Stormwater
Technical Information Report

Lower Columbia College
New Head Start Building
at Barnes Elementary School
401 Barnes Street
Kelso, WA 98626

Submitted To:

CITY OF FRIENDLY PEOPLE
KELSO
WASHINGTON U.S.A.

Prepared By:

GIBBS & OLSON
CIVIL ENGINEERS • LAND SURVEYORS

September 2018

Gibbs & Olson Project No. 0366.0014

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CYNTHIA J. GOWER
35655
FOR REVIEW

This stormwater report includes all required Clark County Information and the proposed stormwater facilities designed are feasible to the best of our knowledge.

September 2018

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Tables

References

City of Kelso Engineering Design Manual, Kelso, WA, February 1, 2011, Amended June 20, 2017.

Washington State Department of Ecology, Olympia, WA; Stormwater Manual for Western Washington, 2012.

U. S. Department of Agriculture Natural Resources Conservation Services; Web Soil Survey available on the NRCS website: http://websoilsurvey.nrcs.usda.gov

Section A – Project Overview

The proposed site for the new head start building is located adjacent to Barnes Elementary School at 401 Barnes Street in Kelso, WA, between the Cowlitz River and Interstate 5. See the Vicinity Map in Appendix A for the general location. The Barnes Elementary campus is on Parcel No. 24033 which totals 8.06 acres and is zoned for residential single-family residential (RSF5) with a current land use of educational service. The proposed improvements for the construction of the new building will include earthwork, a new parking lot with drive isles, sidewalk access, connections to water, sanitary sewer and stormwater utilities, as well as relocating the existing goal post and a section of gravel track north of the existing Barnes Elementary School. These improvements will be located in the northeast portion of the parcel with site access off Bowmont Avenue. The proposed layout meets or exceeds the City of Kelso's landscape and setback criteria. This work will require a building permit and a civil permit, including a grading permit. The proposed project follows the City of Kelso's development design requirements per the City of Kelso Engineering and Design Manual (KEDM) and the Department of Ecology's Stormwater Management Manual for Western Washington (SWMMWW).

Section B – Existing Conditions and Soils

The proposed improvements for this project are located on approximately 0.98 acres on the northeast portion of the parcel occupied by Barnes Elementary School. This portion of the site is approximately 3 feet lower than the adjacent Bowmont Avenue. Therefore, construction will include up to 3 feet of structural fill in the building and parking lot areas. The existing land cover of this portion of the site is generally covered by lawn. There is also a small portion of an existing track surface that will be removed and replaced just west of the new facilities.

The proposed site is bordered by Bowmont Avenue to the east, which is a city street with curb, gutter and a storm drainage collection system. The remaining area surrounding the parcel consists of medium density residential parcels and one large residential parcel directly to the north, which are also flat in nature. Therefore, no off-site runoff from the adjacent properties is anticipated. See the Pre-Developed Drainage Basin Map in Appendix A.

The existing topography of this portion of the site is relatively flat, with the runoff from the site currently collecting near the middle of the site in a low point between the road and the track where it remains until it is infiltrated or makes its way to road side ditches to the north. Therefore, the entire site is contained within one threshold discharge area (TDA). The site is located within the boundaries of Drainage Improvement District No. 1 (DID1). The runoff from DID1 is either conveyed to the north pump station at King Creek or to the south pump station at Redpath. The conveyance systems for the two pump stations are interconnected via a large diameter pipe within Cowlitz County and City of Kelso. The discharge from the site is conveyed to the Redpath pump station and is discharged to the Cowlitz River.

