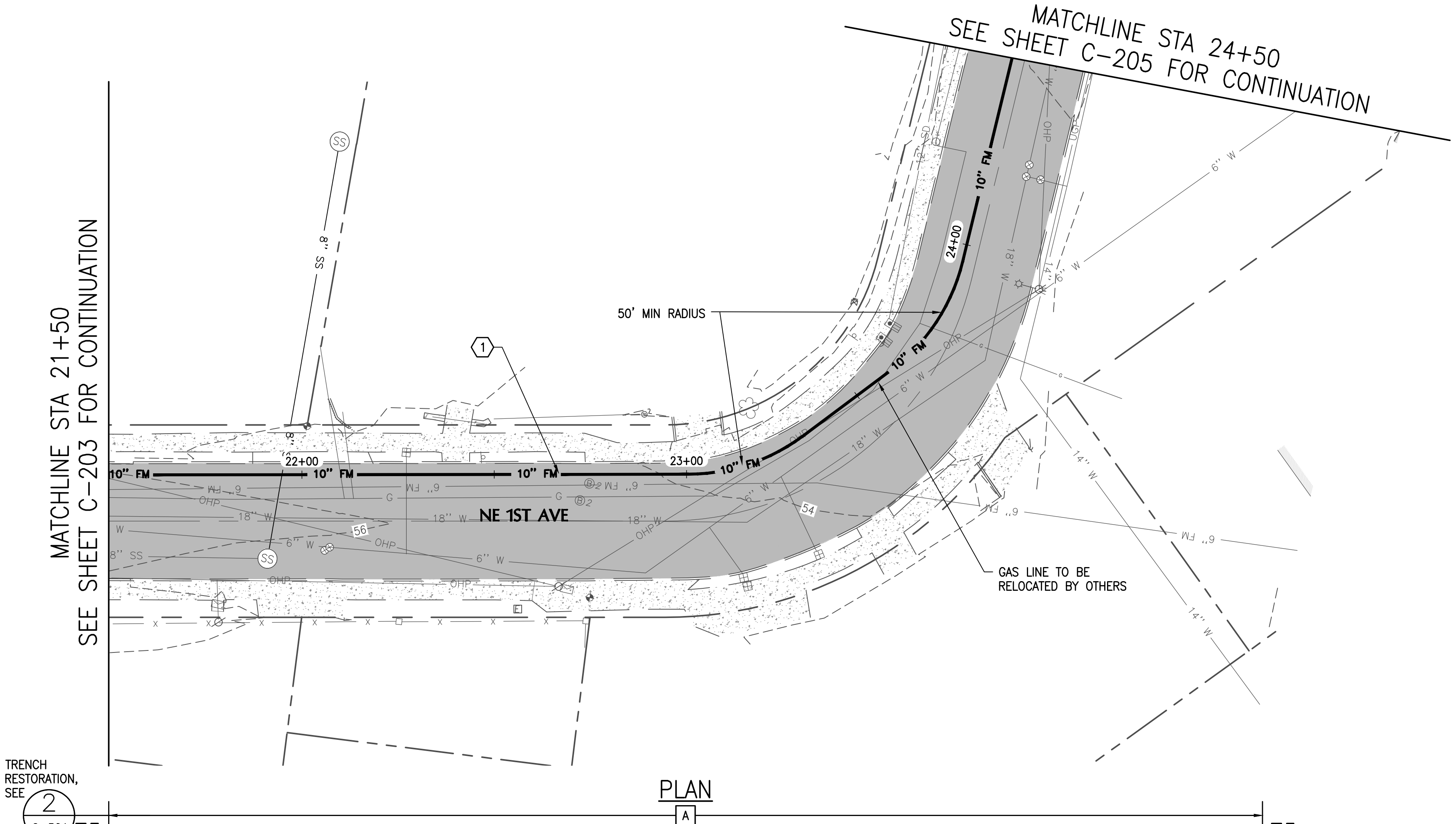
Exhibit C-2: Final Drainage Report

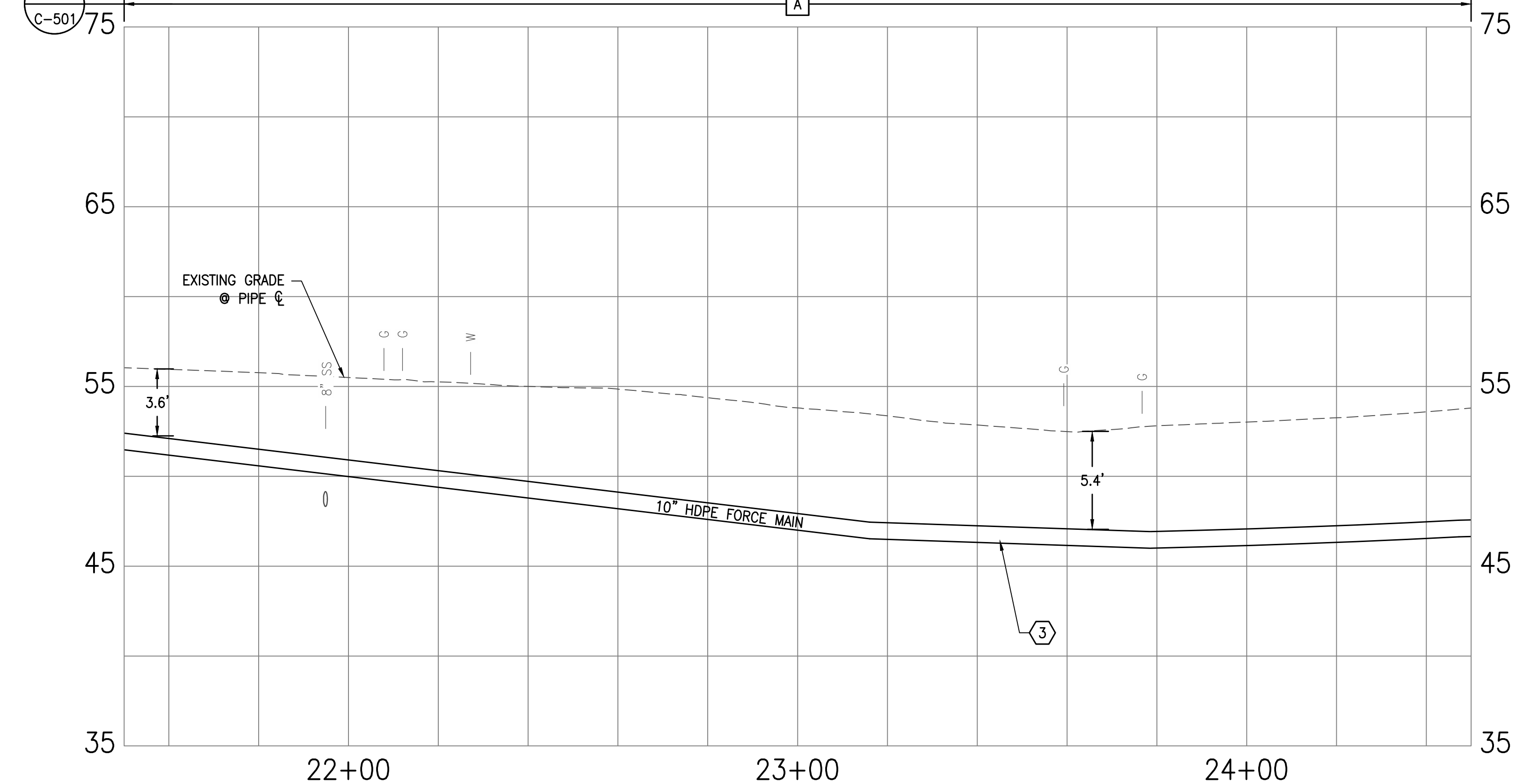
PERMIT SET

KEY NOTES

1. CONSTRUCT 10" HDPE FORCE MAIN.
3. MAINTAIN POSITIVE SLOPE FROM LOW POINTS TO HIGH POINTS, AND NEGATIVE SLOPE FROM LOW POINTS TO HIGH POINTS. DEPTH OF PIPE AS SHOWN ON PROFILE.



PLAN



PROFILE

SCALE: 1" = 20' HORIZ
1" = 5' VERT

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS FORCE MAIN
PLAN & PROFILE STA 21+50 TO 24+50

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
C-204

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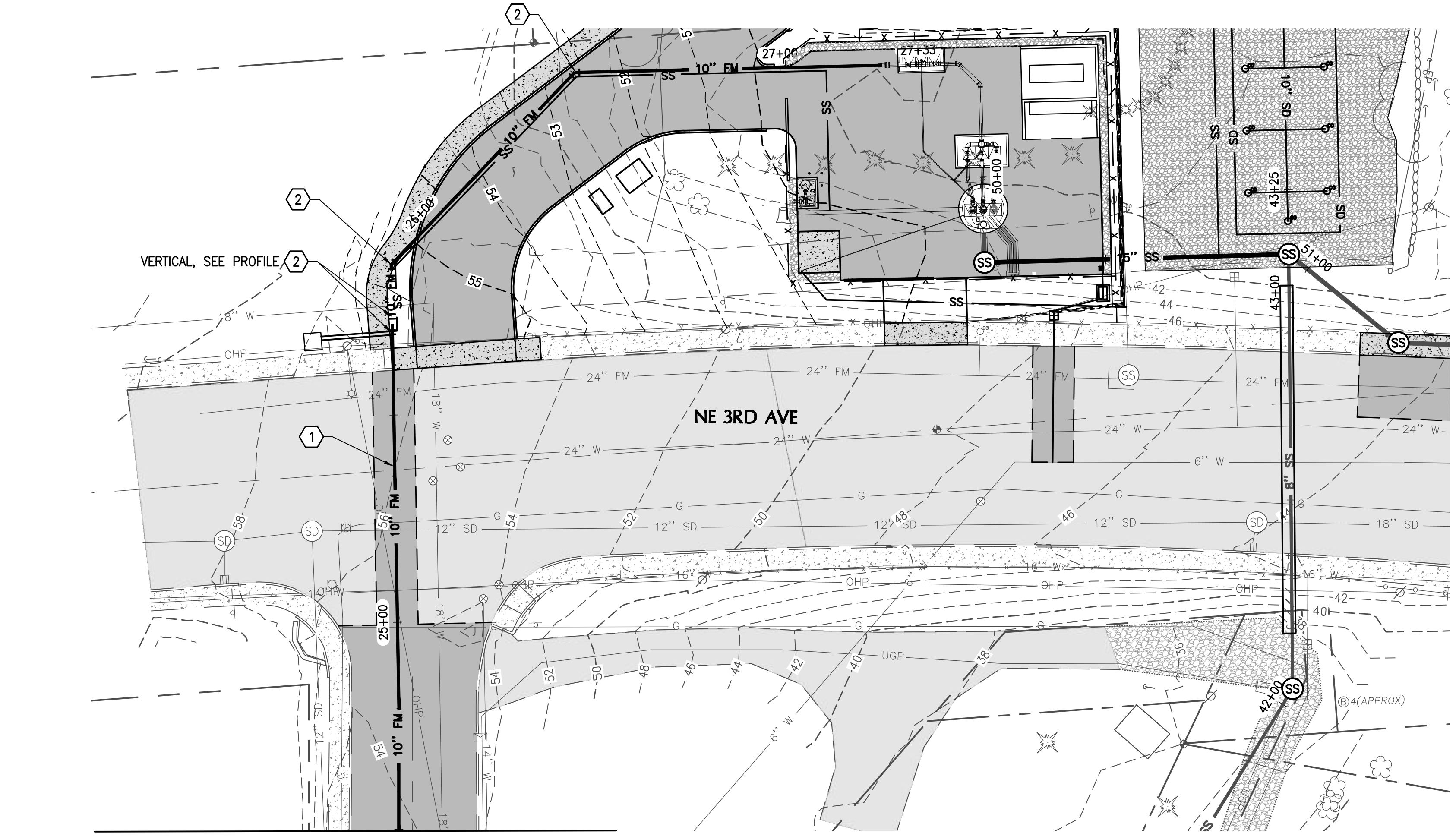
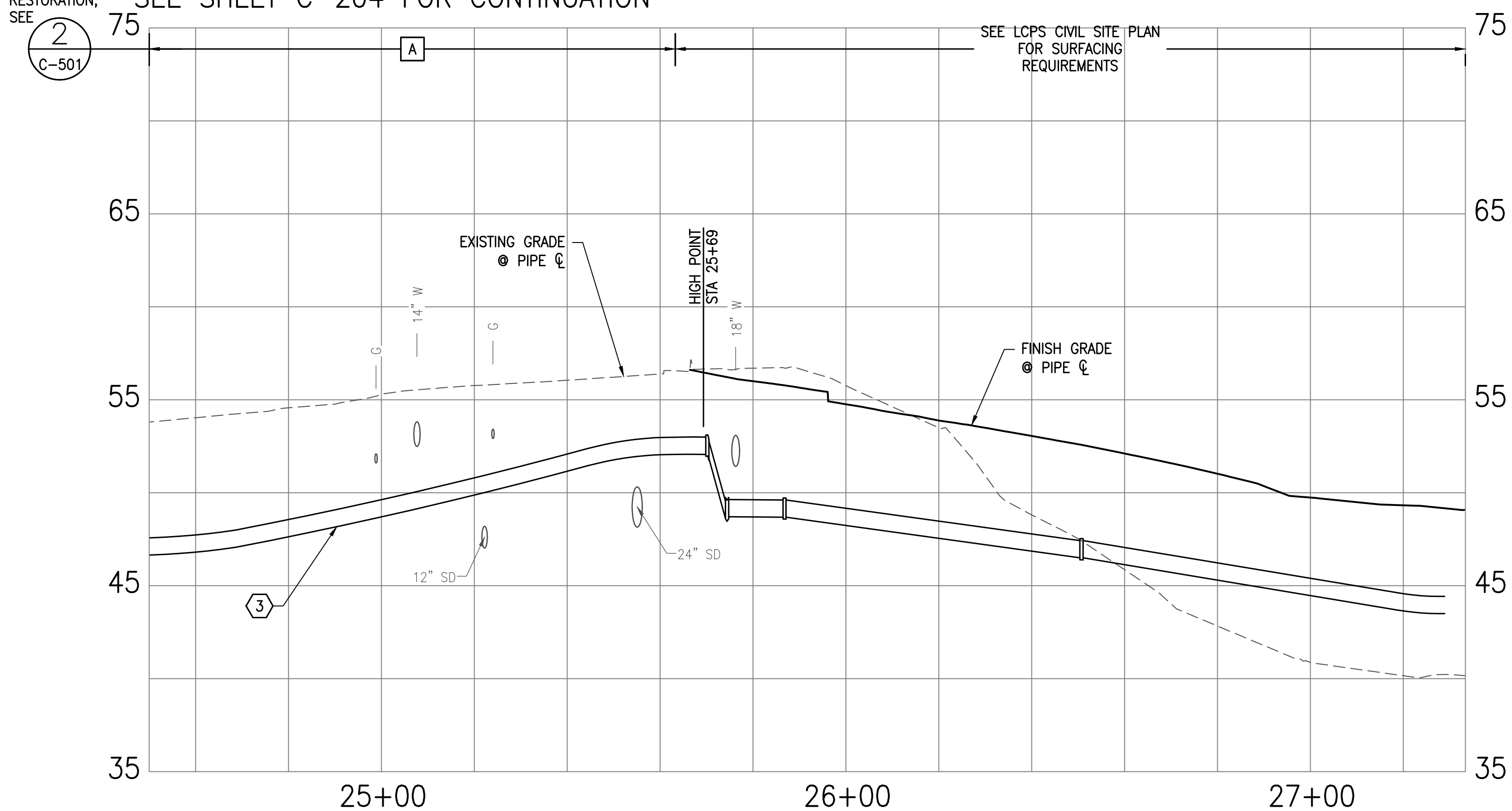
Exhibit C-2: Final Drainage Report



PLAN



PROFILE

SCALE: 1" = 20' HORIZ
1" = 5' VERT

SCALE IN FEET: 0 20 40

KEY NOTES

1. CONSTRUCT 10" HDPE FORCE MAIN.
2. INSTALL 10" HDPE 45° BEND.
3. MAINTAIN POSITIVE SLOPE FROM LOW POINTS TO HIGH POINTS, AND NEGATIVE SLOPE FROM LOW POINTS TO HIGH POINTS. DEPTH OF PIPE AS SHOWN ON PROFILE.

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS FORCE MAIN PLAN & PROFILE STA 24+50 TO END

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:

C-205

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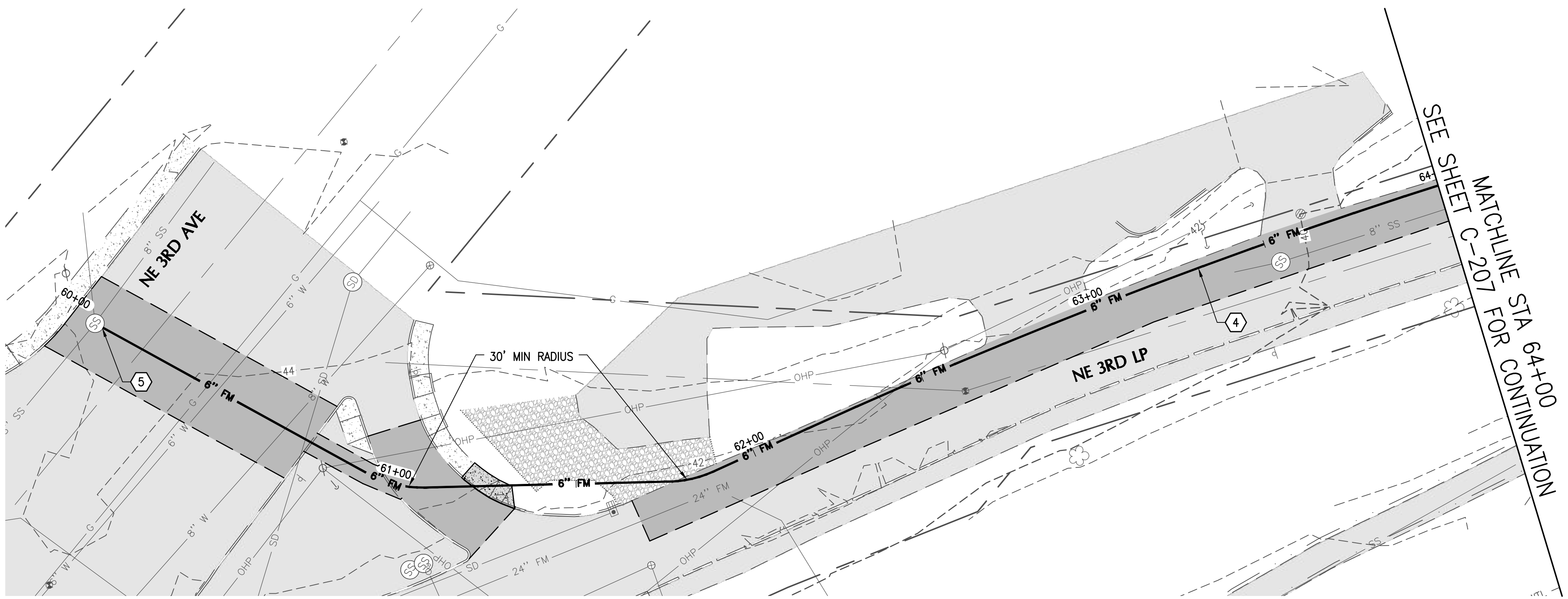
Exhibit C-2: Final Drainage Report

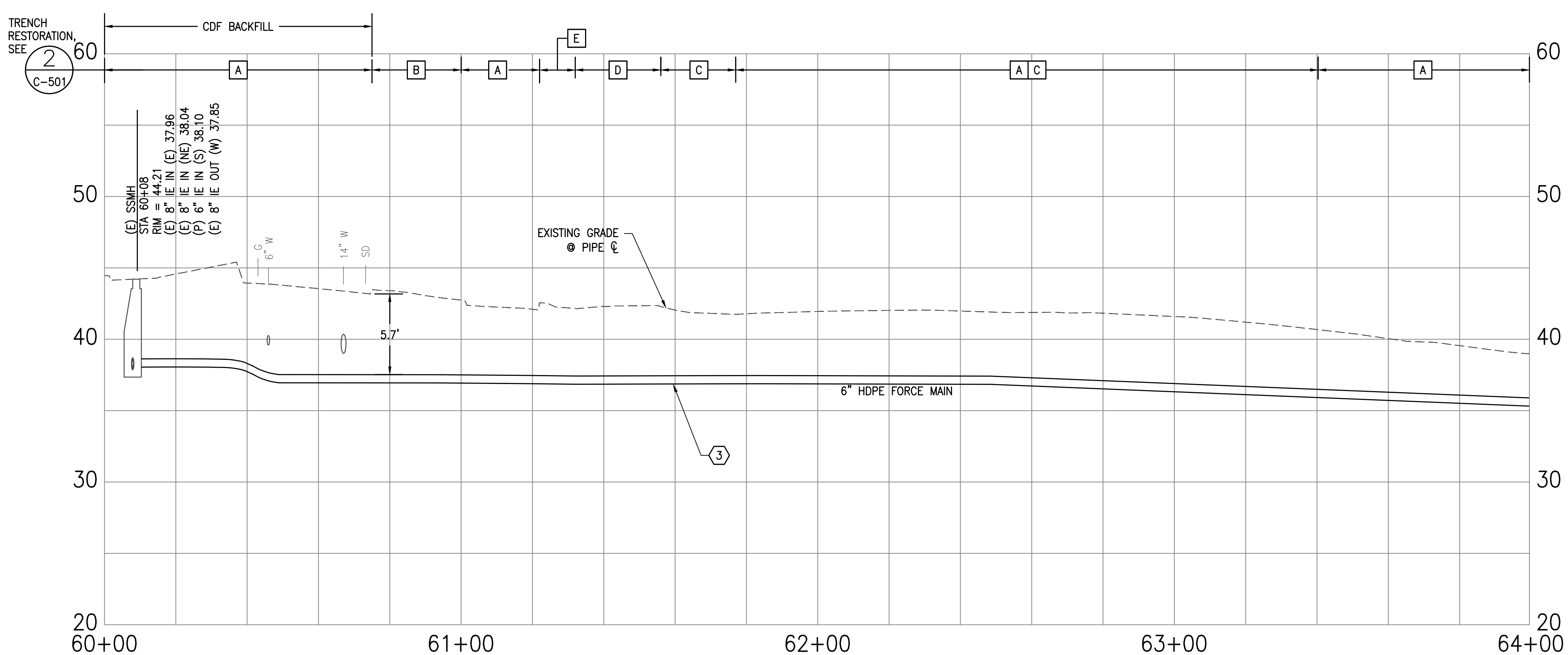


PLAN

0 20 40
SCALE IN FEET

KEY NOTES

3. MAINTAIN POSITIVE SLOPE FROM LOW POINTS TO HIGH POINTS, AND NEGATIVE SLOPE FROM LOW POINTS TO HIGH POINTS. DEPTH OF PIPE AS SHOWN ON PROFILE.
4. CONSTRUCT 6" HDPE FORCE MAIN.
5. CONNECT TO EXISTING MANHOLE WITH MANHOLE BOOT AND MECHANICAL MANHOLE.



PROFILE

SCALE: 1" = 20' HORIZ
1" = 5' VERT

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

PERMIT SET

BPPS FORCE MAIN PLAN & PROFILE STA 60+00 TO STA 64+00

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

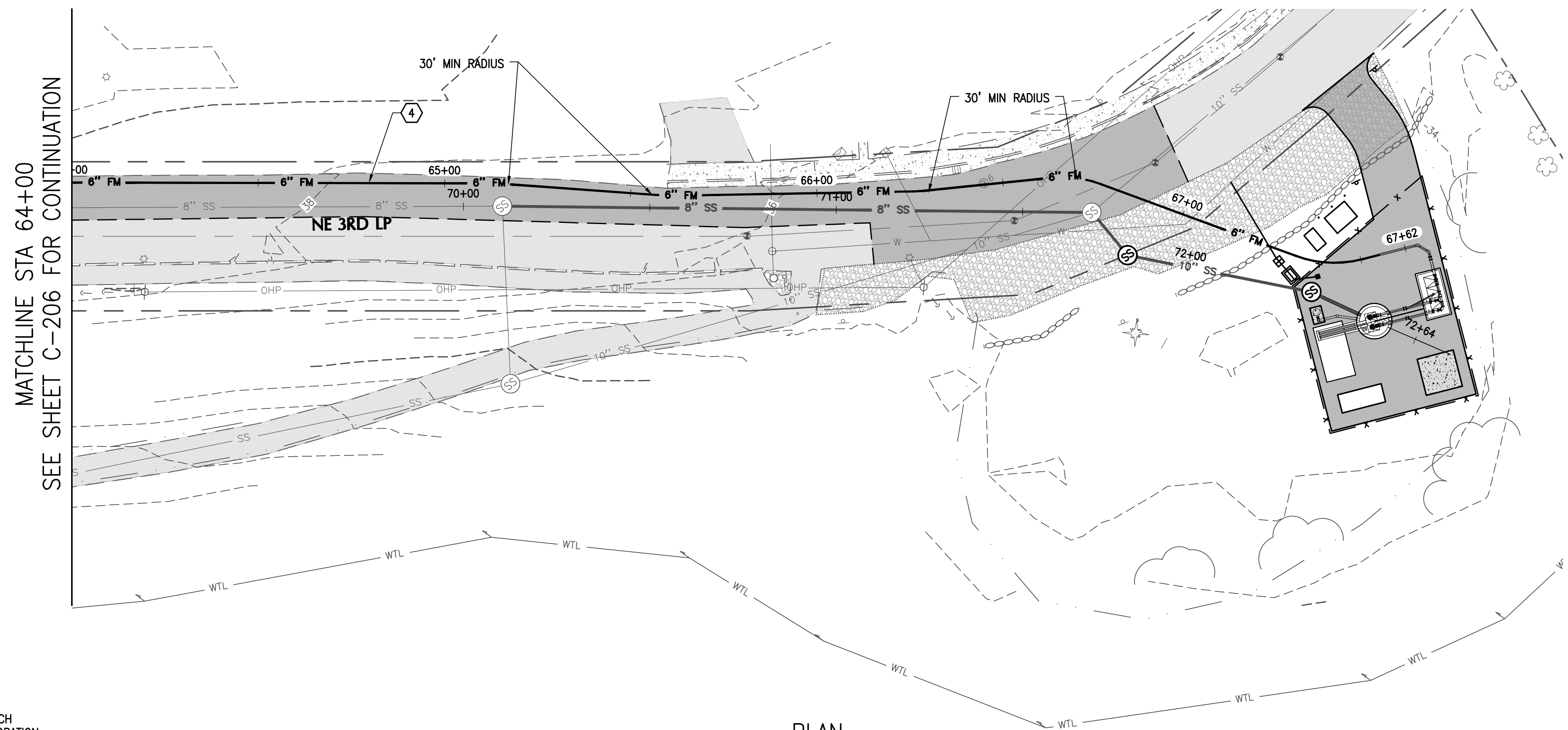
LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
C-206

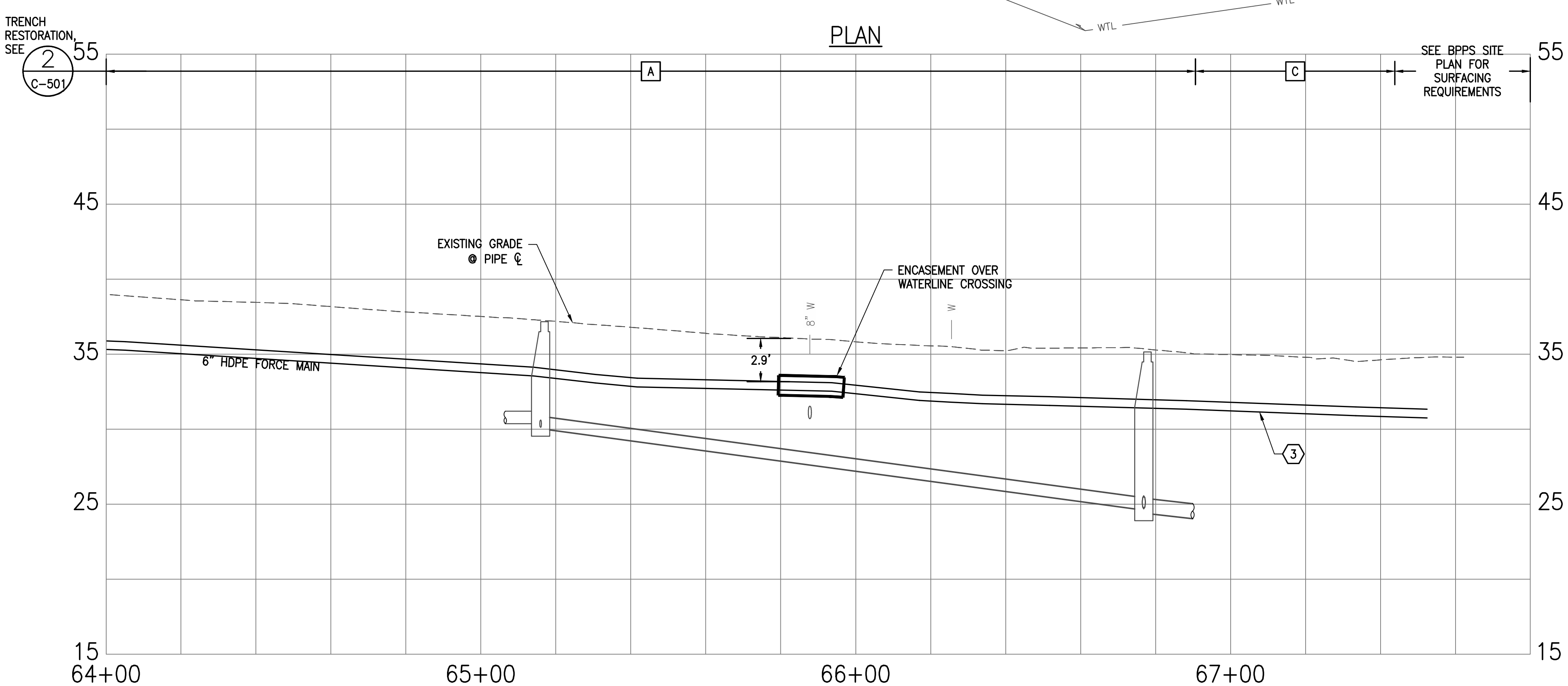
Exhibit C-2: Final Drainage Report



PLAN

KEY NOTES

3. MAINTAIN POSITIVE SLOPE FROM LOW POINTS TO HIGH POINTS, AND NEGATIVE SLOPE FROM LOW POINTS TO HIGH POINTS. DEPTH OF PIPE AS SHOWN ON PROFILE.
4. CONSTRUCT 6" HDPE FORCE MAIN.



PROFILE

SCALE: 1" = 20' HORIZ
1" = 5' VERT

PERMIT SET

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

BPPS FORCE MAIN PLAN & PROFILE STA 64+00 TO END

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:

C-207

Exhibit C-2: Final Drainage Report

SURVEY STAKING COORDINATES

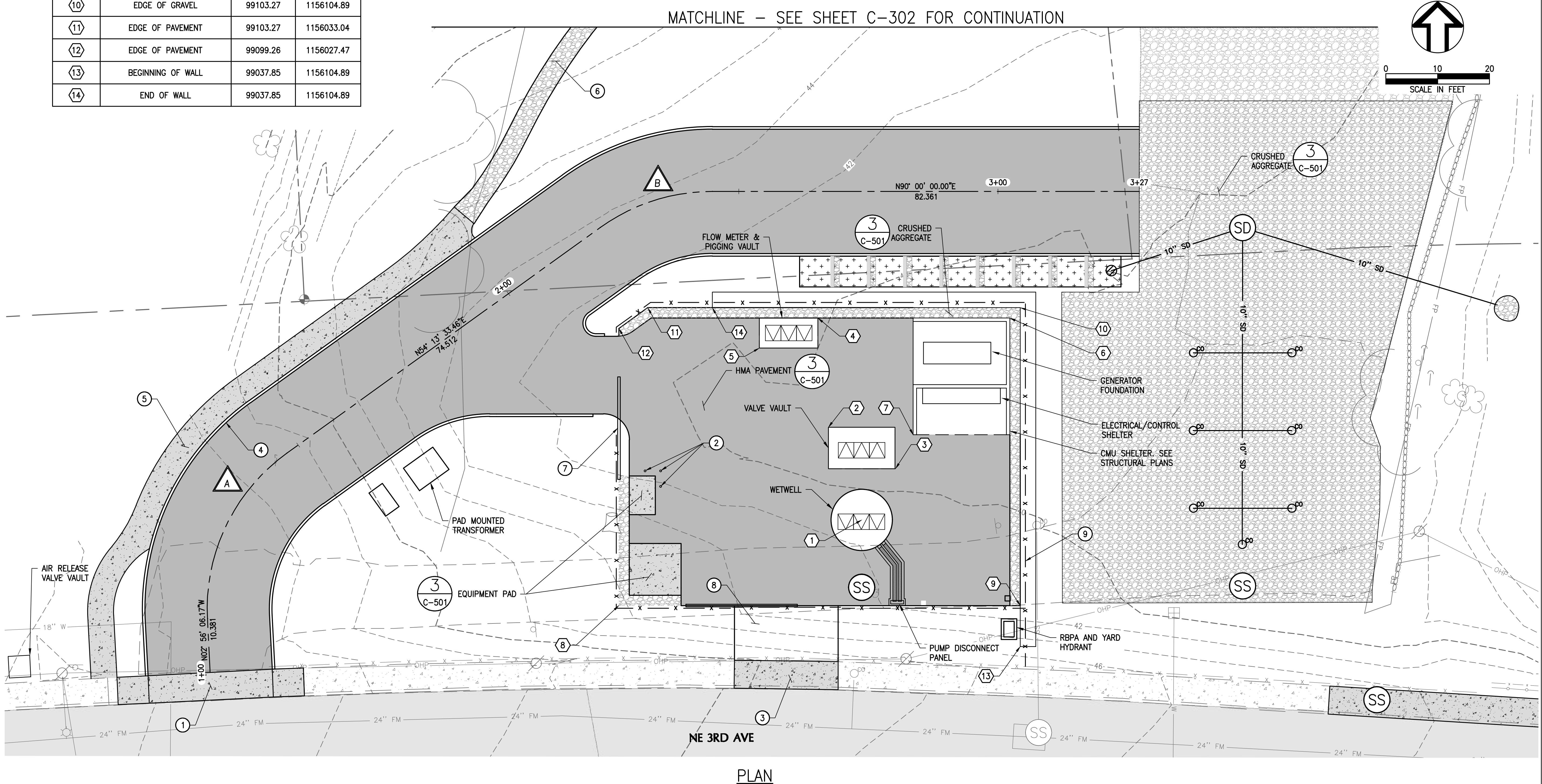
PT	DESCRIPTION	NORTHING	EASTING
1	WETWELL	99057.95	1156084.22
2	VALVE VAULT	99079.27	1156067.76
3	VALVE VAULT	99072.19	1156080.84
4	FLOW METER/PIGGING VAULT	99101.27	1156065.87
5	FLOW METER/PIGGING VAULT	99095.48	1156054.57
6	EQUIPMENT SHELTER	99101.27	1156102.89
7	EQUIPMENT SHELTER	99078.74	1156084.23
8	EDGE OF GRAVEL	99045.76	1156027.47
9	EDGE OF PAVEMENT	99045..76	1156104.89
10	EDGE OF GRAVEL	99103.27	1156104.89
11	EDGE OF PAVEMENT	99103.27	1156033.04
12	EDGE OF PAVEMENT	99099.26	1156027.47
13	BEGINNING OF WALL	99037.85	1156104.89
14	END OF WALL	99037.85	1156104.89

KEY NOTES

1. REPLACE COMMERCIAL DRIVEWAY, SEE CAMAS STANDARD DETAIL ST17, SHEET SD-502
2. REMOVABLE BOLLARD (TYP 3) SEE CAMAS STD DETAIL 10 SHEET SD-502
3. REPLACE SIDEWALK AND CURB WITH COMMERCIAL DRIVEWAY WITH FULL HEIGHT CURB
4. TRAFFIC CURB, SEE CAMAS STANDARD DETAIL ST12, SHEET SD-502
5. SIDEWALK, SEE CAMAS STANDARD DETAIL ST18, SHEET SD-502
6. 4" DEPTH CSTC COMPACTED TO 90% MAX DENSITY OVER COMPACTED SUBGRADE OR FILL
7. 20' WIDTH ROLLING GATE WITH PERFORATED STEEL PANEL
8. REINFORCED TURF. SEE LANDSCAPE PLANS
9. 6' TALL CHAINLINK FENCE

CURVE DATA

CURVE	RADIUS	LENGTH	Δ
A	37.00'	36.91'	57°09'39"
B	37.00'	23.10'	35°46'26"



PLAN

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS CIVIL SITE PLAN

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
C-301

P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\45 BPPS CIVIL SITE PLAN.dwg, 4/24/2019 11:40:30 AM, Chad Kays

Exhibit C-2: Final Drainage Report

KEY NOTES

1. 4" DEPTH CSTC COMPACTED TO 90% MAX DENSITY OVER COMPACTED SUBGRADE OR FILL

MATCHLINE – SEE SHEET C-301 FOR CONTINUATION

PLAN

0 10 20
SCALE IN FEET

PERMIT SET

TIMOTHY C. [illegible]
STATE OF WASHINGTON
26182
REGISTERED
PROFESSIONAL ENGINEER

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH
0 1"
ONE INCH AT FULL SCALE.
IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS CIVIL SITE PLAN II

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:

C-302

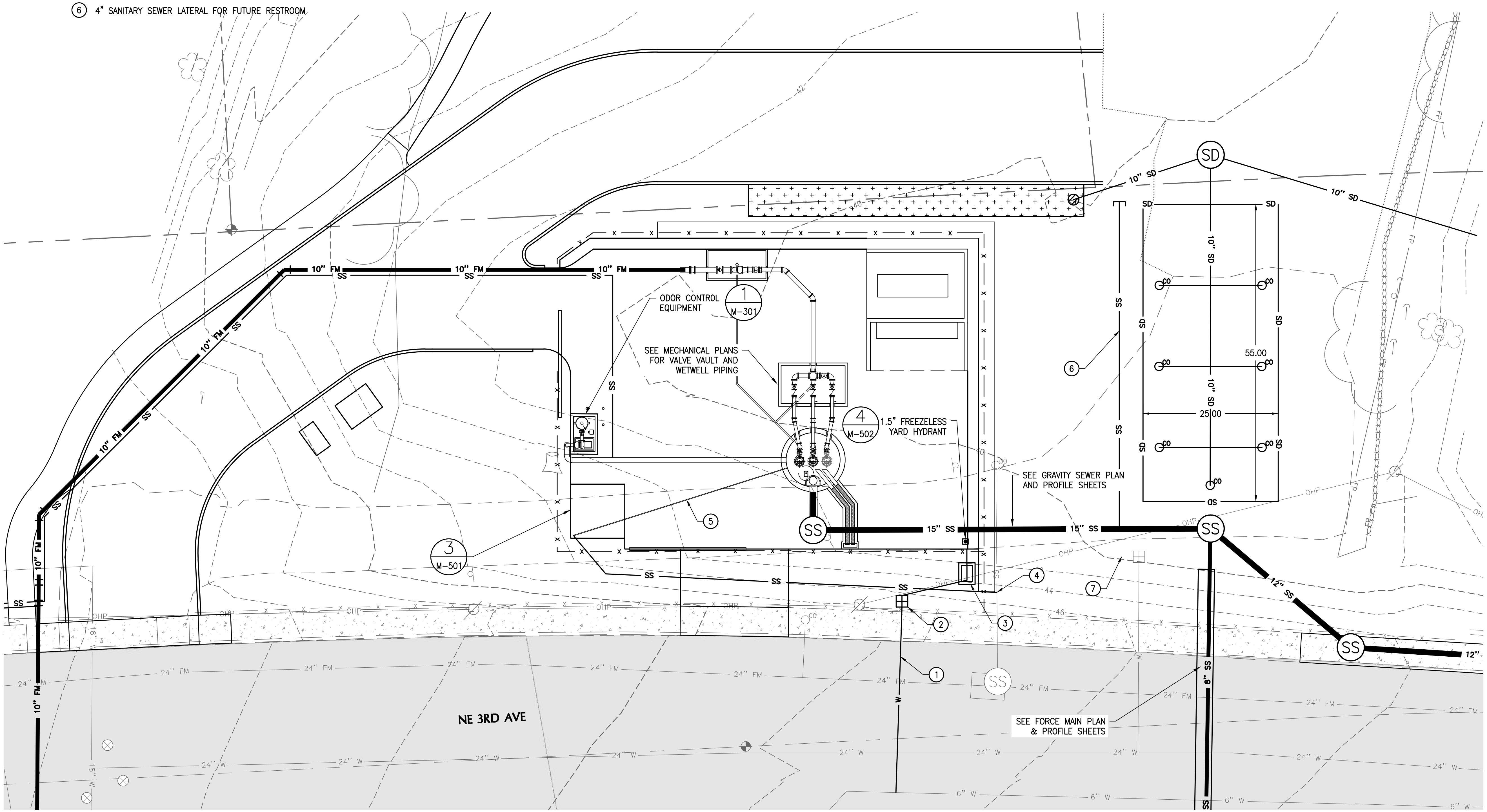
P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\45 BPPS CIVIL SITE PLAN.dwg, 4/23/2019 12:30:37 PM, Chad Keys

Exhibit C-2: Final Drainage Report

KEY NOTES

1. 1" WATER SERVICE STUB FOR FUTURE PARK AND IRRIGATION SUPPLY
2. 3/4" WATER METER FOR PUMP STATION, SEE CAMAS STANDARD DETAIL W6, SHEET SD-502
3. 1.5" RPBA, SEE CAMAS STANDARD DETAIL W24, SHEET SD-502
4. CONNECT 4" HDPE PIPE TO EXISTING 4" HDPE PIPE AND EXTEND TO FUTURE ODOR CONTROL PAD
5. 1" SCH 40 PVC FOR FUTURE CHEMICAL INJECTION
6. 4" SANITARY SEWER LATERAL FOR FUTURE RESTROOM

0 10 20
SCALE IN FEET



PLAN

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS UTILITY & PIPING PLAN

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: C-303

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Exhibit C-2: Final Drainage Report

STRUCTURE/PAD ELEVATIONS

PT	DESCRIPTION	ELEVATION
1	WETWELL	49.53
2	VALVE VAULT	49.50
3	FLOW METER/PIGGING VAULT	49.55
4	ODOR CONTROL EQUIPMENT PAD	50.30
5	EQUIPMENT PAD	50.56
6	GENERATOR FOUNDATION	50.25

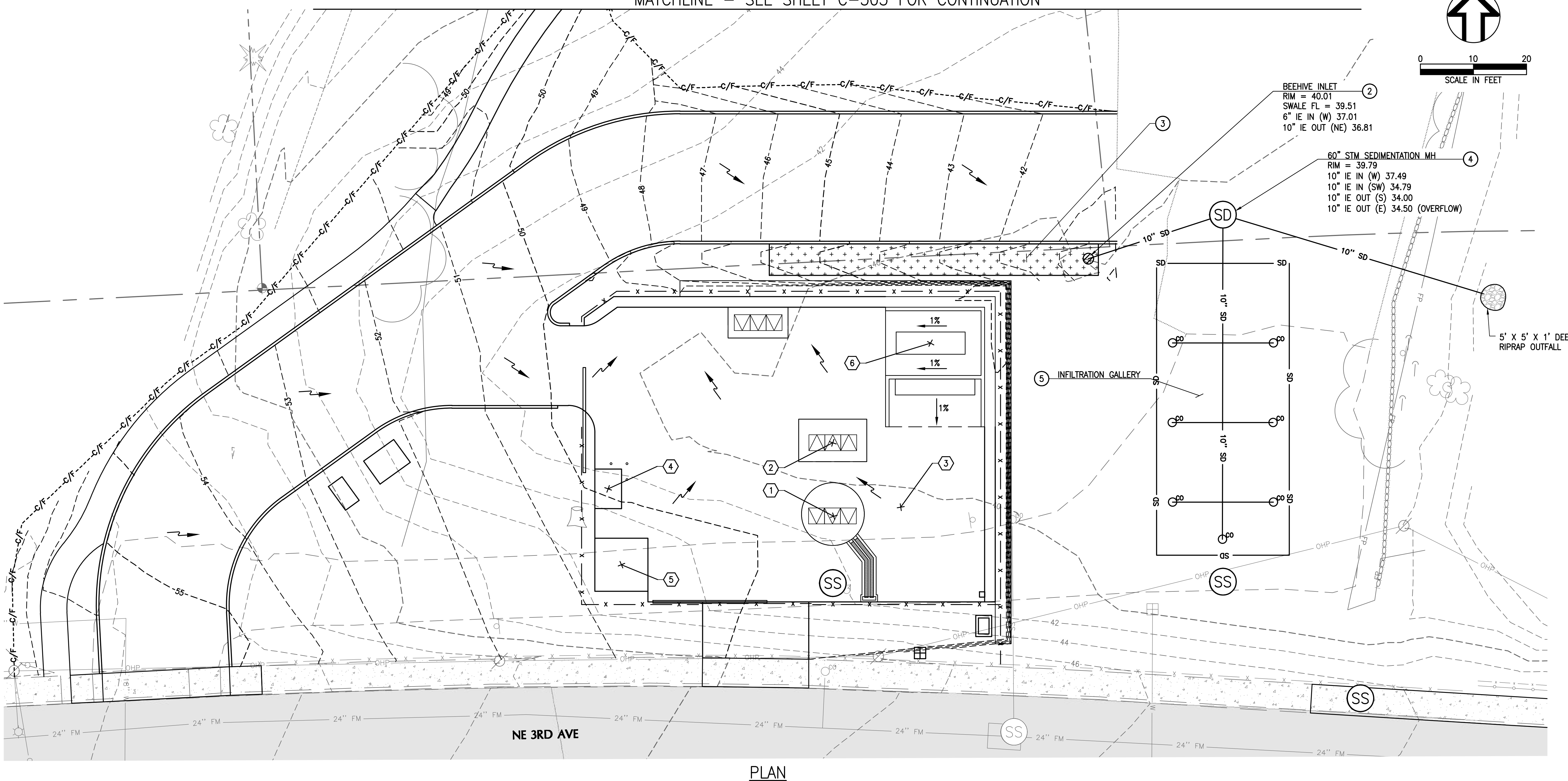
KEY NOTES

1. CONSTRUCT INFILTRATION GALLERY PER DETAIL ON SHEET XX.
2. CONSTRUCT BEEHIVE INLET PER DETAIL, SHEET CX.
3. CONSTRUCT BIORETENTION FACILITY PER DETAIL XX ON SHEET XX.
4. NEW STORM SEDIMENTATION MANHOLE PER DETAIL ON SHEET XX.

GRADING LEGEND

GB	GRADE BREAK
(arrow)	FLOW DIRECTION
(hatched)	STORMWATER BIORETENTION FACILITY
--C/F--	CUT/FILL LINE

MATCHLINE – SEE SHEET C-305 FOR CONTINUATION



PLAN

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS GRADING & DRAINAGE PLAN I

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PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:

C-304

29 OF 71

P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\47 BPPS GRADING & DRAINAGE PLAN.dwg, 4/24/2019 11:43:21 AM, Chad Keys

Exhibit C-2: Final Drainage Report

GRADING LEGEND

- GB — GRADE BREAK
- FLOW DIRECTION
- STORMWATER BIORETENTION FACILITY
- C/F — CUT/FILL LINE

0 10 20
SCALE IN FEET

MATCHLINE – SEE SHEET C-304 FOR CONTINUATION

PLAN

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER
PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH
0 — 1"
ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS GRADING & DRAINAGE PLAN II

wallis engineering

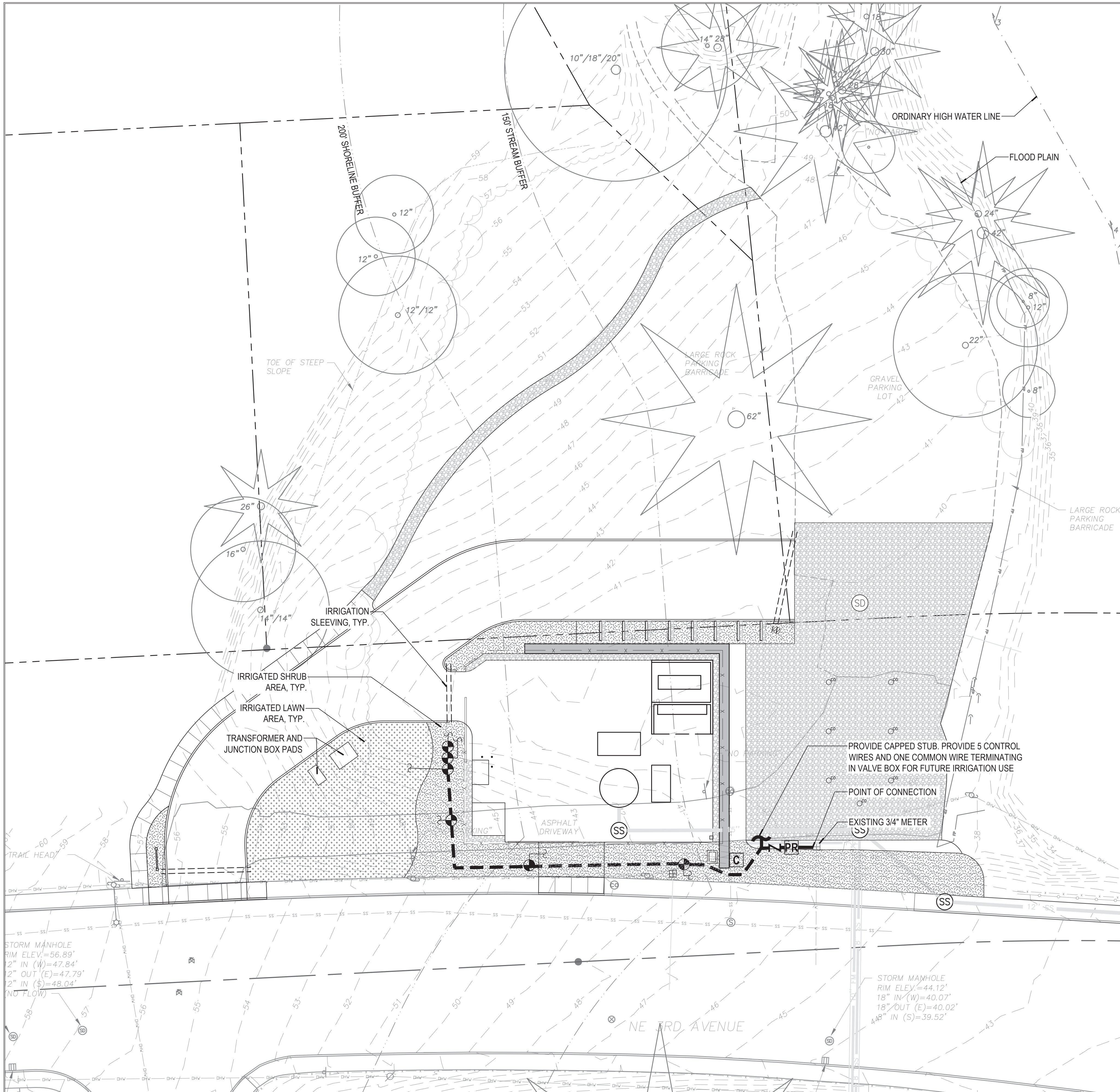
PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
C-305



N

SCALE: 1" = 16'-0"

0' 8' 16' 32'

GreenWorks, P.C.
Landscape Architecture
Environmental Design
24 NW 2nd Avenue, Suite 100
Portland, Oregon 97209
Ph:503.222.5612/F:503.222.2283
Email: info@greenworkspc.com

GREENWORKS PROJECT NO: 118060.2

PERMIT SET

IRRIGATION EQUIPMENT — L-501 L-502

SYMBOL	DESCRIPTION
M	WATER METERS - EXISTING
	REMOTE CONTROL VALVE - RAINBIRD PEB
	QUICK COUPLER - RAINBIRD 44-LRC
	BACKFLOW PREVENTION DEVICE (RPBA) - PER CITY OF CAMAS REQUIREMENTS
C	IRRIGATION CONTROLLER - EXTERIOR WALL MOUNT IN SS BOX - RAINBIRD ESP-LXME
	MANUAL DRAIN VALVE
PR	PRESSURE-REDUCING VALVE - PER CITY OF CAMAS REQUIREMENTS - SEE 1/L501.
	IRRIGATION LATERAL LINE
	IRRIGATION MAIN LINE
	IRRIGATION SLEEVE

CONTROL VALVE TARGET

- STATION NUMBER
- AREA DESIGNATION: L = LAWN S = SHRUB
- FLOW IN GPM
- VALVE SIZE

IRRIGATED PLANTING AREA - RAINBIRD 1800 POP-UP SPRAY HEADS

IRRIGATED LAWN AREA - HUNTER I-20 ROTORS WITH HUNTER I-20 SHORT RADIUS NOZZLES

IRRIGATION NOTES

1. CALL UTILITIES TO LOCATE EXISTING SERVICES PRIOR TO EXCAVATION.
2. SYSTEM OPERATION AND DESIGN IS BASED ON 75 POUNDS OF PRESSURE AND 12 GALLONS PER MINUTE AT THE SHUTOFF VALVE. THE CONTRACTOR SHALL VERIFY THE DESIGN PRESSURE AND VOLUME BEFORE INSTALLATION AND NOTIFY OWNER IF THERE IS A DISCREPANCY.
3. CONTRACTOR SHALL REFERENCE PLANTING PLAN(S) PRIOR TO INSTALLATION OF VALVES. LOCATE VALVES IN PLANTING BEDS WHEREVER POSSIBLE. ADJUST VALVE LOCATIONS TO ELIMINATE CONFLICT WITH PROPOSED PLANTINGS AND PLANTING PATTERNS.
4. VALVE LOCATIONS SHALL BE STAKED BY THE CONTRACTOR AND APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO INSTALLATION OF NEW IRRIGATION SYSTEM.
5. THE CONTRACTOR SHALL VERIFY THE DIMENSIONS AND LAYOUT OF ALL NEW PLANTING AND LAWN AREAS ON SITE BEFORE STARTING WORK AND IMMEDIATELY NOTIFY OWNER OF ANY DEVIATIONS FROM PLAN.
6. NEW TREE LOCATIONS SHALL BE STAKED BY THE CONTRACTOR AND APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO INSTALLATION OF NEW IRRIGATION SYSTEM.
7. THE CONTRACTOR SHALL INSTALL THE IRRIGATION CONTROLLER(S) AT THE LOCATION(S) SHOWN ON THE DRAWINGS, ON THE SPECIFIED PEDESTAL PER THE MANUFACTURER'S RECOMMENDATIONS. THE CONTRACTOR SHALL VERIFY THE LOCATION WITH THE OWNER PRIOR TO INSTALLATION. THE CONTRACTOR SHALL EXTEND CONTROL WIRE CONDUIT FROM CONTROLLER AND DAYLIGHT SIX INCHES INTO PLANTING BED FOR INSTALLATION OF AUTOMATIC VALVE WIRES.
8. ALL BACKFLOW PREVENTION DEVICES SHALL BE LOCATED A MINIMUM OF 5'-0" AWAY FROM CURBS OR PAVING WHEREVER POSSIBLE.
9. MAIN AND LATERAL LINES MAY BE SHOWN DIAGRAMMATICALLY FOR CLARITY. MAIN AND LATERAL LINES SHOWN IN PAVED AREAS SHALL BE PLACED IN ADJACENT PLANTING BEDS UNLESS SPECIFICALLY SHOWN AS PASSING UNDER PAVING IN SLEEVING (SEE LEGEND FOR SLEEVE SYMBOL). THE CONTRACTOR MUST OBTAIN THE LANDSCAPE ARCHITECT'S APPROVAL BEFORE MAKING CHANGES IN ROUTING OF PIPE OR LOCATION OF VALVES.
10. THE CONTRACTOR IS RESPONSIBLE FOR COORDINATING AND PROVIDING AN APPROPRIATE POWER SUPPLY TO THE IRRIGATION CONTROLLER LOCATION.

NO.	REVISION	BY	DATE

DESIGNED BY: BD
DRAWN BY: BD

ONE INCH — 0 1" — ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS IRRIGATION PLAN

wallis engineering

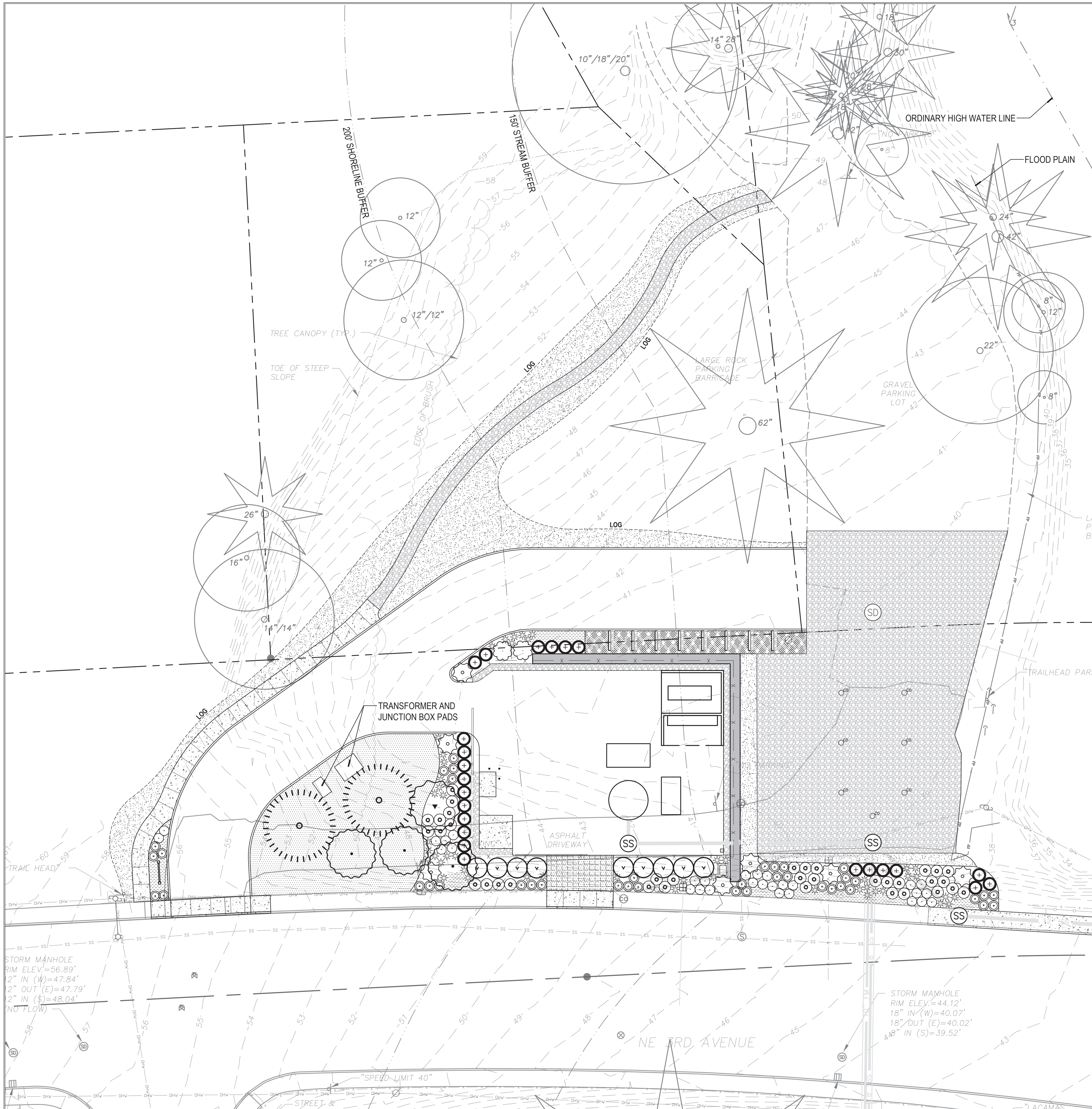
PROJECT NO: 1460A
DATE: 4/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: L-301



N

SCALE: 1" = 16'-0"

0' 8' 16' 32'

GreenWorks, P.C.

Landscape Architecture
Environmental Design

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Portland, Oregon 97209
Ph:503.222.5612/F:503.222.2283
Email: info@greenworkspc.com

GREENWORKS PROJECT NO: 118060.2

PERMIT SET

PLANTING LEGEND

TREES

L-503

EXISTING DECIDUOUS TREE TO REMAIN

EXISTING CONIFER TREE TO REMAIN

BOTANICAL NAME	COMMON NAME	SIZE & TYPE	SPACING	QTY.
CORNUS NUTTALLI X FLORIDA	EDDIE'S WHITE WONDER DOGWOOD	2", CAL, B&B	15' O.C.	3
RHAMNUS PURSHIANA	CASCARA	2" CAL, B&B	15' O.C.	3
PSEUDOTSUGA MENZIESII	DOUGLAS FIR	4-6" CAL., B&B	25' O.C.	2

SHRUBS / GROUNDCOVERS

L-503

BOTANICAL NAME	COMMON NAME	SIZE & TYPE	SPACING	QTY.
GAULTHERIA SHALLON	SALAL	1 GAL. CONT.	3' O.C.	42
OSMANTHUS DELAVAYI	DELAVAY OSMANTHUS	5 GAL. CONT.	6' O.C.	19
POLYSTICHUM MUNITUM	WESTERN SWORD FERN	1 GAL. CONT.	30" O.C.	55
RIBES SANGUINEUM	RED-FLOWERING CURRANT	5 GAL. CONT.	6' O.C.	11
SPIRAEA BETULIFOLIA	WHITE SPIRAEA	1 GAL. CONT.	3' O.C.	62
SYMPHORICARPOS ALBUS	SNOWBERRY	1 GAL. CONT.	42" O.C.	30
VACCINIUM OVATUM	EVERGREEN HUCKLEBERRY	5 GAL. CONT.	4' O.C.	21
VIBURNUM TINUS 'COMPACTUM'	SPRING BOUQUET VIBURNUM	5 GAL. CONT.	5' O.C.	11
MAHONIA REPENS	CREEPING OREGON GRAPE	1 GAL. CONT.	24" O.C.	142

RAIN GARDEN PLANTING:
DENSE SEDGE (CAREX DENSA)
DOUGLAS SPIRAEA (SPIRAEA DOUGLASII)
PACIFIC NINEBARK (PHYSOCARPUS CAPITATUS)
SPREADING RUSH (JUNCUS PATENS)
TWINBERRY (LONICERA INVOLUCRATA)

IRRIGATED LAWN

IRRIGATED LAWN W/ REINFORCED TURF (SUCH AS GRASSPAVE2)

NON-IRRIGATED ROUGH LAWN - SEED AREAS DISTURBED BY CONSTRUCTION

BARK MULCH ONLY

NOTE:
SEE L-402 FOR PLANTING NOTES.

NO.	REVISION	BY	DATE

DESIGNED BY: AH
DRAWN BY: NGQ
REV:

ONE INCH 1"
0
ONE INCH AT FULL SCALE.
IF NOT ONE INCH ADJUST
SCALE ACCORDINGLY

LCPS PLANTING PLAN

wallis engineering
215 W 4th Street, Suite 200
Vancouver, WA 98660
360.695.7041

PROJECT NO: 1460A
DATE: 4/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

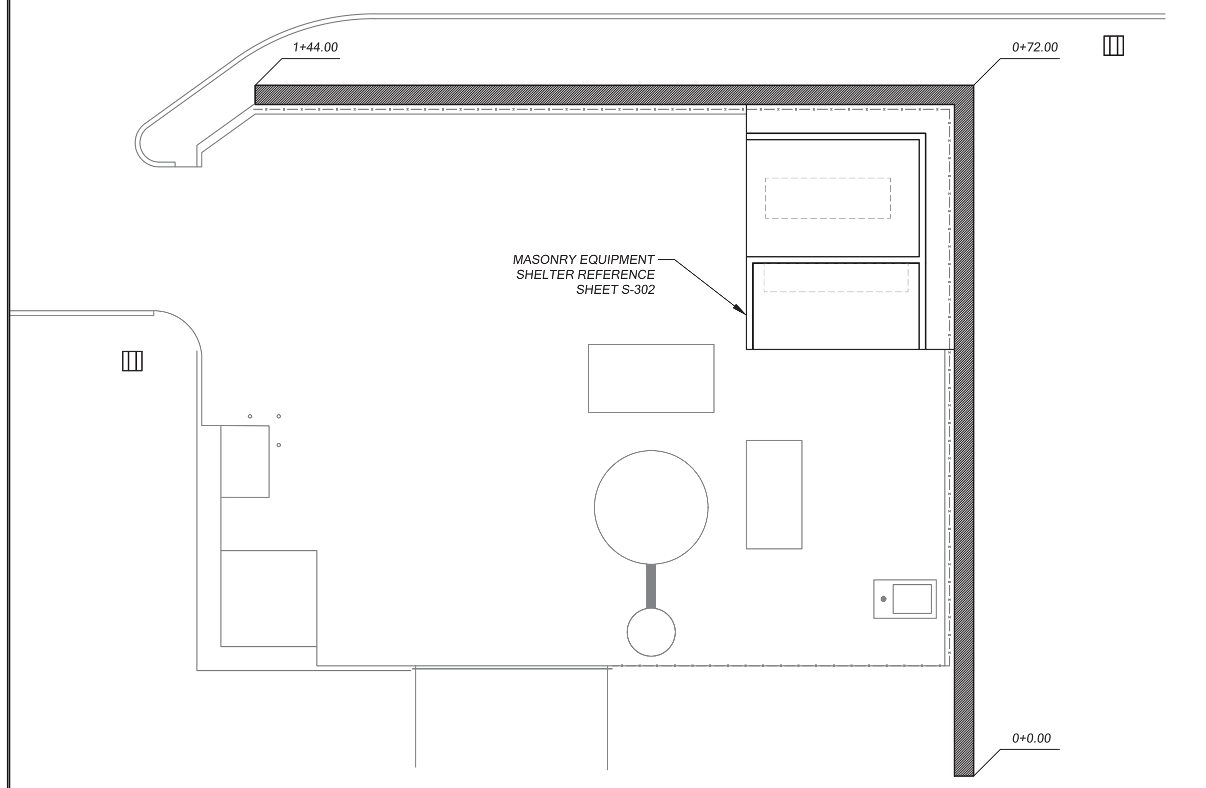
CITY PROJECT NO. S1000

DRAWING NO:

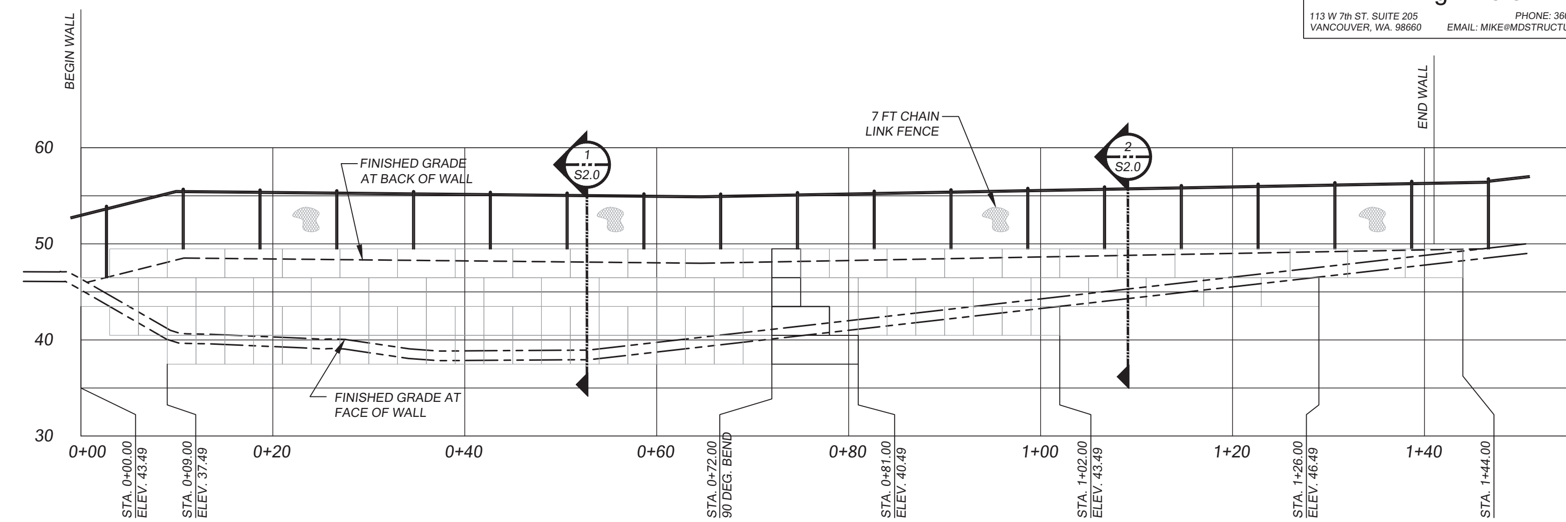
L-302

Exhibit C-2: Final Drainage Report

MD Structural Engineering
113 W 7th ST. SUITE 205
VANCOUVER, WA. 98660
PHONE: 360-433-9093
EMAIL: MIKE@MDSTRUCTURAL.COM



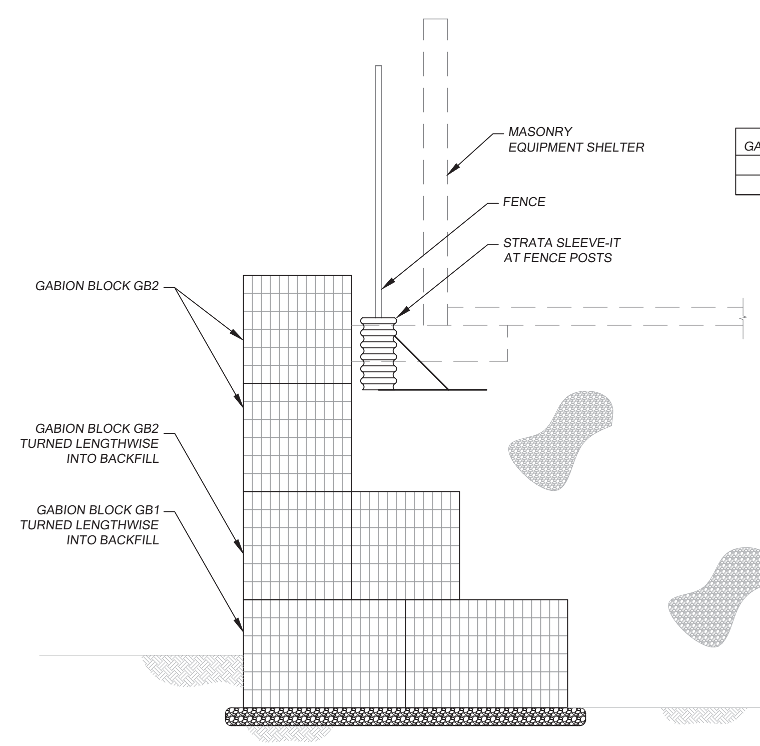
GABION BASKET RETAINING WALL PLAN



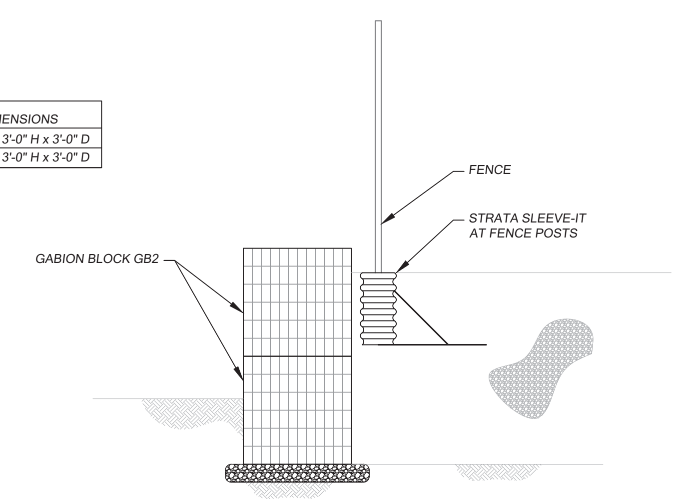
GABION BASKET RETAINING WALL ELEVATION

SCALE: 1" = 10'-0"

GABION BLOCK	DIMENSIONS
GB1	9'-0" L x 3'-0" H x 3'-0" D
GB2	6'-0" L x 3'-0" H x 3'-0" D



1 WALL SECTION
SCALE: 3/8"=1'-0"



2 WALL SECTION
SCALE: 3/8"=1'-0"

PRELIMINARY 60% DESIGN SUBMITTAL

NO.	REVISION	BY	DATE

DESIGNED BY: BK
DRAWN BY: BK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS RETAINING WALL PLAN, ELEVATION & DETAILS

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

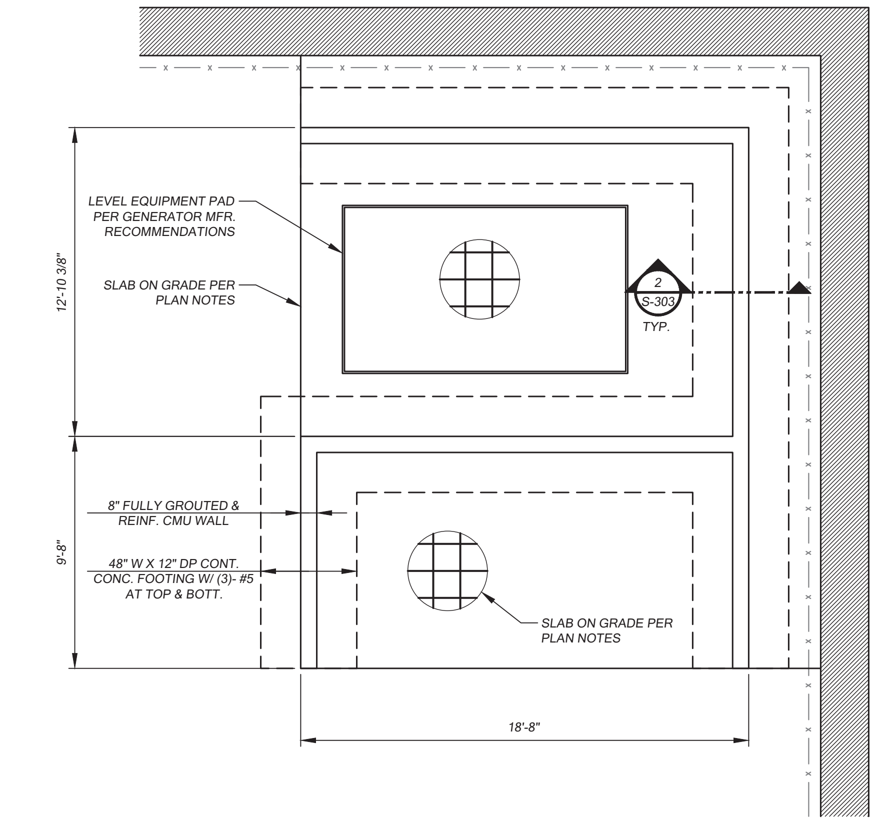
City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: S-301

MD Structural Engineering
113 W 7th ST. SUITE 205
VANCOUVER, WA. 98660
PHONE: 360-433-9093
EMAIL: MIKE@MDSTRUCTURAL.COM

PRELIMINARY 60% DESIGN SUBMITTAL

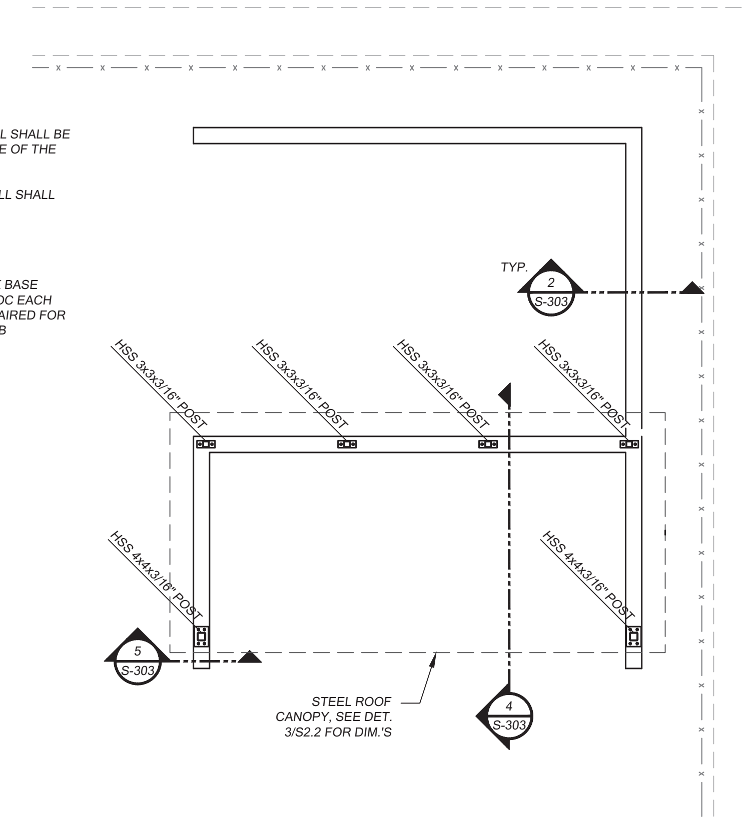


MASONRY EQUIPMENT SHELTER FOUNDATION PLAN

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

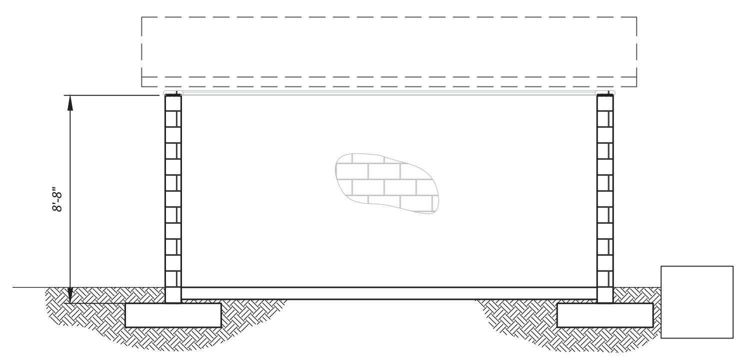
NOTES:

1. OPENINGS IN THE MASONRY WALL SHALL BE TRIMMED WITH (1) #5 BAR EA. SIDE OF THE OPENING.
2. ALL CELLS OF THE MASONRY WALL SHALL BE FULLY GROUTED.
3. SLAB ON GRADE:
   - 6" COMPACTED CRUSHED ROCK BASE
   - 6" CONCRETE SLAB W/ #4 @ 18" OC EACH WAY OR 6x6 W2.9-W2.9 WWF CHAIRED FOR 1-1/2" COVER FROM TOP OF SLAB



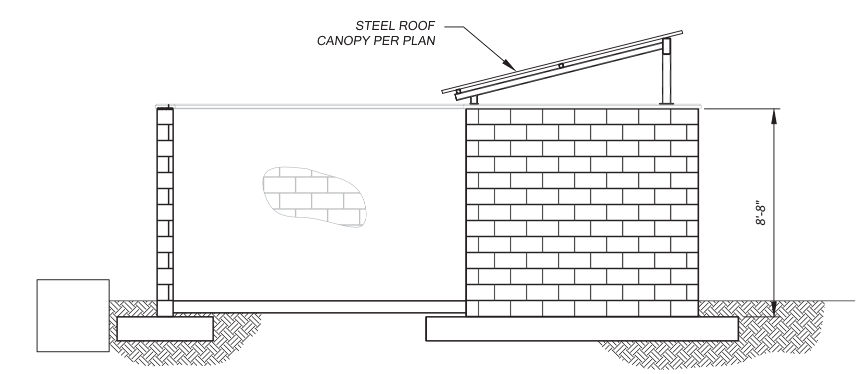
MASONRY EQUIPMENT SHELTER CANOPY PLAN

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



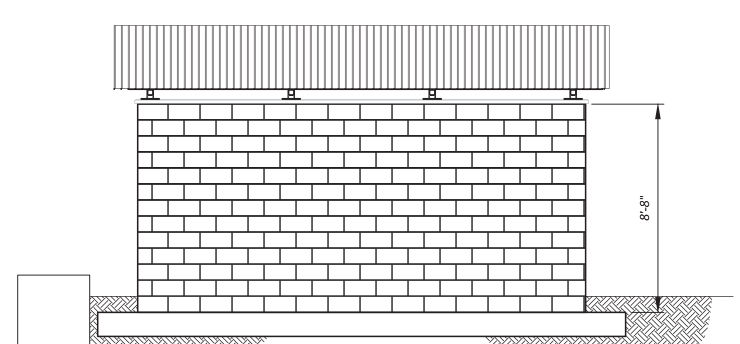
ENCLOSURE NORTH ELEVATION

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



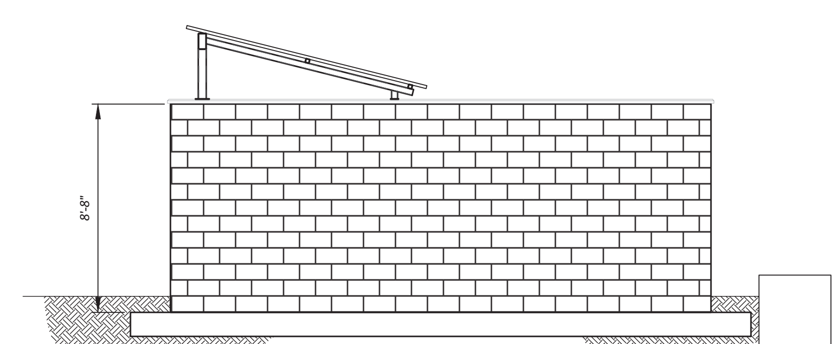
ENCLOSURE WEST ELEVATION

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



ENCLOSURE SOUTH ELEVATION

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



ENCLOSURE EAST ELEVATION

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

NO.	REVISION	BY	DATE

DESIGNED BY: BK
DRAWN BY: BK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS EQUIPMENT SHELTER PLANS & ELEVATIONS

wallis engineering
215 W 4th Street, Suite 200
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360.695.7041

PROJECT NO: 1460A
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LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
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Exhibit C-2 Final Drainage Report

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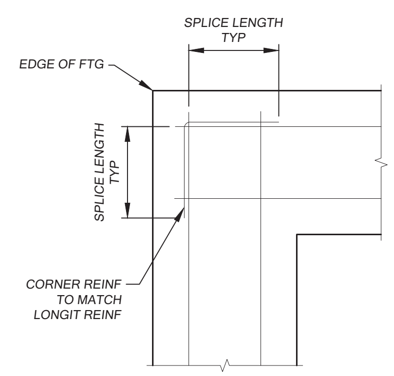
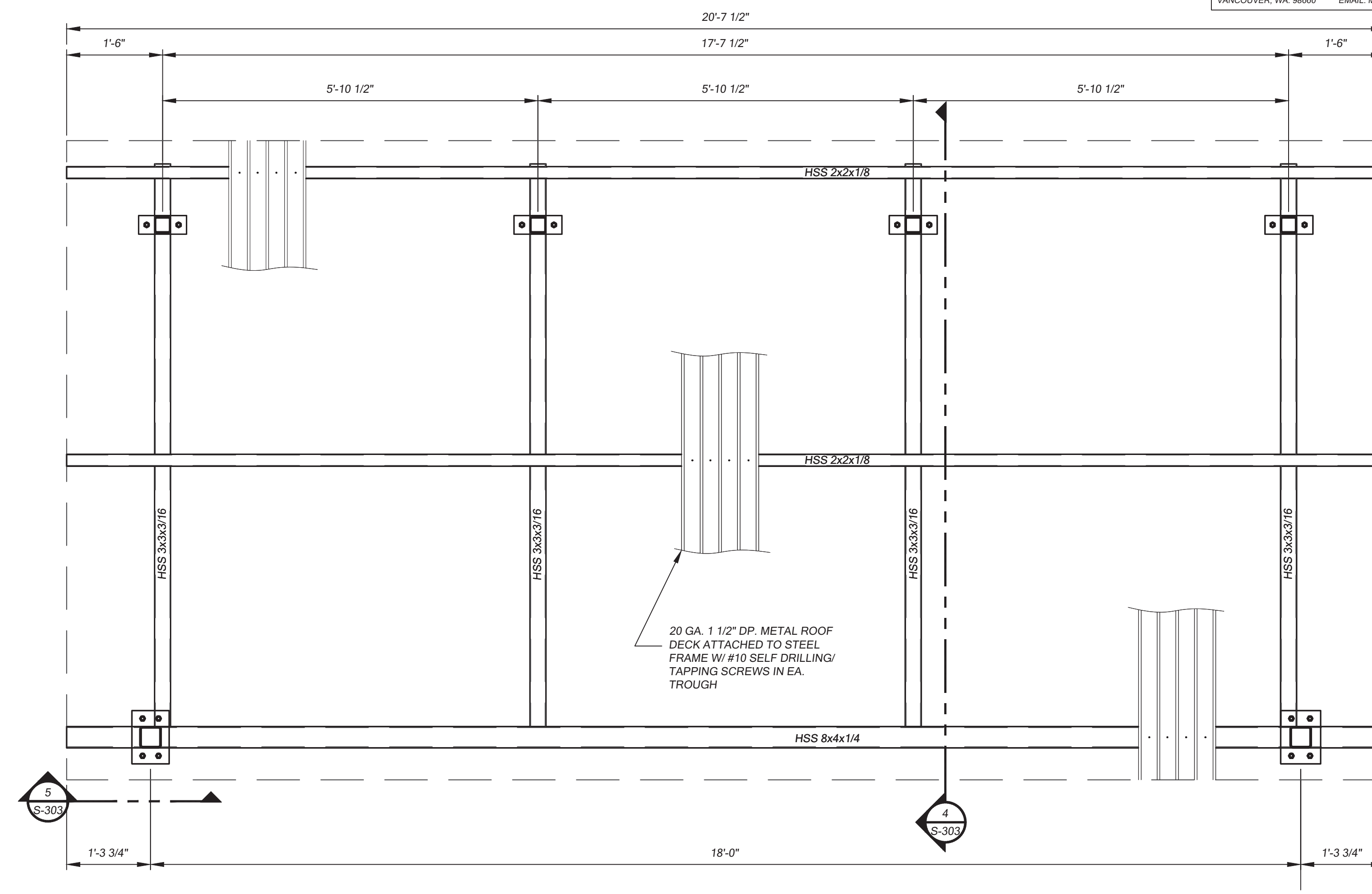


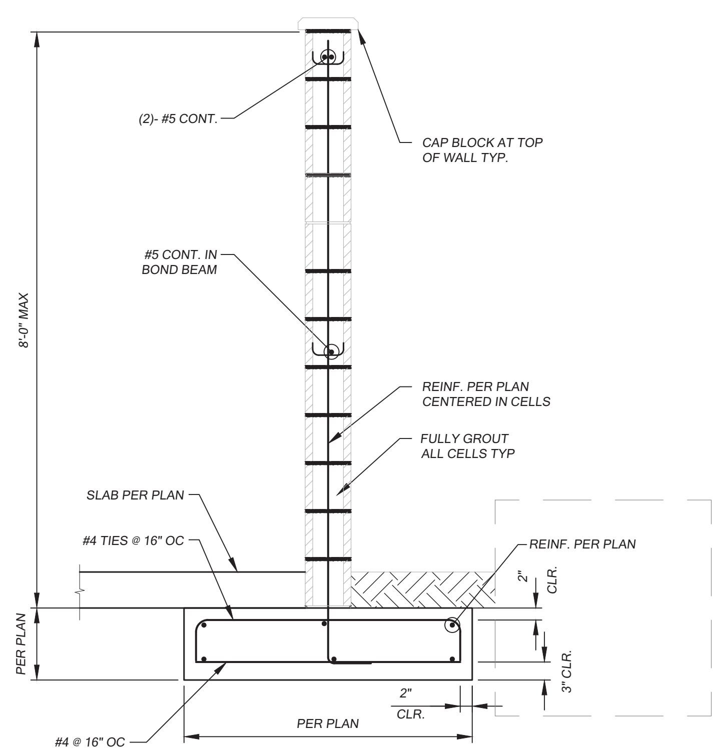
NOTES:

1. FOR SPLICE LENGTHS REFERENCE LAP SPLICE AND DEVELOPMENT LENGTH SCHEDULE PER S1.0.
2. FOR FOOTING REINFORCING, REFERENCE PLAN, SECTIONS AND DETAILS.
3. CORNER REINFORCING TO MATCH LONGITUDINAL FOOTING REINFORCING.

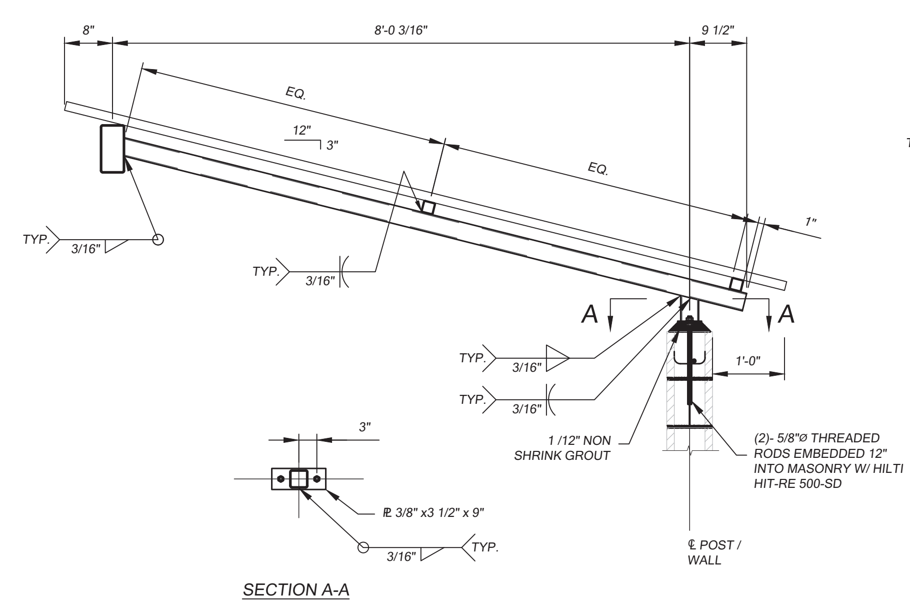
1 TYP CORNER REINF AT CONCRETE FOOTINGS
SCALE: NONE



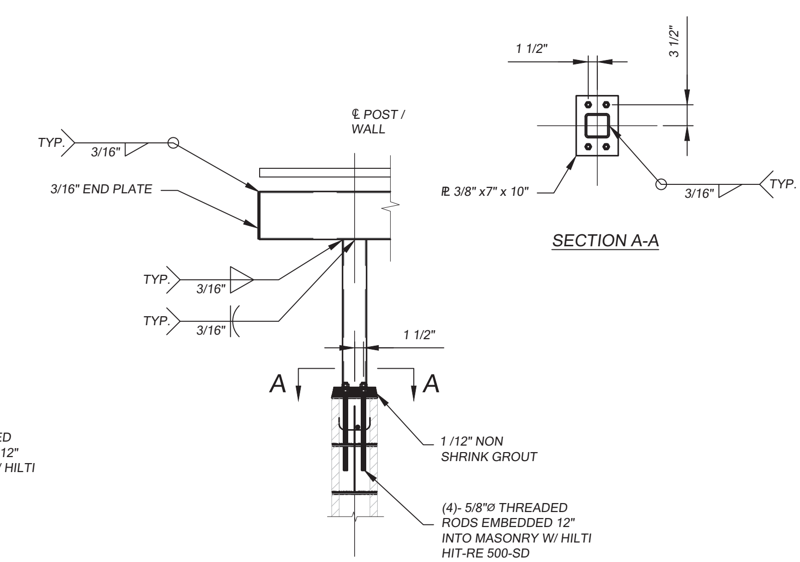
3 STEEL ROOF CANOPY
SCALE: NONE



2 TYPICAL WALL SECTION
SCALE: 3/4" = 1'-0"



4 CANOPY SECTION
SCALE: NONE



5 CANOPY SECTION
SCALE: NONE

PRELIMINARY 60% DESIGN SUBMITTAL

NO.	REVISION	BY	DATE

DESIGNED BY: BK
DRAWN BY: BK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

LCPS EQUIPMENT SHELTER ROOF STRUCTURE & DETAILS

wallis engineering
215 W 4th Street, Suite 200
Vancouver, WA 98660
360.695.7041

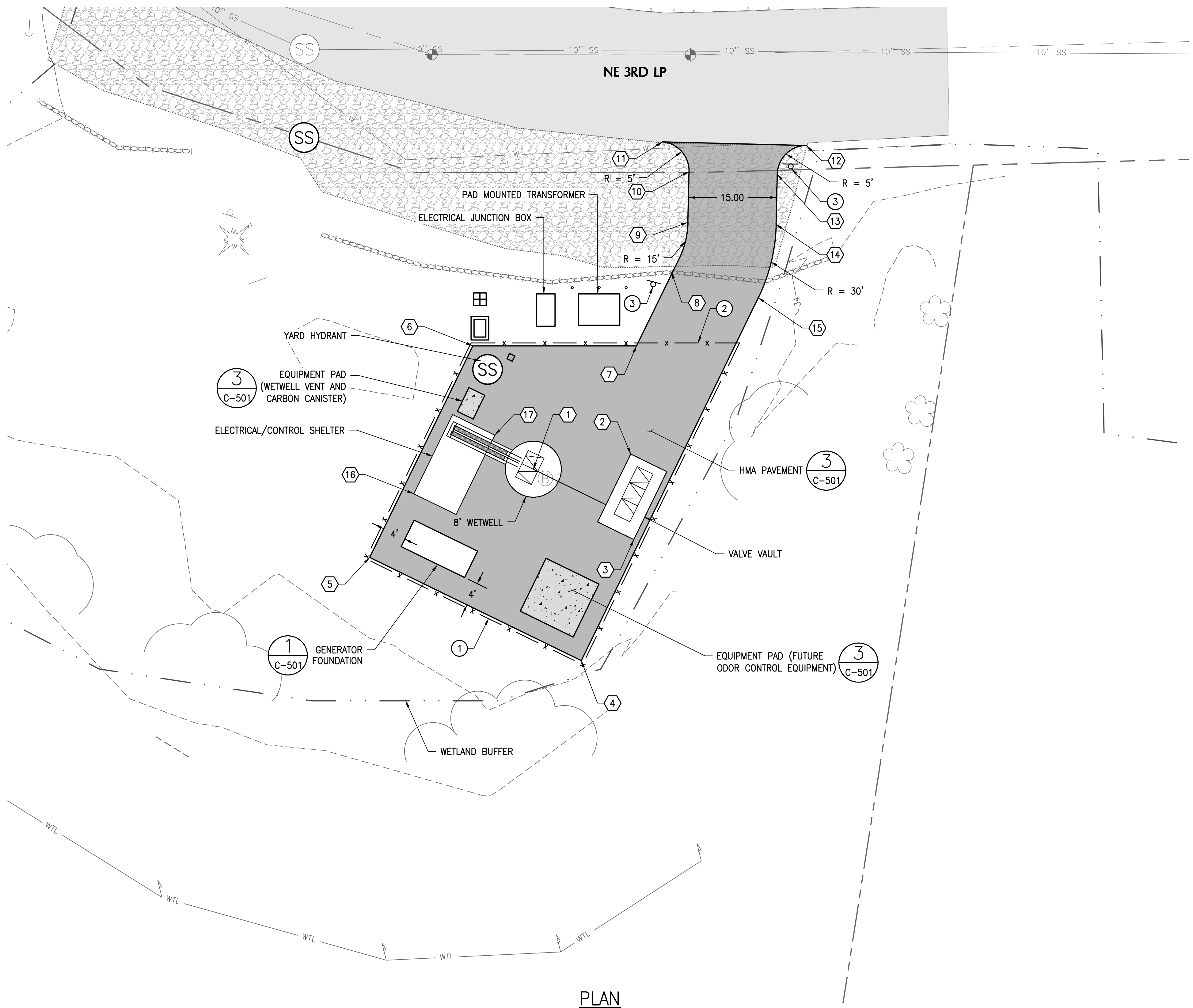
PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
S-303



PLAN

KEY NOTES

1. INSTALL 6' TALL BLACK PVC COATED CHAINLINK FENCE. POST TO BE PLACED AGAINST THE EDGE OF PAVEMENT.
2. INSTALL 6' TALL, 18' WIDE PVC COATED DRAIN LINK SLIDING GATE.
3. INSTALL "NO PARKING" SIGN

SURVEY STAKING COORDINATES

PT	DESCRIPTION	NORTHING	EASTING
1	WETWELL	98436.66	1157124.37
2	VALVE VAULT	98439.25	1157140.93
3	VALVE VAULT	98424.72	1157141.45
4	EDGE OF PAVEMENT	98404.14	1157132.53
5	EDGE OF PAVEMENT	98421.68	1157096.57
6	EDGE OF PAVEMENT	98457.63	1157114.11
7	EDGE OF PAVEMENT	98457.63	1157141.92
8	EDGE OF PAVEMENT	98470.16	1157147.87
9	EDGE OF PAVEMENT	98478.62	1157150.64
10	EDGE OF PAVEMENT	98487.24	1157150.84
11	EDGE OF PAVEMENT	98492.30	1157146.35
12	EDGE OF PAVEMENT	98491.67	1157170.81
13	EDGE OF PAVEMENT	98486.78	1157165.83
14	EDGE OF PAVEMENT	98478.28	1157165.63
15	EDGE OF PAVEMENT	98465.82	1157162.61
16	EQUIPMENT SHELTER	98432.49	1157104.07
17	EQUIPMENT SHELTER	98442.46	1157117.84