Natural drainage patterns were maintained to the greatest extent possible. The proposed site was divided into three basins within the existing TDA. See the Developed Basin Map in Appendix A. After

Development, all stormwater from the pollution generating hard surfaces will sheet flow across the parking lot to a bioretention planter for treatment prior to collection in the underdrain, discharge to the new storm drain discharge manhole and the existing large diameter pipe and ultimately to the Cowlitz River via either of the two pump stations. The Cowlitz River is listed in Appendix I-E, Flow Control-Exempt Surface Waters in Volume 1 of the Stormwater Management Manual for Western Washington (SWMMWW). Therefore, no on-site flow control is required. See the Flow Control Exempt Surface Water List in Appendix B. The roof does not require treatment and will connect directly to the new storm drain discharge manhole and the existing large diameter pipe.

There are no wetlands onsite and the site is not located within the shoreline management area. The Federal Emergency Management Agency (FEMA) identifies the site within an area of reduced flood risk due to protection by a levee. The site is located near a moderately sensitive critical aquifer recharge area, however, all runoff from pollution generating hard surface will be treated prior to collection and discharge from the site. Infiltration will not be used to address the stormwater management for this site. See the maps in Appendix A.

According to the USDA Natural Resources Conservation Service (NRCS) Soil Survey, the soils for this property have been identified as Caples silty clay loam. The Caples soil is classified as a soils hydrologic group C/D. See the soils map in Appendix A.

A geotechnical evaluation was performed in December 2017 and is included in Appendix C. At the time of the soils testing, groundwater was not encountered. Moisture content suggested groundwater was present at about 5 feet below ground surface. The site soils generally consist of 12 inches of low to medium plasticity brown silt below the grass surface. Silt and clay extend to a depth of approximately 3 to 5 feet followed by very loose to lose dark gray silt and sand to approximately 20 feet below ground surface and loose to medium dense sand and gravel at approximately 20 feet below ground surface. The geotechnical infiltration testing found the field measured infiltration rate to be 0.3 inches per hour before any correction factors were applied. Therefore, infiltration will not be used to address the stormwater management for this site.

Section C – Minimum Requirements Analysis

The total area of land disturbing activities for this project is approximately 0.98 acres and the increase in pollution generating hard surface is approximately 0.39 acres. See Table C.1 below. Since the project results in greater than 5,000 square feet of new plus replaced hard surface area, the project falls under the new development requirements of Figure 2.4.1 of the Department of Ecology SMMWW and all minimum requirements (#1-#9) from the SMMWW apply per the Manual and the City of Kelso Engineering Design Manual (KEDM) 17.

Table C.1 – Land Disturbing Activities and Proposed Land Use

Description	Basin 1 (AC)	Basin 2 (AC)	Basin 3 (AC)	Total (AC)
Existing Hard Surface	0.03	0.01	0.02	0.06
New Hard Surface	0.39	0.12	0.03	0.54
Replaced Impervious Surface	0	0	0.06	0.06
Native Vegetation Converted to Lawn or Landscaping	0.09	0	0.29	0.38
Native Vegetation Converted to Pasture	0	0	0	0
Amount of Land Disturbing Activity	0.48	0.12	0.38	0.98
Pollution Generating Hard Surface	0.39	0	0	0.39
Pollution Generating Pervious Surface	0	0	0	0
Total Amount of Effective Impervious Surface	0.39	0	0	0.39

Per section 2.5.7, Vol. 1 of the SWMMWW, flow control is not required for projects that discharge directly to, or indirectly to a water listed in Appendix I-E. Projects that discharge to the Cowlitz River downstream of the confluence of the Ohanapecosh River and the Clear Fork River, are listed on the exempt surface water list. Since flow control is not required, the pre-developed condition was not analyzed. All other Minimum Requirements still apply. See the Flow Control Exempt Surface Water List in Appendix B.

This project exceeds the threshold requirement of section 2.5.2 of Volume I of the manual; therefore, a Construction Stormwater Pollution Prevention Plan (SWPPP) will be required. A preliminary SWPPP will be prepared and submitted as part of the submittal package. The contractor will be responsible to complete the scheduling portions of the construction SWPPP and re-submit for approval. The Construction SWPPP will be retained on-site and updated throughout the life of the project.