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

BPPS CIVIL SITE PLAN

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

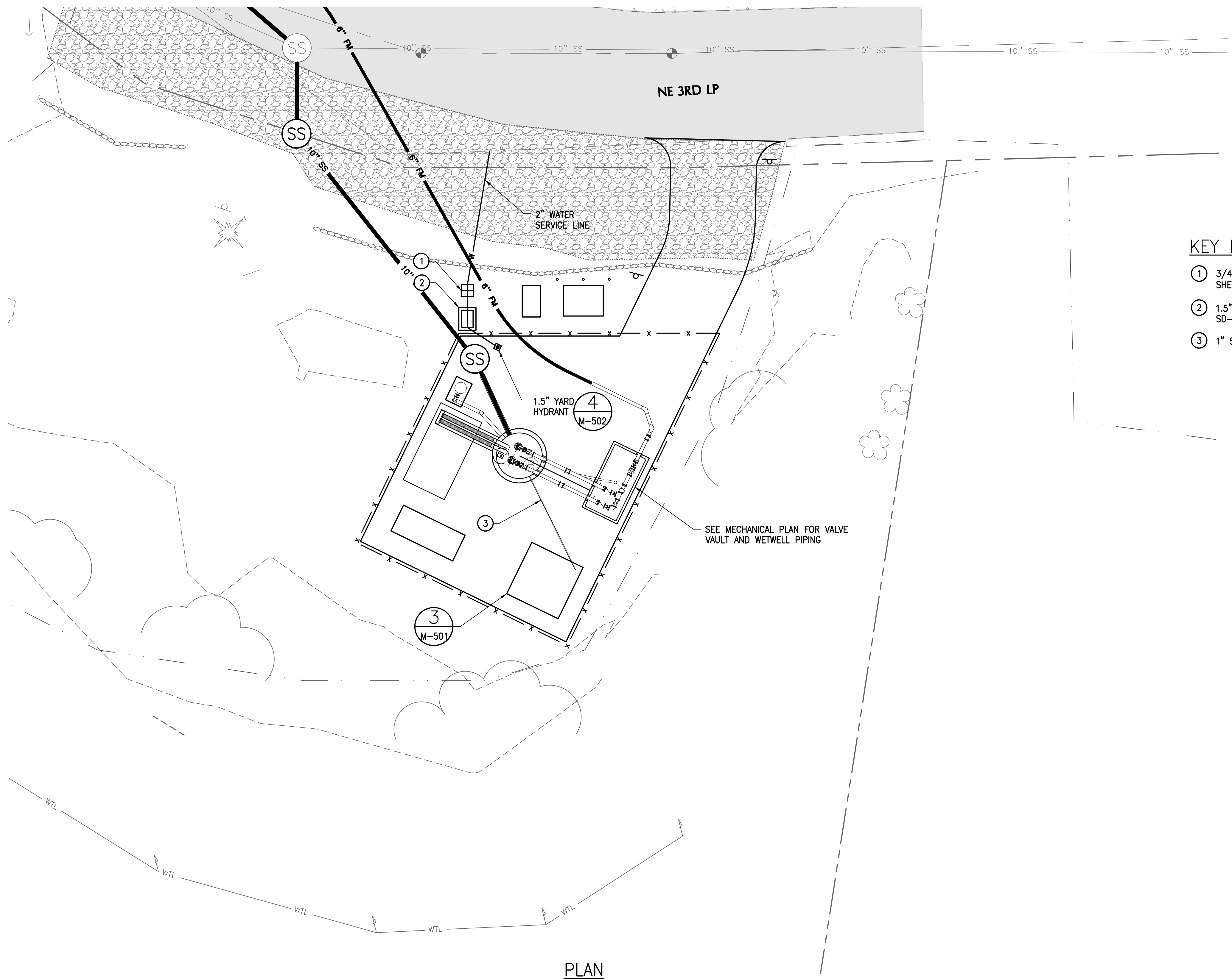
CITY PROJECT NO. S1000

DRAWING NO:

C-401

P:\14\1460A Camas Lacamas PS Imp\500 DWG\501 Plan Sheets\45 BPPS CIVIL SITE PLAN.dwg, 4/23/2019 12:31:17 PM, Chad Kays

Exhibit C-2: Final Drainage Report



PLAN

KEY NOTES

1. 3/4" WATER METER SEE CAMAS STANDARD DETAIL W6, SHEET SD-502
2. 1.5" RPBA PER CAMAS STANDARD DETAIL W24, SHEET SD-502
3. 1" SCH 40 PVC FOR FUTURE CHEMICAL INJECTION

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

BPPS UTILITY & PIPING PLAN

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
C-402

Exhibit C-2: Final Drainage Report

PLAN

SCALE IN FEET 0 10 20

GRADING LEGEND

GB	GRADE BREAK
→	FLOW DIRECTION

STRUCTURE/PAD ELEVATIONS

PT	DESCRIPTION	ELEVATION
1	WETWELL	35.86
2	VALVE VAULT	35.86
3	GENERATOR FOUNDATION	36.03
4	EQUIPMENT PAD	35.79
5	EQUIPMENT PAD	35.80

PERMIT SET

TIMOTHY C. ... STATE OF WASHINGTON 26182 REGISTERED PROFESSIONAL ENGINEER

NO.	REVISION	BY	DATE

DESIGNED BY: JW/WW
DRAWN BY: CK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

BPPS GRADING & DRAINAGE PLAN

wallis engineering

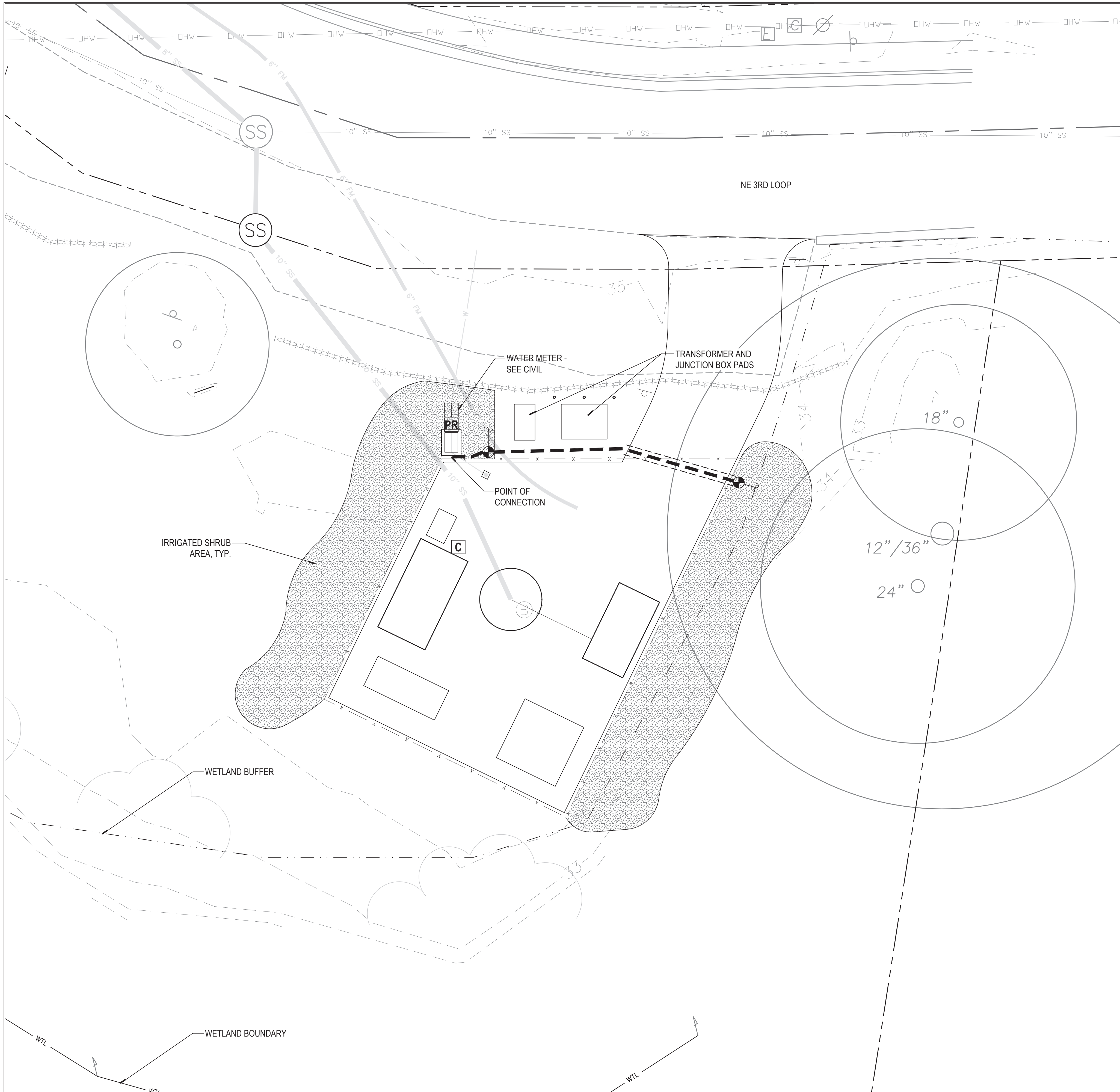
PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: C-403



N

SCALE: 1/8" = 1'-0"

0' 4' 8' 16'

Exhibit C-2: Final Drainage Report

GREENWORKS

GreenWorks, P.C.

Landscape Architecture
Environmental Design

24 NW 2nd Avenue, Suite 100
Portland, Oregon 97209
Ph:503.222.5612/F:503.222.2283
Email: info@greenworkspc.com

GREENWORKS PROJECT NO: 118060.2

L501 L502

PERMIT SET

IRRIGATION EQUIPMENT

SYMBOL	DESCRIPTION
M	3/4" WATER METER - SEE CIVIL
	REMOTE CONTROL VALVE - RAINBIRD PEB
	QUICK COUPLER - RAINBIRD 44-LRC
	BACKFLOW PREVENTION DEVICE (1.5" RPBA) - PER CITY OF CAMAS REQUIREMENTS - SEE CIVIL
C	IRRIGATION CONTROLLER - EXTERIOR WALL MOUNT IN SS BOX - RAINBIRD ESP-LXME
	MANUAL DRAIN VALVE
PR	PRESSURE-REDUCING VALVE -PER CITY OF CAMAS REQUIREMENTS - SEE 1/L5.01
	IRRIGATION LATERAL LINE
	IRRIGATION MAIN LINE
	IRRIGATION SLEEVE

CONTROL VALVE TARGET

1 — STATION NUMBER
L — AREA DESIGNATION: S = SHRUB
14" — FLOW IN GPM
1" — VALVE SIZE

IRRIGATED PLANTING AREA - HUNTER PRS30 - 12" POP-UP SPRAY BODIES WITH HUNTER PRO-SPRAY FIXED ARC NOZZLES

IRRIGATION NOTES

1. CALL UTILITIES TO LOCATE EXISTING SERVICES PRIOR TO EXCAVATION.
2. SYSTEM OPERATION AND DESIGN IS BASED ON 112 POUNDS OF PRESSURE AND XX GALLONS PER MINUTE AT THE SHUTOFF VALVE. THE CONTRACTOR SHALL VERIFY THE DESIGN PRESSURE AND VOLUME BEFORE INSTALLATION AND NOTIFY OWNER IF THERE IS A DISCREPANCY.
3. CONTRACTOR SHALL REFERENCE PLANTING PLAN(S) PRIOR TO INSTALLATION OF VALVES. LOCATE VALVES IN PLANTING BEDS WHEREVER POSSIBLE. ADJUST VALVE LOCATIONS TO ELIMINATE CONFLICT WITH PROPOSED PLANTINGS AND PLANTING PATTERNS.
4. VALVE LOCATIONS SHALL BE STAKED BY THE CONTRACTOR AND APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO INSTALLATION OF NEW IRRIGATION SYSTEM.
5. THE CONTRACTOR SHALL VERIFY THE DIMENSIONS AND LAYOUT OF ALL NEW PLANTING AREAS ON SITE BEFORE STARTING WORK AND IMMEDIATELY NOTIFY OWNER OF ANY DEVIATIONS FROM PLAN.
6. NEW TREE LOCATIONS SHALL BE STAKED BY THE CONTRACTOR AND APPROVED BY THE OWNER'S REPRESENTATIVE PRIOR TO INSTALLATION OF NEW IRRIGATION SYSTEM.
7. THE CONTRACTOR SHALL INSTALL THE IRRIGATION CONTROLLER(S) AT THE LOCATION(S) SHOWN ON THE DRAWINGS, ON THE SPECIFIED PEDESTAL PER THE MANUFACTURER'S RECOMMENDATIONS. THE CONTRACTOR SHALL VERIFY THE LOCATION WITH THE OWNER PRIOR TO INSTALLATION. THE CONTRACTOR SHALL EXTEND CONTROL WIRE CONDUIT FROM CONTROLLER AND DAYLIGHT SIX INCHES INTO PLANTING BED FOR INSTALLATION OF AUTOMATIC VALVE WIRES.
8. ALL BACKFLOW PREVENTION DEVICES SHALL BE LOCATED A MINIMUM OF 5'-0" AWAY FROM CURBS OR PAVING WHEREVER POSSIBLE.
9. MAIN AND LATERAL LINES MAY BE SHOWN DIAGRAMMATICALLY FOR CLARITY. MAIN AND LATERAL LINES SHOWN IN PAVED AREAS SHALL BE PLACED IN ADJACENT PLANTING BEDS UNLESS SPECIFICALLY SHOWN AS PASSING UNDER PAVING IN SLEEVING (SEE LEGEND FOR SLEEVE SYMBOL). THE CONTRACTOR MUST OBTAIN THE LANDSCAPE ARCHITECT'S APPROVAL BEFORE MAKING CHANGES IN ROUTING OF PIPE OR LOCATION OF VALVES.
10. THE CONTRACTOR IS RESPONSIBLE FOR COORDINATING AND PROVIDING AN APPROPRIATE POWER SUPPLY TO THE IRRIGATION CONTROLLER LOCATION.

NO.	REVISION	BY	DATE

DESIGNED BY: BD
DRAWN BY: BD
REV:

0 ONE INCH 1"
ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

BPPS IRRIGATION PLAN

wallis engineering
215 W 4th Street, Suite 200
Vancouver, WA 98660
360.695.7041

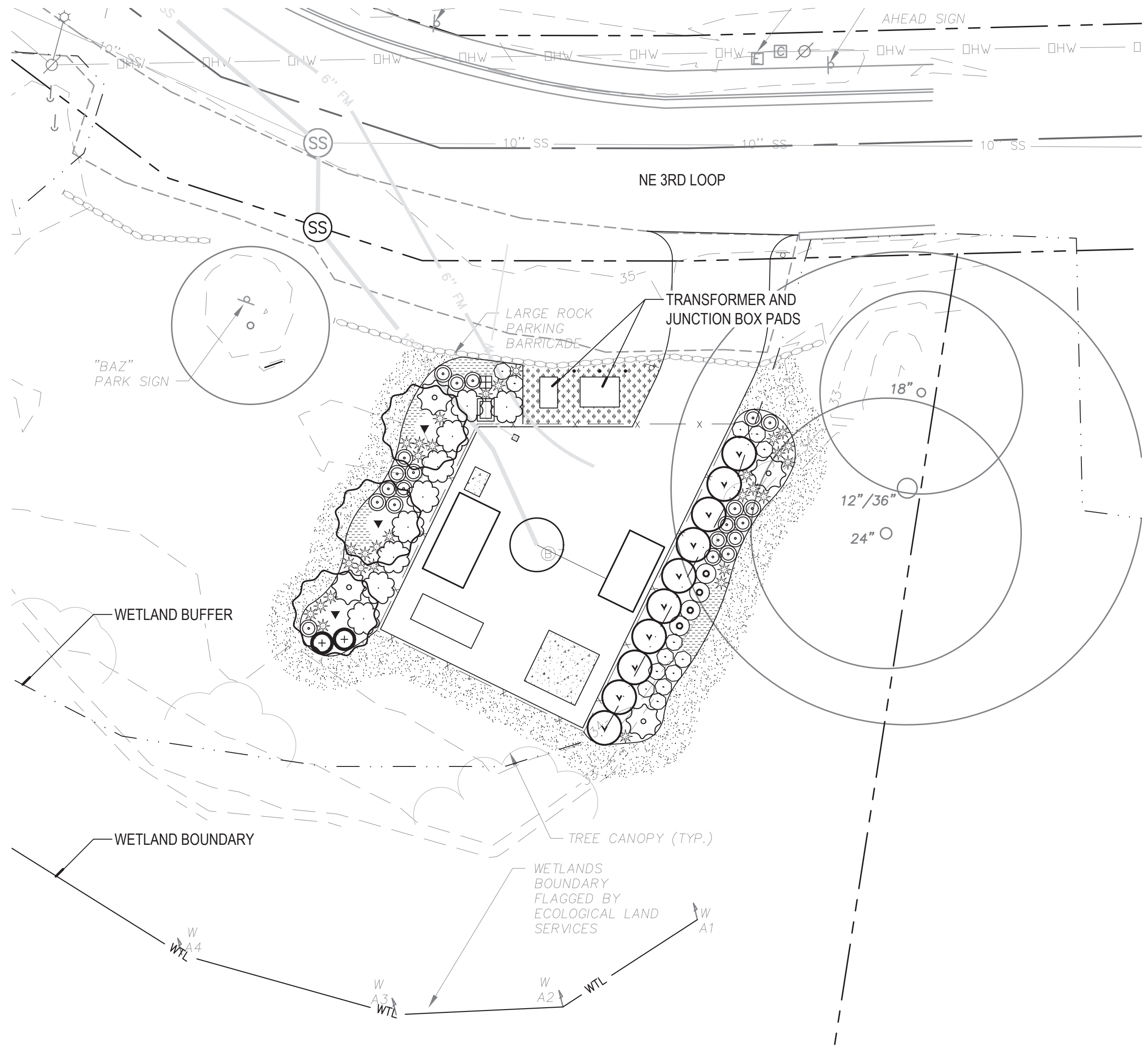
PROJECT NO: 1460A
DATE: 4/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO: L-401



N

SCALE: 1" = 16'-0"

0' 8' 16' 32'

GreenWorks, P.C.
Landscape Architecture
Environmental Design
24 NW 2nd Avenue, Suite 100
Portland, Oregon 97209
Ph:503.222.5612/F:503.222.2283
Email: info@greenworkspc.com

GREENWORKS PROJECT NO: 118060.2

PLANTING LEGEND

TREES L-503

EXISTING DECIDUOUS TREE TO REMAIN

EXISTING CONIFER TREE TO REMAIN

BOTANICAL NAME	COMMON NAME	SIZE & TYPE	SPACING	QTY.
CORNUS NUTTALLI X FLORIDA	EDDIE'S WHITE WONDER DOGWOOD	2", CAL, B&B	15' O.C.	3
RHAMNUS PURSHIANA	CASCARA	2" CAL, B&B	15' O.C.	3
PSEUDOTSUGA MENZIESII	DOUGLAS FIR	4-6" CAL., B&B	25' O.C.	2

SHRUBS / GROUNDCOVERS L-503

BOTANICAL NAME	COMMON NAME	SIZE & TYPE	SPACING	QTY.
GAULTHERIA SHALLON	SALAL	1 GAL. CONT.	3' O.C.	42
OSMANTHUS DELAVAYI	DELAVAY OSMANTHUS	5 GAL. CONT.	6' O.C.	19
POLYSTICHUM MUNITUM	WESTERN SWORD FERN	1 GAL. CONT.	30" O.C.	55
RIBES SANGUINEUM	RED-FLOWERING CURRANT	5 GAL. CONT.	6' O.C.	11
SPIRAEA BETULIFOLIA	WHITE SPIRAEA	1 GAL. CONT.	3' O.C.	62
SYMPHORICARPOS ALBUS	SNOWBERRY	1 GAL. CONT.	42" O.C.	30
VACCINIUM OVATUM	EVERGREEN HUCKLEBERRY	5 GAL. CONT.	4' O.C.	21
VIBURNUM TINUS 'COMPACTUM'	SPRING BOUQUET VIBURNUM	5 GAL. CONT.	5' O.C.	11
MAHONIA REPENS	CREEPING OREGON GRAPE	1 GAL. CONT.	24" O.C.	142

RAIN GARDEN PLANTING:
DENSE SEDGE (CAREX DENSA)
DOUGLAS SPIRAEA (SPIRAEA DOUGLASII)
PACIFIC NINEBARK (PHYSOCARPUS CAPITATUS)
SPREADING RUSH (JUNCUS PATENS)
TWINBERRY (LONICERA INVOLUCRATA)

IRRIGATED LAWN

IRRIGATED LAWN W/ REINFORCED TURF (SUCH AS GRASSPAVE2)

NON-IRRIGATED ROUGH LAWN - SEED AREAS DISTURBED BY CONSTRUCTION

BARK MULCH ONLY

PLANTING NOTES

1. CONTRACTOR SHALL PROVIDE PLANTING SOIL, SOIL AMENDMENTS, AND BARK MULCH TO THE COMPOSITION AND DEPTHS IN ACCORDANCE WITH THE DRAWINGS AND SPECIFICATIONS OF THE CONTRACT DOCUMENTS.
2. ALL PLANTS SHALL BE INSTALLED IN ACCORDANCE WITH THE DRAWINGS AND THE SPECIFICATIONS PROVIDED AS PART OF THE CONTRACT DOCUMENTS.
3. QUANTITIES ARE LISTED FOR THE CONTRACTOR'S CONVENIENCE ONLY. ALL COUNTS MUST BE VERIFIED BY THE CONTRACTOR. IN THE CASE OF A DISCREPANCY BETWEEN THE LEGEND AND THE PLAN, PLANTS INDICATED ON THE PLAN SHALL SUPERCEDE QUANTITIES LISTED IN THE LEGEND.
4. UTILITY LOCATIONS SHOWN ON PLANS MAY DIFFER FROM FIELD CONDITIONS. CONTRACTOR TO FIELD VERIFY ALL UTILITIES BEFORE INSTALLATION. CONFLICTS BETWEEN ANY EXISTING AND PROPOSED UTILITIES ARE TO BE BROUGHT TO THE ATTENTION OF THE OWNER'S REPRESENTATIVE IMMEDIATELY.

PERMIT SET

NO.	REVISION	BY	DATE

DESIGNED BY: NGQ
DRAWN BY: NGQ

0 ONE INCH 1"
ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

BPPS PLANTING PLAN

wallis engineering

PROJECT NO: 1460A
DATE: 4/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

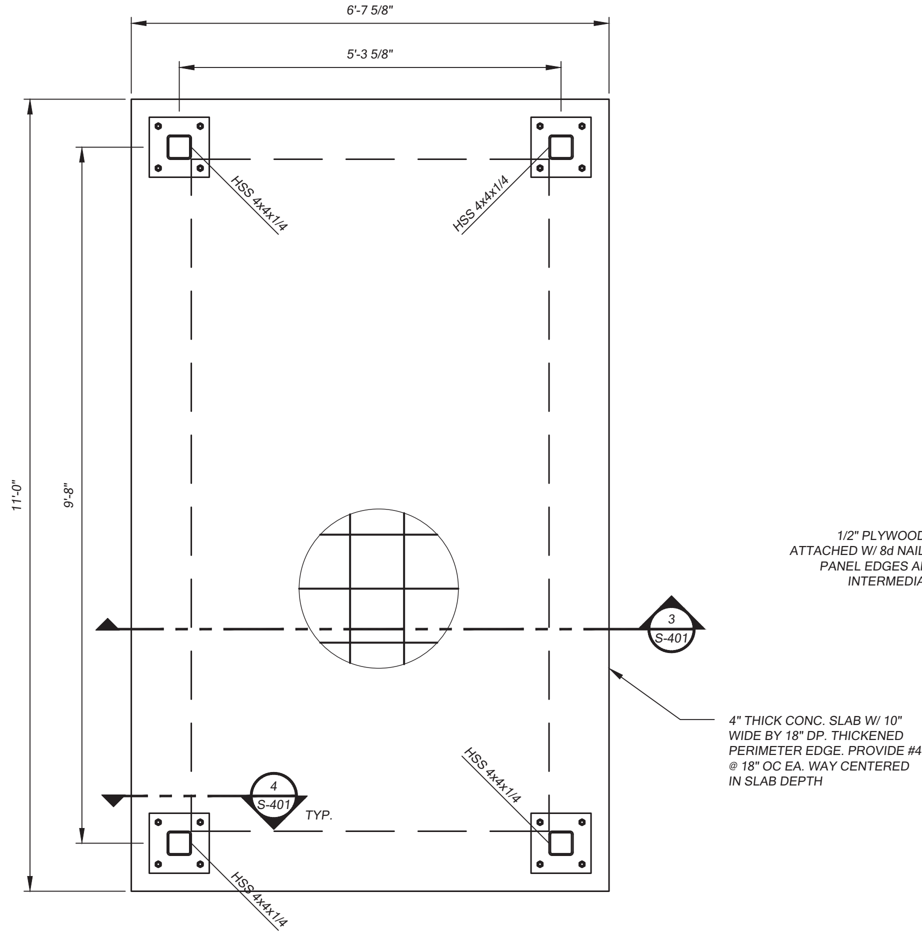
City of Camas WASHINGTON

CITY PROJECT NO. S1000

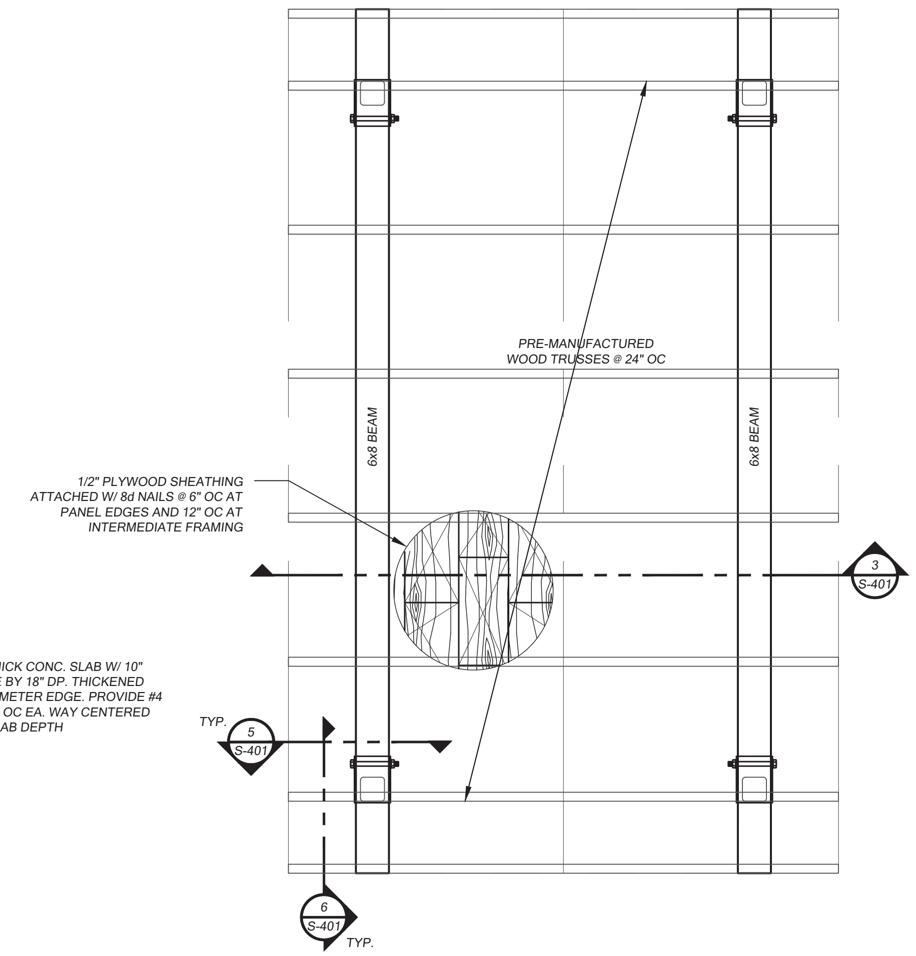
DRAWING NO: L-402

g:\Projects\118060.1_lacamas_creek_pump_station\02_production\01_CAD\01_Plot_Sheets\18060_PLNT.dwg 4/23/2019 3:33 PM

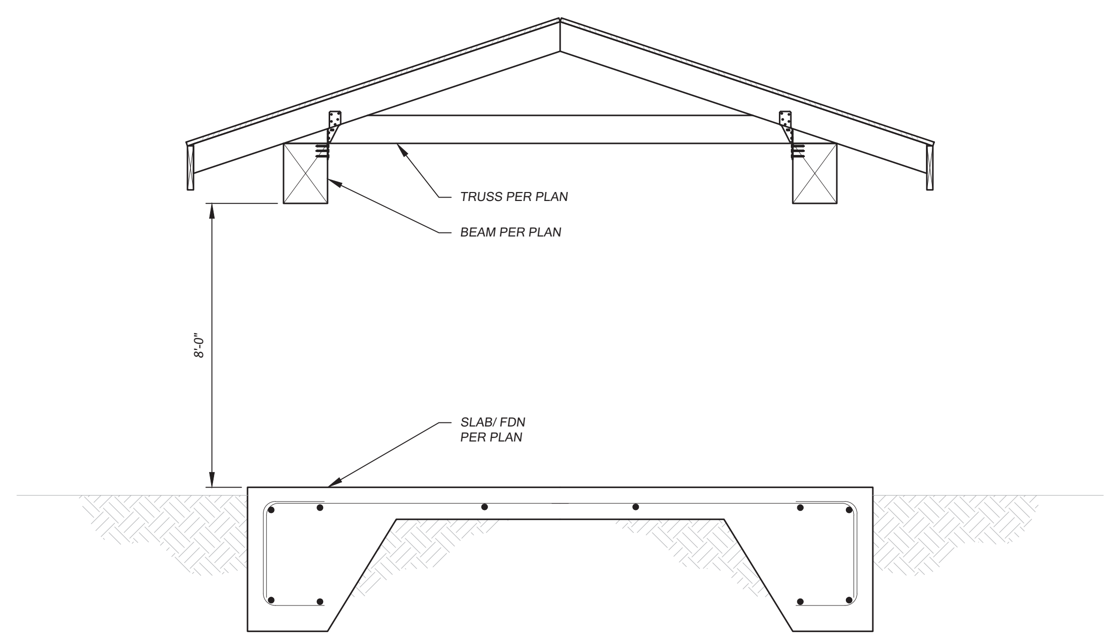
Exhibit C-2 Final Drainage Report



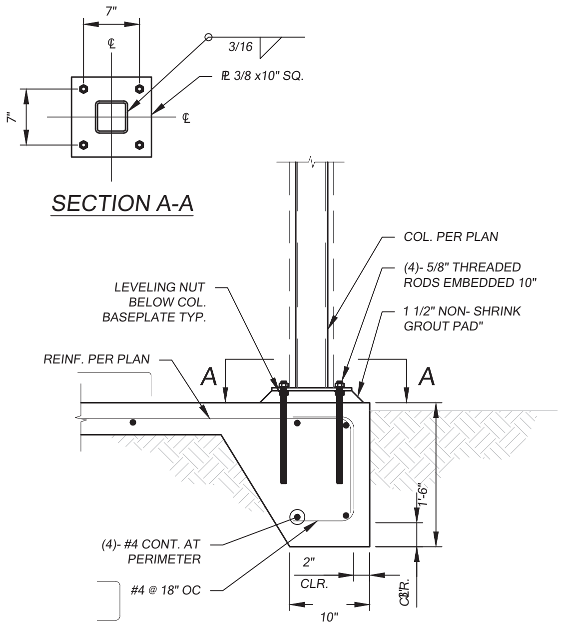
1 CONTROL PANEL SHELTER FOUNDATION
SCALE: 3/4" = 1'-0"



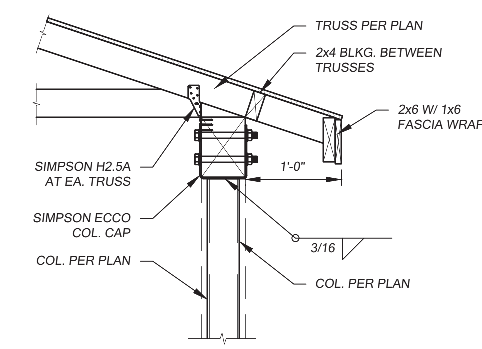
2 CONTROL PANEL SHELTER FRAMING PLAN
SCALE: 3/4" = 1'-0"



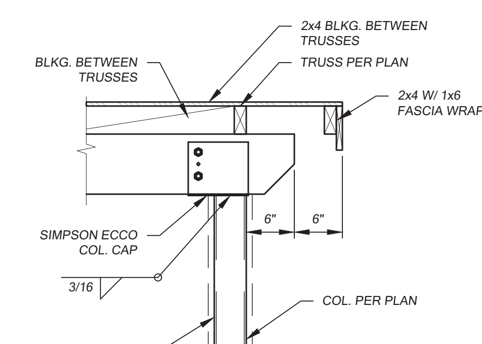
3 COL. TO BEAM CONNECTION
SCALE: 1" = 1'-0"



4 COL. TO FDN. CONNECTION
SCALE: 1" = 1'-0"



5 COL. TO BEAM CONNECTION
SCALE: 1" = 1'-0"



6 COL. TO BEAM CONNECTION
SCALE: 1" = 1'-0"

MD Structural Engineering
113 W 7th ST. SUITE 205 VANCOUVER, WA. 98660
PHONE: 360-433-9093
EMAIL: MIKE@MDSTRUCTURAL.COM

PRELIMINARY 60% DESIGN SUBMITTAL

NO.	REVISION	BY	DATE

DESIGNED BY: BK
DRAWN BY: BK
REV: XX

ONE INCH AT FULL SCALE. IF NOT ONE INCH ADJUST SCALE ACCORDINGLY

BPPS EQUIPMENT SHELTER PLAN & DETAILS

wallis engineering

PROJECT NO: 1460A
DATE: 3/2019

LACAMAS CREEK SANITARY SEWER PUMP STATION IMPROVEMENTS

City of Camas WASHINGTON

CITY PROJECT NO. S1000

DRAWING NO:
S-401

GRI
1101 Broadway, Suite 215
Vancouver, WA 98660
p | 360-213-1690 f | 360-213-1697
www.gri.com

April 18, 2019

W1241 GEOTECHNICAL RPT
(REVISED)

Wallis Engineering, PLLC
215 W 4th Street, Suite 200
Vancouver, WA 98660

Attention: Tim Shell

**SUBJECT: Geotechnical Investigation
Lacamas Creek Sewer Pump Station Improvements
Camas, Washington**

As requested, GRI completed a geotechnical investigation for the Lacamas Creek Sewer Pump Station improvement project located in Camas, Washington. The Vicinity Map, Figure 1, shows the general location of the site. The evaluation included review of existing geotechnical data, subsurface explorations, laboratory testing, engineering analyses, and preparation of this report. The report summarizes our findings and presents our preliminary conclusions and recommendations related to the planned improvements.

In addition to this geotechnical investigation, GRI completed infiltration testing for the proposed stormwater facility at Lacamas Creek Park. The results were provided in our March 15, 2019, report titled "Infiltration Testing, Lacamas Creek Sewer Pump Station Improvements, Camas, Washington." The infiltration report is included as an appendix to this document.

Unless otherwise noted, all elevations in this report refer to the National Geodetic Vertical Datum of 1929 (NGVD 29).

PROJECT DESCRIPTION

The existing Lacamas Creek Pump Station was constructed in 1958 and is located just east of 1642 NE 3rd Avenue in Camas on the west shoreline of Lacamas Creek. The pump station is nearing its design capacity, and many of its components have reached their useful life. The project includes replacing this pump station with a new pump station at Lacamas Creek Park (Lacamas Creek Park Pump Station) on the north side of NE 3rd Avenue and constructing a smaller pump station at Baz Park (Baz Park Pump Station) to serve homes and businesses in the NE 3rd Loop area and new sewer gravity and force mains. The locations of the proposed improvements are shown on the Site Plans, Figures 2 through 4.

Site grades at the Lacamas Creek Park Pump Station site will be raised up to 9 ft to match the adjacent grades of NE 3rd Avenue. The north and east sides of the fill will be retained with a modular-block or mechanically stabilized earth retaining wall. We understand this fill will be placed after the wet well is installed. The invert elevation for the wet well at Lacamas Creek Park Pump Station will be at about elevation 24 ft. The rim of the wet well and pipe-invert for the Baz Park Pump Station will be at elevations 35 and 23.5 ft, respectively. We assumed the base of each pump-station wet well will be about 5 ft below the pipe-invert elevation, necessitating excavations on the order of 25 ft at Lacamas Creek Park and 15 ft at the Baz Park site.

A jack-and-bore crossing is planned underneath NE 3rd Avenue in the location shown on Figure 3; the launching pit for the crossing will be located in Lacamas Creek Park just east of the proposed pump station site and the receiving pit will be located in the undeveloped area south of the NE 3rd Avenue embankment and north of the existing pump station. Gravity and sewer force mains will be installed with the jack-and-bore carrier pipe with an invert at about elevation 24 ft. The base of the launching and receiving pits will be about 20 and 15 ft deep, respectively.

New gravity sewer lines and manholes are planned from near the existing pump station site through the jack-and-bore crossing to the new Lacamas Creek Park Pump Station; from the new Lacamas Creek Park Pump Station east along the north side of NE 3rd Avenue; above the Lacamas Creek culvert to Manhole 7-3-2 located at the northwest corner of the intersection of NE 3rd Avenue and SE Crown Road; and from the proposed Baz Park Pump Station northwest along NE 3rd Loop about 250 ft to MH 7-4-1. New sewer force mains are planned along NE 3rd Loop between the Baz Park Pump Station and NE 3rd Avenue; from the proposed jack-and-bore crossing along the south side of the NE 3rd Avenue embankment to E 1st Avenue; in the paved right-of-way of E 1st Avenue between NE 3rd Avenue and NE Joy Street; and in the paved right-of-way of NE Joy Street between E 1st Avenue and NE 2nd Avenue. The gravity sewer lines will be less than 15 ft and the force mains less than 5 ft below existing grades. We understand these sewer lines will be constructed using open-cut, shored trenching methods.

A stormwater facility is planned at the Lacamas Creek Park site. As discussed above, recommendations for design of the stormwater facility are summarized in a supplemental report, which is included as Appendix C to this document.

SITE DESCRIPTION

Topography and Surface Conditions

The Lacamas Creek Park Pump Station will be constructed in the southern portion of Lacamas Creek Park and immediately north of NE 3rd Avenue. The ground surface at the location of the pump-station wet well is at elevation 41 ft and the overall topography in this area generally slopes downward to the southeast toward Lacamas Creek. The northern portion of the park site is covered with a gravel-surfaced parking lot separated from a grass area by large trees and a row of rocks.

In the project area, NE 3rd Avenue is on a fill embankment between the jack-and-bore crossing and the intersection of NE 3rd Avenue and NE 3rd Loop. The elevation of NE 3rd Avenue ranges from 46 ft at the jack-and-bore crossing to 40.5 ft at the intersection of NE 3rd Avenue and NE 3rd Loop. The embankment side slopes in this area are inclined at about 2H:1V (Horizontal to Vertical). The ground surface near the jack-and-bore receiving pit, located on the south side of the NE 3rd Avenue crossing, is about elevation 38 ft and slopes downward to the southeast toward the existing Lacamas Creek Pump Station.

The Baz Park Pump Station will be constructed about 60 ft south of NE 3rd Loop. The park site is vegetated with grass and relatively level at about elevation 34 ft. The ground surface slopes downwards to the west, south, and east at inclinations ranging from 3H:1V to 2H:1V to the Washougal River floodplain which is situated at about elevation 14 to 18 ft. This slope is vegetated with large deciduous and evergreen trees. We understand undocumented fill has been historically placed at the Baz Park site. The elevation of NE 3rd Loop, which consists of an asphalt-paved, two-lane roadway, ranges from about elevation 34 ft at Baz Park to about 42 ft at its intersection of with NE 3rd Avenue. Southwest of NE 3rd Loop, the ground slopes down to the Washougal River floodplain. Development along the northeast side of NE 3rd Loop is primarily residential, with some businesses located on NE 3rd Avenue.

East 1st Avenue and NE Joy Street are asphalt-paved roads with a single traffic lane in each direction and on-street parking. The E 1st Avenue road elevation increases to the west from about elevation 55 ft at its intersection of with NE 3rd Avenue to about elevation 68 ft at its intersection of with NE Joy Street. Site grades along NE Joy Street are relatively level at about elevation 68 to 70 ft. Land use in this area is primarily residential except for Louis Bloch Park, which is located at the northeast corner of the intersection between E 1st Avenue and NE Joy Street.

The 100-year flood elevation at Lacamas Creek Park varies from elevation 37.2 near NE 3rd Avenue to elevation 40.2 ft near the northern edge of the park. At Baz Park, the 100-year flood elevation is at elevation 35 ft. According to the project drawings, ordinary high water in the area is about elevation 13 ft.

Geology

Geologic information for the project site indicates subsurface conditions at Lacamas Creek Park, the jack-and-bore crossing, and Baz Park and along NE 3rd Loop consist of Pleistocene- and/or Holocene-age terrace deposits of the lower Washougal River (Evarts and O'Connor, 2008). The terrace deposits include unconsolidated open-work gravel, gravel with a sand matrix, or sand. Subsurface conditions along E 1st Avenue and NE Joy Street are mapped as catastrophic flood deposits consisting primarily of gravel. Basaltic andesite is mapped northeast of the project site and present at depth below the terrace deposits. Fill soils have been used to establish existing site grades along the NE 3rd Avenue embankment and at Baz Park. The mapped geology is generally consistent with the conditions observed in our borings.

SUBSURFACE CONDITIONS

General

Subsurface materials and conditions at the site were investigated between September 7 and September 12, 2018, with seven borings, designated B-1 through B-7. The borings were advanced at the approximate locations shown on the Site Plan, Figures 2 to 4, to depths of 6.6 to 46.5 ft below the existing ground surface using rotosonic drilling techniques. A detailed discussion of the field explorations and laboratory testing program completed for this investigation is provided in Appendix A. Logs of the borings are provided on Figures 1A through 7A. The terms and symbols used to describe the soils and rock encountered in the borings are defined in Tables 1A and 2A and on the attached legend. The results of laboratory testing are summarized in Table 3A and on the boring logs. Photographs of the rotosonic cores are included in Appendix B.

For discussion, we describe the subsurface conditions for each of the project areas shown in Table 1 below individually.

Table 1: PROJECT AREAS

Area	Borings
NE Joy Street and E 1st Avenue Force Main	B-1 and B-2
Lacamas Creek Park Pump Station and Jack-and-Bore Crossing	B-3 and B-4
NE 3rd Avenue Embankment	B-5
NE 3rd Loop Sewer and Baz Park Pump Station	B-6 and B-7

In the discussion of each area, the soil and rock conditions along the project alignment are grouped into categories based on their physical characteristics and engineering properties.

NE Joy Street and E 1st Avenue Force Main

Borings B-1 and B-2 were advanced in this portion of the alignment. The following units were encountered at this location:

1. **SILT**
2. **GRAVEL**

The following paragraphs provide a detailed description of these units.

1. SILT. Boring B-1 was advanced through the paved right-of-way of E 1st Avenue, while boring B-2 was advanced in a landscaped area between E 1st Avenue and the sidewalk. The pavement section at boring B-1 consists of 4 in. of asphalt concrete underlain by 4 in. of crushed-rock surfacing. Silt was encountered below the pavement section in boring B-1 and at the ground surface in boring B-2 and extends to depths of 3 to 5 ft. The silt contains trace to some fine- to coarse-grained sand and subrounded gravel. Cobbles were observed in the silt in boring B-1. Based on observations made during drilling, the consistency of the silt is soft to medium stiff. The natural moisture content of the silt ranges from 10 to 28%.

2. GRAVEL. Gravel was encountered below the silt in borings B-1 and B-2 and throughout the depths explored, between 6.6 and 7.5 ft. The gravel contains variable fine- to coarse-grained sand content, ranging from some sand to sandy, and variable silt content, ranging from trace silt to silty. Based on Standard Penetration Test (SPT) N-values of between 17 blows/ft and refusal, defined as more than 50 blows for 6 in. of sampler penetration, the relative density of the gravel ranges from medium dense to very dense and is typically medium dense to dense. The natural moisture content of the gravel ranges from 10 to 13%.

Lacamas Creek Park Pump Station and Jack-and-Bore Crossing

Boring B-3 was advanced near the proposed wet well for the Lacamas Creek Park Pump Station, and boring B-4 was advanced near the receiving pit for the proposed jack-and-bore crossing. The following units were encountered at this location:

1. **SILT**
2. **GRAVEL and GRAVELLY SAND**
3. **SAND**
4. **Decomposed BASALT**
5. **BASALT**

The following paragraphs provide a detailed description of these units.

1. SILT. Silt was encountered at the ground surface in borings B-3 and B-4 and extends to depths of 7 ft (elevation 35 ft) and 9 ft (elevation 26 ft), respectively. The silt contains variable fine- to coarse-grained sand content, ranging from trace to sandy, and trace to some gravel. A 12-in.-diameter boulder was encountered at a depth of 5 ft in boring B-4. Based on SPT N-values between 16 and 41 blows/ft, the relative consistency of the silt is very stiff to hard. However, it should be noted SPT N-values tend to overpredict the relative consistency of soils that contain gravel, cobbles, and boulders. The natural moisture content of the silt ranges from 6 to 23%.

2. GRAVEL and GRAVELLY SAND. Gravel and gravelly sand were encountered below the silt to a depth of 23 ft (elevation 19 ft) in boring B-3 and 25 ft (elevation 10 ft) in boring B-4. Gravelly sand was also encountered between depths of 35 and 37.5 ft (elevations 7 to 4.5 ft) in boring B-3. The unit typically consists of silty gravel and variable fine- to coarse-grained sand content ranging from a trace of sand to sandy and also includes silty, gravelly, sand. Cobbles were encountered throughout the unit and 1- to 2-ft-diameter boulders were encountered at depths of 14 ft in boring B-3 and 10 and 17.5 ft in boring B-4. During the supplemental infiltration investigation (refer to test pit log TP-1 in Appendix C), about 15 boulders up to 2.5 ft in diameter were observed in a 14.5-ft-deep test pit advanced about 60 ft north of the jacking pit. A photograph of the boulders encountered in the test pit is also included as Figure 8 in Appendix C. Based on SPT N-values ranging from 25 blows/ft to refusal, the relative consistency density of the gravel and gravelly sand unit ranges from medium dense to very dense and is typically medium dense to dense. However, it should be noted SPT N-values tend to overpredict the relative density of coarse soils that contain gravel, cobbles, and boulders. The natural moisture content of the gravel and gravelly sand unit ranges from 9 to 18%.

3. SAND. Sand was encountered between depths of 23 and 35 ft (elevation 19 to 7 ft) in boring B-3. The sand is fine to coarse grained and contains variable silt content ranging from some silt to silty. Based on SPT N-values of 18 and 19 blows/ft, the relative density of the sand unit is medium dense. The natural moisture content of the sand ranges from 9 to 20%.

4. Decomposed BASALT. Decomposed basalt was encountered in boring B-3 from a depth of 37.5 ft (elevation 4.5 ft) to the maximum depth explored, about 46.5 ft (elevation -4.5 ft), and in boring B-4 from 25 to 33 ft (elevation 10 to 2 ft). In the supplemental test pit advanced about 60 ft north of the jacking pit, decomposed basalt was encountered at a depth of 13 ft (elevation 26 ft). The decomposed basalt in boring B-3 and test pit TP-1 consists of silty sand to sandy silt, while the decomposed basalt in boring B-4 consists of sand with some silt and gravel- to cobble-sized pieces of weathered basalt. The sand is fine to medium grained. Based on SPT N-values of 27 blows/ft to refusal, the relative density/relative consistency of the decomposed basalt is medium dense to dense/very stiff to hard. The decomposed basalt has a natural moisture content of 14 to 40%.

5. BASALT. Basalt was encountered in boring B-4 from a depth of 33 ft (elevation 2 ft) to the maximum depth explored, 36.5 ft (elevation -1.5 ft). The basalt weathering is classified as predominantly decomposed, and the rock hardness ranges from extremely soft to very soft (R0 to R1).

NE 3rd Avenue Embankment

Boring B-5 was advanced in the NE 3rd Avenue embankment. The following units were encountered at this location:

1. **FILL**

The following paragraph provides a detailed description of this unit.

1. FILL. Boring B-5 was advanced through the paved right-of-way of NE 3rd Avenue. The pavement section at this location consists of 4 in. of asphalt concrete underlain by 18 in. of crushed-rock surfacing. The pavement section is underlain by fill to the maximum depth explored, about 21.5 ft. The fill typically consists of silty sand or sandy silt with trace to some gravel. The fill encountered between depths of 3 and 5 ft consists of silty gravel with some sand. Organic material was observed at a depth of 8.5 ft and between 17 and 21.5 ft. Based on SPT N-values of 8 to 11 blows/ft, the relative density of the sand and gravel fill is loose to medium dense, while the relative consistency of the silt fill is stiff based on an SPT N-value of 14 blows/ft. The natural moisture content of the fill ranges from 7 to 16%.

NE 3rd Loop Sewer and Baz Park Pump Station

Boring B-6 was advanced within the paved right-of-way of NE 3rd Loop and boring B-7 was advanced at the proposed location of the Baz Park Pump Station. The following units were encountered at these locations:

1. **FILL**
2. **SILT**
3. **GRAVEL**
4. **Decomposed BASALT**
5. **BASALT**

The following paragraphs provide a detailed description of these units.

1. FILL. Fill was encountered at the ground surface to a depth of 10 ft (elevation 24 ft) in boring B-7 advanced at the Baz Park Pump Station. The fill consists of 4 ft of silty gravel, with some fine- to coarse-grained sand, underlain by silt with some gravel, organics, metal fragments, and cobbles. Based on observations made during drilling, the relative density of the gravel fill is medium dense. Based on an SPT N-value of 10 blows/ft, the relative consistency of the silt fill is stiff. The natural moisture content of the gravel fill ranges between 8 and 11%, and the natural moisture content of the silt fill ranges from 7 to 23%.

2. SILT. Boring B-6 was advanced within the paved right-of-way of NE 3rd Loop, and the pavement section in boring B-6 consists of 4 in. of asphalt concrete over 16 in. of crushed rock. Silt was encountered beneath the pavement section to a depth of 5 ft in boring B-6. The silt contains some fine- to coarse-grained sand and gravel. Based on observations made during drilling, the relative consistency of the silt is stiff. The silt has a natural moisture content of 22%.

3. GRAVEL. Gravel was encountered below the fill in boring B-7 to a depth of 30 ft (elevation 24 to 4 ft) and below the silt in boring B-6 to the maximum depth explored, 16.5 ft. The gravel includes variable sand content, ranging from trace sand to sandy, and variable silt content, ranging from trace silt to silty. The sand is fine to coarse grained. Cobbles were encountered throughout the unit and 1- to 2-ft-diameter boulders were encountered at a depth of 11 ft in boring B-6 and depths of 13 and 20 ft in boring B-7. Based on SPT N-values between 25 blows/ft and refusal, the relative density of the gravel ranges from medium dense to very dense and is typically medium dense to dense. However, it should be noted that SPT N-values tend to overpredict the relative density of coarse soils that contain gravel, cobbles, and boulders. The natural moisture content of the gravel unit ranges from 5 to 13%.

4. Decomposed BASALT. Decomposed basalt was encountered between depths of 30 and 33 ft (elevation 4 to 1 ft) in boring B-7. The decomposed basalt consists of silty gravel with some sand. Based on refusal SPT N-values, the relative density of the decomposed basalt is very dense. The decomposed basalt has a natural moisture content of 7%.

5. BASALT. Basalt was encountered in boring B-7 from a depth of 33 ft (elevation 1 ft) through the maximum depth explored, 36.3 ft (elevation -2.3 ft). The basalt weathering is classified as predominately decomposed, and the rock hardness ranges from extremely soft to very soft (R0 to R1).

Groundwater

To evaluate groundwater levels, vibrating-wire piezometers were installed at elevations -1.5 and 0 ft in borings B-3 and B-7, respectively. The vibrating-wire piezometers were connected to a data-logger system that automatically recorded the groundwater level at regular intervals. Installation details for the piezometers are described in Appendix A. Groundwater-level data were measured in these borings between September 12, 2018, and April 11, 2019. During the time period measured, the groundwater level in boring B-3 fluctuated between about elevations 6.5 and 11.6 ft and the groundwater in boring B-7 fluctuated between elevations 8.3 and 16.5 ft. The groundwater data are presented on Figure 5.

We anticipate the groundwater level at the site will closely reflect the level of the nearby Lacamas Creek and Washougal River and fluctuate in response to the water levels in the adjacent creek and river as well as precipitation. Perched groundwater conditions may develop in the less-permeable, silty zones during periods of heavy precipitation.

CONCLUSIONS AND RECOMMENDATIONS

General

The subsurface explorations completed for this project indicate the proposed site is typically mantled with a thin layer of silt underlain by a gravel unit that includes cobbles and significant quantities of boulders. For example, in a 14.5-ft-deep test pit exploration advanced about 60 ft north of the proposed jacking pit, about 15 boulders up to 2.5 ft in diameter were encountered within the gravel unit. Fill was encountered along the NE 3rd Avenue embankment and at Baz Park. The gravel unit is typically underlain by decomposed basalt that becomes less weathered and decomposed with depth. Between September 12, 2018, and April 11, 2019, the groundwater level at the Lacamas Creek Park Pump Station site fluctuated between elevations 6.5 and 11.6 ft while the groundwater level at the Baz Park Pump Station site fluctuated between elevations 8.3 and 16.5 ft.

Excavations for the Lacamas Creek Park Pump Station wet well and gravity sewer will extend more than 20 ft below the existing ground surface, which will require shoring to complete construction and protect the nearby existing utilities and embankments. The presence of cobbles and boulders will be a significant consideration for installation of temporary shoring and installation of the NE 3rd Avenue crossing using jack-and-bore methods. Other geotechnical considerations include the presence of potentially liquefiable soils at the Lacamas Creek Park Pump Station site and the presence of moisture-sensitive soils that mantle the site and will be encountered in the excavations.

The following sections of this report summarize our conclusions and recommendations for consideration during design and construction of the pump stations and new sewer lines.

Earthwork

Site Preparation. Demolition within the limits of the new structures, structural fills, or pavement and hardscape areas should include removal of existing pavements and underground utilities that will be abandoned. Demolished hardscape materials, such as existing pavements, should be removed from the site. Alternatively, these hardscape materials can be reused as structural fill if processed to meet the gradation requirements specified in the Structural Fill section of this report.

The Lacamas Creek Park Pump Station and Baz Park Pump Station sites are mantled with a surficial layer of topsoil. Where vegetation is present, the ground surface should be stripped to remove the surface vegetation and rooted zone. Deeper stripping and grubbing depths should be anticipated to remove stumps and roots larger than about ½ in. associated with the larger trees present at the Lacamas Creek Park Pump Station site. Strippings will not be suitable for structural fill and should only be used in landscaped areas or removed from the site. The lateral limits of stripping and grubbing should extend at least 10 ft beyond improvement areas.

To reduce the risk of disturbing the near-surface soils during demolition and stripping and grubbing activities, we recommend using hydraulic excavators equipped with smooth cutting edges. Excavations made during demolition and stripping and grubbing should be backfilled with structural fill prepared in accordance with the Structural Fill section of this report.

Subgrade Preparation and Wet Weather Construction. Following site preparation activities and any additional excavation needed to reach the planned subgrade in areas to receive fill or other improvements, the exposed subgrade should be evaluated by a member of GRI's geotechnical engineering staff. Loose, soft, or disturbed areas should either be moisture conditioned and recompacted as structural fill (dry weather conditions only) or removed and replaced with imported structural fill. Proof rolling with a loaded dump truck or other heavy, rubber-tired vehicle may be part of the evaluation.

Near-surface soils that mantle the site consist primarily of silt or sand and gravel with considerable fines (i.e., material passing the No. 200 sieve) content. These soils are sensitive to moisture content and during wet ground or weather conditions can be easily disturbed, rutted, and weakened by construction activities. For this reason, we recommend, if possible, all earthwork activities be accomplished during the dry summer and early-fall months. If wet-ground conditions exist, we recommend making all excavations using large hydraulic excavators equipped with smooth cutting edges in lieu of bulldozers to prevent softening of the subgrade soils. Also, the contractor should plan the earthwork operations such that no construction equipment, e.g., bulldozers, dump trucks, etc., traffic the exposed, moisture-sensitive soils. This will require the placement of imported granular fill for working pads and/or haul roads as the excavation progresses. If the subgrade is disturbed during construction, soft, disturbed soils should be overexcavated to firm soil and backfilled with clean, granular materials.

During wet weather or ground conditions, it should be anticipated haul roads or granular work pads constructed of Select Granular Fill and described in this report will be necessary to provide access and protect the subgrade from damage due to construction traffic. In our opinion, a 12-in.-thick granular work pad should be sufficient to prevent disturbance of the fine-grained sand and silt subgrade by lighter construction equipment and limited traffic by dump trucks. Haul roads and other high-density traffic areas will require at least 18 to 24 in. of crushed rock to prevent subgrade deterioration. Haul-road requirements will be minimized if work is accomplished during the driest months of the year. The performance of haul roads can usually be improved by placing a woven geotextile over the fine-grained subgrade prior to placing the rock.

Structural Fill. Up to 9 ft of structural fill will be required to raise site grades at the Lacamas Creek Park Pump Station site. In our opinion, on-site soils free of organics, debris, and cobbles and boulders greater than about 6 in. in diameter are suitable for use in structural fills. As noted above, the on-site soils contain a significant amount of silt and fine-grained sand. These silty soils are moisture sensitive and can be placed and adequately compacted only during the dry summer months. For construction during the wet winter and spring months, site fills should be constructed using relatively clean granular materials.

In general, approved on-site or imported, organic-free, fine-grained sand and silty soils used to construct structural fills within areas of slopes, mass filling, and structures should be placed in 9-in.-thick lifts (loose) and compacted using medium-size (48-in.-diameter), segmented-pad rollers to a density not less than 95% of the maximum dry density determined by ASTM International (ASTM) D698. Pieces of rock and cobbles and boulders larger than about 6 in. should be removed from the fill prior to compaction. Fill placed in landscaped areas should be compacted to a minimum of about 90% of the maximum dry density determined by ASTM D698. In our opinion, the moisture content of fine-grained soils at the time of compaction should be controlled to within 3% of optimum. Moisture-conditioning of the on-site, fine-grained sand and silty soils will be required to achieve the recommended compaction criteria. All structural fills should extend a minimum horizontal distance of 5 ft beyond the limits of the structural improvements.

On-site or imported granular material used to construct structural fills or work pads during wet ground or weather can consist of relatively clean, granular material with a maximum particle size of 4 in. and not more than about 7% passing the No. 200 sieve (washed analyses), such as sand, sand and gravel, or crushed rock. The first lift of granular-fill material placed over silt subgrade should be in the range of 12 to 18 in. thick (loose), and subsequent lifts should be 12 in. thick (loose). All lifts should be compacted to at least 95% of the maximum dry density determined by ASTM D698 using a medium-weight (48-in.-diameter drum), smooth, steel-wheeled, vibratory roller. Generally, compaction should be achieved by a minimum of four passes with the roller.

Fill Settlement. We understand up to 9 ft of fill will be needed to achieve final site grades at the Lacamas Creek Park Pump Station site. We estimate total settlement due to placement of this fill will be in the range of 1 to 2 in. and a majority of the settlement will occur during fill placement. However, we recommend any mass grading to raise site grades be accomplished early in the construction schedule to allow the majority of settlement associated with fill placement to occur prior to installation of utilities, hardscapes, and buildings.

Excavations

General. We understand the bases of the Lacamas Creek Park Pump Station and the Baz Park Pump Station will each be at about elevation 19 ft, and the inverts for the gravity sewers and sewer force mains will be less than 15 and 5 ft below existing grades, respectively. The method of excavation and design of temporary shoring, trench support, and groundwater-management system are the responsibilities of the contractor. The means, methods, and sequencing of construction operations and site safety are also the responsibilities of the contractor. We recommend that the contractor submit an excavation and dewatering plan prepared by a Washington-registered professional engineer or hydrogeologist for review by the owner and engineer. The information provided below is for use by the owner and engineer and should not be interpreted to mean GRI is assuming responsibility for the contractor's actions, site safety, or design.

It has been our experience that good trench excavation, shoring, and backfilling procedures will reduce, but may not totally eliminate, settlement at the ground surface following backfilling. Pavement settlement can be further reduced by preventing water from ponding in the trench bottom, excavating and placing the pipe bedding in the closest practical sequence, and waiting until significant lengths of the trench are backfilled before installing the permanent pavement. Where used, pavement patches should be wider than the width of the trench, and the edges should be keyed into the existing pavement section.

Excavations and Groundwater Control. The explorations completed for this investigation typically encountered silt underlain by a gravel unit that includes cobbles and boulders. Fill consisting of sandy silt, silty gravel, or silty sand was encountered in boring B-5, which was advanced within the NE 3rd Avenue embankment. Decomposed or predominantly decomposed basalt was encountered in borings B-3, B-4, B-7, and TP-1 (see Appendix C) at elevations 4.5, 10, 4, and 26 ft.

Based on our experience with similar materials in the region, we anticipate the fill, silt, gravel, and decomposed basalt encountered within the anticipated depths of excavation can be excavated using conventional excavation methods, such as a large (e.g., a 75,000-lb machine with more than 270 hp) hydraulic excavator equipped with rock teeth (i.e., replacement hardened-steel points). Cobbles and boulders were encountered in the silt and gravel units in our explorations, and the contractor should be prepared to handle these over-size materials. In our opinion, the fill and near-surface silt soils should be classified as Type C soil according to current Occupational Safety and Health Administration (OSHA) regulations, while the underlying gravel unit should be classified as a Type B soil. All excavations should be safely sloped or shored in accordance with all applicable OSHA regulations.

The groundwater level at the locations of borings B-3 and B-7 was measured between September 12, 2018, and April 11, 2019. During the time period measured, the groundwater level in boring B-3 fluctuated between about elevation 6.5 and 11.6 ft and the groundwater level in boring B-7 fluctuated between elevation 8.3 and 16.5 ft, which are below the anticipated maximum depth of excavation. However, depending on the time of year, precipitation, and water levels in the adjacent Lacamas Creek and Washougal River, groundwater could be encountered in deeper excavations. Furthermore, we anticipate shallow perched-groundwater conditions may develop above the silty soils, especially during periods of wet weather.

Control of groundwater, if encountered, will depend on the soils and groundwater levels encountered in the excavation and the contractor/owner's approach to the work. To minimize dewatering requirements, we recommend construction of the deeper structures occur during the late-summer and early-fall months, when the groundwater and creek/river levels are near their seasonal lows and below the anticipated maximum depths of excavation. In our opinion, perched groundwater seepage entering from the sides of the shored excavations can be managed by pumping from sumps in the bottom of the excavation.

To provide a level and firm surface to place the wet-well base and facilitate any necessary dewatering, if required, we recommend placing a minimum1-ft thickness of free-draining base course at the bottom of the excavation beneath the structure. All soft or loose material present in the bottom of the excavation should be removed prior to placement of the base course and the prepared subgrade should be observed by GRI. The base-course material should consist of clean, open-graded, angular, crushed rock with a maximum size of about 2.5 in. and containing less than 2% passing the No. 200 sieve (washed analysis). Permeable ballast material meeting the requirements of Section 9-03.9(2) of the 2018 Washington State Department of Transportation (WSDOT) Standard Specifications can be used for this purpose. Base-course material should be placed in one loose lift and compacted until well-keyed. The open-graded base-course material may need to be capped with about 3 to 6 in. of well-compacted, 1½- or ¾-in.-minus, crushed rock to serve as a leveling course and choke off the surface of the coarser-graded stabilization material to facilitate placement of the wet-well base. If the subgrade consists of sand or silt, a woven geotextile fabric meeting the requirements for soil stabilization in Table 3 of Section 9-33.2 of the 2018 WSDOT Standard Specifications should be placed over the subgrade prior to placing the stabilization material.

Temporary Shoring. We understand the Baz Park Pump Station wet well and much of the gravity sewer line will be embedded less than 15 ft below existing site grades and the force mains will be embedded less than about 5 ft below existing site grades. Due to the relatively shallow embedment of these features, we anticipate excavations can likely be completed using typical shoring shields/trench boxes or possibly open-cut, sloped excavations. If the conveyance system is installed using trench shields, some sloughing or localized movement of the adjacent soil should be anticipated, particularly if granular materials, such as sand and gravel, are present. The risk of sloughing can be reduced by using good trenching and shoring practices, such as limiting the depth of the excavation before placing the shield, digging from the inside of the shield, placing fill material between the shield and the unsupported trench wall, and backfilling the excavation in the shortest possible sequence as each section of pipe is installed.

The wet well for the Lacamas Creek Park Pump Station will be embedded about 25 ft below existing site grades and the incoming gravity sewer will be embedded between 15 and 18 ft deep. Relatively deep excavations are also anticipated for the jack-and-bore-crossing launching and receiving pits, which will be located near the bases of the northern and southern extents of the NE 3rd Avenue embankment. Due to the required depth of excavation and/or the proximity of the existing embankment slope, we anticipate a relatively robust, braced shoring system will be required to complete construction of these project elements.

A potential shored-excavation approach for this project could include steel H-piles installed prior to excavating with lagging. Cobbles and boulders were encountered within the surficial silt and gravel unit. If encountered at the steel H-pile locations, these materials may preclude the advancement of the piles and need to be removed in order to install the piles to the required depth. Because of the potential for encountering cobbles and boulders, we anticipate that the H-pile, will need to be fitted with tip protection and that a large vibratory and/or impact hammer will be required to install the piles to the required depth. We anticipate it will not be feasible to install steel H-piles more than a few feet into the underlying decomposed basalt. Internal cross-bracing would be installed as the excavation advances. In lieu of internal cross-bracing, the soldier-pile shoring could also be restrained laterally by using tie-back or deadman anchors with tie rods. A self-braced slide-rail shoring system may also be an effective shoring method for the wet well and deep gravity-line excavations and is commonly used for similar applications.

The lateral earth pressure criteria shown on Figures 6 and 7 can be used for the design of a temporary, braced or anchored system. The earth pressures shown on Figure 6 assume a horizontal ground surface behind the wall, while the earth pressures shown on Figure 7 are appropriate for a 2H:1V backslope above the wall. The lateral earth pressures assume construction occurs when the groundwater table is located below the base of the excavation. Additional lateral pressures due to surcharge loads that may be placed behind the top of the shoring can be estimated using the guidelines provided on Figure 8. To minimize surcharge loads, we recommend excavation spoils and the material-laydown area be set back at least 10 ft from the edge of excavations.

Shoring walls at the back of the launching pit will serve to provide the reaction necessary to develop the thrust required for the jack-and-bore crossing operations. The available thrust capacity at the back wall of a shoring pit can be evaluated on the basis of a passive earth pressure based on an equivalent fluid weight of 250 pcf. This value provides a factor of safety of about 1.5 to limit the deflection of the back wall.

Backfill and Compaction Criteria. Backfill placed in utility-trench excavations and the annulus between the embedded structures and the excavation sides should consist of sand, sand and gravel, or crushed rock with a maximum size of up to 2½ in. and not more than 8% passing the No. 200 sieve (washed analysis). An example of a material that satisfies this requirement is Bank Run Gravel for Trench Backfill meeting the requirements of Section 9-03.19 of the 2018 WSDOT Standard Specifications. The granular material should be placed in lifts and compacted to at least 95% of the maximum dry density determined by ASTM D698. Lift thicknesses should be no thicker than 8 in. for hand-operated equipment and 12 in. for trackhoe-mounted, vibratory compactors (hoepack). The groundwater level should be maintained at least 2 ft below the backfill surface while the excavation is being backfilled. Flooding or jetting the backfill with water to achieve the recommended compaction should not be permitted.

Compaction techniques can significantly affect the actual lateral earth pressure. Overcompaction of the backfill behind cast-in-place concrete walls should be avoided. We recommend compacting backfill within 5 ft of concrete walls to at least 95% of the maximum dry density determined by ASTM D698 using hand-operated, vibratory-plate compactors. Heavy compactors and large pieces of construction equipment should not operate within 5 ft of any of the concrete walls to avoid the buildup of excessive lateral pressures.

Jack-and-Bore Crossing

Jack-and-bore construction methods are planned to complete the crossing under NE 3rd Avenue. We understand the crossing will consist of constructing a 36-in.-diameter carrier pipe; the invert elevation of the carrier pipe will be at about elevation 24 ft. The launching pit will be constructed on the north side of NE 3rd Avenue. Based on the conditions observed in our borings, subsurface conditions along the length of the crossing are anticipated to consist of silty gravel with trace to some sand; silty, gravelly sand; or silt with trace to some sand and gravel. Cobbles and boulders were encountered throughout the silt, sand, and gravel and should be anticipated along the alignment of the crossing. The groundwater table is anticipated to be within several feet of the elevation of the adjacent Lacamas Creek and Washougal River and below the invert elevation of the jack-and-bore crossing. The contractor should be provided a copy of the boring logs and core photographs for review to assist in the design of the jack-and-bore crossing and bid cost.

Removal of cobbles and boulders to advance the jack-and-bore pipe installation will likely cause overexcavation beyond the pipe diameter. The resulting void spaces in the soil surrounding the pipe can result in post-construction subsidence at the ground surface. This settlement could occur soon after or many years after installation of the carrier pipe and may necessitate repaving of NE 3rd Avenue. Grouting to fill the annulus can reduce the amount of subsidence. The grouting would be completed by pumping grout into holes drilled through the installed pipe. However, granular material may begin to cave before grouting can be completed, limiting the effectiveness of post-installation grouting. We recommend the contractor monitor ground-surface settlement during the construction of the jack-and-bore crossing to confirm the construction process is not resulting in excessive loss of ground. If excessive settlement is observed, installation of the carrier pipe should cease until the cause of the increased settlement is evaluated and mitigated.

Seismic Design Considerations

General. The following section of this report presents seismic design parameters for design of the Lacamas Creek Park Pump Station and Baz Park Pump Station sites. A discussion of the liquefaction and lateral spreading hazard at the Lacamas Creek Park Pump Station site is also provided.

Seismic Design Parameters. We understand the project will be designed in conformance with the 2018 International Building Code (IBC) and American Society of Civil Engineers (ASCE) document 7-16, Minimum Design Loads for Buildings and Other Structures (ASCE 7-16). The IBC and ASCE design methodologies use two spectral response coefficients, S_S and S_1, corresponding to periods of 0.2 and 1.0 sec to develop the Risk-Targeted Maximum Considered Earthquake (MCE_R) response spectrum. The spectral response parameters were obtained from the U.S. Geological Survey (USGS) Hazard Response Spectra Curves for the coordinates 45.5890° N latitude and 122.3919° W longitude for the Lacamas Creek Park Pump Station site and 45.5875° N latitude and 122.3879° W longitude for the Baz Park Pump Station site. The S_S and S_1 parameters identified for both sites are 0.80 and 0.35 g, respectively, for Site Class B/C boundary conditions. To establish the ground-surface MCE_R spectrum, these bedrock spectral parameters are adjusted for site class using the short- and long-period site coefficients, F_a and F_v, in accordance with Section 11.4.3 of ASCE 7-16. The design-level response spectrum is calculated as two-thirds of the ground-surface MCE_R spectrum.

Based on our review of the subsurface conditions disclosed in boring B-3 and the anticipated ground motions, we identified a potential risk for seismically induced liquefaction at Lacamas Creek Park. According to Section 20.3.1 of ASCE 7-16, soil profiles containing potentially liquefiable soil would classify as Site Class F and require a site-specific response analysis to determine the response spectrum. An exception to this requirement is provided in Section 20.3.1 of ASCE 7-16 for structures that have a fundamental period less than or equal to 0.5 sec. For structures with a fundamental period less than or equal to 0.5 sec, ASCE 7-16 allows for the site coefficients to be equal to the site coefficients if the soil profile were not susceptible to liquefaction. We have assumed the structures at the Lacamas Creek Park Pump Station site will have a fundamental building period of less than 0.5 sec and the site coefficients can be based on Site Class D, which is representative of the soil profile for non-liquefied conditions. Based on the conditions observed in boring B-7, the near-surface soils at Baz Park are representative of Site Class D. The MCE_R-level and design-level, 5%-damping response spectra coefficients for both the Lacamas Creek Park and Baz Park sites are tabulated in Table 2 below.

Table 2: 2018 IBC SEISMIC DESIGN RECOMMENDATIONS

Seismic Variable	Recommended Value
Site Class	D
MCE_R 0.2-Sec Period Spectral Response Acceleration, S_{MS}	0.96 g
MCER 1.0-Sec Period Spectral Response Acceleration, S_{M1}	0.68 g
Design 0.2-Sec Period Spectral Response Acceleration, S_{DS}	0.64 g
Design 1.0-Sec Period Spectral Response Acceleration, S_{D1}	0.45 g

Liquefaction. Liquefaction is a process by which saturated, granular materials, such as sand, and non-plastic and low-plasticity silts temporarily lose strength during and immediately after a seismic event. Liquefaction occurs as seismic shear stresses propagate through saturated soil and distort the soil structure, causing loosely packed groups of particles to contract or collapse. If drainage is impeded and cannot occur quickly, the collapsing soil structure increases the pore-water pressure between the soil grains. If the pore-water pressure increases to a level approaching the weight of the overlying soil, the granular layer temporarily behaves as a viscous liquid rather than a solid. At the Lacamas Creek Park site, liquefaction will likely result in settlement of the proposed improvements and lateral spreading deformations towards Lacamas Creek.

The potential for liquefaction at the Lacamas Creek Park site was evaluated using the simplified procedure as described by Boulanger and Idriss (2014). The simplified procedure compares the cyclic shear stresses (referred to as the CSR) induced within a soil profile during an earthquake with the ability of the soil to resist these stresses (referred to as the CRR). The stresses induced within the profile are estimated on the basis of earthquake magnitude and the accelerations within the profile. The ability of the soil to resist these stresses is based on their strength as characterized by SPT N-values or CPT tip resistances normalized for overburden pressures and corrected for other factors, such as fines content, i.e., silt and clay materials passing the U.S. No. 200 sieve. The factor of safety against liquefaction can then be calculated as the CRR/CSR. As the factor of safety against liquefaction decreases to 1.0, there is an increased risk of cyclic strength loss and liquefaction-induced settlement.

Section 11.8.3 of ASCE 7-16 requires liquefaction and cyclic softening be evaluated for site peak ground acceleration, earthquake magnitude, and source characteristics consistent with the Geometric Mean Maximum Considered Earthquake (MCE_G) peak ground acceleration (PGA_M). The liquefaction analyses were conducted using magnitude-acceleration pairs consistent with the 2014 USGS disaggregation of seismic sources that contribute to the site's seismic exposure. The 2014 USGS National Seismic Hazard Maps form the basis for the 2018 IBC and ASCE 7-16. A moment magnitude (M_w) of 6.6 was used for a shallow crustal earthquake source and M_w 9.0 was used for a Cascadia Subduction Zone earthquake. Mean peak ground-surface accelerations of 0.45 and 0.42 g were used for the local crustal and subduction-zone earthquakes, respectively. The recommended peak ground accelerations meet the intent of ASCE 7-16. For the purpose of our liquefaction studies, we assumed the water table is at elevation 13 ft, which corresponds to ordinary high water at the site.

Our analysis indicates the medium-dense sand located below the groundwater to about elevation 7 ft at the Lacamas Creek Park site has a factor of safety less than 1.0 and is potentially liquefiable as a result of the level of seismic loading required by the ASCE 7-16. We estimated liquefaction-induced free-field settlements using an empirical method described by Yoshimine et al. (2006), which is based on case histories of areas that have experienced liquefaction. Using this empirical methodology, we estimate liquefaction-induced settlement as a result of the design earthquake at the Lacamas Creek Park site will be on the order of 2 in. Due to the relatively thick layer of non-liquefiable soils that mantle the site, the potential for differential seismic settlement across the site can be estimated as approximately half of the total settlement. Associated lateral-spreading movements toward the river would also contribute to vertical ground-surface displacements at the site and are not included in the estimates provided above.

Lateral Spreading. The potential for lateral spreading at the Lacamas Creek Park site was evaluated using an empirical methodology developed by Zhang et al. (2004). Using this method, we estimate lateral spreading at the location of the Lacamas Creek Park Pump Station site may be on the order of 0.5 to 1 ft for the 2018 IBC code-based earthquake. The method used to estimate the seismically induced horizontal ground displacement is empirical and consequently does not provide a precise estimate of the actual ground movement that may occur. Seismic events of a lesser magnitude or of the same magnitude but occurring at a greater epicentral distance from the site would be expected to produce less ground deformation. In this regard, the displacement estimates provided by these approaches are commonly presented with a range of 50 to 200% of the estimated values. Vertical displacements as a result of lateral spreading are typically assumed to be equal to about 25% to 50% of the horizontal displacements.

NE 3rd Avenue Embankment. Completion of a detailed assessment of the seismic stability of the NE 3rd Avenue embankment was not included in our scope of services; however, we anticipate the embankment is underlain by potentially liquefiable soils and may be susceptible to large vertical and lateral deformations that may damage the pipeline as a result of the code-based seismic event.

Other Seismic Considerations. Although detailed tsunami modeling of the Columbia River in response to a Cascadia Subduction Zone earthquake has not been completed, the limited tsunami modeling by Kalmbacher and Hill (2014) indicates the risk of damage by tsunami is low due to the distance from the Pacific Ocean. According to the USGS, the Lacamas Lake fault is located about ½ km northeast of the site (Personius, 2002). This fault has not been considered active in the last 750,000 years, and, in our opinion, the risk of fault rupture along the alignment is low.

Structure Design

Wet Well Foundation Support. We anticipate the bases of the wet wells at the Lacamas Creek Park Pump Station and Baz Park Pump Station will be established in medium-dense to dense sand or gravel. These materials will generally provide adequate support of the wet wells provided the foundation subgrade is prepared in accordance with the Excavations and Groundwater Control section of this report. Footings established in accordance with the above criteria can be designed to impose an allowable bearing pressure of 3,000 psf. This value applies to the total of all dead plus frequently or permanently applied live loads and can be increased by one-third for the total of all loads: dead, live, and wind or seismic. We estimate the total settlement of the wet-well facility during static loads will be less than 1 in. and this settlement will occur rapidly as the wet well is installed and backfilled.

As described in the Seismic Design Considerations section of this report, the wet well at the Lacamas Creek Park Pump Station could be subjected to additional seismic settlement as a result of liquefaction and lateral spreading.

At-Grade Foundations. At the Lacamas Creek Park Pump Station site, near-surface soil conditions are anticipated to consist of very stiff, sandy silt, while near-surface soil conditions at the Baz Park Pump Station site are anticipated to consist of medium-dense, silty gravel fill. In our opinion, support of lightly loaded equipment with a maximum plan dimension of 15 ft can be provided by a mat foundation established in these soils and at least 6 in. below the lowest adjacent site grades. To provide uniform support, the mat foundation should be underlain by a minimum 1-ft thickness of well-graded, crushed rock with a maximum particle size of 1½ in. and containing less than 8% passing the No. 200 sieve (washed analysis). Crushed Surfacing Base Course meeting the requirements of Section 9-03.9(3) of the 2018 WSDOT Standard Specifications meets these criteria and can be used to provide uniform mat-foundation support. The crushed rock should be compacted to at least 95% of the maximum dry density determined by ASTM D698. Prior to placing the foundation material, the subgrade should be prepared in accordance with the recommendations contained in the Subgrade Preparation and Wet Weather Construction section of this report.

Settlement of a mat foundation with a maximum plan dimension of 15 ft and a maximum load of 50 kips is anticipated to be less than 1 in. We anticipate the settlement described above will occur rapidly as the loads are applied to the mat foundation. A coefficient of subgrade reaction, k, of 150 pci can be used for evaluating point loads on mat foundations.

Lateral loads (seismic, soil, etc.) can be resisted partially or completely by frictional forces developed between the base of the mat foundation and the underlying crushed rock. The total frictional resistance between the mat foundation and underlying material is the normal force times the coefficient of friction between soil and the foundation. We recommend an ultimate value of 0.4 for the coefficient of friction between mass concrete cast directly on a 12-in.-thick layer of compacted, crushed rock. If additional lateral resistance is required, passive earth pressures against foundations can be computed on the basis of an equivalent fluid having a unit weight of 250 pcf. This design passive earth pressure assumes the backfill for the foundations is horizontal and placed as compacted structural fill.

Design Lateral and Uplift Pressures. The walls of the below-grade structures (e.g., manholes, wet wells, and vaults) should be considered rigid and non-yielding for design purposes. We recommend lateral earth pressures be evaluated on the basis of an equivalent fluid having a unit weight of 90 pcf. This value assumes the groundwater level could rise to near the ground surface and the surrounding ground is level. This value does not include the influence of additional surface surcharge loads. Additional lateral loading induced by surcharge loads should be evaluated in accordance with the criteria shown on Figure 8. These values assume the excavations around that below-grade structures are backfilled with relatively clean, granular material placed as structural fill.

We recommend designing below-grade structures to resist the full hydrostatic uplift pressure for groundwater at the 100-year flood level. The uplift force is computed by multiplying the submerged volume of the structure by the unit weight of water (62.4 pcf). Common methods used to resist the uplift force include increasing the thickness of the walls and/or base or extending the base slab beyond the sidewalls of the structure.

Only the compacted backfill directly over the extended base slab should be considered additional load to resist the uplift force. The effective unit weight of the submerged backfill should be evaluated using a buoyant unit weight of 60 pcf. This assumes the backfill consists of imported granular material.

Retaining Walls

General. Design lateral earth pressures for embedded walls will depend on the drainage condition behind the wall and the ability of the wall to yield. We recommend a drainage system be provided behind the wall. As discussed above, a modular-block or mechanically stabilized earth retaining wall is being considered to construct level grades for the Lacamas Creek Park Pump Station. These type of retaining walls can yield or rotate slightly away from the backfill and be designed using active earth pressures.

Foundation Design. The base of all modular-block or mechanically stabilized earth walls should be embedded a minimum of 1 ft below adjacent site grades and founded on firm, on-site soil or structural fill placed above these on-site materials. Excavation for the walls should be made with excavators equipped with a smooth-edged bucket, and the wall subgrade should be evaluated by a member of GRI's geotechnical engineering staff. If soft soils are encountered at the base of the excavation, it will be necessary to overexcavate and replace the unsuitable materials with well-graded, crushed rock, such as Crushed Surfacing Base Course meeting the requirements of Section 9-03.9(3) of the 2018 WSDOT Standard Specifications. All prepared foundation bearing surfaces should be free of loose soil and water. To provide uniform support, the modular-block or the facing units of mechanically stabilized earth walls should be founded on a minimum 6-in. thickness of compacted crushed rock.

Provided the subgrade is prepared as described above, retaining walls can be designed on the basis of an allowable bearing capacity of 2,000 psf. Settlement of the modular-block or mechanically stabilized earth retaining walls will approach the settlement of the fill, which is described in the Fill Settlement section of this report.

Lateral Earth Pressures. Modular-block or mechanically stabilized earth retaining walls free to yield can be designed using an equivalent fluid unit weight of 35 pcf for level backfill and drained conditions. Additional lateral pressures due to surcharge loading in the backfill area, such as vehicle or construction traffic or soil stockpiles, can be estimated using the guidelines provided on Figure 8. The dynamic lateral earth pressure increment for yielding walls can be estimated using an equivalent fluid unit weights of 6 pcf for walls with level backslopes. The dynamic lateral earth pressure increment should be added to the static lateral earth pressure. Transient surcharge loads, such as wheel loads, do not need to be included in the seismic-loading case.

If internal design of the retaining wall is completed using a wall-design software program, the following soil parameters in Table 3 can be used for design of modular-block walls, assuming on-site soils are used to raise site grades and backfill behind the wall and this material is compacted as structural fill. For evaluating seismic loading, a peak horizontal ground acceleration of 0.45 g can be used for evaluating seismic loading. In the wall-design evaluation, we recommend assuming the groundwater level can approach the 100-year flood elevation. Lateral earth pressures due to surcharge loading should be considered as discussed above.

Table 3: MODULAR BLOCK OR MECHANICALLY STABILIZED EARTH WALL SOIL DESIGN PARAMETERS

Soil Property	Wall Backfill	Retained Soil	Foundation Soil
Unit Weight, pcf	130	130	120
Friction Angle	36°	36°	32°
Cohesion, psf	0	0	0

Resistance to Lateral Loads. Lateral loads (seismic, soil, etc.) can be resisted partially or completely by frictional forces developed between the base of the wall foundation and underlying crushed rock. Assuming a minimum 6-in.-thick leveling course of compacted crushed-rock fill placed over foundation subgrade, we recommend an ultimate value for the coefficient of friction of 0.35 for precast concrete blocks and a coefficient of friction of 0.50 for gabion baskets. If additional lateral resistance is required, passive earth pressure against the embedded portion of the wall can be computed on the basis of an equivalent fluid having a unit weight of 250 pcf for deformations up to about ½ in. and 300 pcf for larger deflections. This passive earth pressure assumes the backfill for the footings is placed as granular structural fill and does not slope downward away from the retaining wall.

Wall Backfill and Compaction Criteria. The use of on-site soils for wall backfill will only be practical during periods of dry weather or dry conditions, when the moisture content of the on-site soils can be maintained near optimum. Furthermore, it will be necessary to screen gravels, cobbles, and boulder materials greater than about 2 in. if the on-site soils will be used for backfill in the reinforced zone of mechanically stabilized earth walls. Imported backfill for modular-block walls, if used, should consist of Gravel Backfill for Walls as described in Section 9-03.12(2) of the 2018 WSDOT Standard Specifications. Imported backfill for mechanically stabilized earth walls, if used, should consist of Gravel Borrow for Structural Earth Wall as described in Section 9-03.14(4) of the 2018 WSDOT Standard Specifications. Wall backfill should be compacted to at least 95% of the maximum dry density determined by ASTM D698. Heavy compactors and large pieces of construction equipment should not operate within 5 ft of any backs of modular-block- or mechanically-stabilized-earth-wall-facing units to avoid the buildup of excessive lateral pressures. Compaction close to the backs of modular-block- or mechanically-stabilized-earth-wall-facing units should be accomplished using hand-operated, vibratory-plate compactors.

Drainage of the wall backfill is an essential element of wall design. Drainage requirements depend on the type of backfill used. If on-site soil is used as backfill, we recommend a full-height drainage blanket at the back of the mechanically stabilized earth wall-reinforcement zone, a drainage blanket at the base of the wall-reinforcement zone, and a vertical drainage blanket between the backfill and the wall's facing units. Figure 9 shows the recommended drainage for a mechanically stabilized earth wall constructed of on-site soils. The drainage blankets behind the reinforced zone and the facing units should be a minimum of 18 in. wide and extend the full height of the wall. The drainage blanket at the base of the wall should be at least 12 in. thick. All drainage blankets behind and under the wall should be interconnected with each other and consist of open-graded, angular, crushed rock with a maximum size of 1½ in. and not more than about 2% passing the No. 200 sieve (washed analysis). Crushed rock meeting the gradation requirements for Gravel Backfill for Drains in Section 9-03.12(4) of the 2018 WSDOT Standard Specifications is suitable for this purpose. A minimum 4-in.-diameter perforated drainpipe should be placed at the bottom of the drainage blanket located behind the zone of reinforcement and at the bottom of the drainage blanket behind the wall's facing units. The perforated drainpipe should be surrounded by a minimum of 12 in. of open-graded, angular, crushed rock encapsulated with non-woven geotextile, such as Mirafi 160N, meeting the requirements for moderate survivability in Section 9-33.2 of the 2018 WSDOT Standard Specifications. If imported granular backfill is used for wall construction, only the drain-pipe system behind the zone of reinforcement is required. For modular-block walls, a full-height drainage blanket should be placed behind the modular blocks as described above.

The retaining-wall design should include positive drainage measures to prevent ponding of surface water behind the top of the wall.

DESIGN REVIEW AND CONSTRUCTION SERVICES

We welcome the opportunity to review and discuss construction plans and specifications for this project as they are being developed. In addition, GRI should be retained to review all geotechnical-related portions of the plans and specifications to evaluate whether they are in conformance with the recommendations provided in our report. Additionally, to observe compliance with the intent of our recommendations, the design concepts, and the plans and specifications, we are of the opinion all construction operations dealing with earthwork should be observed by a GRI representative. Our construction-phase services will allow for timely design changes if site conditions are encountered that are different from those described in this report. If we do not have the opportunity to confirm our interpretations, assumptions, and analyses during construction, we cannot be responsible for the application of our recommendations to subsurface conditions different from those described in this report.

LIMITATIONS

This report has been prepared to aid in the design and construction of the proposed project. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the earthwork and design and construction of the pump stations and associated gravity and force main sewer lines. In the event any changes in the design and location of the project elements as outlined in this report are planned, we should be given the opportunity to review the changes and modify or reaffirm our conclusions and recommendations in writing.

The conclusions and recommendations provided in this report are based on the data obtained from the borings made at the locations indicated on the Site Plans, Figure 2 through 4, and other sources of information discussed in this report. In the performance of subsurface investigations, specific information is obtained at specific locations at specific times. However, it is acknowledged variations in soil and groundwater conditions may exist between exploration locations. This report does not reflect any variations that may occur between these explorations. The nature and extent of variation may not become evident until construction. If, during construction, subsurface conditions differ from those encountered in the explorations, we should be advised at once so we can observe and review these conditions and reconsider our recommendations where necessary.

Please contact the undersigned if you have any questions.

Submitted for GRI,

(9/12/2018) Renews 04/2020

Matthew S. Shanahan, PE
Principal

Brian A. Bennetts, PE
Senior Engineer

This document has been submitted electronically.

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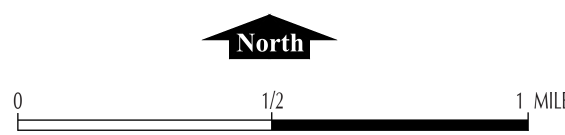
Exhibit D-1: Final Drainage Report

USGS TOPOGRAPHIC MAP
CAMAS, WASH. (2017)
WASHOUGAL, WASH. (2017)



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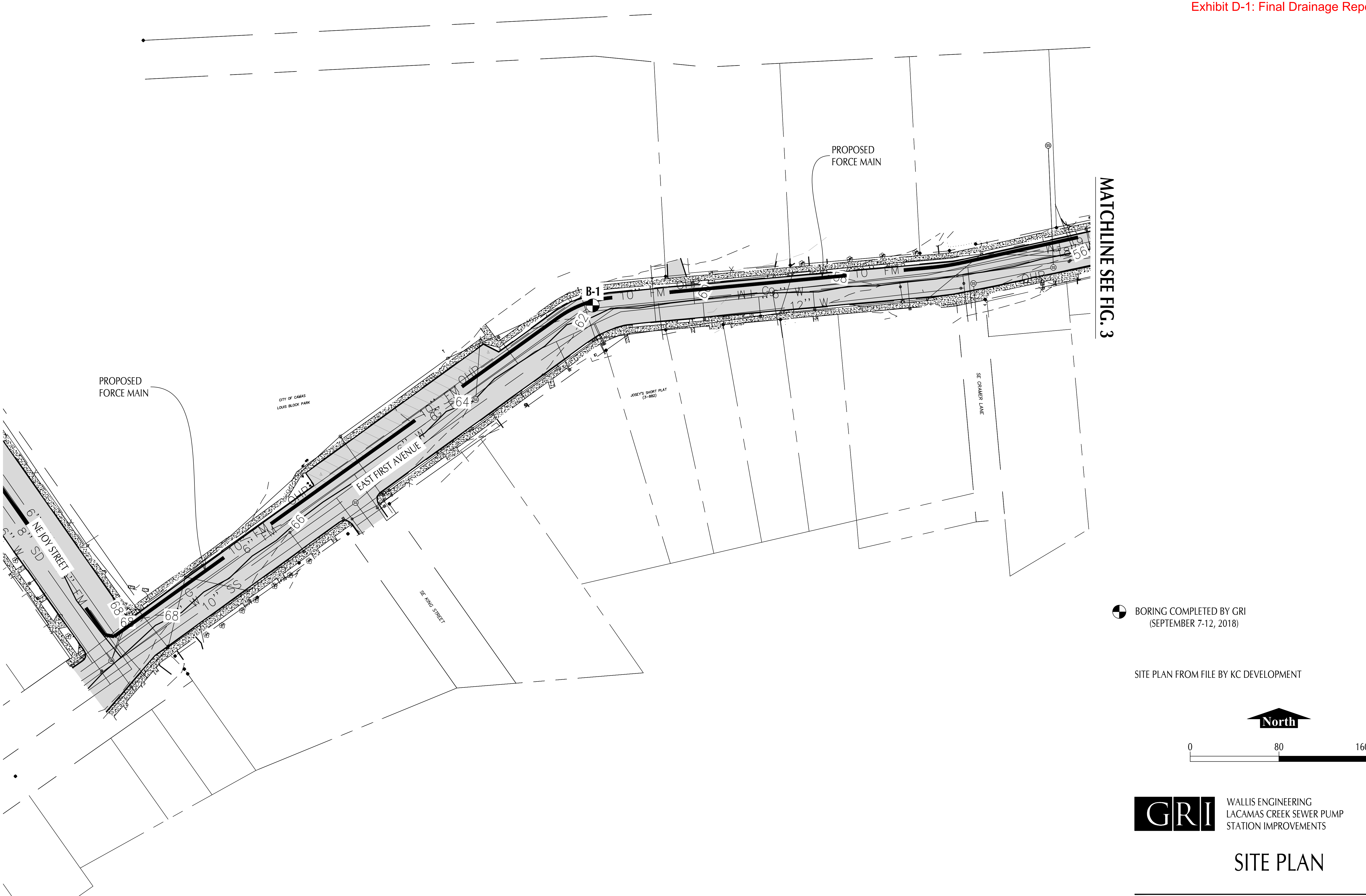
VICINITY MAP

APR. 2019 | JOB NO. W1241 | FIG. 1



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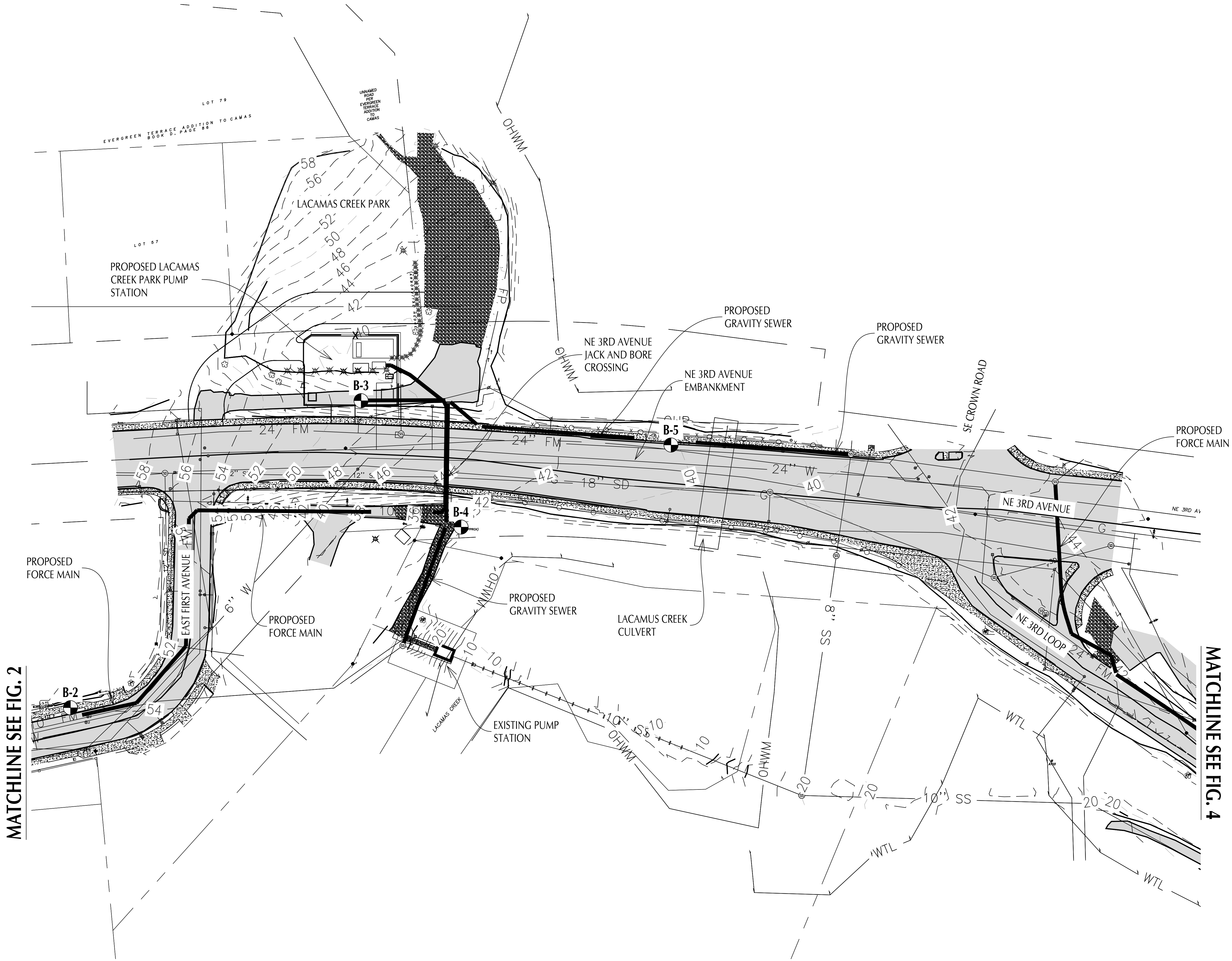
SITE PLAN

APR. 2019 JOB NO. W1241 FIG. 2

Exhibit D-1: Final Drainage Report



BORINGS COMPLETED BY GRI (SEPTEMBER 7-12, 2018)