Section D – On-Site Stormwater Mgmt Selection and Sizing – (MR5)

Per Section 2.5.5, Vol. 1 of the SWMMWW, projects qualifying as flow control exempt in accordance with Section 2.5.7 of this chapter are not required to achieve the LID performance standard, nor consider bioretention, rain gardens, permeable pavement, and full dispersion if using List #1 or List #2. However, those projects must implement BMP T5.13; BMPs T5.10A, B, or C; and BMP T5.11or T5.12, if feasible. See Figure 2.5.1, the flow chart for determining LID minimum requirements, Vol. I of the SWMMWW in Appendix C.

For the lawn and landscaped areas, the post-construction soil quality and depth shall be implemented in accordance with BMP T5.13. For the roofs, BMP T5.10 A and T5.10B are not feasible, therefore, perforated stub-out connections shall be constructed in accordance with BMP T5.10C. Based on the constraints of the site, BMP T5.11 and T5.12 are not feasible for the other hard surfaces of this project.

Section E – Runoff Treatment Analysis and Design

This project will add greater than 5,000 square feet of pollution generating impervious surface with the construction of a parking lot for the new head start facility. Water quality treatment for the new pollution generating hard surfaces will be addressed through the use of a bioretention planter prior to discharge to the City of Kelso's conveyance system through the construction of a new manhole.

Since the runoff from the roof area does not require treatment, the roof downspouts will be piped directly to the new storm drain manhole, S1 on the construction plan set, and discharged directly to the City of Kelso's conveyance system.

The proposed bioretention planter was designed to receive sheet flow runoff from the parking lot and surrounding sidewalk and landscaped areas. The water quality flow rate was calculated by WWHM2012 continuous model to meet the state requirements of treating 91% or greater of the runoff volume. The bottom of the proposed bioretention facility is 4 feet by 85 feet with a 0% slope and 3 to 1 side slopes. The surface elevation of the bottom of the facility is 17.58 feet with 3 inches of coarse compost and 18 inches of bioremediation soil mix (BSM). The ponding depth is 0.5 feet and the freeboard depth is 0.5-feet.

The proposed bioretention planter is for treatment of the stormwater runoff. A perforated underdrain will be installed to collect the treated runoff. It will then be conveyed to the downstream discharge manhole, S1 on the construction plan set. Infiltration is not being used as part of the bioretention design, therefore, it is not being used to meet the LID minimum requirement #5. See Section D above.

See the construction plan set for the locations and details of the stormwater facilities. See Appendix A for the Developed Basin Map and Appendix D for the WWHM modeling results.

Section F – Flow Control Analysis and Design

The existing topography of this portion of the site is relatively flat, with the runoff from the site currently collecting near the middle of the site in a low point between the road and the track where it remains until it is infiltrated or makes its way to road side ditches to the north.

The site is located within the boundaries of Drainage Improvement District No. 1 (DID1). The runoff is normally conveyed to the Redpath pump station however during large storm events can flow to the northern pump station at King Creek and both pump stations discharge to the Cowlitz River. Per section 2.5.7, Vol. 1 of the SWMMWW, flow control is not required for projects that discharge directly to, or indirectly to a water listed in Appendix I-E. The runoff from this site discharges to the Cowlitz River which is listed on the exempt surface water list.

After development, all stormwater from the pollution generating hard surfaces will sheet flow across the parking lot to a bioretention planter for treatment prior to collection in the underdrain and discharged to the existing large diameter conveyance pipe located in the City of Kelso's right of way.

See the construction plan set for the location and details of the manhole and connection. See Appendix A for the Developed Basin Map.