SITE PLAN FROM FILE BY KC DEVELOPMENT

North

0 80 160 FT

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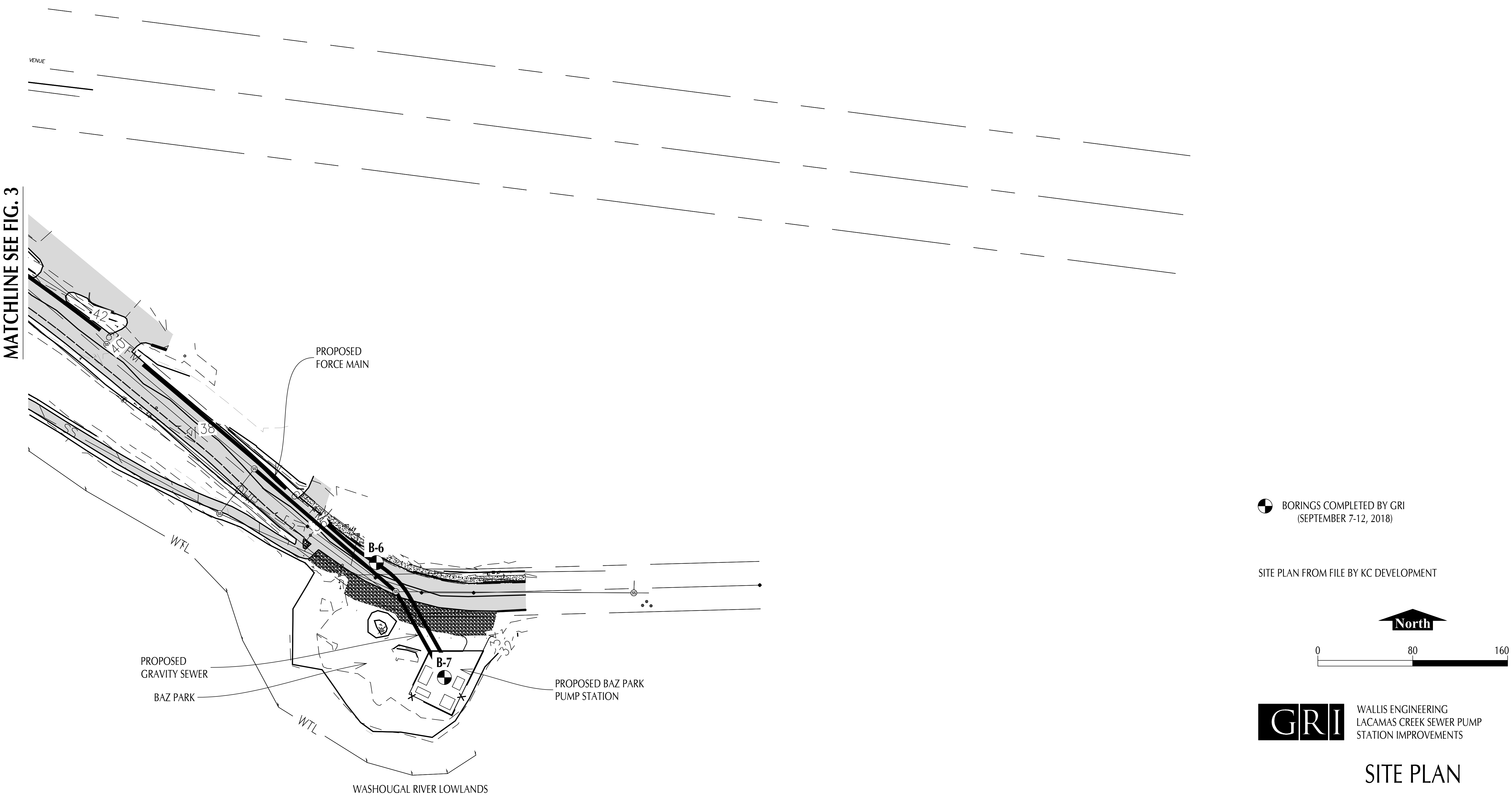
SITE PLAN

APR. 2019 JOB NO. W1241 FIG. 3



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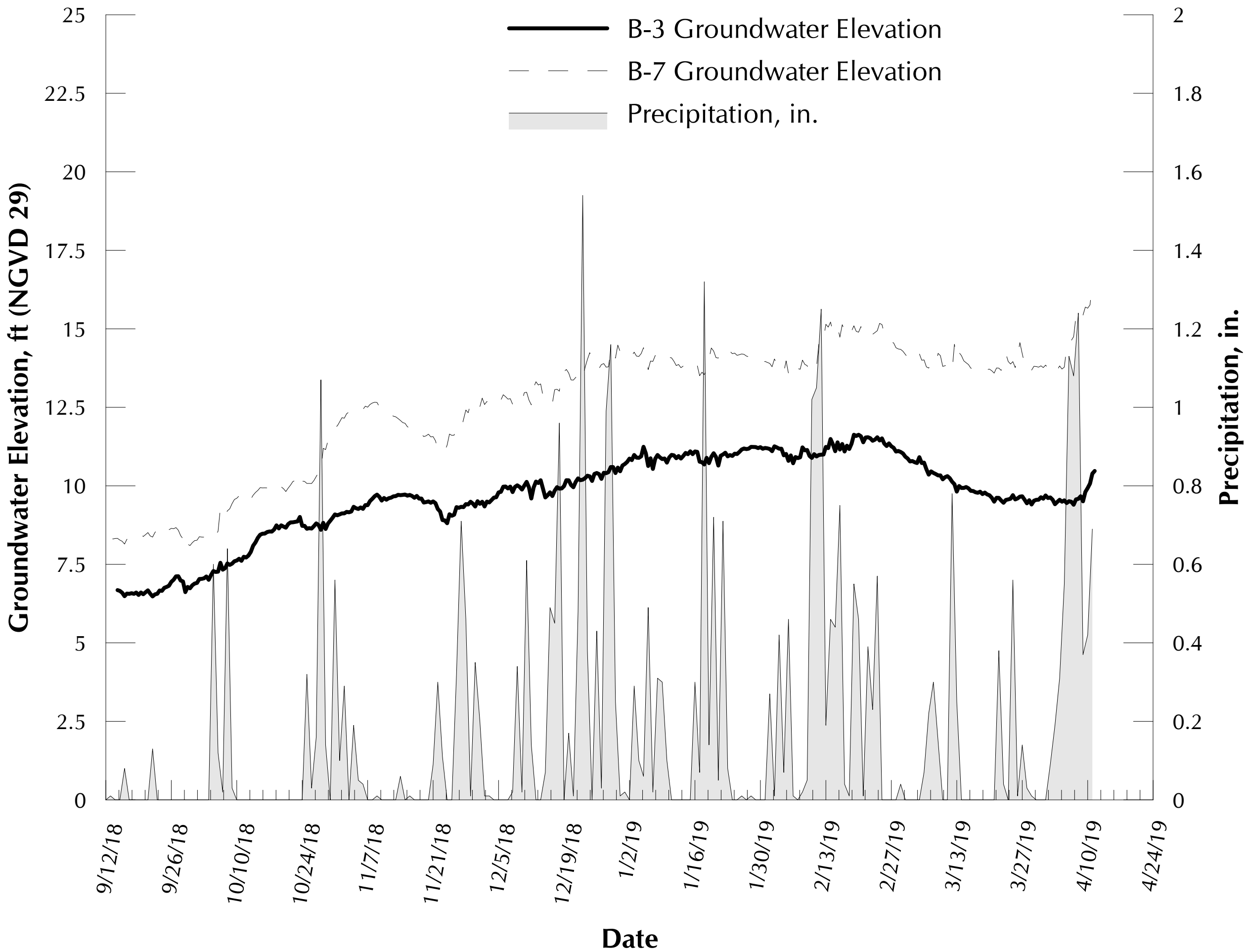
SITE PLAN



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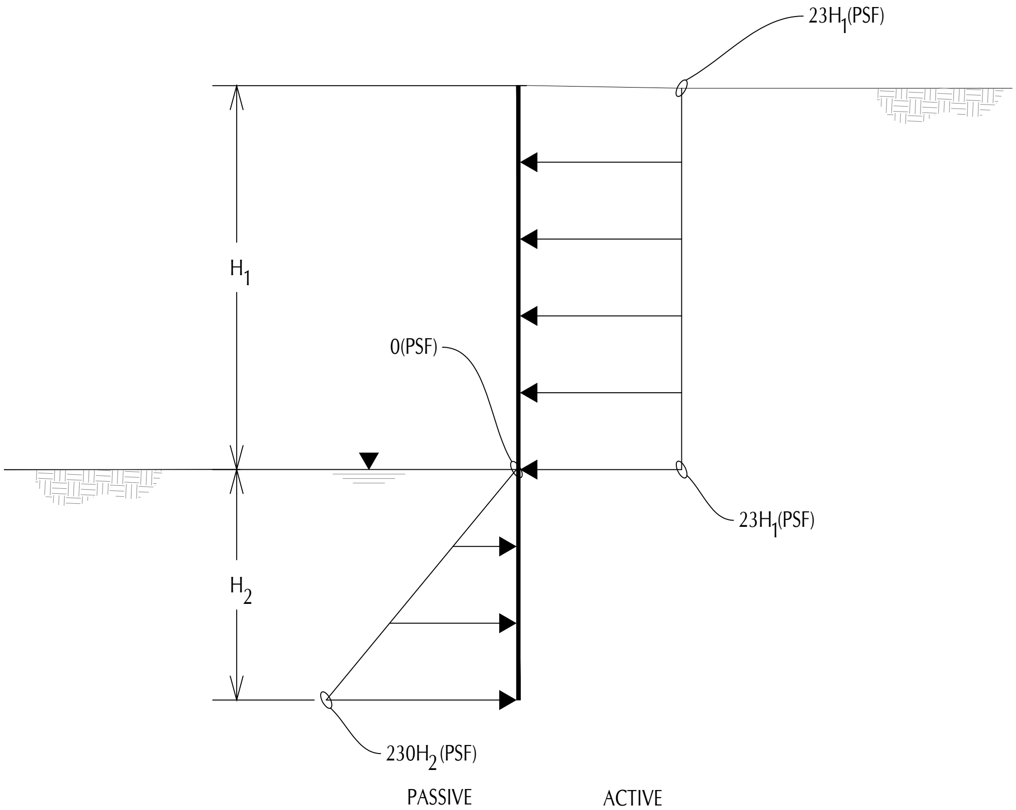
GROUNDWATER DATA

APR. 2019 | JOB NO. W1241 | FIG. 5



NOTES:

1) THE ABOVE ACTIVE AND PASSIVE PRESSURES ASSUME THAT GROUNDWATER IS BELOW THE BASE OF THE EXCAVATION.

2) THE ACTIVE PRESSURE ACTS OVER THE SURFACE AREA OF THE EXPOSED WALL.

3) THE PASSIVE PRESSURE ACTS OVER THE EMBEDDED SURFACE AREA OF THE SHEETPILE WALL, OR 2 DIAMETERS OF A SOLDIER PILE, ASSUMING A MINIMUM CENTER TO CENTER SPACING OF THREE DIAMETERS.

4) ADDITIONAL LOADS DUE TO SURCHARGE EFFECTS SHOULD BE ADDED TO THE ABOVE PRESSURES USING THE GUIDELINES PROVIDED ON FIGURE 8.

5) EARTH PRESSURES PROVIDED ASSUME THE GROUND IS HORIZONTAL BEHIND THE WALL.

6) PASSIVE PRESSURE ASSUMES EMBEDMENT IN GRAVELS.

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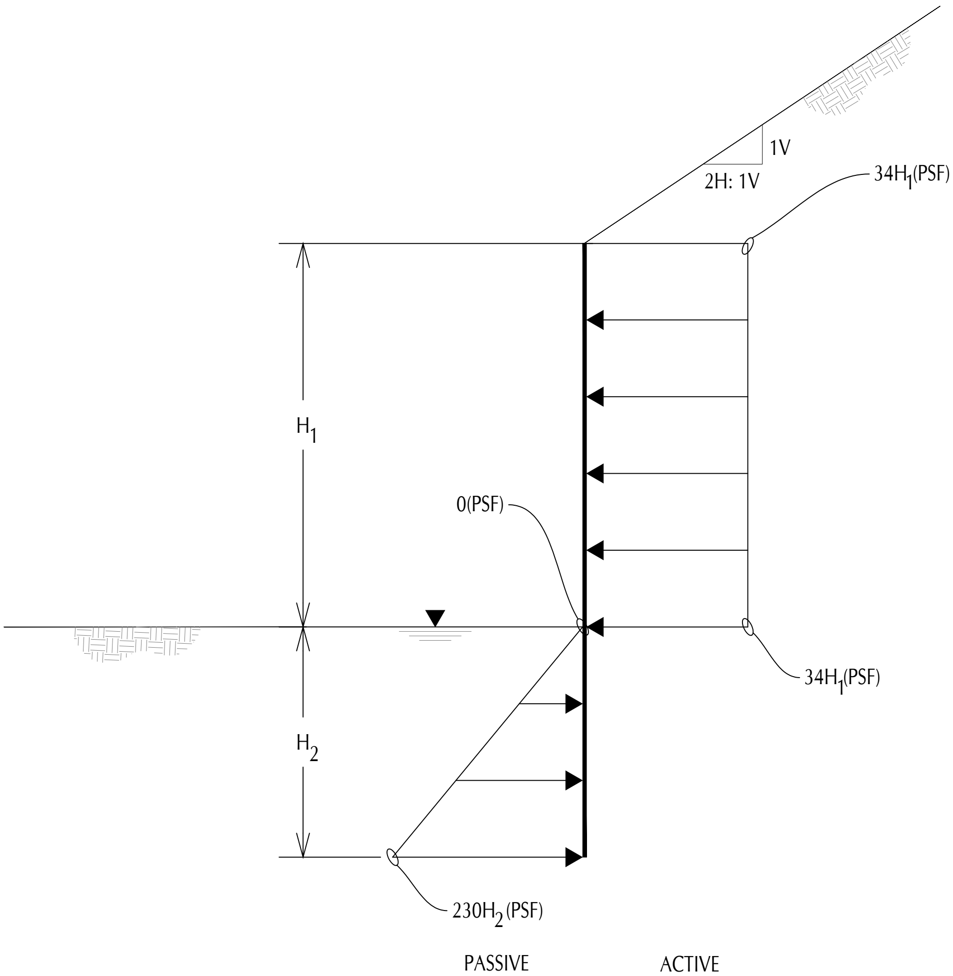
LATERAL EARTH PRESSURES

TEMPORARY BRACED SHORING SYSTEM
HORIZONTAL BACKSLOPE

APR. 2019 JOB NO. W1241 FIG. 6



NOTES:

1) THE ABOVE ACTIVE AND PASSIVE PRESSURES ASSUME THAT GROUNDWATER IS BELOW THE BASE OF THE EXCAVATION.

2) THE ACTIVE PRESSURE ACTS OVER THE SURFACE AREA OF THE EXPOSED WALL..

3) THE PASSIVE PRESSURE ACTS OVER THE EMBEDDED SURFACE AREA OF THE SHEETPILE WALL, OR 2 DIAMETERS OF A SOLDIER PILE, ASSUMING A MINIMUM CENTER TO CENTER SPACING OF THREE DIAMETERS.

4) ADDITIONAL LOADS DUE TO SURCHARGE EFFECTS SHOULD BE ADDED TO THE ABOVE PRESSURES USING THE GUIDELINES PROVIDED IN FIGURE 8.

5) EARTH PRESSURES PROVIDED ASSUME THE GROUND IS INCLINED AT 2H:1V BEHIND THE WALL.

6) PASSIVE PRESSURE ASSUMES EMBEDMENT IN GRAVELS.

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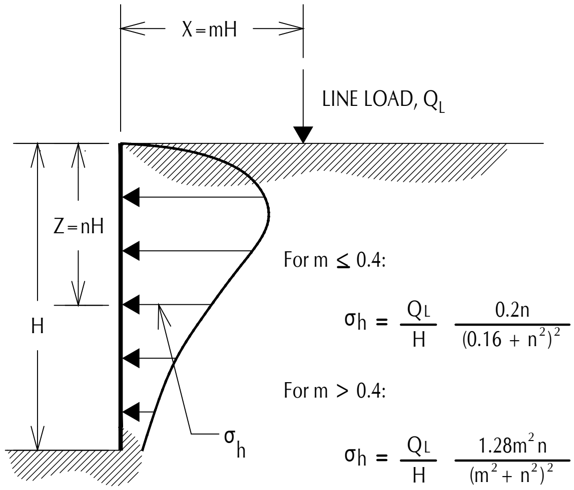
LATERAL EARTH PRESSURES

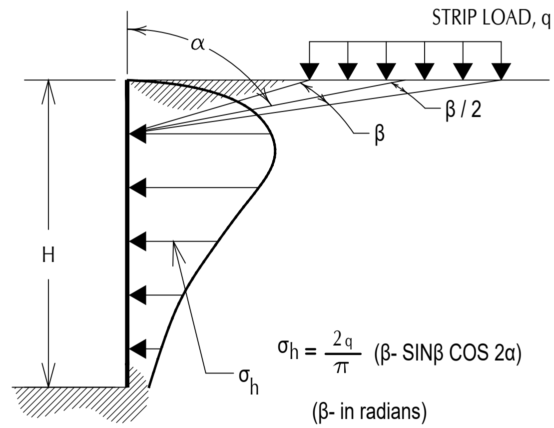
TEMPORARY BRACED SHORING SYSTEM
2H:1V BACKSLOPE

APR. 2019 | JOB NO. W1241 | FIG. 7

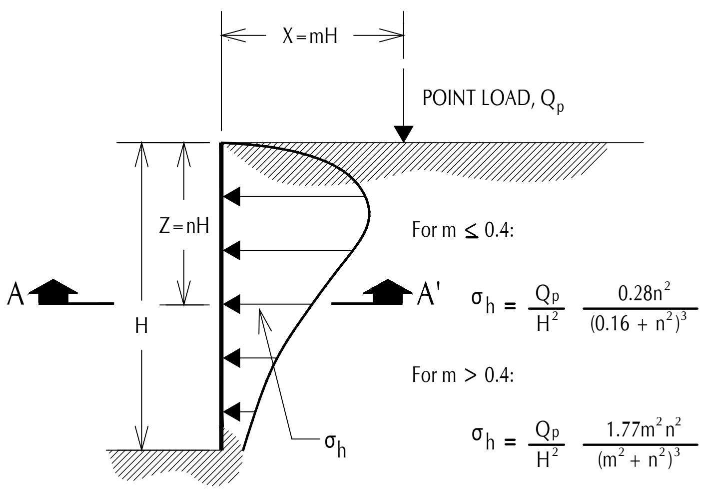
Exhibit D-1: Final Drainage Report

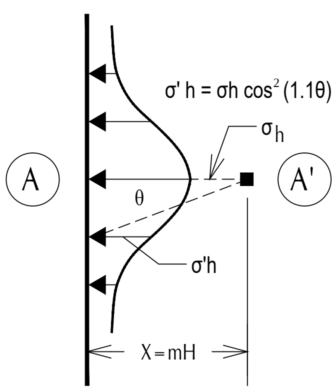


LINE LOAD PARALLEL TO WALL



STRIP LOAD PARALLEL TO WALL





DISTRIBUTION OF HORIZONTAL PRESSURES

VERTICAL POINT LOAD

NOTES:

1) THESE GUIDELINES APPLY TO RIGID WALLS WITH POISSON'S RATIO ASSUMED TO BE 0.5 FOR BACKFILL MATERIALS.

2) LATERAL PRESSURES FROM ANY COMBINATION OF ABOVE LOADS MAY BE DETERMINED BY THE PRINCIPLE OF SUPERPOSITION.

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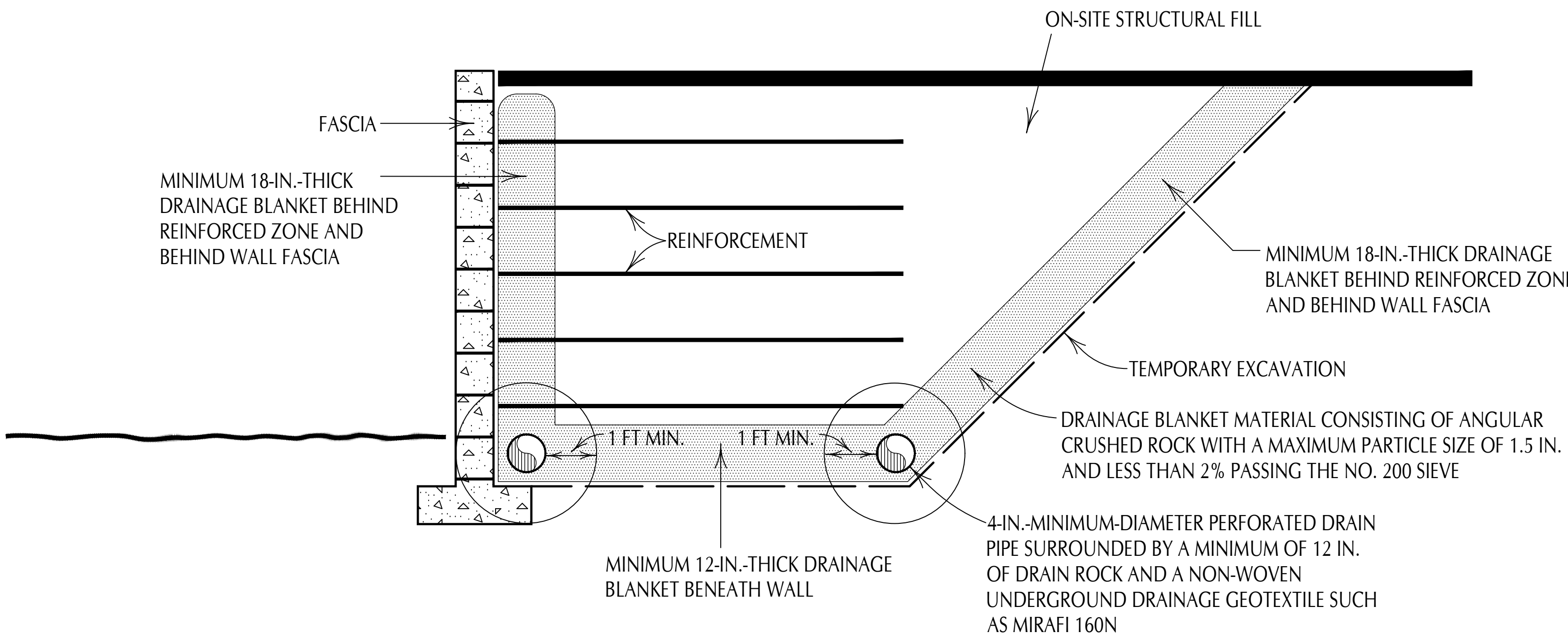
SURCHARGE-INDUCED LATERAL PRESSURE

APR. 2019 | JOB NO. W1241 | FIG. 8



NO SCALE

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TYPICAL DRAINAGE FOR MSE WALL CONSTRUCTED WITH ON-SITE SOILS

APR. 2019 | JOB NO. W1241 | FIG. 9

APPENDIX A

Field Explorations and Laboratory Testing

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

Subsurface materials and conditions at the site were evaluated between September 7 and 12, 2018, with seven borings, designated B-1 through B-7. The approximate locations of the borings completed for this study are shown on the Site Plans, Figures 2 through 4.

The borings were advanced to depths of 6.6 to 46.5 ft with a Terra Sonic TSi 150 rotosonic, track-mounted drill rig provided and operated by Holt Services, Inc., of Vancouver, Washington. Experienced geotechnical engineering staff from GRI maintained a detailed log of materials and conditions encountered in each boring. Continuous, 4-in.-diameter runs were obtained from the borings and stored in flexible plastic tubing. The plastic tubing was opened in the field for visual classifications, and digital photographs were taken of each of the runs. Representative grab soil samples were carefully examined in the field and saved in plastic sample bags for further examination in our laboratory. The photographs of the runs are provided in Appendix B. In addition, the Standard Penetration Test was conducted at 5-ft intervals of depth. This test consists of driving a standard split-spoon sampler into the soil a distance of 18 in. using a 140-lb hammer dropped 30 in. The number of blows required to drive the sampler the last 12 in. is known as the standard penetration resistance, or SPT N-value. SPT N-values provide a measure of the relative density of granular soils, such as sand, and the relative consistency, or stiffness, of cohesive soils, such as silt.

Logs of the rotosonic borings are provided on Figures 1A through 7A. Each log presents a descriptive summary of the various types of materials encountered in the borings and notes the depths at which the materials and/or characteristics of the materials change. To the right of the descriptive summary, the number and type of sample obtained during the drilling operation are indicated. Farther to the right, SPT N-values are shown graphically, along with the natural moisture content and percentage passing the No. 200 sieve. The terms and symbols used to describe the soil and rock encountered in the borings are defined in Tables 1A and 2A and on the attached legend.

INSTRUMENTATION

RST Instruments Model VW2100 vibrating-wire piezometers were installed at about elevations -1.5 and 0 ft in borings B-3 and B-7. The piezometers are equipped with an RST Model DT2011B single-channel data logger programmed to record data at regular intervals. At the time of installation, the piezometers were saturated with water, taped to a 1-in.-outside-diameter (O.D.) PVC grout pipe in an inverted position to maintain saturation, and inserted into the open borehole to the desired depth. The borings were then filled with cement-bentonite grout to near the ground surface. The performance of each piezometer was verified before installation and immediately after insertion to design depth. The installation is equipped with a steel monument casing that was cement grouted into the borehole collar to protect the data logger and readout cables from vehicle traffic and the elements. The data loggers are being downloaded periodically to evaluate the data.

LABORATORY TESTING

General

All samples obtained from the field were returned to our laboratory, where the physical characteristics of the samples were noted and the field classifications modified where necessary. At the time of classification, the natural moisture content of each sample was determined. Grain-size testing was completed on representative samples of the soil obtained from the explorations. A summary of the laboratory test results is provided in Table 3A. The following paragraphs describe the testing program in more detail.

Natural Moisture Content

Natural moisture content determinations were made in conformance with ASTM International (ASTM) D2216. The results are provided on Figures 1A through 7A and summarized in Table 3A.

Grain-Size Analysis

Washed-sieve analyses were performed on representative samples of the soil to assist in their classification. The test is performed by taking a sample of known dry weight and washing it over a No. 200 sieve. The material retained on the sieve is oven-dried and weighed. The percentage of material that passes the No. 200 sieve is then calculated. The results are provided on Figures 1A through 7A and in Table 3A.

A dry-sieve analysis was completed on representative samples obtained from borings B-3, B-4, and B-7. The mechanical-sieve analyses were completed in substantial conformance with ASTM D6913. The test is performed by taking a sample of known dry weight and washing it over a No. 200 sieve. The material retained on the sieve is oven-dried and weighed, and the percentage of material passing the No. 200 sieve is calculated. The soil retained on the No. 200 sieve is then screened through a series of sieves of various sizes using a sieve shaker. The weight of each sieve is measured prior to and after the test. The weight of the sample retained on each sieve is recorded and expressed as a percentage of the total sample weight. The test results are shown on Figures 8A and 9A.

Table 1A

GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values), blows per ft
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-values), blows per ft	Torvane or Undrained Shear Strength, tsf
Very Soft	0 - 2	less than 0.125
Soft	2 - 4	0.125 - 0.25
Medium Stiff	4 - 8	0.25 - 0.50
Stiff	8 - 15	0.50 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	over 30	over 2.0

Grain-Size Classification

Boulders:
>12 in.

Cobbles:
3 - 12 in.

Gravel:
1/4 - 3/4 in. (fine)
3/4 - 3 in. (coarse)

Sand:
No. 200 - No. 40 sieve (fine)
No. 40 - No. 10 sieve (medium)
No. 10 - No. 4 sieve (coarse)

Silt/Clay:
pass No. 200 sieve

Modifier for Subclassification

Adjective	Primary Constituent SAND or GRAVEL	Primary Constituent SILT or CLAY
	Percentage of Other Material (by weight)	
trace:	5 - 15 (sand, gravel)	5 - 15 (sand, gravel)
some:	15 - 30 (sand, gravel)	15 - 30 (sand, gravel)
sandy, gravelly:	30 - 50 (sand, gravel)	30 - 50 (sand, gravel)
trace:	<5 (silt, clay)	*Relationship of clay and silt determined by plasticity index test*
some:	5 - 12 (silt, clay)	
silty, clayey:	12 - 50 (silt, clay)	

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Table 2A

GUIDELINES FOR CLASSIFICATION OF ROCK

Relative Rock Weathering Scale

Term	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 in. into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Relative Rock Hardness Scale

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife and scratched with fingernail.	100 - 1,000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1,000 - 4,000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4,000 - 8,000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8,000 - 16,000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16,000 psi

RQD and Rock Quality

Relation of RQD and Rock Quality

RQD (Rock Quality Designation), %	Description of Rock Quality
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

Terminology for Planar Surface

Bedding	Joints and Fractures	Spacing
Laminated	Very Close	< 2 in.
Thin	Close	2 in. – 12 in.
Medium	Moderately Close	12 in. – 36 in.
Thick	Wide	36 in. – 10 ft
Massive	Very Wide	> 10 ft

Terms Used to Describe Degree of Cementation

Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

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Table 3A

SUMMARY OF LABORATORY RESULTS

Sample Information						Atterberg Limits			
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	Soil Type
B-1	S-1	2.5	58.5	19	--	--	--	--	SILT
	S-2	5.5	55.5	13	--	--	--	20	Silty GRAVEL
B-2	S-1	1.0	53.0	10	--	--	--	--	SILT
	S-2	2.0	52.0	28	--	--	--	82	SILT
	S-3	5.0	49.0	10	--	--	--	--	Sandy GRAVEL
B-3	S-1	1.0	41.0	14	--	--	--	--	Sandy SILT
	S-2	2.0	40.0	16	--	--	--	--	Sandy SILT
	S-3	3.0	39.0	15	--	--	--	--	Sandy SILT
	S-4	4.5	37.5	15	--	--	--	53	Sandy SILT
	S-5	6.5	35.5	23	--	--	--	--	Sandy SILT
	S-6	8.0	34.0	15	--	--	--	--	Gravelly SAND
	S-7	9.5	32.5	18	--	--	--	--	Gravelly SAND
	S-8	11.5	30.5	15	--	--	--	53	Sandy SILT
	S-9	12.5	29.5	14	--	--	--	--	Silty GRAVEL
	S-10	14.5	27.5	15	--	--	--	29	Silty GRAVEL
	S-11	17.0	25.0	11	--	--	--	--	Silty GRAVEL
	S-12	23.0	19.0	20	--	--	--	24	Silty SAND
	S-13	25.0	17.0	11	--	--	--	12	SAND
	S-14	29.5	12.5	9	--	--	--	--	SAND
	S-15	31.5	10.5	10	--	--	--	--	SAND
	S-16	36.5	5.5	15	--	--	--	--	Gravelly SAND
	S-17	39.0	3.0	40	--	--	--	--	Silty SAND
	S-18	44.0	-2.0	31	--	--	--	--	Silty SAND
B-4	S-1	2.5	32.5	10	--	--	--	--	SILT
	S-2	6.5	28.5	12	--	--	--	61	SILT
	S-3	8.0	27.0	6	--	--	--	--	SILT
	S-4	11.5	23.5	10	--	--	--	--	Silty GRAVEL
	S-5	14.0	21.0	11	--	--	--	--	Silty GRAVEL
	S-6	19.0	16.0	14	--	--	--	17	Silty GRAVEL
	S-7	23.0	12.0	9	--	--	--	--	Silty GRAVEL
	S-8	25.0	10.0	32	--	--	--	--	SAND
	S-9	28.0	7.0	14	--	--	--	--	SAND
	S-10	32.0	3.0	39	--	--	--	--	SAND
	S-11	34.5	0.5	33	--	--	--	--	BASALT
B-5	S-1	1.8	38.2	10	--	--	--	--	FILL
	S-2	2.5	37.5	9	--	--	--	--	FILL
	S-3	5.0	35.0	10	--	--	--	36	FILL
	S-4	7.0	33.0	7	--	--	--	--	FILL
	S-5	12.5	27.5	7	--	--	--	--	FILL
	S-6	14.0	26.0	7	--	--	--	56	FILL

Table 3A

SUMMARY OF LABORATORY RESULTS

Sample Information						Atterberg Limits			
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	Soil Type
B-5	S-7	16.5	23.5	9	--	--	--	--	FILL
	S-8	19.0	21.0	16	--	--	--	--	FILL
B-6	S-1	3.0	32.5	22	--	--	--	--	SILT
	S-2	6.5	29.0	10	--	--	--	--	Silty GRAVEL
	S-3	8.0	27.5	5	--	--	--	4	Sandy GRAVEL
	S-4	14.0	21.5	13	--	--	--	--	Silty GRAVEL
B-7	S-1	1.0	33.0	8	--	--	--	--	FILL
	S-2	3.0	31.0	11	--	--	--	--	FILL
	S-3	4.0	30.0	23	--	--	--	65	FILL
	S-4	4.5	29.5	7	--	--	--	--	FILL
	S-5	6.5	27.5	13	--	--	--	--	FILL
	S-6	8.0	26.0	16	--	--	--	--	FILL
	S-7	12.0	22.0	5	--	--	--	--	Silty GRAVEL
	S-8	14.0	20.0	10	--	--	--	10	Sandy GRAVEL
	S-9	19.0	15.0	11	--	--	--	--	Sandy GRAVEL
	S-10	21.5	12.5	9	--	--	--	--	Sandy GRAVEL
	S-11	23.0	11.0	12	--	--	--	--	Sandy GRAVEL
	S-13	31.5	2.5	7	--	--	--	30	Silty GRAVEL
	S-14	34.0	0.0	19	--	--	--	--	BASALT
	S-15	35.0	-1.0	26	--	--	--	--	BASALT

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
	LANDSCAPE MATERIALS
	FILL
	GRAVEL; clean to some silt, clay, and sand
	Sandy GRAVEL; clean to some silt and clay
	Silty GRAVEL; up to some clay and sand
	Clayey GRAVEL; up to some silt and sand
	SAND; clean to some silt, clay, and gravel
	Gravelly SAND; clean to some silt and clay
	Silty SAND; up to some clay and gravel
	Clayey SAND; up to some silt and gravel
	SILT; up to some clay, sand, and gravel
	Gravelly SILT; up to some clay and sand
	Sandy SILT; up to some clay and gravel
	Clayey SILT; up to some sand and gravel
	CLAY; up to some silt, sand, and gravel
	Gravelly CLAY; up to some silt and sand
	Sandy CLAY; up to some silt and gravel
	Silty CLAY; up to some sand and gravel
	PEAT

BEDROCK SYMBOLS

Symbol	Typical Description
	BASALT
	MUDSTONE
	SILTSTONE
	SANDSTONE

SURFACE MATERIAL SYMBOLS

Symbol	Typical Description
	Asphalt concrete PAVEMENT
	Portland cement concrete PAVEMENT
	Crushed rock BASE COURSE

SAMPLER SYMBOLS

Symbol	Sampler Description
	2.0-in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
	Shelby tube sampler with recovery (ASTM D1587)
	3.0-in. O.D. split-spoon sampler with recovery (ASTM D3550)
	Grab Sample
	Rock core sample interval
	Sonic core sample interval
	Geoprobe sample interval

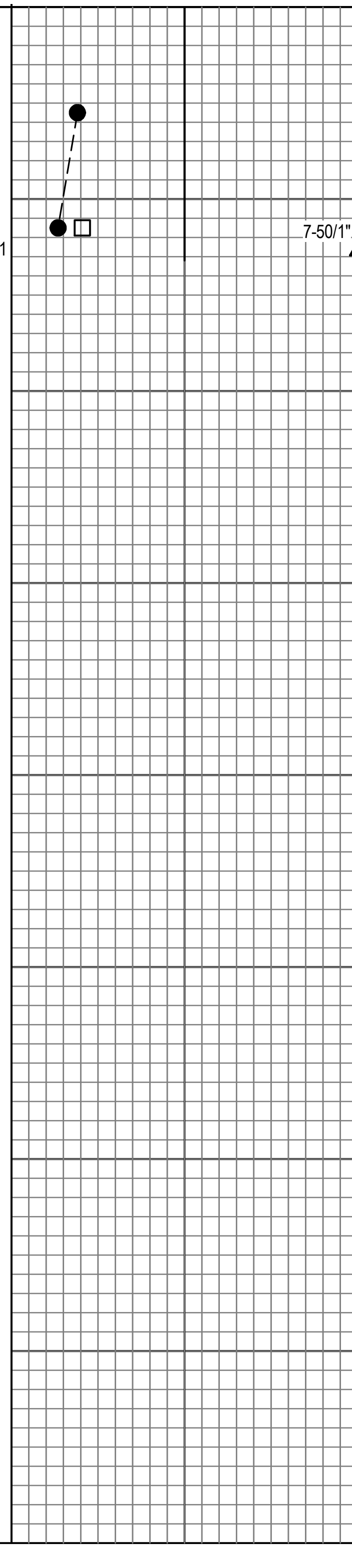
INSTALLATION SYMBOLS

Symbol	Symbol Description
	Flush-mount monument set in concrete
	Concrete, well casing shown where applicable
	Bentonite seal, well casing shown where applicable
	Filter pack, machine-slotted well casing shown where applicable
	Grout, vibrating-wire transducer cable shown where applicable
P	Vibrating-wire pressure transducer
	1-in.-diameter solid PVC
	1-in.-diameter hand-slotted PVC
	Grout, inclinometer casing shown where applicable

FIELD MEASUREMENTS

Symbol	Typical Description
▽	Groundwater level during drilling and date measured
▼	Groundwater level after drilling and date measured
	Rock core recovery (%)
	Rock quality designation (RQD, %)

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL Surface Elevation: 61.0 ft [±] (NGVD 29)	ELEVATION, FT / DEPTH, FT	INSTALLATION	RUN NO.	SAMPLE TYPE	SAMPLE NO.	● MOISTURE CONTENT, % □ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS
		Asphalt concrete PAVEMENT (4 in.) over crushed rock BASE COURSE (4 in.)	60.4 / 0.6						
		SILT, some fine- to coarse-grained sand and subrounded gravel, brown, soft to medium stiff, contains cobbles	58.0 / 3.0		R-1		S-1		
5		Silty GRAVEL, some fine- to coarse-grained sand, red-brown, medium dense, angular	54.4 / 6.6				S-2 SPT-1	7-50/1"	Blow counts may not be representative
		(9/10/2018)							
10									
15									
20									
25									
30									
35									
40									



GRI SONIC BORING (GPS) GRI DATA TEMPLATE.GDT 4/19/19

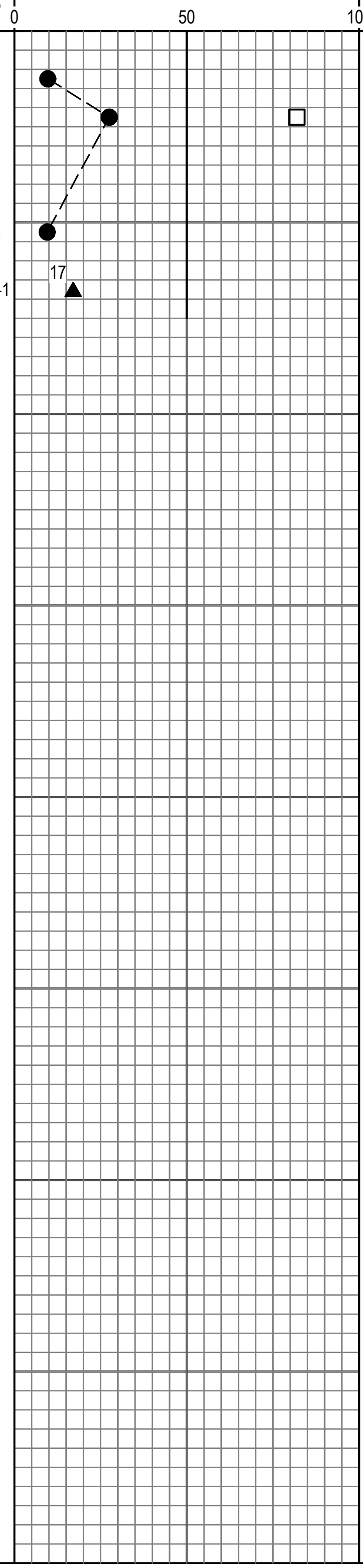
Logged By: C. Martin	**Drilled by:** Holt Services, Inc.
Date Started: 9/10/18	**GPS Coordinates:** 45.5883° N -122.3929° W (WGS 84)
Drilling Method: Roto Sonic **Equipment:** Terra Sonic TSi 150 **Hole Diameter:** 4 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:**
Note: See Legend for Explanation of Symbols	

GRI

BORING B-1

APR. 2019 JOB NO. W1241 FIG. 1A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL Surface Elevation: 54.0 ft [±] (NGVD 29)	ELEVATION, FT / DEPTH, FT	INSTALLATION	RUN NO.	SAMPLE TYPE	SAMPLE NO.	● MOISTURE CONTENT, % / □ FINES CONTENT, % / LIQUID LIMIT, % / PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS
		SILT, trace to some fine- to coarse-grained sand and subrounded gravel, brown, soft to medium stiff			R-1		S-1 S-2 S-3		
5		Sandy GRAVEL, trace silt, brown, medium dense, medium- to coarse-grained sand, subrounded to subangular gravel	49.0 / 5.0				SPT-1	17	
		(9/10/2018)	46.5 / 7.5						
10									
15									
20									
25									
30									
35									
40									



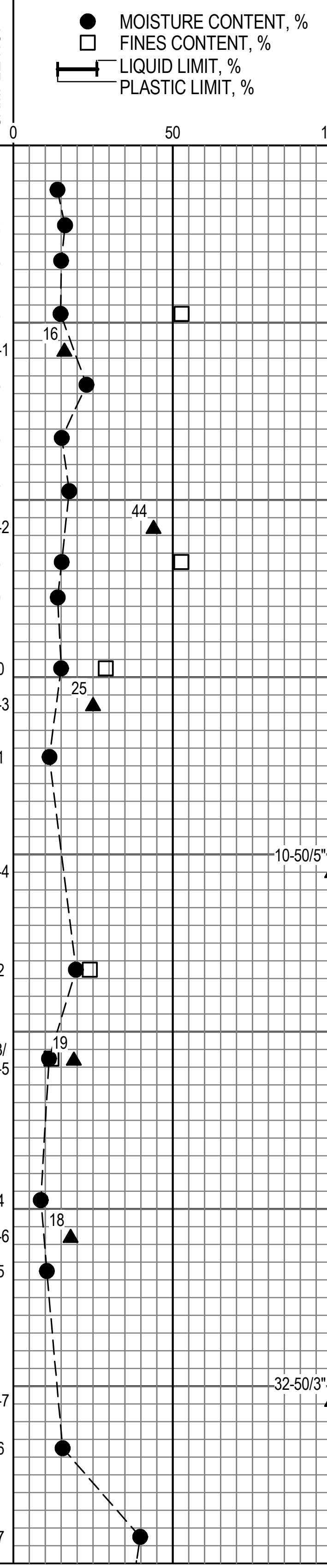
Logged By: C. Martin	Drilled by: Holt Services, Inc.
Date Started: 9/10/18	GPS Coordinates: 45.588° N -122.3948° W (WGS 84)
Drilling Method: Roto Sonic Equipment: Terra Sonic TSi 150 Hole Diameter: 4 in.	Hammer Type: Auto Hammer Weight: 140 lb Drop: 30 in. Energy Ratio:
Note: See Legend for Explanation of Symbols	

GRI

BORING B-2

APR. 2019 JOB NO. W1241 FIG. 2A

DEPTH, FT	CLASSIFICATION OF MATERIAL (Surface Elevation: 42.0 ft [±] (NGVD 29))	ELEVATION, FT / DEPTH, FT	RUN NO.	SAMPLE NO.	COMMENTS AND ADDITIONAL TESTS
0	Sandy SILT, some angular gravel, brown, very stiff, fine- to coarse-grained sand		R-1	S-1, S-2, S-3	SPT samples were driven at the end of each Sonic interval. Subsequent Sonic runs were started from the same elevation following the SPT.
4.5	---light brown, fine-grained sand at 4.5 ft			S-4	
6	---trace gravel, red-brown below 6 ft		R-2	SPT-1, S-5	
7.0	Silty, gravelly SAND, red-brown, dense, subangular gravel, fine- to coarse-grained sand, contains cobbles	35.0 / 7.0		S-6, S-7	
11.5	---6-in.-thick layer of sandy silt, trace gravel at 11.5 ft		R-3	SPT-2, S-8, S-9	
12.0	Silty GRAVEL, some fine- to coarse-grained sand to sandy, red-brown, dense, subrounded to subangular, contains woody debris and cobbles	30.0 / 12.0		S-10	
14	---boulder encountered at 14 ft		R-4	SPT-3, S-11	
20			R-5	SPT-4	
23.0	Silty SAND, trace subangular gravel, brown, dense, fine to coarse grained	19.0 / 23.0		S-12	
25.0	SAND, some silt, brown, medium dense, fine to medium grained	17.0 / 25.0	R-6	S-13/ SPT-5	
30	---interbedded with thin lenses of sandy silt below 30 ft		R-7	S-14, SPT-6, S-15	
35.0	Gravelly SAND, trace to some silt, brown, medium dense to very dense, subrounded to subangular gravel, fine- to coarse-grained sand	7.0 / 35.0		SPT-7, S-16	Blow counts may not be representative; ▽ 35.3 ft (9/12/2018)
37.5	Silty SAND to sandy SILT (Decomposed Basalt) see following page for full description	4.5 / 37.5	R-8	S-17	



(CONTINUED NEXT PAGE)

Logged By: C. Martin | **Drilled by:** Holt Services, Inc.
Date Started: 9/12/18 | **GPS Coordinates:** 45.589° N -122.392° W (WGS 84)
Drilling Method: Roto Sonic
Equipment: Terra Sonic TSi 150
Hole Diameter: 4 in.
Note: See Legend for Explanation of Symbols
Hammer Type: Auto Hammer
Weight: 140 lb
Drop: 30 in.
Energy Ratio:

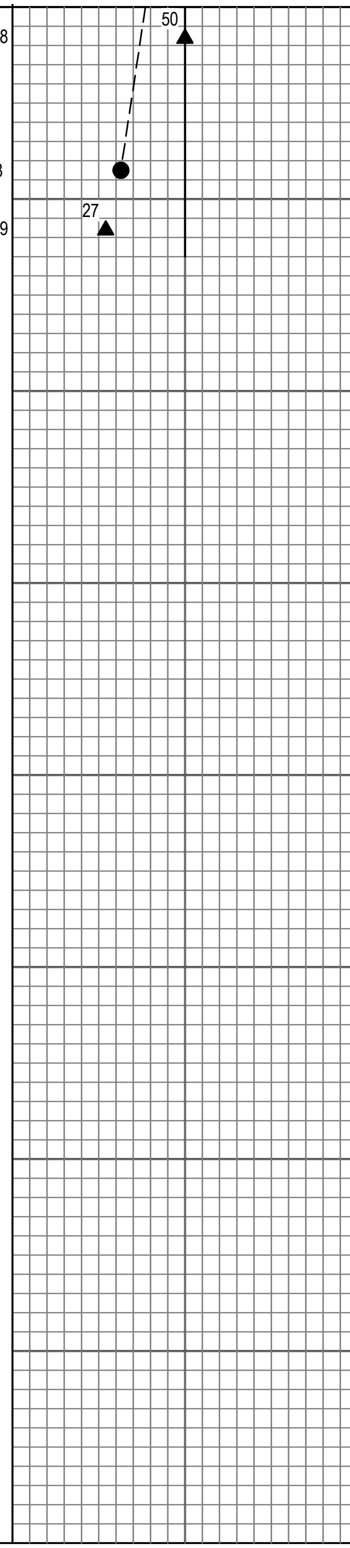
GRI

BORING B-3

APR. 2019 JOB NO. W1241 FIG. 3A

Exhibit D-1: Final Drainage Report

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	INSTALLATION	RUN NO.	SAMPLE TYPE	SAMPLE NO.	● MOISTURE CONTENT, % ☐ FINES CONTENT, % LIQUID LIMIT, % PLASTIC LIMIT, % (0 50 100)	COMMENTS AND ADDITIONAL TESTS
		Surface Elevation: 42.0 ft [±] (NGVD 29)							
45		Silty SAND to sandy SILT, yellow-brown with white and black mineral staining, medium dense to dense/very stiff to hard, fine- to medium-grained sand (Decomposed Basalt)		P	R-9		SPT-8 S-18 SPT-9	50 27	
		(9/12/2018)	-4.5 46.5						
50									
55									
60									
65									
70									
75									
80									



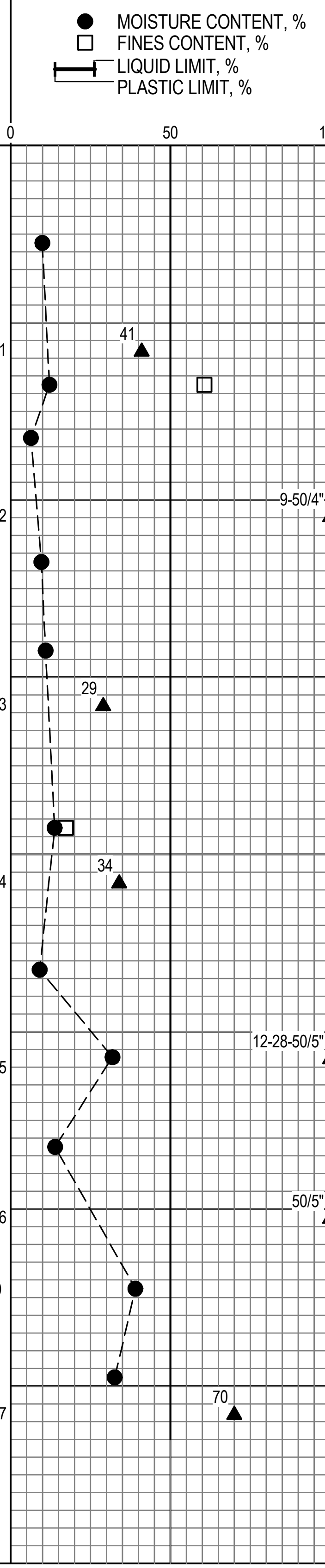
GRI SONIC BORING (GPS) GRI DATA TEMPLATE.GDT 4/19/19

GRI

BORING B-3

APR. 2019 JOB NO. W1241 FIG. 3A

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	RUN NO.	SAMPLE NO.	COMMENTS AND ADDITIONAL TESTS
	Surface Elevation: 35.0 ft [±] (NGVD 29)				
0	SILT, trace to some fine- to coarse-grained sand and subangular gravel, brown, soft to medium stiff, contains organics		R-1	S-1	SPT samples were driven at the end of each Sonic interval. Subsequent Sonic runs were started from the same elevation following the SPT.
5	---boulder encountered at 5 ft			SPT-1	Blow counts may not be representative
	---gravel content increases with depth, gray below 6 ft		R-2	S-2, S-3	
9	Silty GRAVEL, trace to some fine- to coarse-grained sand, gray, medium dense to very dense, subrounded to subangular, contains cobbles	26.0 / 9.0			
10	---boulder encountered at 10 ft			SPT-2	Blow counts may not be representative
			R-3	S-4, S-5	
15				SPT-3	
	---boulder encountered at 17.5 ft		R-4	S-6	
20				SPT-4	
			R-5	S-7	
25	SAND, some silt and gravel- to cobble-sized fragments of weathered basalt, brown, very dense, fine to medium grained (Decomposed Basalt)	10.0 / 25.0		S-8/ SPT-5	
			R-6	S-9	
30				SPT-6	
			R-7	S-10	
33	BASALT, yellow-brown with white, some black mineral staining, predominately decomposed, extremely soft to very soft (R0 to R1)	2.0 / 33.0			
35				S-11, SPT-7	
36.5	(9/10/2018)	-1.5 / 36.5			
40					



GRI SONIC BORING (GPS) GRI DATA TEMPLATE.GDT 4/19/19

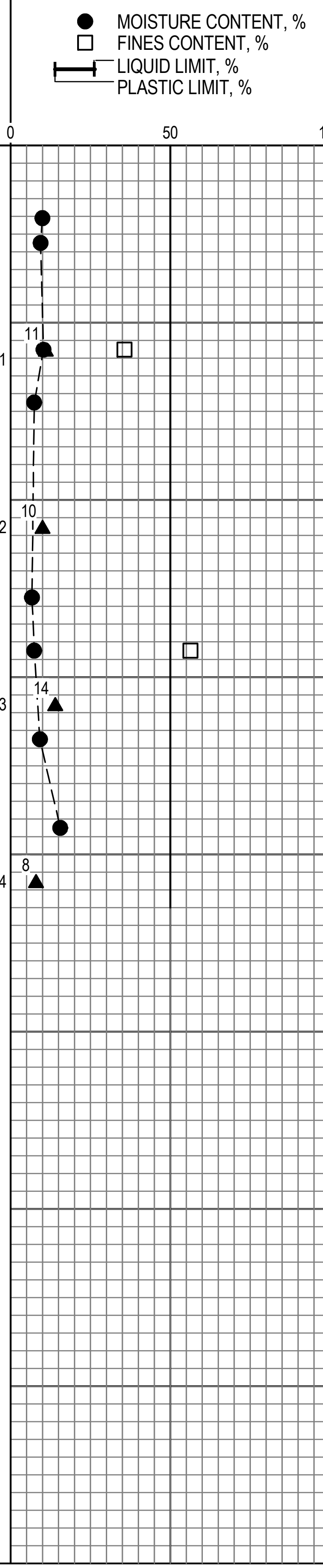
Logged By: C. Martin	**Drilled by:** Holt Services, Inc.
Date Started: 9/10/18	**GPS Coordinates:** 45.5888° N -122.3919° W (WGS 84)
Drilling Method: Roto Sonic **Equipment:** Terra Sonic TSi 150 **Hole Diameter:** 4 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:**
Note: See Legend for Explanation of Symbols	

GRI

BORING B-4

APR. 2019 JOB NO. W1241 FIG. 4A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL (Surface Elevation: 40.0 ft [±] (NGVD 29))	ELEVATION, FT / DEPTH, FT	INSTALLATION	RUN NO.	SAMPLE TYPE	SAMPLE NO.	COMMENTS AND ADDITIONAL TESTS
0		Asphalt concrete PAVEMENT (4 in.) over crushed rock BASE COURSE (18 in.)	38.2 / 1.8		R-1		S-1, S-2	SPT samples were driven at the end of each Sonic interval. Subsequent Sonic runs were started from the same elevation following the SPT.
		Sandy SILT, trace subangular gravel, brown, stiff, fine- to coarse-grained sand (Fill)	37.0 / 3.0					
		Silty GRAVEL, some fine- to coarse-grained sand, angular, contains cobbles (Fill)	35.0 / 5.0					
5		Silty SAND, trace to some subangular to subrounded gravel, gray, medium dense, fine to medium grained (Fill)			R-2		S-3/ SPT-1, S-4	
		---some silt, brown, contains organics at 8.5 ft						
10					R-3		SPT-2, S-5, S-6	
		Sandy SILT, trace subangular to subrounded gravel, brown, stiff, fine- to medium-grained sand, contains cobbles (Fill)	26.0 / 14.0					
15		Silty SAND, trace to some subangular to subrounded gravel, gray, loose, fine to medium grained, contains organics (Fill)	23.0 / 17.0		R-4		SPT-3, S-7, S-8	
20							SPT-4	
		(9/7/2018)	18.5 / 21.5					
25								
30								
35								
40								

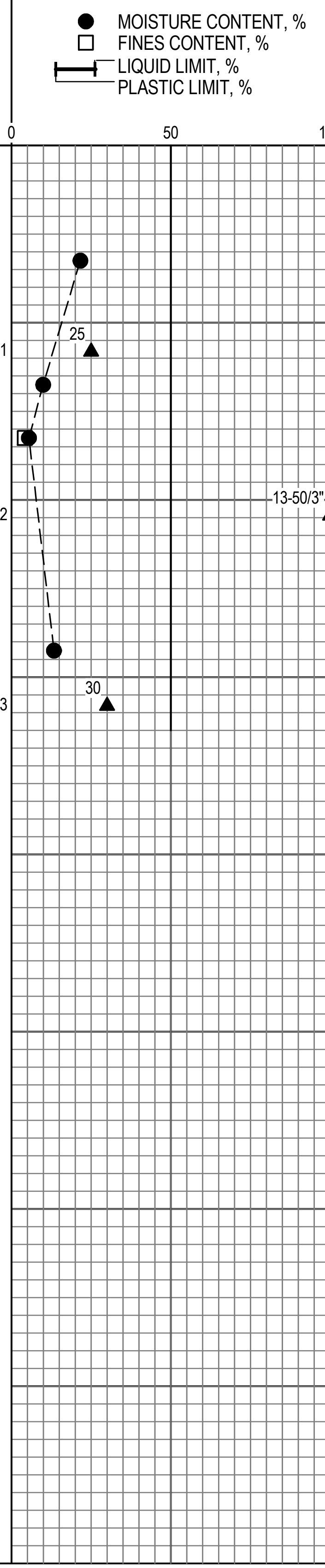


Logged By: C. Martin	**Drilled by:** Holt Services, Inc.
Date Started: 9/7/18	**GPS Coordinates:** 45.589° N -122.3908° W (WGS 84)
Drilling Method: Roto Sonic **Equipment:** Terra Sonic TSi 150 **Hole Diameter:** 4 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:**
Note: See Legend for Explanation of Symbols	

GRI

BORING B-5

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL Surface Elevation: 35.5 ft [±] (NGVD 29)	ELEVATION, FT / DEPTH, FT	INSTALLATION	RUN NO.	SAMPLE TYPE	SAMPLE NO.	COMMENTS AND ADDITIONAL TESTS
		Asphalt concrete PAVEMENT (4 in.) over crushed rock BASE COURSE (16 in.)	33.9 / 1.6					SPT samples were driven at the end of each Sonic interval. Subsequent Sonic runs were started from the same elevation following the SPT.
		SILT, some fine- to coarse-grained sand and subrounded gravel, red-brown, stiff	30.5 / 5.0		R-1		S-1	
5		Silty GRAVEL, trace to some fine- to coarse-grained sand, gray to brown, medium dense to dense, subrounded to subangular, contains cobbles	27.5 / 8.0		R-2		SPT-1, S-2, S-3	
10		Sandy GRAVEL, trace to some silt, gray to brown, medium dense to dense, fine- to coarse-grained sand, subrounded to subangular gravel, contains cobbles ---boulder encountered at 11 ft	22.5 / 13.0		R-3		SPT-2	Blow counts may not be representative
15		Silty GRAVEL, trace to some fine- to coarse-grained sand, gray to brown, medium dense to dense, subrounded to subangular, contains cobbles	19.0 / 16.5				S-4, SPT-3	
		(9/7/2018)						
20								
25								
30								
35								
40								



Logged By: C. Martin	Drilled by: Holt Services, Inc.
Date Started: 9/7/18	GPS Coordinates: 45.5876° N -122.388° W (WGS 84)
Drilling Method: Roto Sonic Equipment: Terra Sonic TSi 150 Hole Diameter: 4 in.	Hammer Type: Auto Hammer Weight: 140 lb Drop: 30 in. Energy Ratio:
Note: See Legend for Explanation of Symbols	

GRI

BORING B-6

APR. 2019 JOB NO. W1241 FIG. 6A

Exhibit D-1: Final Drainage Report

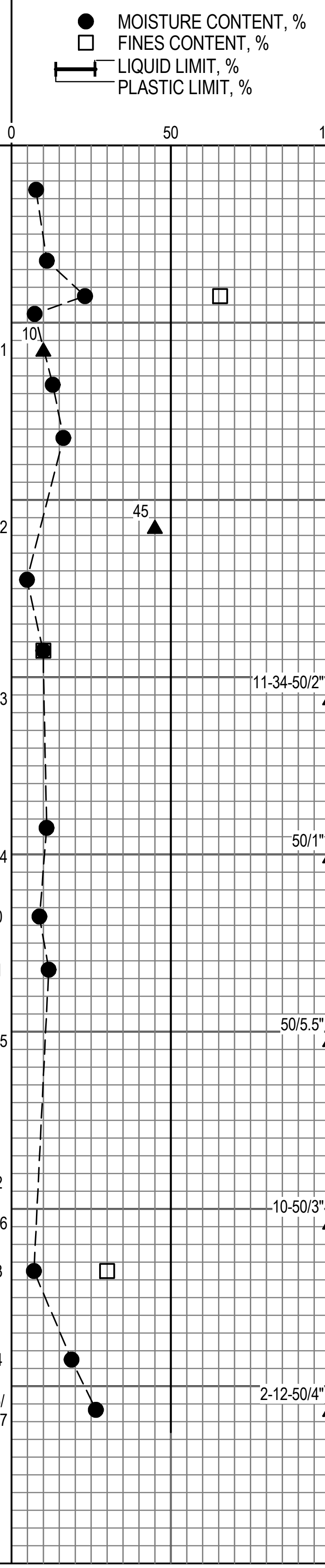
BORING B-7

CLASSIFICATION OF MATERIAL

Surface Elevation: 34.0 ft [±] (NGVD 29)

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT
0–4	Silty GRAVEL, some fine- to coarse-grained sand, brown, medium dense, contains organics (Fill)	30.0 / 4.0
4–10	SILT, some subangular to subrounded gravel and fine- to coarse-grained sand, brown, stiff, contains organics, metal fragments, and cobbles (Fill)	24.0 / 10.0
10–30	Silty GRAVEL, trace to some fine- to coarse-grained sand, brown, dense to very dense, subrounded to subangular, contains cobbles ---boulder encountered at 13 ft ---sandy, some silt below 14 ft ---boulder encountered at 20 ft	4.0 / 30.0
30–33	Silty GRAVEL, some fine- to coarse-grained sand, brown, very dense, subangular (Decomposed Basalt)	1.0 / 33.0
33–36.3	BASALT, red-brown and yellow with white and black mineral staining, predominately decomposed, extremely soft to very soft (R0 to R1)	-2.3 / 36.3
	(9/11/2018)	

RUN NO.	SAMPLE NO.	SPT BLOWS
R-1	S-1	
R-1	S-2	
R-1	S-3	
R-1	S-4	
R-2	SPT-1	10
R-2	S-5	
R-2	S-6	
R-3	SPT-2	45
R-3	S-7	
R-3	S-8	
R-4	SPT-3	11-34-50/2"
R-4	S-9	
R-5	SPT-4	50/1"
R-5	S-10	
R-5	S-11	
R-6	SPT-5	50/5.5"
R-6	S-12	
R-7	SPT-6	10-50/3"
R-7	S-13	
R-7	S-14	
	S-15/ SPT-7	2-12-50/4"



COMMENTS AND ADDITIONAL TESTS

SPT samples were driven at the end of each Sonic interval. Subsequent Sonic runs were started from the same elevation following the SPT.

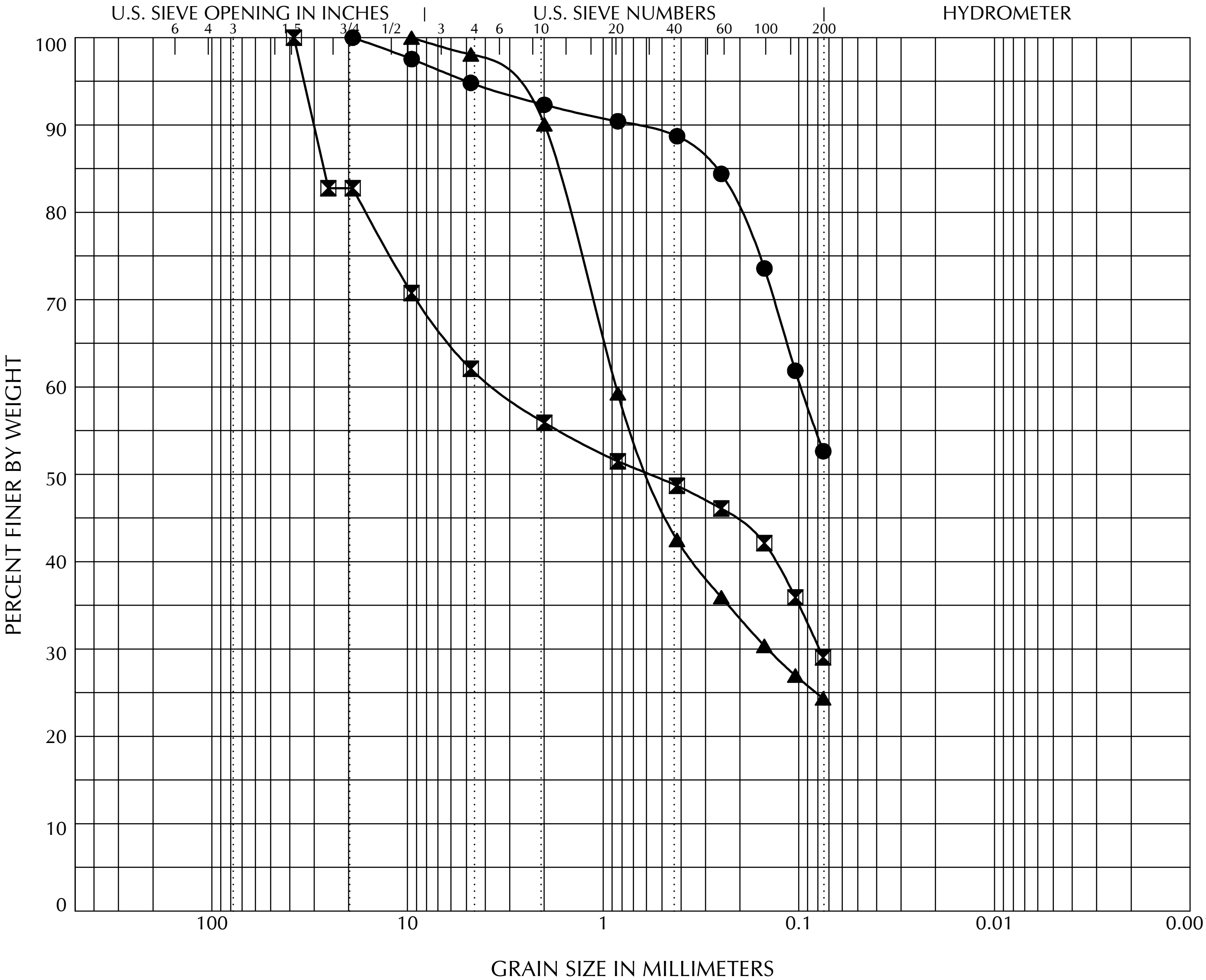
25.7 ft (9/11/2018)

Logged By: C. Martin	**Drilled by:** Holt Services, Inc.
Date Started: 9/11/18	**GPS Coordinates:** 45.5875° N -122.3877° W (WGS 84)
Drilling Method: Roto Sonic **Equipment:** Terra Sonic TSi 150 **Hole Diameter:** 4 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:**
Note: See Legend for Explanation of Symbols	

GRI

BORING B-7

APR. 2019 JOB NO. W1241 FIG. 7A



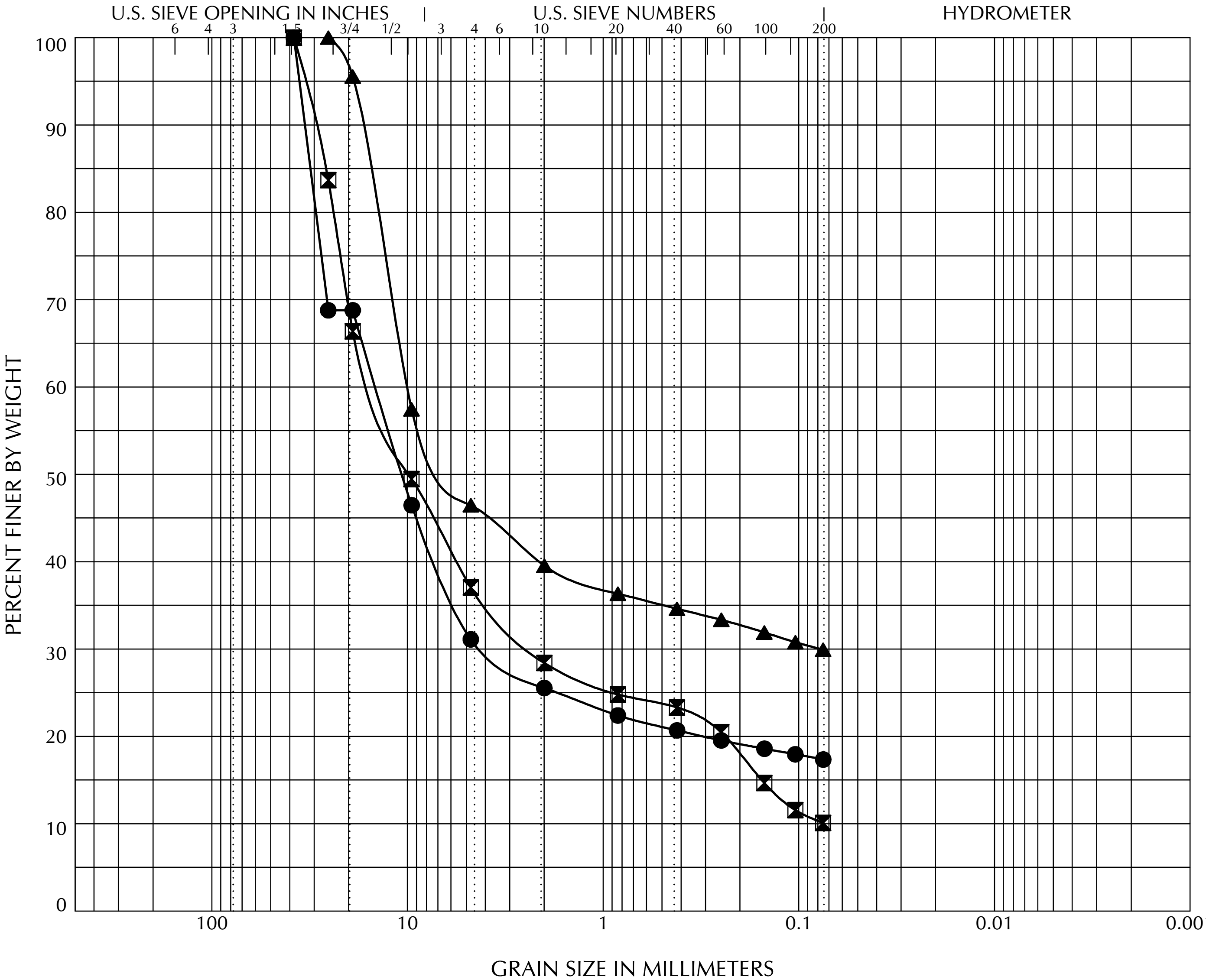
COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

	Location	Sample	Depth, ft	Classification	Gravel, %	Sand, %	Fines, %
●	B-3	S-8	11.5	Sandy SILT, trace rounded gravel, red-brown, fine- to medium-grained sand	5.2	42.2	52.6
⧗	B-3	S-10	14.5	Silty sandy GRAVEL, red-brown, fine- to coarse-grained sand, subrounded to subangular gravel	37.9	33.0	29.1
▲	B-3	S-12	23.0	Silty SAND, trace subangular gravel, brown, fine to coarse grained	1.9	73.7	24.4

GRI

GRAIN SIZE DISTRIBUTION

APR. 2019 JOB NO. W1241 FIG. 8A



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

	Location	Sample	Depth, ft	Classification	Gravel, %	Sand, %	Fines, %
●	B-4	S-6	19.0	Silty GRAVEL, trace fine- to coarse-grained sand, subrounded to subangular	68.9	13.8	17.4
⧗	B-7	S-8	14.0	Sandy GRAVEL, some silt, fine- to coarse-grained sand, subangular to subrounded gravel	62.9	27.0	10.1
▲	B-7	S-13	31.5	Silty GRAVEL, some fine- to coarse-grained sand, subangular (Decomposed Basalt)	53.5	16.5	29.9

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GRAIN SIZE DISTRIBUTION

APR. 2019 JOB NO. W1241 FIG. 9A

GRAIN SIZE GRI-THREE PER PAGE GRI DATA TEMPLATE.GDT 4/19/19

APPENDIX B

Photographs of Core Logs

BORING B-1

Bottom of Run **Boring B-1, Run 1, 0 to 6 ft** Top of Run

BORING B-2

Bottom of Run **Boring B-2, Run 1, 0 to 6 ft** Top of Run

BORING B-3

Bottom of Run **Boring B-3, Run 1, 0 to 5 ft** Top of Run

Bottom of Run **Boring B-3, Run 2, 5 to 10 ft** Top of Run

Bottom of Run **Boring B-3, Run 3, 10 to 15 ft** Top of Run

Bottom of Run **Boring B-3, Run 4, 15 to 20 ft** Top of Run

Bottom of Run **Boring B-3, Run 5, 20 to 25 ft** Top of Run

Bottom of Run **Boring B-3, Run 6, 25 to 30 ft** Top of Run

GRI

SONIC CORE PHOTOGRAPHS

Bottom of Run **Boring B-3, Run 7, 30 to 35 ft** Top of Run

Bottom of Run **Boring B-3, Run 8, 35 to 40 ft** Top of Run

Bottom of Run **Boring B-3, Run 9, 40 to 45 ft** Top of Run

GRI

SONIC CORE PHOTOGRAPHS

BORING B-4

Top of Run | **Boring B-4, Run 1, 0 to 5 ft** | Bottom of Run

Bottom of Run | **Boring B-4, Run 2, 5 to 10 ft** | Top of Run

Bottom of Run **Boring B-4, Run 3, 10 to 15 ft** Top of Run

Bottom of Run **Boring B-4, Run 4, 15 to 20 ft** Top of Run

Bottom of Run **Boring B-4, Run 5, 20 to 25 ft** Top of Run

GRI

SONIC CORE PHOTOGRAPHS

Bottom of Run **Boring B-4, Run 6, 25 to 30 ft** Top of Run

Bottom of Run **Boring B-4, Run 7, 30 to 35 ft** Top of Run

BORING B-5

Top of Run | **Boring B-5, Run 1, 0 to 5 ft** | Bottom of Run

Top of Run | **Boring B-5, Run 2, 5 to 10 ft** | Bottom of Run

Top of Run **Boring B-5, Run 3, 10 to 15 ft** Bottom of Run

Top of Run **Boring B-5, Run 4, 15 to 20 ft** Bottom of Run

BORING B-6

Top of Run | **Boring B-6, Run 1, 0 to 5 ft** | Bottom of Run

Top of Run | **Boring B-6, Run 2, 5 to 10 ft** | Bottom of Run

Top of Run | **Boring B-6, Run 3, 10 to 15 ft** | Bottom of Run

GRI

SONIC CORE PHOTOGRAPHS

APR. 2019 JOB NO. W1241 FIG. 10B

BORING B-7

Bottom of Run | **Boring B-7, Run 1, 0 to 5 ft** | Top of Run

Bottom of Run | **Boring B-7, Run 2, 5 to 10 ft** | Top of Run

Bottom of Run | **Boring B-7, Run 3, 10 to 15 ft** | Top of Run

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SONIC CORE PHOTOGRAPHS

Top of Run **Boring B-7, Run 4, 15 to 20 ft** Bottom of Run

Top of Run **Boring B-7, Run 5, 20 to 25 ft** Bottom of Run

Bottom of Run **Boring B-7, Run 7, 30 to 35 ft** Top of Run

GRI

SONIC CORE PHOTOGRAPHS

APPENDIX C

March 15, 2019, Infiltration Testing Report by GRI

GRI
1101 Broadway, Suite 215
Vancouver, WA 98660
p | 360-213-1690 f | 360-213-1697
www.gri.com

March 15, 2019 W1241-A INFILTRATION RPT

Wallis Engineering, PLLC
215 W 4th Street, Suite 200
Vancouver, WA 98660

Attention: Tim Shell, PE

SUBJECT: Infiltration Testing
Lacamas Creek Sewer Pump Station Improvements
Camas, Washington

At your request, GRI completed field infiltration testing in support of the Lacamas Creek Sewer Pump Station Project in Camas, Washington. The location of the proposed sidewalk improvement project is shown on the Vicinity Map, Figure 1. The purpose of this investigation was to develop recommended stormwater infiltration rates for the infiltration facility that will be constructed as part of the improvements. The investigation included review of available geotechnical information for the alignment and vicinity, subsurface explorations, field infiltration tests, laboratory testing, and engineering analyses. This report documents the work accomplished and provides the recommended infiltration rate for the proposed facility.

GRI recently completed a geotechnical investigation for the project. The results of this investigation are summarized in the following report and were reviewed when developing our proposal:

> GRI, January 3, 2019, "Geotechnical Investigation, Lacamas Creek Sewer Pump Station Improvements, Camas, Washington;" prepared for Wallis Engineering, PLLC.

This infiltration report is considered to be an addendum to our geotechnical report referenced above, and as such, is subject to the same limitations described therein.

PROJECT DESCRIPTION

As part of the Lacamas Creek Sewer Pump Station Improvement project, we understand a new infiltration facility is planned at the location of the proposed jacking pit at Lacamas Creek Park. The infiltration facility will be an infiltration trench, the base of which will be at about elevation 20 ft or about 18 ft below existing site grades. The infiltration system will have an overflow into Lacamas Creek and be designed in general accordance with the 2014 Stormwater Management Manual for Western Washington (SWMMWW). All elevations in this report reference the National Geodetic Vertical Datum of 1929 (NGVD 29) unless otherwise noted.

FIELD EXPLORATION AND LABORATORY TESTING PROGRAM

General

Subsurface materials and conditions at the location of the proposed infiltration facility were investigated between January 17 and February 1, 2019, with three borings and one test pit, designated TP-1. The approximate locations of the borings and test pits completed for this study are shown on Figure 2.

As originally envisioned, we planned to complete a falling head infiltration test in a borehole advanced at the location and to the planned depth of the infiltration facility. Because of the presence of cobbles and boulders encountered during drilling, it was not feasible to advance the boring to the base of the planned infiltration facility. In order to obtain some information regarding the feasibility of infiltrating stormwater at the site, a small-scale pilot infiltration test was completed in a test pit advanced approximately 40 ft to the north of the jacking pit. The test pit was completed in a gravel-surfaced area which was selected to not damage the existing asphalt pavement present at the jacking pit location. Due to safety considerations and limitations of equipment, the infiltration test was completed in the same geologic unit but at a shallower depth than the planned base of infiltration facility. This depth was selected by the design team based on the data collected from boring B-3 completed as part of the original geotechnical investigation and the assumption that the soil conditions in the test pit would be similar to the soil conditions at the base of the facility.

Borings

Three borings, designated B-9, B-9A, and B-9B, were completed on January 17, 2019, using a truck-mounted drill rig and hollow-stem auger drilling techniques. Each boring was advanced until refusal conditions on cobbles and boulders at depths of about 9.5 to 10.1 ft below the ground surface. The borings were advanced by Western States Soil Conservation, Inc., of Hubbard, Oregon, under subcontract to GRI.

Disturbed soil samples were obtained from boring B-9 at depths of about 5 and 10 ft and representative grab samples of the soil cuttings were collected from the other explorations. At the time of sampling, the Standard Penetration Test (SPT) was conducted. This test consists of driving a standard split-spoon sampler into the soil a distance of 18 in. using a 140-lb hammer dropped 30 in. The number of blows required to drive the sampler the last 12 in. is known as the standard penetration resistance, or SPT N-value. The SPT N-values provide a measure of the relative density of granular soils, such as sand, and the relative consistency, or stiffness, of cohesive soils, such as silt. The samples were carefully examined in the field and representative portions were saved in airtight jars or bags and returned to our laboratory for further classification and testing. After the borings were advanced to their final depth and sampled, the boreholes were decommissioned in accordance with Washington State well regulations.

Logs of the borings are provided on Figures 3 through 5. The logs present a descriptive summary of the various types of materials encountered in the borings and note the depth at which the materials and/or characteristics of the materials change. The sample number and type are indicated to the right of the descriptive summary. The terms and symbols used to describe the soils encountered in the probes are defined in Table 1 and the attached legend.

Small-Scale Pilot Infiltration Tests

A small-scale pilot infiltration test was conducted on February 1, 2019, at a depth of about 12.3 ft in test pit TP-1, which was made using a tracked excavator. The excavator was supplied and operated under subcontract to GRI by Scott Lee Excavating, Inc., of Battle Ground, Washington.

The test excavation was 2.8 ft wide by 6.7 ft long and 12.3 ft deep. Upon reaching the test depth, the test excavation was filled with about 12 in. of water, which is consistent with the depth of water recommended in the 2014 SWMMWW for a small-scale pilot infiltration test. After filling the test pit with 12 in. of water, the water inflow was stopped and the amount of time necessary for the water level to drop 2 in. was recorded.

The water level in the test pit was re-established at 12 in. and the test was repeated until consistent measurements were obtained. A total of 10 runs, designated R-1 through R-10, were completed over an approximately 2-hour period. After the final run, the drop in water level in the test pit was monitored for a period of 1.5 hours. The average field infiltration was determined over the initial 2-in. water level drop in the last run in order to simulate constant-head conditions, which is consistent with the requirements of the Small-Scale Pilot Infiltration Test as described in the 2014 SWMMWW. The amount of time recorded for the water level in the excavation to drop 2 in. is summarized in Table 2 and the data from the falling-head portion of R-10 are provided in Table 3.

Table 2: TIME NECESSARY FOR WATER LEVEL IN TEST PIT TO DROP 2 IN.

Run	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10
Time, minutes	3.4	3.5	3.55	3.6	3.65	3.65	3.75	3.8	3.8	3.8

Table 3: FALLING HEAD INFILTRATION TEST DATA

Head, in.	Time, minutes
12	0.0
11	1.7
10	3.8
9	5.4
8	9.6
7	17.2
6	32.3
5	56.8
4	94.8

Subsequent to the infiltration test, the excavation was advanced an additional 2 ft to characterize the soil below the test depth and the excavation was backfilled with the excavated soil. A log of the test pit excavation is provided on Figure 6.

Laboratory Testing

All samples obtained from the borings and test pits were returned to our laboratory, where the physical characteristics of the samples were noted and the field classifications modified where necessary. A mechanical-sieve analysis was completed on two representative samples obtained from the base of the infiltration test pit in substantial conformance with ASTM International (ASTM) D6913. The test is performed by taking a sample of known dry weight and washing it over a No. 200 sieve. The material retained on the sieve is oven-dried and weighed and the percentage of material passing the No. 200 sieve is calculated. The soil retained on the No. 200 sieve is then screened through a series of sieves of various sizes using a sieve shaker. The weight of each sieve is measured prior to and after the test. The weight of the sample retained on each sieve is recorded and expressed as a percentage of the total sample weight. The test results are shown on Figure 7.

A sample obtained from the infiltration test pit was tested to determine the organic content and cation exchange capacity (CEC). The testing was completed by Specialty Analytical, Inc. of Clackamas, Oregon under subcontract to GRI. The CEC and organic content tests were completed in accordance with Environmental Protection Agency (EPA) Method 9081 and ASTM D2974, respectively. The test results are summarized in Table 4 below and the Specialty Analytical report included as an attachment at the end of this report.

Table 4: CATION EXCHANGE CAPACITY AND ORGANIC CONTENT TEST RESULTS

Location	Test Depth, ft	Cation Exchange Capacity, meq/100 g	Organic Content, %
TP-1	12.25	218	2.4

SUBSURFACE CONDITIONS

For the purpose of discussion, the materials disclosed by the borings and test pit completed for this study have been grouped into the following units based on their physical characteristics and engineering properties. Borings B-9, B-9A, and B-9B were advanced through an asphalt concrete pavement section consisting of about 1.5 in. of asphalt underlain by about 6 in. of crushed-surfacing base course. Test pit TP-1 was advanced through a 10-in.-thick crushed-rock surfacing layer. Listed as they were encountered from the ground surface downward, the units are:

1. **FILL**
2. **SILT**
3. **Silty GRAVEL**
4. **BASALT**

1. FILL. Fill was encountered in below the pavement section to a depth of about 4.5 ft in boring B-9A. The fill consists of gravelly, sandy silt. Concrete and metal debris were encountered in the fill between a depth of about 1.5 to 2 ft. Based on observations during drilling and our experience in the area, the fill is typically soft to medium stiff.

2. SILT. Silt was encountered below the asphalt concrete pavement in borings B-9 and B-9B and below the crushed surfacing in test pit TP-1. The silt extends to depths of between 2 and 4.5 ft. The silt includes variable fine- to medium-grained sand content, ranging from some sand to sandy, and a trace of gravel. Based on observations during drilling and digging and our experience in the area, the relative consistency of the silt is medium stiff to hard.

3. Silty GRAVEL. Silty gravel was encountered below the fill or silt and extends to the maximum depth explored (i.e., between about 9.5 and 10.1 ft) in borings B-9, B-9A, and B-9B and to a depth of about 13 ft in test pit TP-1. The unit typically consists of silty gravel with some fine- to coarse-grained sand. Cobbles were encountered throughout the unit. Boulders were encountered in boring B-9 at a depth of about 9 ft, boring B-9A at depths of about 4.5 and 9 ft, and boring B-9B at depths of about 4.5 and 9.25 ft. During the advancement of test pit TP-1, we encountered about 15 boulders up to 2.5 ft in diameter at various depths within the unit. A photograph of the soil excavated from the test pit is provided on Figure 8 below. Based on SPT N-values ranging from 66 blows/ft to refusal, defined as more than 50 blows for 6 in. of sampler penetration, the relative density of the gravel is very dense. However, it should be noted that SPT N-values tend to overpredict the relative density of soils that contain gravel, cobbles, and boulders.

Figure 8: Materials Excavated from Test Pit TP-1

4. Decomposed BASALT. Decomposed basalt was encountered below the silty gravel to the maximum depth explored of about 14.5 ft in test pit TP-1. The decomposed basalt consists of silty, fine- to medium-grained sand. Based on SPT N-values from nearby borings, we anticipate the decomposed basalt is dense to very dense.

Groundwater

Groundwater was not encountered in the explorations advanced for this infiltration investigation. However, the groundwater level was measured in a vibrating wire piezometer installed in boring B-3 advanced as part of our original geotechnical investigation for the project and about 80 ft west of the proposed infiltration feature. The groundwater level in the piezometer was measured between September 12, 2018, and December 17, 2018, and fluctuated between about elevations 6.5 and 10.2 ft during this time period.

INFILTRATION RATE

General

The small-scale pilot infiltration test was conducted at a depth of about 12.3 ft in silty gravel with cobbles and boulders. Above a depth of about 11 ft, the silt content of the silty gravel unit is higher than between about 11 and 12.3 ft and anticipated to be less permeable. The pilot infiltration test method described in the 2014 SWMMWW is intended to evaluate the vertical infiltration rate over the bottom surface area of the test pit. However, predominantly decomposed basalt was encountered at a depth of 13 ft, or about 1 ft below the depth of the infiltration test. In our opinion, the decomposed basalt is essentially impermeable and the infiltration observed in the infiltration test occurred horizontally rather than vertically. In this regard, we recommend sizing the infiltration facility based on horizontal infiltration into a 12-in.-thick layer of the silty gravel soil unit. The horizontal infiltration rate for the 12-in.-thick layer can be estimated as 2.6 ft^3/hr per ft^2 of wetted area assuming a minimum water head of 12 in. It should be noted that our infiltration test was completed in a portion of the silty gravel unit with less silt than observed at other depths and locations. This is accounted for by using a site variability factor at the low end of the range, as described by the 2014 SWMMWW.

Correction factors be applied to the initial vertical infiltration rate in accordance with Section 3.3.6 of Volume III of the 2014 SWMMWW. We recommend assuming a site variability and number of locations tested correction factor, CF_V, of 0.33 and a test method correction factor, CF_T, of 0.50. The degree of influent control correction factor, CF_M, should be determined by the project civil engineer in accordance with the guidelines of 2014 SWMMWW.

The presence of boulders prevented borehole infiltration testing at the actual proposed facility location and depth. Rather, the infiltration test was completed at a shallower depth (i.e., about elevation 27 ft) and about 40 ft north of the proposed facility in a soil unit anticipated to be similar to the soil (i.e., silty gravel) present at the location of the proposed stormwater infiltration facility. The explorations completed for this project indicate significant variability in the silt content and permeability of the silty gravel as well as the depth of the underlying impermeable decomposed basalt. For these reasons, we recommend an additional infiltration test be completed at the time of construction at the actual facility location and the actual facility design include some flexibility should the soil conditions vary from the assumed conditions. If an infiltration test is completed at the base of the proposed infiltration facility and with a water head consistent with the design water head, it may be possible to use higher infiltration rates and correction factors than assumed above.

Our experience has indicated the infiltration rate of compacted soils can be more than an order of magnitude less than soil that has not been compacted, especially for silty soils. Therefore, the specifications should not allow construction equipment to compact the soil at the base of the proposed infiltration facilities.

DESIGN REVIEW AND CONSTRUCTION SERVICES

We welcome the opportunity to review and discuss other portions of the construction specifications and plans as they are being developed. In addition, GRI should be retained to review all geotechnical-related portions of the plans and specifications to evaluate whether they are in conformance with the recommendations provided in our report. To observe compliance with the intent of our recommendations, the design concepts, and the plans and specifications, we are of the opinion all construction operations dealing with stormwater infiltration, including any full-scale infiltration testing, be observed by a GRI representative. Our construction-phase services will allow for timely design changes if site conditions are encountered that are different from those described in our report. If we do not have the opportunity to confirm our interpretations, assumptions, and analyses during construction, we cannot be responsible for the application of our recommendations to subsurface conditions different from those described in this report.

Please contact the undersigned if you have any questions regarding this report.

Submitted for GRI,

BRIAN A. BENNETTS
STATE OF WASHINGTON
43153
REGISTERED
PROFESSIONAL ENGINEER

(12-12-2017) Renews 03/2020

Matthew S. Shanahan, PE, GE Principal	Brian A. Bennetts, PE Senior Engineer	Alex K. Baumann, PE Engineering Staff

This document has been submitted electronically.

Table 1: GUIDELINES FOR CLASSIFICATION OF SOIL

Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values) blows per ft
very loose	0 - 4
Loose	4 - 10
medium dense	10 - 30
dense	30 - 50
very dense	over 50

Consistency for Fine-Grained (Cohesive) Soil

Consistency	Standard Penetration Resistance (N-value) blows per ft	Torvane or Undrained Shear Strength, tsf
very soft	0 – 2	less than 0.125
soft	2 – 4	0.125 - 0.25
medium stiff	4 – 8	0.25 - 0.50
stiff	8 – 15	0.50 - 1.0
very stiff	15 – 30	1.0 - 2.0
hard	over 30	over 2.0

Sandy silt materials which exhibit general properties of granular soils are given a relative density description.

Grain-Size Classification

Boulders
>12 in.

Cobbles
3 - 12 in.

Gravel
1/4 - 3/4 in. (fine)
3/4 - 3 in. (coarse)

Sand
No. 200 - No. 40 sieve (fine)
No. 40 - No. 10 sieve (medium)
No. 10 - No. 4 sieve (coarse)

Silt/Clay - pass No. 200 sieve

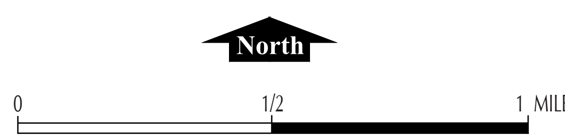
Modifier for Subclassification

Adjective	Percentage of Other Material in Total Sample
clean	0 - 2
trace	2 - 10
some	10 - 30
sandy, silty, clayey, etc.	30 - 50

GRI

Exhibit D-1: Final Drainage Report

USGS TOPOGRAPHIC MAP
CAMAS, WASH. (2017)
WASHOUGAL, WASH. (2017)

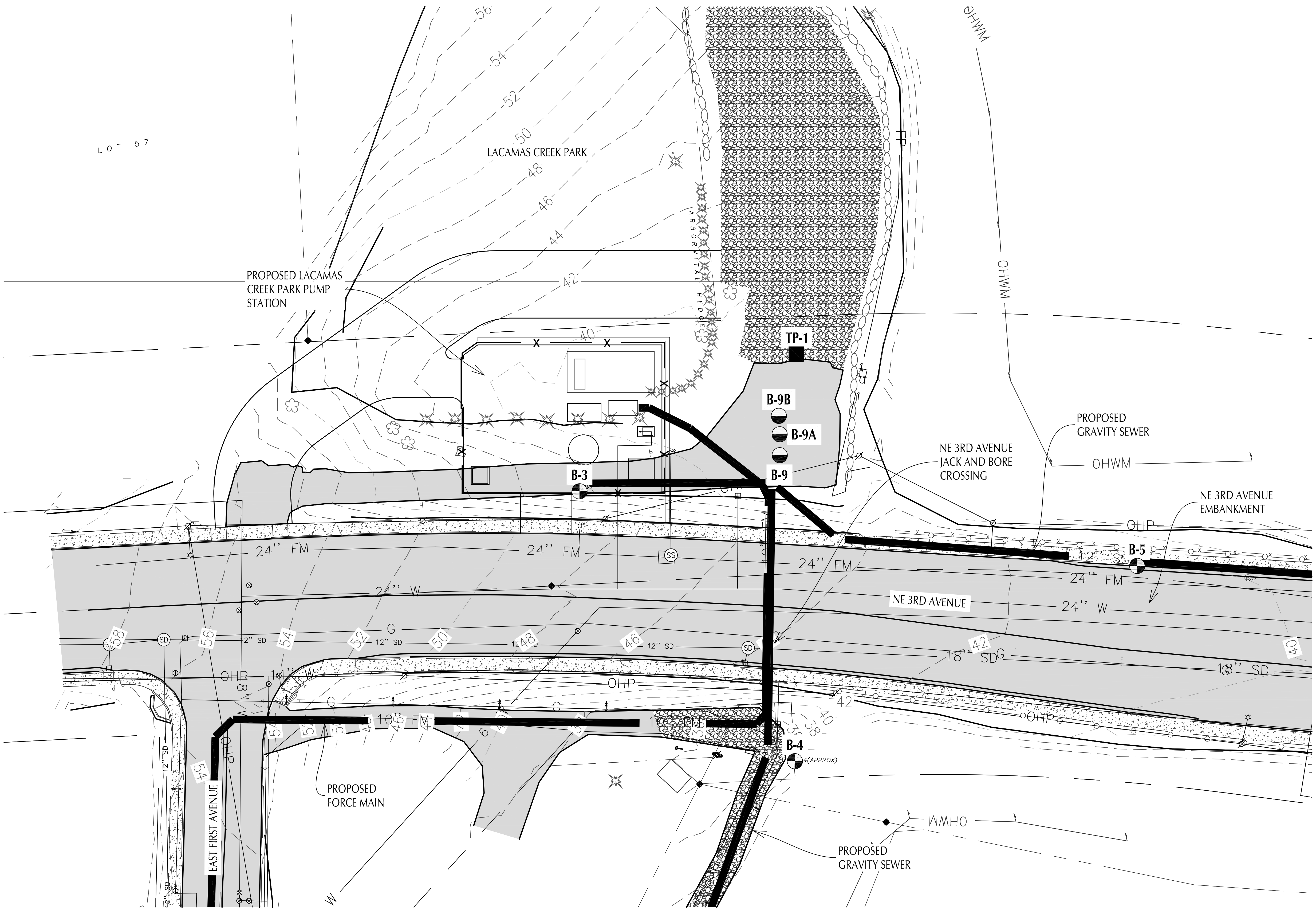


GRI

WALLIS ENGINEERING
LACAMAS CREEK SEWER PUMP
STATION IMPROVEMENTS

VICINITY MAP

MAR. 2019 JOB NO. W1241-A FIG. 1



BORING COMPLETED BY GRI (SEPTEMBER 7-12, 2018)

BORING COMPLETED BY GRI (JANUARY 17, 2019)

TEST PIT COMPLETED BY GRI (FEBRUARY 1, 2019)

SITE PLAN FROM FILE BY WALLIS ENGINEERING, 2018

North

0 40 80 FT

GRI

WALLIS ENGINEERING
LACAMAS CREEK SEWER PUMP STATION IMPROVEMENTS

SITE PLAN

MAR. 2019 JOB NO. W1241-A FIG. 2

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
	LANDSCAPE MATERIALS
	FILL
	GRAVEL; clean to some silt, clay, and sand
	Sandy GRAVEL; clean to some silt and clay
	Silty GRAVEL; up to some clay and sand
	Clayey GRAVEL; up to some silt and sand
	SAND; clean to some silt, clay, and gravel
	Gravelly SAND; clean to some silt and clay
	Silty SAND; up to some clay and gravel
	Clayey SAND; up to some silt and gravel
	SILT; up to some clay, sand, and gravel
	Gravelly SILT; up to some clay and sand
	Sandy SILT; up to some clay and gravel
	Clayey SILT; up to some sand and gravel
	CLAY; up to some silt, sand, and gravel
	Gravelly CLAY; up to some silt and sand
	Sandy CLAY; up to some silt and gravel
	Silty CLAY; up to some sand and gravel
	PEAT

BEDROCK SYMBOLS

Symbol	Typical Description
	BASALT
	MUDSTONE
	SILTSTONE
	SANDSTONE

SURFACE MATERIAL SYMBOLS

Symbol	Typical Description
	Asphalt concrete PAVEMENT
	Portland cement concrete PAVEMENT
	Crushed rock BASE COURSE

SAMPLER SYMBOLS

Symbol	Sampler Description
	2.0-in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
	Shelby tube sampler with recovery (ASTM D1587)
	3.0-in. O.D. split-spoon sampler with recovery (ASTM D3550)
	Grab Sample
	Rock core sample interval
	Sonic core sample interval
	Geoprobe sample interval

INSTALLATION SYMBOLS

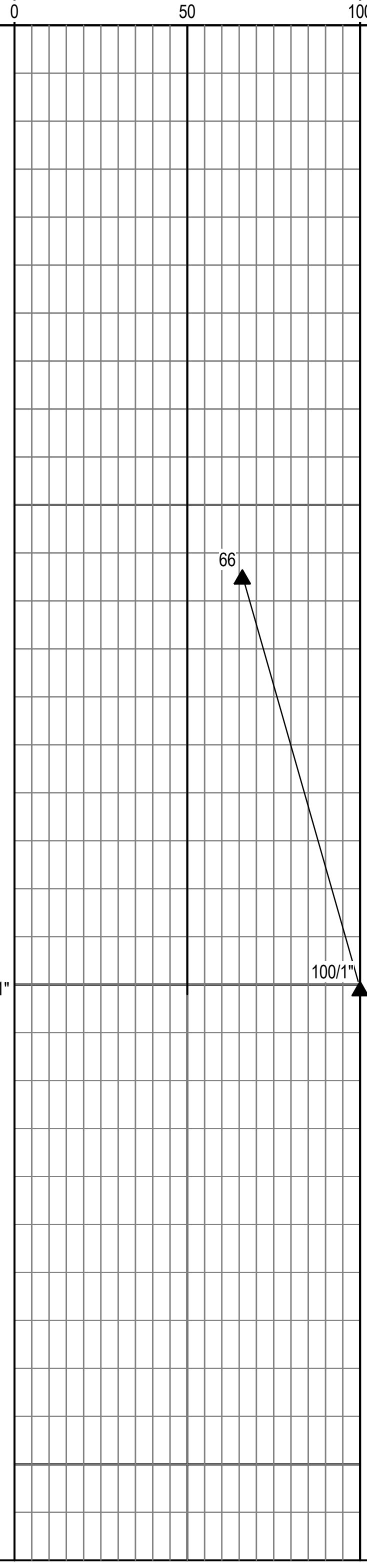
Symbol	Symbol Description
	Flush-mount monument set in concrete
	Concrete, well casing shown where applicable
	Bentonite seal, well casing shown where applicable
	Filter pack, machine-slotted well casing shown where applicable
	Grout, vibrating-wire transducer cable shown where applicable
P	Vibrating-wire pressure transducer
	1-in.-diameter solid PVC
	1-in.-diameter hand-slotted PVC
	Grout, inclinometer casing shown where applicable

FIELD MEASUREMENTS

Symbol	Typical Description
	Groundwater level during drilling and date measured
	Groundwater level after drilling and date measured
	Rock core recovery (%)
	Rock quality designation (RQD, %)

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL Surface Elevation: 39.0 ft [±] (NGVD 29)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Asphalt concrete PAVEMENT (1.5 in.) over crushed rock BASE COURSE (6 in.)	38.4 / 0.6					
		SILT, some fine- to medium-grained sand, trace gravel, brown, medium stiff to hard			S-1	⊠		
2								
4		Silty GRAVEL, some fine- to coarse-grained sand, very dense, contains cobbles and boulders	35.0 / 4.0					
6					S-2		19 33 33	
8								
		---boulder encountered at 9 ft						
10			28.9 / 10.1		S-3		100/1"	
		(1/17/2019) Refusal on boulder at 10.1 ft Groundwater not encountered						
12								
14								
16								