Section G – Conveyance System Analysis and Design

The onsite collection and conveyance system will be privately owned and maintained. The onsite collection and conveyance system will consist of sheet flow to the new bioretention planter. The overflow stand pipe from the new bioretention planter will connect to the existing conveyance system with a 12-inch Corrugated Polyethylene Pipe (CPEP) at a minimum slope of 0.5%. The WWHM 100-year flow from Basin 1 is 0.79 cfs. Using Manning's equation, a 12-inch CPEP pipe at a slope of 0.5% has a conveyance capacity of approximately 1.15 cfs, which is greater than the peak flow from Basin 1. Therefore, a 12-inch pipe at 0.5% slope is adequate to connect the runoff from the proposed bioretention planter to the existing conveyance system.

The roof downspout drain pipe shall be connected to the existing conveyance system with a 6-inch PVC pipe at a minimum slope of 1.0%. The WWHM 100-year flow from Basin 2, the roof area, is 0.19 cfs. Using Manning's equation, a 6-inch PVC pipe at a slope of 1.0% has a conveyance capacity of approximately 0.80 cfs, which is greater than the peak flow from Basin 2. Therefore, a 6-inch pipe at 1.0% slope is adequate to connect the runoff from the proposed roof downspouts to the existing conveyance system.

See the construction plan set for the size, location, and construction details for the connection to existing conveyance system. See Appendix E for the modeling results.

Section H – Source Control

All known, available and reasonable source control BMPs shall be applied to this project to prevent stormwater from coming in contact with pollutants from pollution generating hard surfaces.

Construction source control will employ various temporary erosion control BMPs and will include the following temporary BMPs:

- BMP C105: Stabilized Construction Entrance/Exit
- BMP C220: Storm Drain Inlet Protection
- BMP C233: Silt Fence

On-site source control from pollution generating impervious surfaces (PGIP) will be addressed by water quality treatment through the use of a bioretention planter.

See the construction plan set for the proposed erosion control and stormwater improvements for this project.

Section I – Ongoing Operation and Maintenance

Operation and Maintenance of the onsite collection, conveyance, and treatment facilities will be privately maintained by the Kelso School District. Additional details and attachments are included in the Long-Term Stormwater Site Management Plan that will accompany the submittal package.

A Stormwater Improvement Restrictive Covenant form is included in Appendix B of the Long-Term Stormwater Site Management Plan and will be completed by the owner and submitted to the City of Kelso prior to final acceptance of the stormwater improvements.

Section J – Groundwater Monitoring Program

A groundwater monitoring program does not apply for this project.