▲ BLOWS PER FOOT
● MOISTURE CONTENT, %
□ FINES CONTENT, %
LIQUID LIMIT, %
PLASTIC LIMIT, %



◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: A. Baumann	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 1/17/19	**GPS Coordinates:** 45.59° N -122.3916° W (WGS 84)
Drilling Method: Hollow-Stem Auger **Equipment:** CME 75 HT Truck-Mounted Drill Rig **Hole Diameter:** 8 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** 0.8
Note: See Legend for Explanation of Symbols	

GRI

BORING B-9

MAR. 2019 JOB NO. W1241 FIG. 3

GRI BORING LOG (GPS) - 16' PP GRI DATA TEMPLATE.GDT 3/1/19

DEPTH, FT	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
	Surface Elevation: 39.0 ft [±] (NGVD 29)						
0	Asphalt concrete PAVEMENT (1.5 in.) over crushed rock BASE COURSE (6 in.)	38.4 / 0.6					
	Gravelly, sandy SILT, brown, stiff to very stiff, fine- to medium-grained sand (Fill) ---6-in.-thick layer of concrete and metal debris encountered at 1.5 ft			S-1			
	Silty GRAVEL, some fine- to coarse-grained sand, very dense, contains cobbles and boulders ---boulder encountered at 4.5 ft	34.5 / 4.5					
				S-2			
	---boulder encountered at 9 ft						
	(1/17/2019) Refusal on boulder at 9.5 ft Groundwater not encountered	29.5 / 9.5					

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16

Chart legend:
- ▲ BLOWS PER FOOT
- ● MOISTURE CONTENT, %
- □ FINES CONTENT, %
- LIQUID LIMIT, %
- PLASTIC LIMIT, %

Scale: 0 50 100

Scale: 0 0.5 1.0

- ◆ TORVANE SHEAR STRENGTH, TSF
- ■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: A. Baumann	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 1/17/19	**GPS Coordinates:** 45.59° N -122.3916° W (WGS 84)
Drilling Method: Hollow-Stem Auger **Equipment:** CME 75 HT Truck-Mounted Drill Rig **Hole Diameter:** 8 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** 0.8
Note: See Legend for Explanation of Symbols	

GRI

BORING B-9A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO. / SAMPLE TYPE / BLOW COUNT	▲ BLOWS PER FOOT; ● MOISTURE CONTENT, %; □ FINES CONTENT, %; LIQUID LIMIT, %; PLASTIC LIMIT, % (0 / 50 / 100)	COMMENTS AND ADDITIONAL TESTS
		Surface Elevation: 39.0 ft [±] (NGVD 29)					
0		Asphalt concrete PAVEMENT (1.5 in.) over crushed rock BASE COURSE (6 in.)	38.4 / 0.6				
		Sandy SILT, trace gravel, brown, medium stiff to hard, fine- to medium-grained sand	34.5 / 4.5				
4.5		Silty GRAVEL, some fine- to coarse-grained sand, very dense, contains cobbles and boulders ---boulder encountered at 4.5 ft ---boulder encountered at 9.25 ft	29.5 / 9.5				
9.5		(1/17/2019) Refusal on boulder at 9.5 ft Groundwater not encountered					

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16

Lower scale: 0, 0.5, 1.0

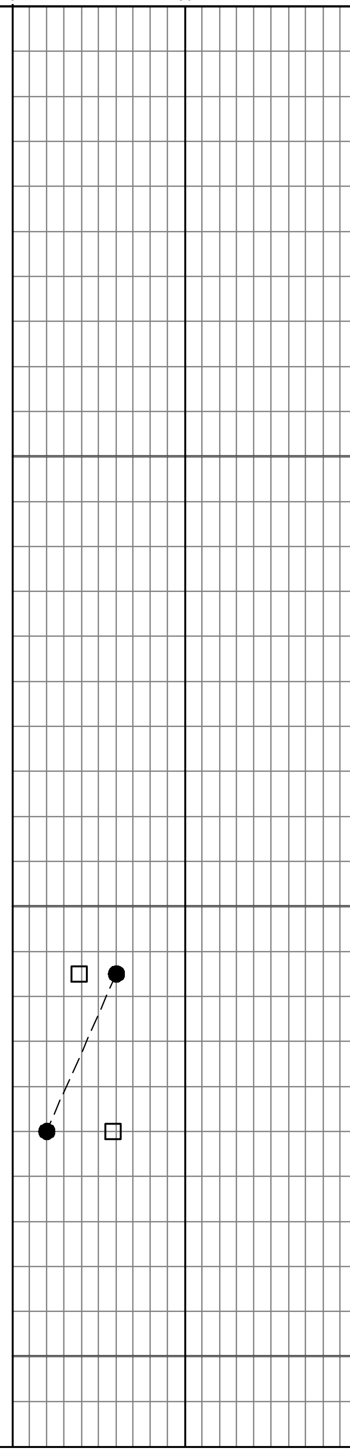
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

Logged By: A. Baumann	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 1/17/19	**GPS Coordinates:** 45.59° N -122.3916° W (WGS 84)
Drilling Method: Hollow-Stem Auger **Equipment:** CME 75 HT Truck-Mounted Drill Rig **Hole Diameter:** 8 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** 0.8
Note: See Legend for Explanation of Symbols	

GRI

BORING B-9B

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL Surface Elevation: 39.0 ft [±] (NGVD 29)	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	MOISTURE CONTENT, % / FINES CONTENT, % / LIQUID LIMIT, % / PLASTIC LIMIT, % (0 – 50 – 100)	COMMENTS AND ADDITIONAL TESTS
		Crushed rock SURFACING (10 in.)	38.2 / 0.8				
		SILT, some fine-grained sand, trace gravel, brown, medium stiff to hard	37.0 / 2.0	S-1			
		Silty GRAVEL, some fine- to coarse-grained sand, very dense, contains cobbles and boulders		S-2			Approximately 15 boulders up to 2.5 ft in diameter encountered between depths of 2 to 13 ft
5				S-3			
				S-4			
				S-5			
10				S-6			
			26.0 / 13.0	S-7			
		Silty SAND, yellow-brown with white and black mineral staining, dense to very dense, fine to coarse grained (Decomposed Basalt)	24.5 / 14.5	S-8 S-9			
15		(2/1/2019) Groundwater not encountered					

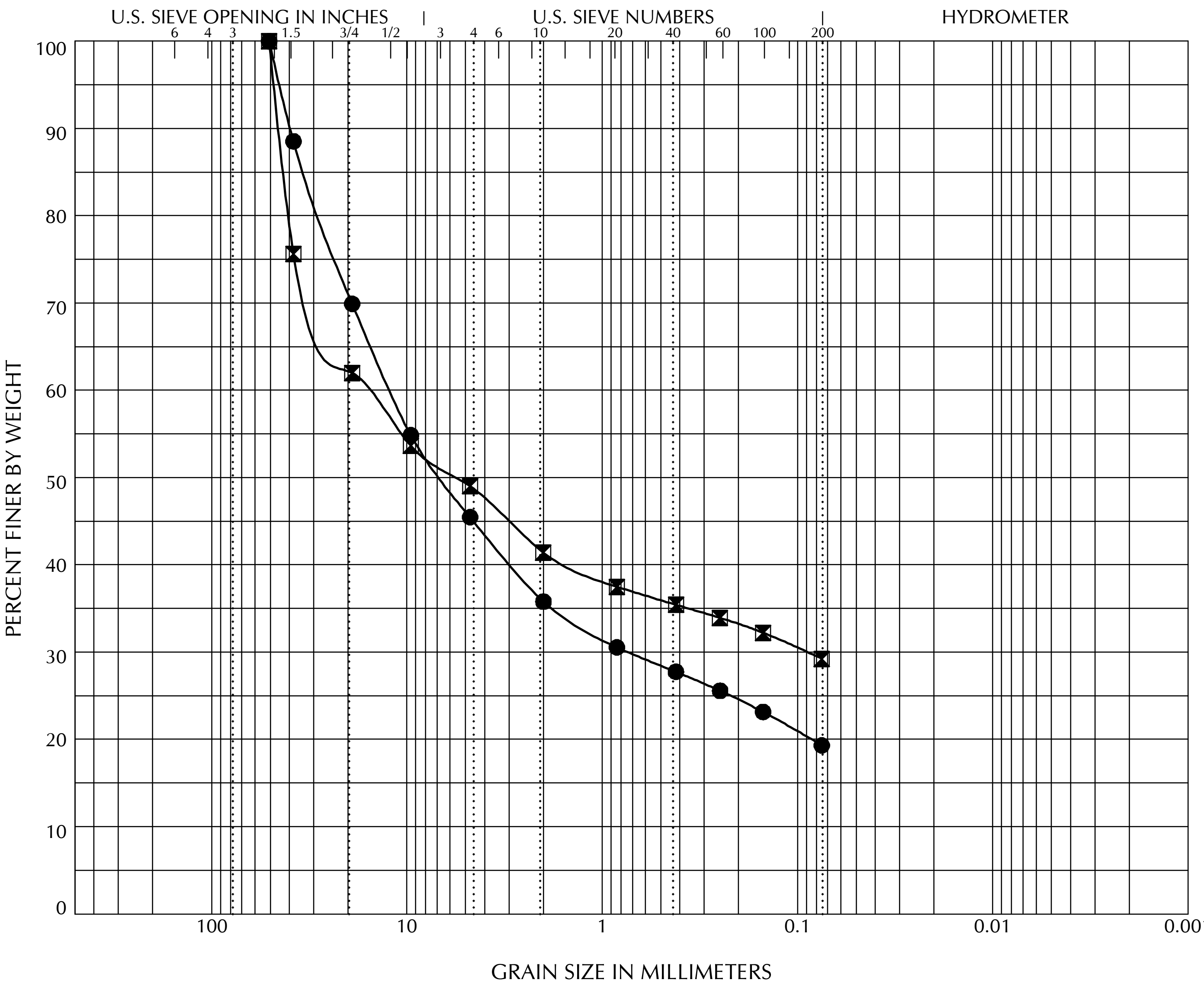


Logged By: A. Baumann	**Excavated by:** Scott Lee Excavating, LLC	**Equipment:** Track-Mounted Excavator
Date Started: 2/1/19	**GPS Coordinates:** 45.5891° N -122.3915° W (WGS 84)	**Note:** See Legend for Explanation of Symbols

GRI TP LOG (GPS) GRI DATA TEMPLATE.GDT 3/1/19

GRI

TEST PIT TP-1



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

	Location	Sample	Depth, ft	Classification	Gravel, %	Sand, %	Fines, %
●	TP-1	S-6	10.5	Silty GRAVEL, some fine- to coarse-grained sand	54.5	26.1	19.3
⧗	TP-1	S-7	12.3	Silty GRAVEL, some fine- to coarse-grained sand	51.0	19.8	29.2

GRI

GRAIN SIZE DISTRIBUTION

MAR. 2019 JOB NO. W1241 FIG. 7

Specialty Analytical Cation Exchange Capacity and Organic Content Test Results

Specialty Analytical

9011 SE Jannsen Rd
Clackamas, Oregon 97015
TEL: 503-607-1331 FAX: 503-607-1336
Website: www.specialtyanalytical.com

March 07, 2019

Brian Bennetts
GRI
1101 Broadway, Suite 215
Vancouver, WA 98660

TEL: (360) 213-1690
FAX
RE: Lacamas Creek Pump Station / W1241-A

Dear Brian Bennetts: Order No.: 1903042

Specialty Analytical received 1 sample(s) on 3/6/2019 for the analyses presented in the following report.

There were no problems with the analysis and all data for associated QC met EPA or laboratory specifications, except where noted in the Case Narrative, or as qualified with flags. Results apply only to the samples analyzed. Without approval of the laboratory, the reproduction of this report is only permitted in its entirety.

If you have any questions regarding these tests, please feel free to call.

Sincerely,

Marty French
Lab Director

Specialty Analytical

Date Reported: **07-Mar-19**

CLIENT: GRI
Project: Lacamas Creek Pump Station / W1241-A

Lab Order: 1903042

Lab ID: 1903042-001
Client Sample ID: TP-1, 12.25 ft

Collection Date: 2/1/2019 3:00:00 PM
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
CATION EXCHANGE CAPACITY		**SW9081**				Analyst: **BW**
Cation Exchange Capacity	218	0.109		meq/100g	1	3/7/2019 12:41:23 PM
ORGANIC CONTENT		**D2974 C**				Analyst: **jtt**
Organic Content	2.4	0.10	HT	wt%	1	3/7/2019 1:00:55 PM

QC SUMMARY REPORT

WO#: **1903042**

07-Mar-19

Specialty Analytical

Client: GRI

Project: Lacamas Creek Pump Station / W1241-A

TestCode: CEC_S

Sample ID **ICV** SampType: **ICV** TestCode: **CEC_S** Units: **µg/L** Prep Date: RunNo: **29742**

Client ID: **ICV** Batch ID: **R29742** TestNo: **SW9081** Analysis Date: **3/7/2019** SeqNo: **396489**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cation Exchange Capacity	5170	0.109	5000	0.01605	103	90	110				

Sample ID **1903015-001ADUP** SampType: **DUP** TestCode: **CEC_S** Units: **meq/100g** Prep Date: RunNo: **29742**

Client ID: **ZZZZZZ** Batch ID: **R29742** TestNo: **SW9081** Analysis Date: **3/7/2019** SeqNo: **396492**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cation Exchange Capacity	227	0.109	0	0.01605	0	0	0	249.9	9.71	20	

Sample ID **CCV** SampType: **CCV** TestCode: **CEC_S** Units: **µg/L** Prep Date: RunNo: **29742**

Client ID: **CCV** Batch ID: **R29742** TestNo: **SW9081** Analysis Date: **3/7/2019** SeqNo: **396494**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cation Exchange Capacity	4850	0.109	5000	0.01605	97.1	90	110				

Sample ID **MB-CEC** SampType: **MBLK** TestCode: **CEC_S** Units: **meq/100g** Prep Date: RunNo: **29742**

Client ID: **PBS** Batch ID: **R29742** TestNo: **SW9081** Analysis Date: **3/7/2019** SeqNo: **396495**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cation Exchange Capacity	ND	0.109									

Qualifiers:

B	Analyte detected in the associated Method Blank	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
O	RSD is greater than RSDlimit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted reco

QC SUMMARY REPORT

WO#: **1903042**

07-Mar-19

Specialty Analytical

Client: GRI

Project: Lacamas Creek Pump Station / W1241-A

TestCode: CEC_S

Sample ID **CCV**	SampType: **CCV**	TestCode: **CEC_S**	Units: **µg/L**	Prep Date:	RunNo: **29742**
Client ID: **CCV**	Batch ID: **R29742**	TestNo: **SW9081**		Analysis Date: **3/7/2019**	SeqNo: **396496**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Cation Exchange Capacity	4880	0.109	5000	0.01605	97.6	90	110				

Qualifiers:

B	Analyte detected in the associated Method Blank	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
O	RSD is greater than RSDlimit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted reco

QC SUMMARY REPORT

WO#: **1903042**
07-Mar-19

Specialty Analytical

Client: GRI
Project: Lacamas Creek Pump Station / W1241-A **TestCode:** **ORG_CONT**

Sample ID **1903042-001ADUP** SampType: **DUP** TestCode: **ORG_CONT** Units: **wt%** Prep Date: RunNo: **29735**
Client ID: **TP-1, 12.25 ft** Batch ID: **R29735** TestNo: **D2974 C** Analysis Date: **3/7/2019** SeqNo: **396432**

Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Organic Content	2.7	0.10						2.419	9.71	0	HT

Qualifiers:

B	Analyte detected in the associated Method Blank	H	Holding times for preparation or analysis exceeded	ND	Not Detected at the Reporting Limit
O	RSD is greater than RSDlimit	R	RPD outside accepted recovery limits	S	Spike Recovery outside accepted reco

KEY TO FLAGS

A This sample contains a Gasoline Range Organic not identified as a specific hydrocarbon product. The result was quantified against gasoline calibration standards

A1 This sample contains a Diesel Range Organic not identified as a specific hydrocarbon product. The result was quantified against diesel calibration standards.

A2 This sample contains a Lube Oil Range Organic not identified as a specific hydrocarbon product. The result was quantified against a lube oil calibration standard.

A3 The result was determined to be Non-Detect based on hydrocarbon pattern recognition. The product was carry-over from another hydrocarbon type.

A4 The product appears to be aged or degraded diesel.

B The blank exhibited a positive result great than the reporting limit for this compound.

CN See Case Narrative.

D Result is based from a dilution.

E Result exceeds the calibration range for this compound. The result should be considered as estimate.

F The positive result for this hydrocarbon is due to single component contamination. The product does not match any hydrocarbon in the fuels library.

G Result may be biased high due to biogenic interferences. Clean up is recommended.

H Sample was analyzed outside recommended holding time.

HT At clients request, samples was analyzed outside of recommended holding time.

J The result for this analyte is between the MDL and the PQL and should be considered as estimated concentration.

K Diesel result is biased high due to amount of Oil contained in the sample.

L Diesel result is biased high due to amount of Gasoline contained in the sample.

M Oil result is biased high due to amount of Diesel contained in the sample.

MC Sample concentration is greater than 4x the spiked value, the spiked value is considered insignificant.

MI Result is outside control limits due to matrix interference.

MSA Value determined by Method of Standard Addition.

O Laboratory Control Standard (LCS) exceeded laboratory control limits, but meets CCV criteria. Data meets EPA requirements.

Q Detection levels elevated due to sample matrix.

R RPD control limits were exceeded.

RF Duplicate failed due to result being at or near the method-reporting limit.

RP Matrix spike values exceed established QC limits; post digestion spike is in control.

S Recovery is outside control limits.

SC Closing CCV or LCS exceeded high recovery control limits, but associated samples are non-detect. Data meets EPA requirements.

* The result for this parameter was greater that the maximum contaminant level of the TCLP regulatory limit.

Specialty Analytical
9011 SE Jannsen Rd
Clackamas, OR 97015
Phone: 503-607-1331
Fax: 503-607-1336

Chain of Custody Record

Date: 3/6/19 Page: 1 of: 1

Laboratory Project No (internal): 1903042

Project Name: Lacamas Creek Pump Station

Temperature on Receipt: 3.5°C

Client: Geotechnical Resources, Inc (GRI)

Project No: W1241-A PO No:

Custody Seal: Y (N)

Address: 1101 Broadway, Suite 215

Collected by: Alex Baumann

Notes:

City, State, Zip: Vancouver, WA 98660

State Collected: OR ☐ WA ☒ OTHER

Shipped Via: GA

Telephone: 360-213-1690

Report To (PM): Brian A. Bennetts

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 60 days)

Invoice To: accounting@gri.com

PM Email: bbennetts@gri.com; abaumann@gri.com

Sample Name	Sample Date	Sample Time	Sample Matrix*	# of Containers	Cation Exchange Capacity	Organic Content	Requested Tests									Comments
1 TP-1, 12.25 ft	2/1/19	3:00 PM	S	2	X	X										2 Jars, same sample, need one cation exchange capacity test and one organic content test
2																
3																
4																
5																
6																
7																
8																
9																
10																

*Matrix: A=Air, AQ=Aqueous, O=Other, P=Product, S=Soil, SD=Sediment, SL=Solid, W=Water, DW=Drinking Water, GW=Ground Water, SW=Storm Water, WW=Waste Water **Metals

Turn-around Time: Standard (5-7 Business): ☐ 3 Day: ☐ 2 Day: ☐ Next Day: ☐ Same Day: ☒ or ASAP

Relinquished	Date/Time	Received	Date/Time
x Alex Baumann	3/6/19 11:08 Am	x [signature]	3-6-19 1107
x [signature]	3-6-19 1422	x [signature]	3-6-19 14:22

TECHNICAL APPENDIX

WWHM Project Report

Lacamas Creek Trailhead Park Soil Survey

Baz Park Soil Survey

Clark County WWHM Soils Group Memorandum

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Lacamas Park
Site Name:	Lacamas Park PS
Site Address:	
City:	
Report Date:	4/25/2019
Gage:	Troutdale
Data Start:	1948/10/01
Data End:	2008/09/30
Timestep:	15 Minute
Precip Scale:	1.370
Version Date:	2017/07/05
Version:	4.2.13

POC Thresholds

Low Flow Threshold for POC1:	8 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG3, Forest, Flat	0.5289
Pervious Total	0.5289
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.5289

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 2

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
SG3, Field, Mod	0.0416
Pervious Total	0.0416
Impervious Land Use	acre
PARKING FLAT	0.236
Impervious Total	0.236
Basin Total	0.2776

Element Flows To:

Surface	Interflow	Groundwater
Surface tion Basin 2	Surface tion Basin 2	

Basin 1

Bypass:	No	
GroundWater:	No	
Pervious Land Use	acre	
Pervious Total	0	
Impervious Land Use	acre	
DRIVEWAYS MOD	0.2513	
Impervious Total	0.2513	
Basin Total	0.2513	

Element Flows To:

Surface	Interflow	Groundwater
Surface tion Basin 1	Surface tion Basin 1	

Routing Elements
Predeveloped Routing

Mitigated Routing

Infiltration Gallery

Bottom Length:	55.00 ft.
Bottom Width:	20.00 ft.
Trench bottom slope 1:	0 To 1
Trench Left side slope 0:	0 To 1
Trench right side slope 2:	0 To 1
Material thickness of first layer:	12
Pour Space of material for first layer:	0.4
Material thickness of second layer:	0
Pour Space of material for second layer:	0
Material thickness of third layer:	0
Pour Space of material for third layer:	0
Infiltration On	
Infiltration rate:	1.578
Infiltration safety factor:	1
Total Volume Infiltrated (ac-ft.):	59.298
Total Volume Through Riser (ac-ft.):	0.023
Total Volume Through Facility (ac-ft.):	59.321
Percent Infiltrated:	99.96
Total Precip Applied to Facility:	0
Total Evap From Facility:	0

Discharge Structure
Riser Height: 11 ft.
Riser Diameter: 12 in.
Element Flows To:
Outlet 1 Outlet 2

Gravel Trench Bed Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.025	0.000	0.000	0.000
0.1333	0.025	0.001	0.000	0.040
0.2667	0.025	0.002	0.000	0.040
0.4000	0.025	0.004	0.000	0.040
0.5333	0.025	0.005	0.000	0.040
0.6667	0.025	0.006	0.000	0.040
0.8000	0.025	0.008	0.000	0.040
0.9333	0.025	0.009	0.000	0.040
1.0667	0.025	0.010	0.000	0.040
1.2000	0.025	0.012	0.000	0.040
1.3333	0.025	0.013	0.000	0.040
1.4667	0.025	0.014	0.000	0.040
1.6000	0.025	0.016	0.000	0.040
1.7333	0.025	0.017	0.000	0.040
1.8667	0.025	0.018	0.000	0.040
2.0000	0.025	0.020	0.000	0.040
2.1333	0.025	0.021	0.000	0.040
2.2667	0.025	0.022	0.000	0.040
2.4000	0.025	0.024	0.000	0.040
2.5333	0.025	0.025	0.000	0.040
2.6667	0.025	0.026	0.000	0.040
2.8000	0.025	0.028	0.000	0.040
2.9333	0.025	0.029	0.000	0.040
3.0667	0.025	0.031	0.000	0.040

3.2000	0.025	0.032	0.000	0.040
3.3333	0.025	0.033	0.000	0.040
3.4667	0.025	0.035	0.000	0.040
3.6000	0.025	0.036	0.000	0.040
3.7333	0.025	0.037	0.000	0.040
3.8667	0.025	0.039	0.000	0.040
4.0000	0.025	0.040	0.000	0.040
4.1333	0.025	0.041	0.000	0.040
4.2667	0.025	0.043	0.000	0.040
4.4000	0.025	0.044	0.000	0.040
4.5333	0.025	0.045	0.000	0.040
4.6667	0.025	0.047	0.000	0.040
4.8000	0.025	0.048	0.000	0.040
4.9333	0.025	0.049	0.000	0.040
5.0667	0.025	0.051	0.000	0.040
5.2000	0.025	0.052	0.000	0.040
5.3333	0.025	0.053	0.000	0.040
5.4667	0.025	0.055	0.000	0.040
5.6000	0.025	0.056	0.000	0.040
5.7333	0.025	0.057	0.000	0.040
5.8667	0.025	0.059	0.000	0.040
6.0000	0.025	0.060	0.000	0.040
6.1333	0.025	0.062	0.000	0.040
6.2667	0.025	0.063	0.000	0.040
6.4000	0.025	0.064	0.000	0.040
6.5333	0.025	0.066	0.000	0.040
6.6667	0.025	0.067	0.000	0.040
6.8000	0.025	0.068	0.000	0.040
6.9333	0.025	0.070	0.000	0.040
7.0667	0.025	0.071	0.000	0.040
7.2000	0.025	0.072	0.000	0.040
7.3333	0.025	0.074	0.000	0.040
7.4667	0.025	0.075	0.000	0.040
7.6000	0.025	0.076	0.000	0.040
7.7333	0.025	0.078	0.000	0.040
7.8667	0.025	0.079	0.000	0.040
8.0000	0.025	0.080	0.000	0.040
8.1333	0.025	0.082	0.000	0.040
8.2667	0.025	0.083	0.000	0.040
8.4000	0.025	0.084	0.000	0.040
8.5333	0.025	0.086	0.000	0.040
8.6667	0.025	0.087	0.000	0.040
8.8000	0.025	0.088	0.000	0.040
8.9333	0.025	0.090	0.000	0.040
9.0667	0.025	0.091	0.000	0.040
9.2000	0.025	0.092	0.000	0.040
9.3333	0.025	0.094	0.000	0.040
9.4667	0.025	0.095	0.000	0.040
9.6000	0.025	0.097	0.000	0.040
9.7333	0.025	0.098	0.000	0.040
9.8667	0.025	0.099	0.000	0.040
10.000	0.025	0.101	0.000	0.040
10.133	0.025	0.102	0.000	0.040
10.267	0.025	0.103	0.000	0.040
10.400	0.025	0.105	0.000	0.040
10.533	0.025	0.106	0.000	0.040
10.667	0.025	0.107	0.000	0.040
10.800	0.025	0.109	0.000	0.040

10.933	0.025	0.110	0.000	0.040
11.067	0.025	0.111	0.182	0.040
11.200	0.025	0.113	0.907	0.040
11.333	0.025	0.114	1.683	0.040
11.467	0.025	0.115	2.138	0.040
11.600	0.025	0.117	2.439	0.040
11.733	0.025	0.118	2.697	0.040
11.867	0.025	0.119	2.932	0.040
12.000	0.025	0.121	3.149	0.040

Bioretention Basin 2

Bottom Length:	100.00 ft.
Bottom Width:	2.50 ft.
Material thickness of first layer:	1.5
Material type for first layer:	SMMWW 12 in/hr
Material thickness of second layer:	1.5
Material type for second layer:	GRAVEL
Material thickness of third layer:	0
Material type for third layer:	GRAVEL
Underdrain used	
Underdrain Diameter (feet):	0.5
Orifice Diameter (in.):	6
Offset (in.):	6
Flow Through Underdrain (ac-ft.):	56.674
Total Outflow (ac-ft.):	57.521
Percent Through Underdrain:	98.53

Discharge Structure

Riser Height:	0.5 ft.
Riser Diameter:	24 in.

Element Flows To:

Outlet 1	Outlet 2
Infiltration Gallery	

Bioretention Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.0555	0.0000	0.0000	0.0000
0.0440	0.0553	0.0001	0.0000	0.0000
0.0879	0.0545	0.0001	0.0000	0.0000
0.1319	0.0537	0.0002	0.0000	0.0000
0.1758	0.0528	0.0003	0.0000	0.0000
0.2198	0.0520	0.0004	0.0000	0.0000
0.2637	0.0512	0.0005	0.0000	0.0000
0.3077	0.0504	0.0006	0.0000	0.0000
0.3516	0.0495	0.0007	0.0000	0.0000
0.3956	0.0487	0.0008	0.0000	0.0000
0.4396	0.0479	0.0009	0.0000	0.0000
0.4835	0.0471	0.0010	0.0000	0.0000
0.5275	0.0463	0.0012	0.0000	0.0000
0.5714	0.0455	0.0013	0.0000	0.0000
0.6154	0.0447	0.0014	0.0000	0.0000
0.6593	0.0439	0.0016	0.0000	0.0000
0.7033	0.0431	0.0017	0.0000	0.0000
0.7473	0.0423	0.0019	0.0000	0.0000
0.7912	0.0415	0.0021	0.0000	0.0000
0.8352	0.0408	0.0023	0.0000	0.0000
0.8791	0.0400	0.0024	0.0000	0.0000
0.9231	0.0392	0.0026	0.0000	0.0000
0.9670	0.0384	0.0028	0.0000	0.0000
1.0110	0.0377	0.0030	0.0000	0.0000
1.0549	0.0369	0.0033	0.0013	0.0000
1.0989	0.0361	0.0035	0.0014	0.0000
1.1429	0.0354	0.0037	0.0017	0.0000
1.1868	0.0346	0.0039	0.0021	0.0000
1.2308	0.0339	0.0042	0.0024	0.0000
1.2747	0.0331	0.0044	0.0028	0.0000
1.3187	0.0324	0.0047	0.0033	0.0000

1.3626	0.0316	0.0049	0.0038	0.0000
1.4066	0.0309	0.0052	0.0043	0.0000
1.4505	0.0301	0.0055	0.0049	0.0000
1.4945	0.0294	0.0058	0.0055	0.0000
1.5385	0.0287	0.0060	0.0062	0.0000
1.5824	0.0280	0.0063	0.0069	0.0000
1.6264	0.0272	0.0066	0.0076	0.0000
1.6703	0.0265	0.0069	0.0084	0.0000
1.7143	0.0258	0.0072	0.0093	0.0000
1.7582	0.0251	0.0075	0.0102	0.0000
1.8022	0.0244	0.0078	0.0111	0.0000
1.8462	0.0237	0.0081	0.0121	0.0000
1.8901	0.0230	0.0084	0.0131	0.0000
1.9341	0.0223	0.0087	0.0142	0.0000
1.9780	0.0216	0.0091	0.0154	0.0000
2.0220	0.0209	0.0097	0.0166	0.0000
2.0659	0.0202	0.0104	0.0289	0.0000
2.1099	0.0195	0.0111	0.0289	0.0000
2.1538	0.0188	0.0119	0.0289	0.0000
2.1978	0.0181	0.0126	0.0289	0.0000
2.2418	0.0174	0.0134	0.0289	0.0000
2.2857	0.0168	0.0141	0.0289	0.0000
2.3297	0.0161	0.0149	0.0289	0.0000
2.3736	0.0154	0.0157	0.0289	0.0000
2.4176	0.0147	0.0165	0.0289	0.0000
2.4615	0.0141	0.0173	0.0289	0.0000
2.5055	0.0134	0.0182	0.0289	0.0000
2.5495	0.0128	0.0190	0.0289	0.0000
2.5934	0.0121	0.0199	0.0289	0.0000
2.6374	0.0115	0.0208	0.0289	0.0000
2.6813	0.0108	0.0217	0.0289	0.0000
2.7253	0.0102	0.0226	0.0289	0.0000
2.7692	0.0095	0.0235	0.0289	0.0000
2.8132	0.0089	0.0244	0.0289	0.0000
2.8571	0.0082	0.0254	0.0289	0.0000
2.9011	0.0076	0.0264	0.0289	0.0000
2.9451	0.0070	0.0273	0.0289	0.0000
2.9890	0.0064	0.0284	0.0289	0.0000
3.0000	0.0057	0.0286	0.0289	0.0000

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Infilt(cfs)
3.0000	0.0555	0.0286	0.0000	0.0174	0.0000
3.0440	0.0564	0.0311	0.0000	0.0174	0.0000
3.0879	0.0572	0.0336	0.0000	0.0184	0.0000
3.1319	0.0581	0.0361	0.0000	0.0189	0.0000
3.1758	0.0589	0.0387	0.0000	0.0194	0.0000
3.2198	0.0598	0.0413	0.0000	0.0199	0.0000
3.2637	0.0606	0.0439	0.0000	0.0204	0.0000
3.3077	0.0615	0.0466	0.0000	0.0209	0.0000
3.3516	0.0623	0.0493	0.0000	0.0214	0.0000
3.3956	0.0632	0.0521	0.0000	0.0219	0.0000
3.4396	0.0641	0.0549	0.0000	0.0224	0.0000
3.4835	0.0649	0.0577	0.0000	0.0230	0.0000
3.5275	0.0658	0.0606	0.0967	0.0235	0.0000
3.5714	0.0667	0.0635	0.4049	0.0240	0.0000
3.6154	0.0676	0.0665	0.8304	0.0245	0.0000
3.6593	0.0685	0.0694	1.3452	0.0250	0.0000

3.7033	0.0694	0.0725	1.9330	0.0255	0.0000
3.7473	0.0702	0.0755	2.5809	0.0260	0.0000
3.7912	0.0711	0.0786	3.2771	0.0265	0.0000
3.8352	0.0720	0.0818	4.0103	0.0270	0.0000
3.8791	0.0729	0.0850	4.7689	0.0275	0.0000
3.9231	0.0738	0.0882	5.5408	0.0280	0.0000
3.9670	0.0748	0.0915	6.3140	0.0286	0.0000
4.0000	0.0754	0.0940	7.0765	0.0289	0.0000

Surface tion Basin 2

Element Flows To:

Outlet 1	Outlet 2
Infiltration Gallery	Bioretention Basin 2

Bioretention Basin 1

Bottom Length:	60.00 ft.
Bottom Width:	2.00 ft.
Material thickness of first layer:	1.5
Material type for first layer:	SMMWW 12 in/hr
Material thickness of second layer:	1.5
Material type for second layer:	GRAVEL
Material thickness of third layer:	0
Material type for third layer:	GRAVEL
Underdrain used	
Underdrain Diameter (feet):	0.5
Orifice Diameter (in.):	6
Offset (in.):	6
Flow Through Underdrain (ac-ft.):	53.643
Total Outflow (ac-ft.):	58.47
Percent Through Underdrain:	91.74

Discharge Structure

Riser Height:	0.5 ft.
Riser Diameter:	24 in.

Element Flows To:

Outlet 1	Outlet 2
Infiltration Gallery	

Bioretention Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.0358	0.0000	0.0000	0.0000
0.0440	0.0357	0.0000	0.0000	0.0000
0.0879	0.0351	0.0001	0.0000	0.0000
0.1319	0.0345	0.0001	0.0000	0.0000
0.1758	0.0339	0.0001	0.0000	0.0000
0.2198	0.0333	0.0002	0.0000	0.0000
0.2637	0.0327	0.0002	0.0000	0.0000
0.3077	0.0322	0.0003	0.0000	0.0000
0.3516	0.0316	0.0003	0.0000	0.0000
0.3956	0.0310	0.0004	0.0000	0.0000
0.4396	0.0305	0.0005	0.0000	0.0000
0.4835	0.0299	0.0005	0.0000	0.0000
0.5275	0.0293	0.0006	0.0000	0.0000
0.5714	0.0288	0.0007	0.0000	0.0000
0.6154	0.0282	0.0008	0.0000	0.0000
0.6593	0.0277	0.0009	0.0000	0.0000
0.7033	0.0271	0.0009	0.0000	0.0000
0.7473	0.0266	0.0010	0.0000	0.0000
0.7912	0.0261	0.0011	0.0000	0.0000
0.8352	0.0255	0.0012	0.0000	0.0000
0.8791	0.0250	0.0014	0.0000	0.0000
0.9231	0.0245	0.0015	0.0000	0.0000
0.9670	0.0239	0.0016	0.0000	0.0000
1.0110	0.0234	0.0017	0.0000	0.0000
1.0549	0.0229	0.0018	0.0006	0.0000
1.0989	0.0224	0.0020	0.0007	0.0000
1.1429	0.0218	0.0021	0.0008	0.0000
1.1868	0.0213	0.0022	0.0010	0.0000
1.2308	0.0208	0.0025	0.0012	0.0000
1.2747	0.0203	0.0028	0.0014	0.0000
1.3187	0.0198	0.0031	0.0016	0.0000

1.3626	0.0193	0.0034	0.0018	0.0000
1.4066	0.0188	0.0038	0.0021	0.0000
1.4505	0.0183	0.0041	0.0023	0.0000
1.4945	0.0178	0.0044	0.0026	0.0000
1.5385	0.0174	0.0048	0.0030	0.0000
1.5824	0.0169	0.0051	0.0033	0.0000
1.6264	0.0164	0.0054	0.0037	0.0000
1.6703	0.0159	0.0058	0.0040	0.0000
1.7143	0.0155	0.0061	0.0044	0.0000
1.7582	0.0150	0.0065	0.0049	0.0000
1.8022	0.0145	0.0069	0.0053	0.0000
1.8462	0.0141	0.0073	0.0058	0.0000
1.8901	0.0136	0.0077	0.0063	0.0000
1.9341	0.0131	0.0081	0.0068	0.0000
1.9780	0.0127	0.0085	0.0074	0.0000
2.0220	0.0122	0.0089	0.0080	0.0000
2.0659	0.0118	0.0093	0.0139	0.0000
2.1099	0.0113	0.0098	0.0139	0.0000
2.1538	0.0109	0.0102	0.0139	0.0000
2.1978	0.0105	0.0107	0.0139	0.0000
2.2418	0.0100	0.0111	0.0139	0.0000
2.2857	0.0096	0.0116	0.0139	0.0000
2.3297	0.0092	0.0121	0.0139	0.0000
2.3736	0.0087	0.0126	0.0139	0.0000
2.4176	0.0083	0.0131	0.0139	0.0000
2.4615	0.0079	0.0136	0.0139	0.0000
2.5055	0.0075	0.0142	0.0139	0.0000
2.5495	0.0071	0.0147	0.0139	0.0000
2.5934	0.0067	0.0153	0.0139	0.0000
2.6374	0.0063	0.0158	0.0139	0.0000
2.6813	0.0059	0.0164	0.0139	0.0000
2.7253	0.0055	0.0170	0.0139	0.0000
2.7692	0.0051	0.0176	0.0139	0.0000
2.8132	0.0047	0.0182	0.0139	0.0000
2.8571	0.0043	0.0188	0.0139	0.0000
2.9011	0.0039	0.0194	0.0139	0.0000
2.9451	0.0035	0.0200	0.0139	0.0000
2.9890	0.0031	0.0207	0.0139	0.0000
3.0000	0.0028	0.0209	0.0139	0.0000

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Infilt(cfs)
3.0000	0.0358	0.0209	0.0000	0.0083	0.0000
3.0440	0.0364	0.0224	0.0000	0.0083	0.0000
3.0879	0.0370	0.0241	0.0000	0.0088	0.0000
3.1319	0.0376	0.0257	0.0000	0.0091	0.0000
3.1758	0.0382	0.0274	0.0000	0.0093	0.0000
3.2198	0.0388	0.0291	0.0000	0.0096	0.0000
3.2637	0.0394	0.0308	0.0000	0.0098	0.0000
3.3077	0.0400	0.0325	0.0000	0.0100	0.0000
3.3516	0.0407	0.0343	0.0000	0.0103	0.0000
3.3956	0.0413	0.0361	0.0000	0.0105	0.0000
3.4396	0.0419	0.0379	0.0000	0.0108	0.0000
3.4835	0.0425	0.0398	0.0000	0.0110	0.0000
3.5275	0.0432	0.0417	0.0967	0.0113	0.0000
3.5714	0.0438	0.0436	0.4049	0.0115	0.0000
3.6154	0.0444	0.0455	0.8304	0.0118	0.0000
3.6593	0.0451	0.0475	1.3452	0.0120	0.0000

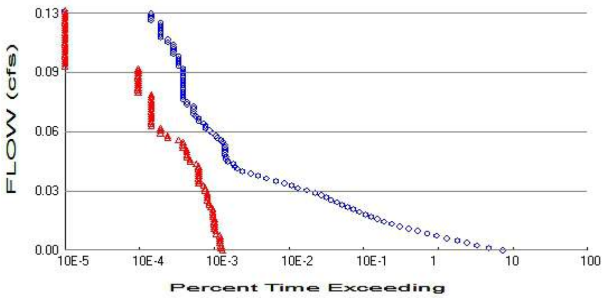
3.7033	0.0457	0.0495	1.9330	0.0122	0.0000
3.7473	0.0464	0.0515	2.5809	0.0125	0.0000
3.7912	0.0470	0.0536	3.2771	0.0127	0.0000
3.8352	0.0477	0.0556	4.0103	0.0130	0.0000
3.8791	0.0483	0.0577	4.7689	0.0132	0.0000
3.9231	0.0490	0.0599	5.5408	0.0135	0.0000
3.9670	0.0496	0.0620	6.3140	0.0137	0.0000
4.0000	0.0501	0.0637	7.0765	0.0139	0.0000

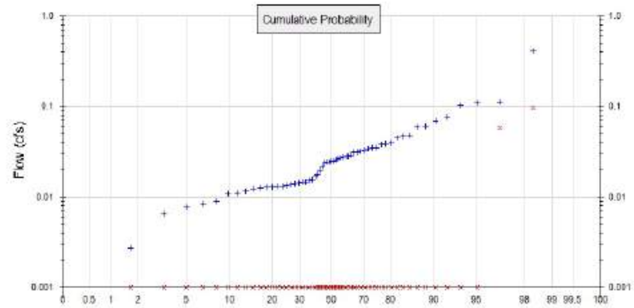
Surface tion Basin 1

Element Flows To:

Outlet 1	Outlet 2
Infiltration Gallery	Bioretention Basin 1

Analysis Results
POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0.5289
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.0416
Total Impervious Area: 0.4873

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.024124
5 year	0.05033
10 year	0.071472
25 year	0.101358
50 year	0.125357
100 year	0.150459

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0
5 year	0
10 year	0
25 year	0
50 year	0
100 year	0

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.032	0.000
1950	0.026	0.000
1951	0.038	0.000
1952	0.027	0.000
1953	0.024	0.000
1954	0.024	0.000
1955	0.028	0.000
1956	0.077	0.000
1957	0.018	0.000
1958	0.011	0.000

1959	0.014	0.000
1960	0.013	0.000
1961	0.025	0.000
1962	0.013	0.000
1963	0.014	0.000
1964	0.028	0.000
1965	0.028	0.000
1966	0.032	0.000
1967	0.019	0.000
1968	0.035	0.000
1969	0.040	0.000
1970	0.409	0.000
1971	0.014	0.000
1972	0.026	0.000
1973	0.012	0.000
1974	0.069	0.000
1975	0.022	0.000
1976	0.112	0.000
1977	0.001	0.000
1978	0.035	0.000
1979	0.011	0.000
1980	0.031	0.000
1981	0.034	0.000
1982	0.060	0.000
1983	0.104	0.000
1984	0.048	0.000
1985	0.029	0.000
1986	0.013	0.000
1987	0.033	0.000
1988	0.012	0.000
1989	0.008	0.000
1990	0.012	0.000
1991	0.014	0.000
1992	0.015	0.000
1993	0.013	0.000
1994	0.025	0.000
1995	0.016	0.058
1996	0.109	0.000
1997	0.045	0.098
1998	0.017	0.000
1999	0.024	0.000
2000	0.009	0.000
2001	0.003	0.000
2002	0.060	0.000
2003	0.039	0.000
2004	0.007	0.000
2005	0.008	0.000
2006	0.047	0.000
2007	0.013	0.000
2008	0.015	0.000

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.4089	0.0976
2	0.1118	0.0582
3	0.1094	0.0000
4	0.1038	0.0000

5	0.0770	0.0000
6	0.0687	0.0000
7	0.0601	0.0000
8	0.0597	0.0000
9	0.0476	0.0000
10	0.0466	0.0000
11	0.0453	0.0000
12	0.0397	0.0000
13	0.0386	0.0000
14	0.0377	0.0000
15	0.0351	0.0000
16	0.0349	0.0000
17	0.0344	0.0000
18	0.0327	0.0000
19	0.0322	0.0000
20	0.0315	0.0000
21	0.0313	0.0000
22	0.0287	0.0000
23	0.0284	0.0000
24	0.0281	0.0000
25	0.0276	0.0000
26	0.0271	0.0000
27	0.0264	0.0000
28	0.0259	0.0000
29	0.0249	0.0000
30	0.0245	0.0000
31	0.0245	0.0000
32	0.0242	0.0000
33	0.0239	0.0000
34	0.0217	0.0000
35	0.0194	0.0000
36	0.0177	0.0000
37	0.0169	0.0000
38	0.0156	0.0000
39	0.0150	0.0000
40	0.0146	0.0000
41	0.0145	0.0000
42	0.0142	0.0000
43	0.0140	0.0000
44	0.0136	0.0000
45	0.0133	0.0000
46	0.0130	0.0000
47	0.0130	0.0000
48	0.0129	0.0000
49	0.0127	0.0000
50	0.0124	0.0000
51	0.0124	0.0000
52	0.0116	0.0000
53	0.0110	0.0000
54	0.0107	0.0000
55	0.0090	0.0000
56	0.0084	0.0000
57	0.0076	0.0000
58	0.0065	0.0000
59	0.0027	0.0000
60	0.0006	0.0000

Duration Flows
The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0019	152360	27	0	Pass
0.0032	99112	26	0	Pass
0.0044	70016	26	0	Pass
0.0057	51144	25	0	Pass
0.0069	37638	25	0	Pass
0.0082	27434	25	0	Pass
0.0094	20047	25	0	Pass
0.0107	14899	22	0	Pass
0.0119	11213	22	0	Pass
0.0132	8424	21	0	Pass
0.0144	6429	21	0	Pass
0.0156	4973	21	0	Pass
0.0169	3905	21	0	Pass
0.0181	3185	21	0	Pass
0.0194	2638	20	0	Pass
0.0206	2217	20	0	Pass
0.0219	1862	20	1	Pass
0.0231	1529	20	1	Pass
0.0244	1276	19	1	Pass
0.0256	1082	18	1	Pass
0.0269	916	18	1	Pass
0.0281	767	17	2	Pass
0.0294	665	17	2	Pass
0.0306	566	17	3	Pass
0.0319	473	17	3	Pass
0.0331	365	16	4	Pass
0.0343	278	16	5	Pass
0.0356	228	15	6	Pass
0.0368	181	13	7	Pass
0.0381	140	13	9	Pass
0.0393	105	13	12	Pass
0.0406	81	13	16	Pass
0.0418	65	13	20	Pass
0.0431	50	13	26	Pass
0.0443	43	13	30	Pass
0.0456	40	13	32	Pass
0.0468	38	12	31	Pass
0.0481	32	10	31	Pass
0.0493	30	10	33	Pass
0.0506	30	9	30	Pass
0.0518	29	9	31	Pass
0.0530	29	9	31	Pass
0.0543	29	9	31	Pass
0.0555	29	8	27	Pass
0.0568	29	8	27	Pass
0.0580	27	8	29	Pass
0.0593	26	7	26	Pass
0.0605	23	5	21	Pass
0.0618	22	5	22	Pass
0.0630	20	4	20	Pass
0.0643	18	4	22	Pass
0.0655	16	4	25	Pass
0.0668	16	3	18	Pass

0.0680	15	3	20	Pass
0.0693	13	3	23	Pass
0.0705	13	3	23	Pass
0.0717	12	3	25	Pass
0.0730	11	3	27	Pass
0.0742	11	3	27	Pass
0.0755	11	3	27	Pass
0.0767	11	3	27	Pass
0.0780	9	3	33	Pass
0.0792	9	3	33	Pass
0.0805	8	3	37	Pass
0.0817	8	3	37	Pass
0.0830	8	3	37	Pass
0.0842	8	2	25	Pass
0.0855	8	2	25	Pass
0.0867	8	2	25	Pass
0.0880	8	2	25	Pass
0.0892	8	2	25	Pass
0.0904	8	2	25	Pass
0.0917	8	2	25	Pass
0.0929	8	2	25	Pass
0.0942	8	2	25	Pass
0.0954	8	2	25	Pass
0.0967	8	2	25	Pass
0.0979	7	0	0	Pass
0.0992	7	0	0	Pass
0.1004	7	0	0	Pass
0.1017	7	0	0	Pass
0.1029	7	0	0	Pass
0.1042	6	0	0	Pass
0.1054	6	0	0	Pass
0.1067	6	0	0	Pass
0.1079	6	0	0	Pass
0.1091	6	0	0	Pass
0.1104	5	0	0	Pass
0.1116	5	0	0	Pass
0.1129	4	0	0	Pass
0.1141	4	0	0	Pass
0.1154	4	0	0	Pass
0.1166	4	0	0	Pass
0.1179	4	0	0	Pass
0.1191	4	0	0	Pass
0.1204	4	0	0	Pass
0.1216	3	0	0	Pass
0.1229	3	0	0	Pass
0.1241	3	0	0	Pass
0.1254	3	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Infiltration Gallery POC	☐	53.98			☐	99.96			
tion Basin 2	☐	0.77			☐	0.00			
tion Basin 1	☐	53.21			☐	0.00			
Total Volume Infiltrated		107.96	0.00	0.00		49.98	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

Model Default Modifications

Total of 0 changes have been made.

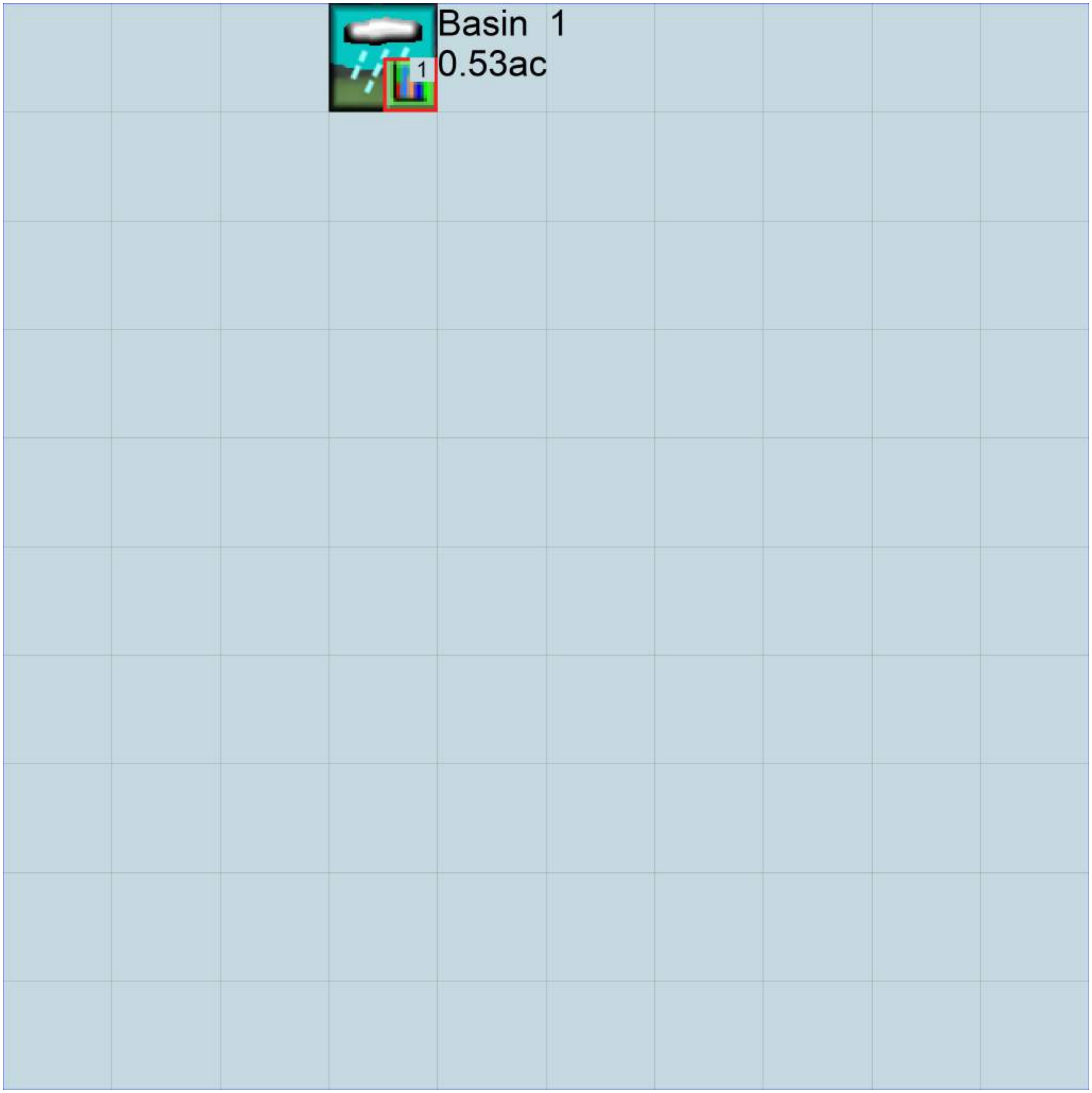
PERLND Changes

No PERLND changes have been made.

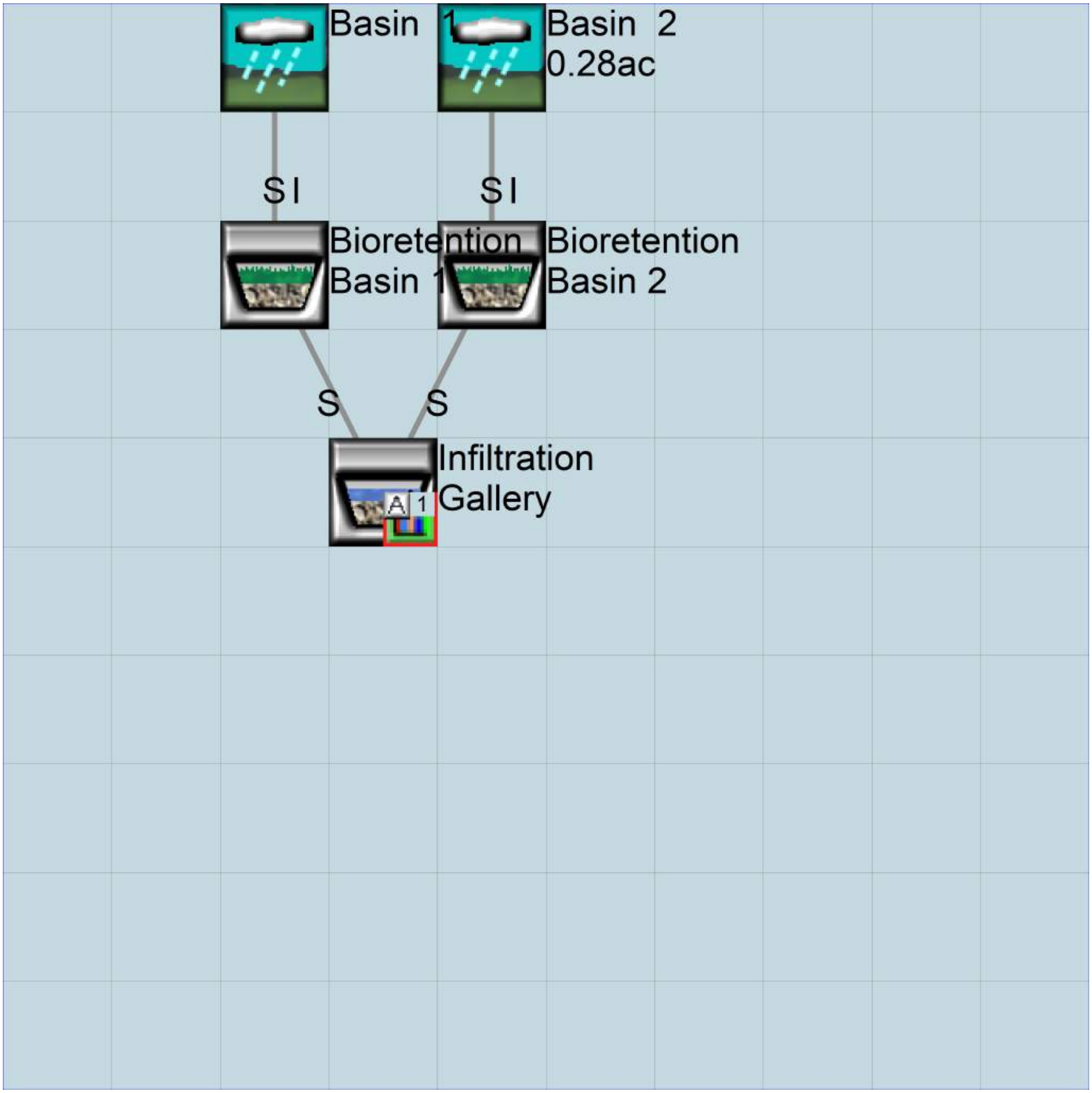
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2008 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                             ***
WDM        26   Lacamas Park.wdm
MESSU      25   PreLacamas Park.MES
           27   PreLacamas Park.L61
           28   PreLacamas Park.L62
           30   POCLacamas Park1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      19
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                   MAX                      1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1        1    1
  501        1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
   19      SG3, Forest, Flat       1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   19         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   19         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
```

```
  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   19         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   19            0         9      0.08       400      0.05         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   19            0         0       2.5         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   19            0.2         1      0.35         4       0.4       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   19            0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1
```

```
END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  19                      0.5289     COPY   501     12
PERLND  19                      0.5289     COPY   501     13

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                           in  out                           ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.37           PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.37           IMPLND   1 999 EXTNL  PREC
```

```
WDM      1 EVAP     ENGL    0.8            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.8            IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2008 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   Lacamas Park.wdm
MESSU      25   MitLacamas Park.MES
           27   MitLacamas Park.L61
           28   MitLacamas Park.L62
           30   POCLacamas Park1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      23
      IMPLND      11
      IMPLND       6
      GENER        2
      RCHRES       1
      RCHRES       2
      GENER        4
      RCHRES       3
      RCHRES       4
      RCHRES       5
      COPY         1
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Infiltration Gallery        MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
    2        24
    4        24
  END OPCODE
  PARM
    #    #         K ***
    2             0.
    4             0.
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
   23     SG3, Field, Mod         1    1    1    1   27    0
  END GEN-INFO
```

```
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   23         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   23         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   23         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   23              0         9      0.06       400       0.1         0      0.96
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   23              0         0       2.5         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   23           0.15         1       0.3         4       0.4       0.4
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
   23              0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
   11      PARKING/FLAT           1    1    1   27    0
    6      DRIVEWAYS/MOD          1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
   11         0    0    1    0    0    0
    6         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
   11         0    0    4    0    0    0    1    9
    6         0    0    4    0    0    0    1    9
  END PRINT-INFO
```

```
  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
   11         0    0    0    0    0
    6         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
   11            400      0.01       0.1       0.1
    6            400      0.05       0.1      0.08
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
   11             0         0
    6             0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
   11             0         0
    6             0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  2***
PERLND  23                      0.0416     RCHRES   1      2
PERLND  23                      0.0416     RCHRES   1      3
IMPLND  11                       0.236     RCHRES   1      5
Basin  1***
IMPLND   6                      0.2513     RCHRES   3      5

******Routing******
RCHRES   1                           1     RCHRES   5      7
RCHRES   1                                 COPY     1     17
RCHRES   1                           1     RCHRES   2      8
RCHRES   4                           1     RCHRES   5      6
RCHRES   4                                 COPY     1     16
RCHRES   3                           1     RCHRES   5      7
RCHRES   3                                 COPY     1     17
RCHRES   3                           1     RCHRES   4      8
RCHRES   5                           1     COPY   501     17
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1
GENER    2 OUTPUT TIMSER      .0011111     RCHRES   1     EXTNL  OUTDGT 1
GENER    4 OUTPUT TIMSER      .0011111     RCHRES   3     EXTNL  OUTDGT 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG           ***
                                           in  out                          ***
```

```
    1     Surface tion Bas-010    3    1    1    1   28    0    1
    2     Bioretention Bas-009    1    1    1    1   28    0    1
    3     Surface tion Bas-017    3    1    1    1   28    0    1
    4     Bioretention Bas-016    1    1    1    1   28    0    1
    5     Infiltration Gal-006    2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
    2         1    0    0    0    0    0    0    0    0    0
    3         1    0    0    0    0    0    0    0    0    0
    4         1    0    0    0    0    0    0    0    0    0
    5         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ****************** PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
    2         4    0    0    0    0    0    0    0    0    0    1    9
    3         4    0    0    0    0    0    0    0    0    0    1    9
    4         4    0    0    0    0    0    0    0    0    0    1    9
    5         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                     ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *        ***
    1        0  1  0  0    4  5  6  0  0       0  1  0  0  0      2  1  2  2  2
    2        0  1  0  0    4  0  0  0  0       0  0  0  0  0      2  2  2  2  2
    3        0  1  0  0    4  5  6  0  0       0  1  0  0  0      2  1  2  2  2
    4        0  1  0  0    4  0  0  0  0       0  0  0  0  0      2  2  2  2  2
    5        0  1  0  0    4  5  0  0  0       0  0  0  0  0      2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1      0.01       0.0       0.0       0.0       0.0
    2             2      0.02       0.0       0.0       0.5       0.0
    3             3      0.01       0.0       0.0       0.0       0.0
    4             4      0.01       0.0       0.0       0.5       0.0
    5             5      0.01       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                        ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
         *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1          0          4.0  5.0  6.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    2          0          4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    3          0          4.0  5.0  6.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    4          0          4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    5          0          4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
*** User-Defined Variable Quantity Lines
***                          addr
***                        <------>
*** kwd   varnam optyp  opn  vari  s1 s2 s3 tp multiply  lc ls ac as agfn ***
  <****> <----> <----> <-> <----><-><-><-><-><--------> <><-> <><-> <--> ***
  UVQUAN vol2   RCHRES   2 VOL               4
  UVQUAN v2m2   GLOBAL     WORKSP  1         3
```

```
  UVQUAN vpo2   GLOBAL     WORKSP  2        3
  UVQUAN v2d2   GENER    2 K       1        3
*** User-Defined Variable Quantity Lines
***                          addr
***                        <------>
*** kwd  varnam optyp  opn  vari  s1 s2 s3 tp multiply  lc ls ac as agfn ***
  <****> <----> <----> <-> <----><-><-><-><-><--------> <><-> <><-> <--> ***
  UVQUAN vol4   RCHRES   4 VOL              4
  UVQUAN v2m4   GLOBAL     WORKSP  3        3
  UVQUAN vpo4   GLOBAL     WORKSP  4        3
  UVQUAN v2d4   GENER    4 K       1        3
*** User-Defined Target Variable Names
***                  addr or                        addr or
***                 <------>                       <------>
*** kwd   varnam ct  vari  s1 s2 s3  frac oper     vari  s1 s2 s3  frac oper
  <****>  <----><-> <----><-><-><-> <---> <-->    <----><-><-><-> <---> <-->
  UVNAME  v2m2    1 WORKSP  1         1.0 QUAN
  UVNAME  vpo2    1 WORKSP  2         1.0 QUAN
  UVNAME  v2d2    1 K       1         1.0 QUAN
*** User-Defined Target Variable Names
***                  addr or                        addr or
***                 <------>                       <------>
*** kwd   varnam ct  vari  s1 s2 s3  frac oper     vari  s1 s2 s3  frac oper
  <****>  <----><-> <----><-><-><-> <---> <-->    <----><-><-><-> <---> <-->
  UVNAME  v2m4    1 WORKSP  3         1.0 QUAN
  UVNAME  vpo4    1 WORKSP  4         1.0 QUAN
  UVNAME  v2d4    1 K       1         1.0 QUAN
*** opt foplop dcdts  yr mo dy hr mn d t   vnam  s1 s2 s3 ac quantity  tc  ts rp
  <****><-><--><><-><--> <> <> <> <><><>  <----><-><-><-><-><--------> <> <-><->
  GENER   2                               v2m2            =  480.71
*** Compute remaining available pore space
  GENER   2                               vpo2            =  v2m2
  GENER   2                               vpo2           -=  vol2
*** Check to see if VPORA goes negative; if so set VPORA = 0.0
IF (vpo2 < 0.0) THEN
  GENER   2                               vpo2            =  0.0
END IF
*** Infiltration volume
  GENER   2                               v2d2            =  vpo2
*** opt foplop dcdts  yr mo dy hr mn d t   vnam  s1 s2 s3 ac quantity  tc  ts rp
  <****><-><--><><-><--> <> <> <> <><><>  <----><-><-><-><-><--------> <> <-><->
  GENER   4                               v2m4            =  418.56
*** Compute remaining available pore space
  GENER   4                               vpo4            =  v2m4
  GENER   4                               vpo4           -=  vol4
*** Check to see if VPORA goes negative; if so set VPORA = 0.0
IF (vpo4 < 0.0) THEN
  GENER   4                               vpo4            =  0.0
END IF
*** Infiltration volume
  GENER   4                               v2d4            =  vpo4
END SPEC-ACTIONS
FTABLES
  FTABLE      5
   92    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)      (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.025253  0.000000  0.000000  0.000000
  0.133333  0.025253  0.001347  0.000000  0.040181
  0.266667  0.025253  0.002694  0.000000  0.040181
  0.400000  0.025253  0.004040  0.000000  0.040181
  0.533333  0.025253  0.005387  0.000000  0.040181
  0.666667  0.025253  0.006734  0.000000  0.040181
  0.800000  0.025253  0.008081  0.000000  0.040181
  0.933333  0.025253  0.009428  0.000000  0.040181
  1.066667  0.025253  0.010774  0.000000  0.040181
  1.200000  0.025253  0.012121  0.000000  0.040181
  1.333333  0.025253  0.013468  0.000000  0.040181
  1.466667  0.025253  0.014815  0.000000  0.040181
  1.600000  0.025253  0.016162  0.000000  0.040181
```

1.733333	0.025253	0.017508	0.000000	0.040181
1.866667	0.025253	0.018855	0.000000	0.040181
2.000000	0.025253	0.020202	0.000000	0.040181
2.133333	0.025253	0.021549	0.000000	0.040181
2.266667	0.025253	0.022896	0.000000	0.040181
2.400000	0.025253	0.024242	0.000000	0.040181
2.533333	0.025253	0.025589	0.000000	0.040181
2.666667	0.025253	0.026936	0.000000	0.040181
2.800000	0.025253	0.028283	0.000000	0.040181
2.933333	0.025253	0.029630	0.000000	0.040181
3.066667	0.025253	0.030976	0.000000	0.040181
3.200000	0.025253	0.032323	0.000000	0.040181
3.333333	0.025253	0.033670	0.000000	0.040181
3.466667	0.025253	0.035017	0.000000	0.040181
3.600000	0.025253	0.036364	0.000000	0.040181
3.733333	0.025253	0.037710	0.000000	0.040181
3.866667	0.025253	0.039057	0.000000	0.040181
4.000000	0.025253	0.040404	0.000000	0.040181
4.133333	0.025253	0.041751	0.000000	0.040181
4.266667	0.025253	0.043098	0.000000	0.040181
4.400000	0.025253	0.044444	0.000000	0.040181
4.533333	0.025253	0.045791	0.000000	0.040181
4.666667	0.025253	0.047138	0.000000	0.040181
4.800000	0.025253	0.048485	0.000000	0.040181
4.933333	0.025253	0.049832	0.000000	0.040181
5.066667	0.025253	0.051178	0.000000	0.040181
5.200000	0.025253	0.052525	0.000000	0.040181
5.333333	0.025253	0.053872	0.000000	0.040181
5.466667	0.025253	0.055219	0.000000	0.040181
5.600000	0.025253	0.056566	0.000000	0.040181
5.733333	0.025253	0.057912	0.000000	0.040181
5.866667	0.025253	0.059259	0.000000	0.040181
6.000000	0.025253	0.060606	0.000000	0.040181
6.133333	0.025253	0.061953	0.000000	0.040181
6.266667	0.025253	0.063300	0.000000	0.040181
6.400000	0.025253	0.064646	0.000000	0.040181
6.533333	0.025253	0.065993	0.000000	0.040181
6.666667	0.025253	0.067340	0.000000	0.040181
6.800000	0.025253	0.068687	0.000000	0.040181
6.933333	0.025253	0.070034	0.000000	0.040181
7.066667	0.025253	0.071380	0.000000	0.040181
7.200000	0.025253	0.072727	0.000000	0.040181
7.333333	0.025253	0.074074	0.000000	0.040181
7.466667	0.025253	0.075421	0.000000	0.040181
7.600000	0.025253	0.076768	0.000000	0.040181
7.733333	0.025253	0.078114	0.000000	0.040181
7.866667	0.025253	0.079461	0.000000	0.040181
8.000000	0.025253	0.080808	0.000000	0.040181
8.133333	0.025253	0.082155	0.000000	0.040181
8.266667	0.025253	0.083502	0.000000	0.040181
8.400000	0.025253	0.084848	0.000000	0.040181
8.533333	0.025253	0.086195	0.000000	0.040181
8.666667	0.025253	0.087542	0.000000	0.040181
8.800000	0.025253	0.088889	0.000000	0.040181
8.933333	0.025253	0.090236	0.000000	0.040181
9.066667	0.025253	0.091582	0.000000	0.040181
9.200000	0.025253	0.092929	0.000000	0.040181
9.333333	0.025253	0.094276	0.000000	0.040181
9.466667	0.025253	0.095623	0.000000	0.040181
9.600000	0.025253	0.096970	0.000000	0.040181
9.733333	0.025253	0.098316	0.000000	0.040181
9.866667	0.025253	0.099663	0.000000	0.040181
10.00000	0.025253	0.101010	0.000000	0.040181
10.13333	0.025253	0.102357	0.000000	0.040181
10.26667	0.025253	0.103704	0.000000	0.040181
10.40000	0.025253	0.105051	0.000000	0.040181
10.53333	0.025253	0.106397	0.000000	0.040181
10.66667	0.025253	0.107744	0.000000	0.040181
10.80000	0.025253	0.109091	0.000000	0.040181
10.93333	0.025253	0.110438	0.000000	0.040181

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11.06667  0.025253  0.111785  0.182234  0.040181
11.20000  0.025253  0.113131  0.907676  0.040181
11.33333  0.025253  0.114478  1.683468  0.040181
11.46667  0.025253  0.115825  2.138326  0.040181
11.60000  0.025253  0.117172  2.439693  0.040181
11.73333  0.025253  0.118519  2.697182  0.040181
11.86667  0.025253  0.119865  2.932146  0.040181
12.00000  0.025253  0.121212  3.149630  0.040181
12.13333  0.025253  0.124579  3.353037  0.040181
END FTABLE  5
FTABLE      2
 70    4
   Depth      Area    Volume  Outflow1 Velocity  Travel Time***
    (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
0.000000  0.055533  0.000000  0.000000
0.043956  0.055323  0.000061  0.000000
0.087912  0.054487  0.000128  0.000000
0.131868  0.053654  0.000201  0.000000
0.175824  0.052824  0.000281  0.000000
0.219780  0.051998  0.000367  0.000000
0.263736  0.051174  0.000460  0.000000
0.307692  0.050354  0.000558  0.000000
0.351648  0.049537  0.000664  0.000000
0.395604  0.048723  0.000776  0.000000
0.439560  0.047913  0.000894  0.000000
0.483516  0.047105  0.001019  0.000000
0.527473  0.046301  0.001151  0.000000
0.571429  0.045500  0.001289  0.000000
0.615385  0.044702  0.001434  0.000000
0.659341  0.043907  0.001585  0.000000
0.703297  0.043116  0.001743  0.000000
0.747253  0.042328  0.001908  0.000000
0.791209  0.041543  0.002080  0.000000
0.835165  0.040761  0.002259  0.000000
0.879121  0.039982  0.002444  0.000000
0.923077  0.039207  0.002636  0.000000
0.967033  0.038434  0.002835  0.000000
1.010989  0.037665  0.003042  0.000000
1.054945  0.036899  0.003255  0.001294
1.098901  0.036137  0.003475  0.001431
1.142857  0.035377  0.003702  0.001732
1.186813  0.034621  0.003936  0.002067
1.230769  0.033868  0.004178  0.002439
1.274725  0.033118  0.004426  0.002849
1.318681  0.032371  0.004682  0.003297
1.362637  0.031627  0.004945  0.003785
1.406593  0.030887  0.005215  0.004315
1.450549  0.030150  0.005492  0.004886
1.494505  0.029416  0.005777  0.005501
1.538462  0.028685  0.006042  0.006160
1.582418  0.027958  0.006313  0.006864
1.626374  0.027233  0.006592  0.007614
1.670330  0.026512  0.006877  0.008412
1.714286  0.025794  0.007169  0.009257
1.758242  0.025079  0.007467  0.010152
1.802198  0.024368  0.007773  0.011097
1.846154  0.023659  0.008085  0.012092
1.890110  0.022954  0.008404  0.013139
1.934066  0.022252  0.008730  0.014238
1.978022  0.021553  0.009064  0.015390
2.021978  0.020858  0.009744  0.016593
2.065934  0.020165  0.010438  0.028935
2.109890  0.019476  0.011146  0.028935
2.153846  0.018790  0.011868  0.028935
2.197802  0.018107  0.012605  0.028935
2.241758  0.017427  0.013355  0.028935
2.285714  0.016751  0.014120  0.028935
2.329670  0.016077  0.014900  0.028935
2.373626  0.015407  0.015693  0.028935
2.417582  0.014740  0.016501  0.028935
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  2.461538  0.014077  0.017324  0.028935
  2.505495  0.013416  0.018162  0.028935
  2.549451  0.012759  0.019013  0.028935
  2.593407  0.012105  0.019880  0.028935
  2.637363  0.011454  0.020762  0.028935
  2.681319  0.010806  0.021658  0.028935
  2.725275  0.010162  0.022569  0.028935
  2.769231  0.009520  0.023495  0.028935
  2.813187  0.008882  0.024436  0.028935
  2.857143  0.008247  0.025392  0.028935
  2.901099  0.007615  0.026363  0.028935
  2.945055  0.006987  0.027349  0.028935
  2.989011  0.006361  0.028351  0.028935
  3.000000  0.005739  0.029202  0.028935
  END FTABLE  2
  FTABLE      1
   24    6
     Depth      Area    Volume  Outflow1  Outflow2  outflow 3 Velocity  Travel
Time***
      (ft)   (acres) (acre-ft)   (cfs)      (cfs)     (cfs)   (ft/sec)
(Minutes)***
  0.000000  0.005739  0.000000  0.000000  0.000000  0.000000
  0.043956  0.056373  0.002459  0.000000  0.017361  0.000000
  0.087912  0.057216  0.004956  0.000000  0.018379  0.000000
  0.131868  0.058063  0.007490  0.000000  0.018887  0.000000
  0.175824  0.058912  0.010060  0.000000  0.019396  0.000000
  0.219780  0.059765  0.012669  0.000000  0.019905  0.000000
  0.263736  0.060621  0.015315  0.000000  0.020414  0.000000
  0.307692  0.061481  0.017998  0.000000  0.020922  0.000000
  0.351648  0.062343  0.020720  0.000000  0.021431  0.000000
  0.395604  0.063209  0.023479  0.000000  0.021940  0.000000
  0.439560  0.064078  0.026276  0.000000  0.022449  0.000000
  0.483516  0.064950  0.029112  0.000000  0.022957  0.000000
  0.527473  0.065825  0.031986  0.096659  0.023466  0.000000
  0.571429  0.066704  0.034899  0.404863  0.023975  0.000000
  0.615385  0.067585  0.037851  0.830375  0.024484  0.000000
  0.659341  0.068470  0.040841  1.345222  0.024992  0.000000
  0.703297  0.069358  0.043870  1.932993  0.025501  0.000000
  0.747253  0.070250  0.046938  2.580854  0.026010  0.000000
  0.791209  0.071144  0.050046  3.277130  0.026519  0.000000
  0.835165  0.072042  0.053193  4.010349  0.027027  0.000000
  0.879121  0.072942  0.056379  4.768866  0.027536  0.000000
  0.923077  0.073846  0.059605  5.540778  0.028045  0.000000
  0.967033  0.074754  0.062871  6.314008  0.028554  0.000000
  1.000000  0.075436  0.065347  7.076496  0.028935  0.000000
  END FTABLE  1
  FTABLE      4
   70    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.035813  0.000000  0.000000
  0.043956  0.035664  0.000030  0.000000
  0.087912  0.035073  0.000063  0.000000
  0.131868  0.034486  0.000100  0.000000
  0.175824  0.033901  0.000141  0.000000
  0.219780  0.033320  0.000186  0.000000
  0.263736  0.032742  0.000235  0.000000
  0.307692  0.032167  0.000288  0.000000
  0.351648  0.031595  0.000345  0.000000
  0.395604  0.031026  0.000406  0.000000
  0.439560  0.030461  0.000471  0.000000
  0.483516  0.029899  0.000540  0.000000
  0.527473  0.029340  0.000613  0.000000
  0.571429  0.028784  0.000691  0.000000
  0.615385  0.028231  0.000772  0.000000
  0.659341  0.027682  0.000858  0.000000
  0.703297  0.027136  0.000948  0.000000
  0.747253  0.026592  0.001042  0.000000
  0.791209  0.026053  0.001141  0.000000
  0.835165  0.025516  0.001244  0.000000
```

0.879121	0.024982	0.001351	0.000000
0.923077	0.024452	0.001463	0.000000
0.967033	0.023925	0.001579	0.000000
1.010989	0.023401	0.001700	0.000000
1.054945	0.022881	0.001825	0.000621
1.098901	0.022363	0.001955	0.000687
1.142857	0.021849	0.002089	0.000831
1.186813	0.021338	0.002228	0.000992
1.230769	0.020830	0.002515	0.001171
1.274725	0.020325	0.002812	0.001367
1.318681	0.019823	0.003118	0.001583
1.362637	0.019325	0.003433	0.001817
1.406593	0.018830	0.003758	0.002071
1.450549	0.018338	0.004093	0.002345
1.494505	0.017849	0.004437	0.002640
1.538462	0.017364	0.004758	0.002957
1.582418	0.016881	0.005088	0.003295
1.626374	0.016402	0.005427	0.003655
1.670330	0.015926	0.005775	0.004038
1.714286	0.015453	0.006132	0.004444
1.758242	0.014984	0.006498	0.004873
1.802198	0.014517	0.006874	0.005326
1.846154	0.014054	0.007258	0.005804
1.890110	0.013594	0.007652	0.006307
1.934066	0.013137	0.008055	0.006834
1.978022	0.012684	0.008468	0.007387
2.021978	0.012233	0.008890	0.007965
2.065934	0.011786	0.009322	0.013889
2.109890	0.011342	0.009763	0.013889
2.153846	0.010901	0.010214	0.013889
2.197802	0.010464	0.010674	0.013889
2.241758	0.010029	0.011145	0.013889
2.285714	0.009598	0.011625	0.013889
2.329670	0.009170	0.012115	0.013889
2.373626	0.008745	0.012615	0.013889
2.417582	0.008323	0.013125	0.013889
2.461538	0.007905	0.013645	0.013889
2.505495	0.007489	0.014175	0.013889
2.549451	0.007077	0.014715	0.013889
2.593407	0.006668	0.015266	0.013889
2.637363	0.006263	0.015827	0.013889
2.681319	0.005860	0.016398	0.013889
2.725275	0.005461	0.016980	0.013889
2.769231	0.005065	0.017572	0.013889
2.813187	0.004672	0.018174	0.013889
2.857143	0.004282	0.018787	0.013889
2.901099	0.003895	0.019411	0.013889
2.945055	0.003512	0.020045	0.013889
2.989011	0.003132	0.020691	0.013889
3.000000	0.002755	0.021141	0.013889

END FTABLE 4
FTABLE 3
24 6

Depth	Area	Volume	Outflow1	Outflow2	outflow 3	Velocity	Travel Time***
(ft)	(acres)	(acre-ft)	(cfs)	(cfs)	(cfs)	(ft/sec)	(Minutes)***
0.000000	0.002755	0.000000	0.000000	0.000000	0.000000		
0.043956	0.036408	0.001587	0.000000	0.008333	0.000000		
0.087912	0.037006	0.003201	0.000000	0.008822	0.000000		
0.131868	0.037607	0.004841	0.000000	0.009066	0.000000		
0.175824	0.038212	0.006507	0.000000	0.009310	0.000000		
0.219780	0.038819	0.008200	0.000000	0.009554	0.000000		
0.263736	0.039430	0.009920	0.000000	0.009799	0.000000		
0.307692	0.040044	0.011666	0.000000	0.010043	0.000000		
0.351648	0.040662	0.013440	0.000000	0.010287	0.000000		
0.395604	0.041282	0.015241	0.000000	0.010531	0.000000		
0.439560	0.041906	0.017069	0.000000	0.010775	0.000000		
0.483516	0.042533	0.018925	0.000000	0.011020	0.000000		
0.527473	0.043163	0.020809	0.096659	0.011264	0.000000		

```
  0.571429  0.043796  0.022720  0.404863  0.011508  0.000000
  0.615385  0.044432  0.024659  0.830375  0.011752  0.000000
  0.659341  0.045072  0.026626  1.345222  0.011996  0.000000
  0.703297  0.045715  0.028621  1.932993  0.012241  0.000000
  0.747253  0.046361  0.030645  2.580854  0.012485  0.000000
  0.791209  0.047010  0.032697  3.277130  0.012729  0.000000
  0.835165  0.047663  0.034778  4.010349  0.012973  0.000000
  0.879121  0.048318  0.036887  4.768866  0.013217  0.000000
  0.923077  0.048977  0.039026  5.540778  0.013462  0.000000
  0.967033  0.049639  0.041193  6.314008  0.013706  0.000000
  1.000000  0.050138  0.042838  7.076496  0.013889  0.000000
  END FTABLE  3
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1.37           PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.37           IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.8            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.8            IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1.37           RCHRES   1     EXTNL  PREC
WDM      2 PREC     ENGL    1.37           RCHRES   3     EXTNL  PREC
WDM      1 EVAP     ENGL    0.5            RCHRES   1     EXTNL  POTEV
WDM      1 EVAP     ENGL    0.8            RCHRES   2     EXTNL  POTEV
WDM      1 EVAP     ENGL    0.5            RCHRES   3     EXTNL  POTEV
WDM      1 EVAP     ENGL    0.8            RCHRES   4     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   5 HYDR   RO     1 1         1     WDM   1000 FLOW     ENGL      REPL
RCHRES   5 HYDR   O      1 1         1     WDM   1001 FLOW     ENGL      REPL
RCHRES   5 HYDR   O      2 1         1     WDM   1002 FLOW     ENGL      REPL
RCHRES   5 HYDR   STAGE  1 1         1     WDM   1003 STAG     ENGL      REPL
COPY     1 OUTPUT MEAN   1 1      48.4     WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1      48.4     WDM    801 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK       3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK       5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK       6
RCHRES     ROFLOW                          RCHRES         INFLOW
  END MASS-LINK    6

  MASS-LINK       7
RCHRES     OFLOW  OVOL   1                 RCHRES         INFLOW IVOL
  END MASS-LINK    7

  MASS-LINK       8
RCHRES     OFLOW  OVOL   2                 RCHRES         INFLOW IVOL
  END MASS-LINK    8

  MASS-LINK      16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
```

```
  END MASS-LINK   16

  MASS-LINK       17
RCHRES     OFLOW  OVOL   1                       COPY            INPUT  MEAN
  END MASS-LINK   17

END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Clark County, Washington

Lacamas Creek Park

January 17, 2019

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map (Lacamas Creek Park)

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

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

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

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

Soil Survey Area: Clark County, Washington
Survey Area Data: Version 16, Sep 10, 2018

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

Date(s) aerial images were photographed: Sep 29, 2015—Jul 22, 2017

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

Map Unit Legend (Lacamas Creek Park)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Fn	Fill land	0.0	0.4%
HlE	Hillsboro loam, 20 to 30 percent slopes	0.1	2.3%
HlF	Hillsboro loam, 30 to 50 percent slopes	0.8	14.2%
OmE	Olympic stony clay loam, 3 to 30 percent slopes	4.2	70.3%
WgE	Washougal gravelly loam, 8 to 30 percent slopes	0.8	12.8%
Totals for Area of Interest		**5.9**	**100.0%**

Map Unit Descriptions (Lacamas Creek Park)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Clark County, Washington

Fn—Fill land

Map Unit Composition

Fill land: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fill Land

Typical profile

H1 - 0 to 6 inches: variable

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s
Hydric soil rating: No

HIE—Hillsboro loam, 20 to 30 percent slopes

Map Unit Setting

National map unit symbol: 2dxm
Elevation: 100 to 390 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 degrees F
Frost-free period: 170 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition

Hillsboro and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hillsboro

Setting

Landform: Terraces
Parent material: Alluvium

Typical profile

H1 - 0 to 5 inches: loam
H2 - 5 to 34 inches: loam
H3 - 34 to 46 inches: sandy loam
H4 - 46 to 60 inches: sand

Properties and qualities

Slope: 20 to 30 percent
Depth to restrictive feature: 40 to 59 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None

Frequency of ponding: None
Available water storage in profile: Moderate (about 8.2 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Forage suitability group: Sloping to Steep Soils (G002XV702WA)
Hydric soil rating: No

HIF—Hillsboro loam, 30 to 50 percent slopes

Map Unit Setting
National map unit symbol: 2dxn
Elevation: 100 to 390 feet
Mean annual precipitation: 40 to 50 inches
Mean annual air temperature: 54 degrees F
Frost-free period: 170 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition
Hillsboro and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hillsboro

Setting
Landform: Terraces
Parent material: Alluvium

Typical profile
H1 - 0 to 4 inches: loam
H2 - 4 to 33 inches: loam
H3 - 33 to 45 inches: sandy loam
H4 - 45 to 60 inches: sand

Properties and qualities
Slope: 30 to 50 percent
Depth to restrictive feature: 40 to 59 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 8.0 inches)

Interpretive groups
Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Hydric soil rating: No

OmE—Olympic stony clay loam, 3 to 30 percent slopes

Map Unit Setting

National map unit symbol: 2dz2
Elevation: 200 to 2,000 feet
Mean annual precipitation: 40 to 80 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 160 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Olympic and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Olympic

Setting

Landform: Mountain slopes
Parent material: Residuum and colluvium from igneous rock

Typical profile

H1 - 0 to 13 inches: stony clay loam
H2 - 13 to 44 inches: clay loam
H3 - 44 to 60 inches: gravelly clay loam

Properties and qualities

Slope: 3 to 30 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 11.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Forage suitability group: Soils with Moderate Limitations (G003XF603WA)
Hydric soil rating: No

WgE—Washougal gravelly loam, 8 to 30 percent slopes

Map Unit Setting

National map unit symbol: 2f03

Elevation: 100 to 490 feet
Mean annual precipitation: 60 to 90 inches
Mean annual air temperature: 48 degrees F
Frost-free period: 170 to 210 days
Farmland classification: Not prime farmland

Map Unit Composition

Washougal and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Washougal

Setting

Landform: Terraces
Parent material: Gravelly alluvium

Typical profile

H1 - 0 to 20 inches: gravelly medial loam
H2 - 20 to 28 inches: very gravelly medial loam
H3 - 28 to 60 inches: very cobbly coarse sand

Properties and qualities

Slope: 8 to 30 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Forage suitability group: Droughty Soils (G002XV402WA)
Hydric soil rating: No

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United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Clark County, Washington

Baz Park

January 17, 2019

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

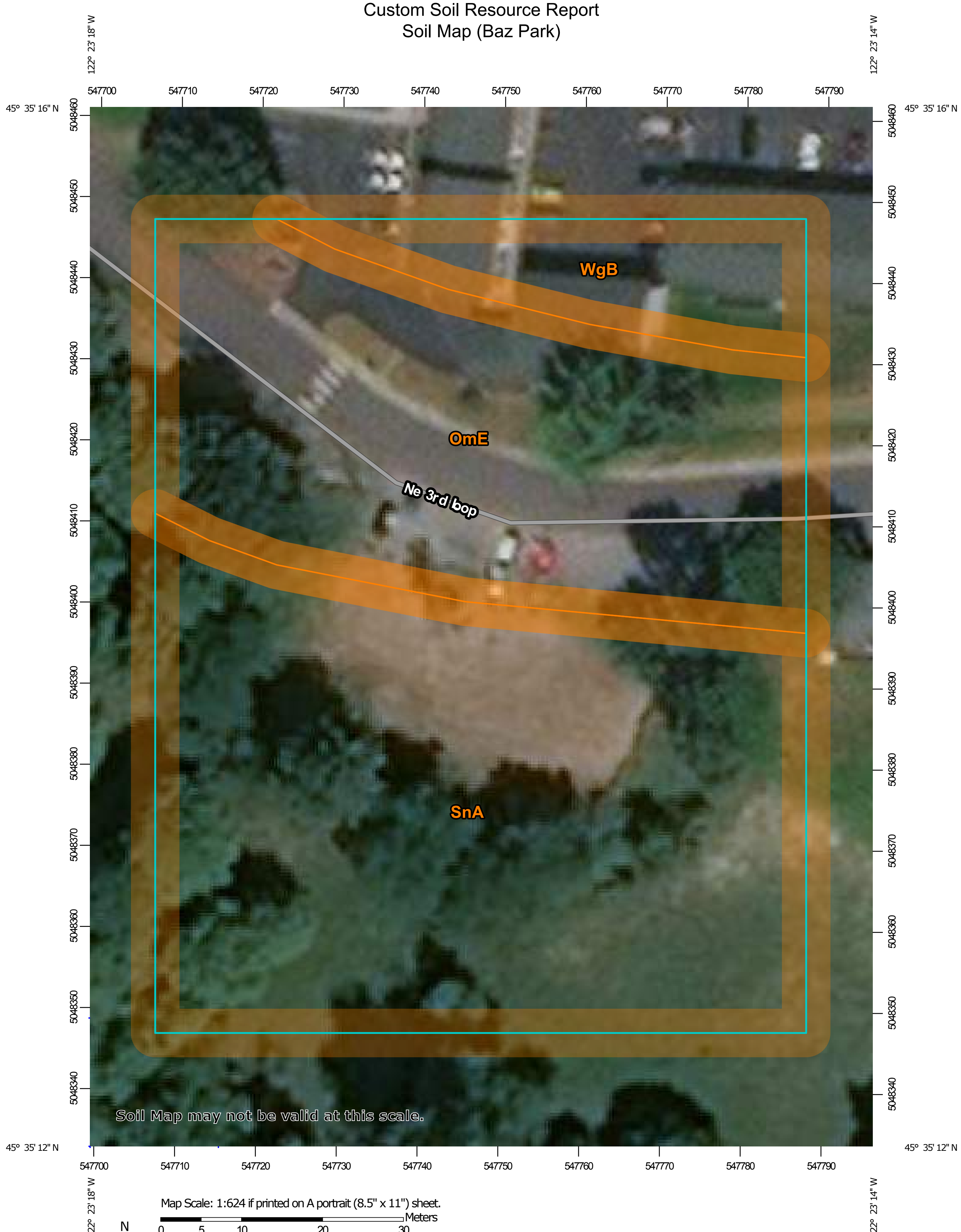
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map (Baz Park)



Map Scale: 1:624 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 5, 10, 20, 30

Feet: 0, 30, 60, 120, 180

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

MAP LEGEND

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

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

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

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

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

Soil Survey Area: Clark County, Washington
Survey Area Data: Version 16, Sep 10, 2018

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

Date(s) aerial images were photographed: Sep 29, 2015—Jul 22, 2017

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

Map Unit Legend (Baz Park)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
OmE	Olympic stony clay loam, 3 to 30 percent slopes	0.7	37.3%
SnA	Sauvie silt loam, sandy substratum, 0 to 3 percent slopes	1.1	54.0%
WgB	Washougal gravelly loam, 0 to 8 percent slopes	0.2	8.6%
Totals for Area of Interest		**2.0**	**100.0%**

Map Unit Descriptions (Baz Park)

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Clark County, Washington

OmE—Olympic stony clay loam, 3 to 30 percent slopes

Map Unit Setting

National map unit symbol: 2dz2
Elevation: 200 to 2,000 feet
Mean annual precipitation: 40 to 80 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 160 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Olympic and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Olympic

Setting

Landform: Mountain slopes
Parent material: Residuum and colluvium from igneous rock

Typical profile

H1 - 0 to 13 inches: stony clay loam
H2 - 13 to 44 inches: clay loam
H3 - 44 to 60 inches: gravelly clay loam

Properties and qualities

Slope: 3 to 30 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 11.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: C
Forage suitability group: Soils with Moderate Limitations (G003XF603WA)
Hydric soil rating: No

SnA—Sauvie silt loam, sandy substratum, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2dzr
Elevation: 10 to 20 feet
Mean annual precipitation: 40 to 60 inches

Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 170 to 210 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Sauvie and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sauvie

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 15 inches: silt loam
H2 - 15 to 36 inches: silty clay loam
H3 - 36 to 60 inches: stratified sandy loam to silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: C/D
Forage suitability group: Soils with Few Limitations (G002XV502WA)
Hydric soil rating: Yes

WgB—Washougal gravelly loam, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2f02
Elevation: 100 to 390 feet
Mean annual precipitation: 60 to 90 inches
Mean annual air temperature: 48 degrees F
Frost-free period: 170 to 210 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Washougal and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Washougal

Setting

Landform: Terraces
Parent material: Gravelly alluvium

Typical profile

H1 - 0 to 22 inches: gravelly medial loam
H2 - 22 to 30 inches: very gravelly medial loam
H3 - 30 to 60 inches: very cobbly coarse sand

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 6.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Forage suitability group: Droughty Soils (G002XV402WA)
Hydric soil rating: No

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Memorandum

otak

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To:	Rod Swanson, Clark County Environmental Services
From:	Tim Kraft
Copies:	File
Date:	December 21, 2010
Subject:	Clark County WWHM Soil Groupings

The Clark County version of the Western Washington Hydrology Model (WWHM) includes five soils groups to represent the many soil types found within the county limits. Although there are over 110 different soil types throughout Clark County, similarities between the soils allows them to be grouped into categories for modeling purposes.

Clark County soils are grouped into five categories largely based on their permeability and runoff potential. These categories include:

- Soil Group (SG) 1 – Excessively drained soils (hydrologic soil groups A & B)
- Soil Group (SG) 2 – Well drained soils (mostly hydrologic soil group B)
- Soil Group (SG) 3 – Moderately drained soils (hydrologic soil groups B & C)
- Soil Group (SG) 4 – Poorly drained soils (slowly infiltrating C soils, as well as D soils)
- Soil Group (SG) 5 – Wetland soils (mucks).

Soil Groups 1 and 2 are those most suitable for traditional infiltration facilities such as trenches and drywells, while Soil Group 3 may only be suitable for slower infiltrating facilities such as rain gardens and other Low Impact Development (LID) measures. Soil Groups 4 and 5 are those which are typically not suitable for infiltration.

For additional information on the classification of soils for use in the Clark County WWHM model, please see the report titled "Development of the Clark County Version of the Western Washington Hydrology Model", which can be found on the county's community development web site.

The following table lists the WWHM soil group for each NCRS soil type in Clark County.

Map Symbol	Soil Name	HSG
Soils Group (SG) 1		
LeB	LAUREN	B
LgB	LAUREN	B
LgD	LAUREN	B
LgF	LAUREN	B
LIB	LAUREN	B
Ro	ROUGH BROKEN LAND	A
SvA	SIFTON	B
WnB	WIND RIVER VARIANT	B
WnD	WIND RIVER VARIANT	B
WnG	WIND RIVER VARIANT	B
WrB	WIND RIVER VARIANT	B
WrF	WIND RIVER VARIANT	B
	PITS	A
	BONNEVILLE STONY SAND LOAM	A

Soils Group (SG) 2

BpB	BEAR PRARIE	B
BpC	BEAR PRARIE	B
CnB	CINEBAR	B
CnD	CINEBAR	B
CnE	CINEBAR	B
CnG	CINEBAR	B
CrE	CINEBAR	B
CrG	CINEBAR	B
CsF	CISPUS	B
CtA	CLOQUATO	B
HlA	HILLSBORO	B
HlB	HILLSBORO	B
HlC	HILLSBORO	B
HlD	HILLSBORO	B
HlE	HILLSBORO	B

Map Symbol	Soil Name	HSG
HlF	HILLSBORO	B
Soils Group (SG) 2 (continued)		
KeC	KINNEY	B
KeE	KINNEY	B
KeF	KINNEY	B
KnF	KINNEY	B
LaE	LARCHMOUNT	B
LaG	LARCHMOUNT	B
LcG	LARCHMOUNT	B
MsB	MOSSYROCK	B
NbA	NEWBERG	B
NbB	NEWBERG	B
PhB	PILCHUCK	C
PuA	PUYALLUP	B
SaC	SALKUM	B
VaB	VADER	B
VaC	VADER	B
WaA	WASHOUGAL	B
WgB	WASHOUGAL	B
WgE	WASHOUGAL	B
WhF	WASHOUGAL	B
YaA	YACOLT	B
YaC	YACOLT	B
YcB	YACOLT	B

Soils Group (SG) 3

DoB	DOLLAR	C
HcB	HESSON	C
HcD	HESSON	C
HcE	HESSON	C
HcF	HESSON	C
HgB	HESSON	C
HgD	HESSON	C
HhE	HESSON	C
HoA	HILLSBORO	B

Map Symbol	Soil Name	HSG
HoB	HILLSBORO	B
Soils Group (SG) 3 (continued)		
HoC	HILLSBORO	B
HoD	HILLSBORO	B
HoE	HILLSBORO	B
HoG	HILLSBORO	B
HsB	HILLSBORO	B
McB	McBEE	C
MeA	McBEE	C
MIA	McBEE	C
OeD	OLEQUA	B
OeE	OLEQUA	B
OeF	OLEQUA	B
OlB	OLYMPIC	B
OID	OLYMPIC	B
OlE	OLYMPIC	B
OIF	OLYMPIC	B
OmE	OLYMPIC	B
OmF	OLYMPIC	B
OpC	OLYMPIC VARIANT	C
OpE	OLYMPIC VARIANT	C
OpG	OLYMPIC VARIANT	C
OrC	OLYMPIC VARIANT	C
PoB	POWELL	C
PoD	POWELL	C
PoE	POWELL	C
SmA	SAUVIE	B
SmB	SAUVIE	B
SnA	SAUVIE	D
SpB	SAUVIE	B

Soils Group (SG) 4

CvA	COVE	D
CwA	COVE	D
GeB	GEE	C

Map Symbol	Soil Name	HSG
GeD	GEE	C
Soils Group (SG) 4 (continued)		
GeE	GEE	C
GeF	GEE	C
GuB	GUMBOOT	D
HtA	HOCKINSON	D
HuB	HOCKINSON	D
HvA	HOCKINSON	D
LrC	LAUREN	C
LrF	LAUREN	C
MnA	MINNIECE	D
MnD	MINNIECE	D
MoA	MINNIECE VARIANT	D
OdB	ODNE	D
OhD	OLEQUA VARIANT	C
OhF	OLEQUA VARIANT	C
SlB	SARA	D
SlD	SARA	D
SlF	SARA	D

Soils Group (SG) 5

Sr	SEMIAHMOO	C
Su	SEMIAHMOO VARIANT	D
ThA	TISCH	D