Section K – Appendices

Appendix A

Map Submittals

Appendix B

Flow Charts

Appendix C

Geotechnical Report

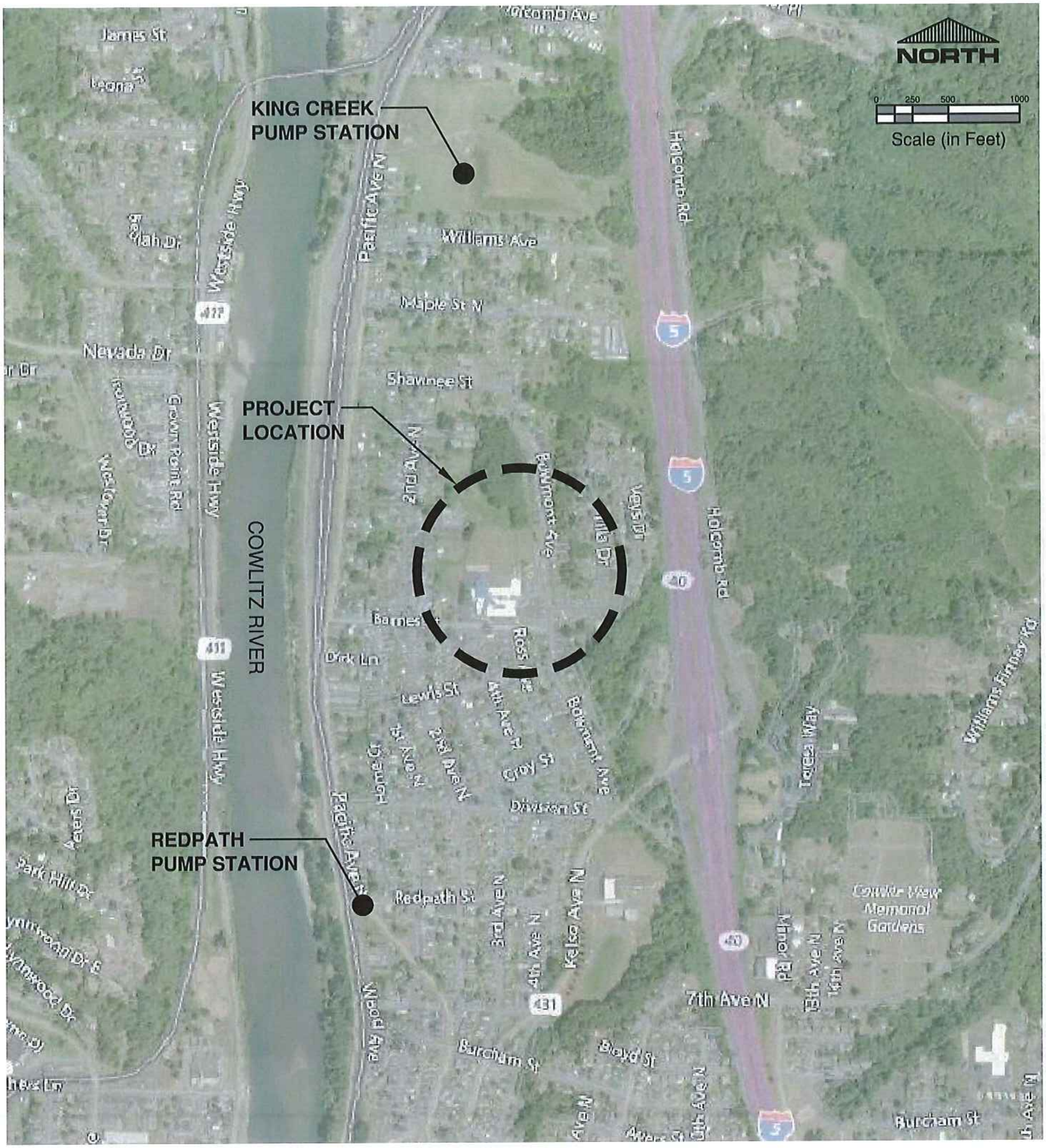
Appendix D

Modeling Results
Technical Data

Appendix A

Map Submittals

Vicinity Map
Pre-Developed Drainage Basin Map
Developed Drainage Basin Map
Shoreline Map
FEMA Map
Aquafer Recharge Area Map
NRCS Soils Map



Vicinity Map

Scale: 1" = 1000'

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Lower Columbia College
New Head Start Bldg at Barnes School
Vicinity Map

DRAWING: T:\CIVIL 3D\PROJECTS\03580014-ACT\FIGURES & EXHIBITS\VICINITY MAP.DWG, LAYOUT TAB: VICINITY MAP, PLOT DATE: 3/1/2018 2:47:35 PM, DRAWING SAVE DATE: 3/1/2018 2:47:01 PM, PLOTTED BY: KROGERS
PLOT DEVICE: GIBBS & OLSON – DWG TO PDF.PC3, PLOT STYLE TABLE: GIBBS-OLSON STANDARD COLOR & BLACK.CTB, PAPER SIZE: GIBBS & OLSON – FIGURE A SIZE (PORTRAIT – 8.50 X 11.00 INCHES)

NORTH

0 12.5 25 50

Scale (in Feet)

PRE-DEVELOPED BASIN INFORMATION

TOTAL AREA:	0.98 ACRES
LANDSCAPING:	0.91 ACRES
EXISTING SIDEWALK:	0.01 ACRES
EXISTING GRAVEL TRACK:	0.06 ACRES

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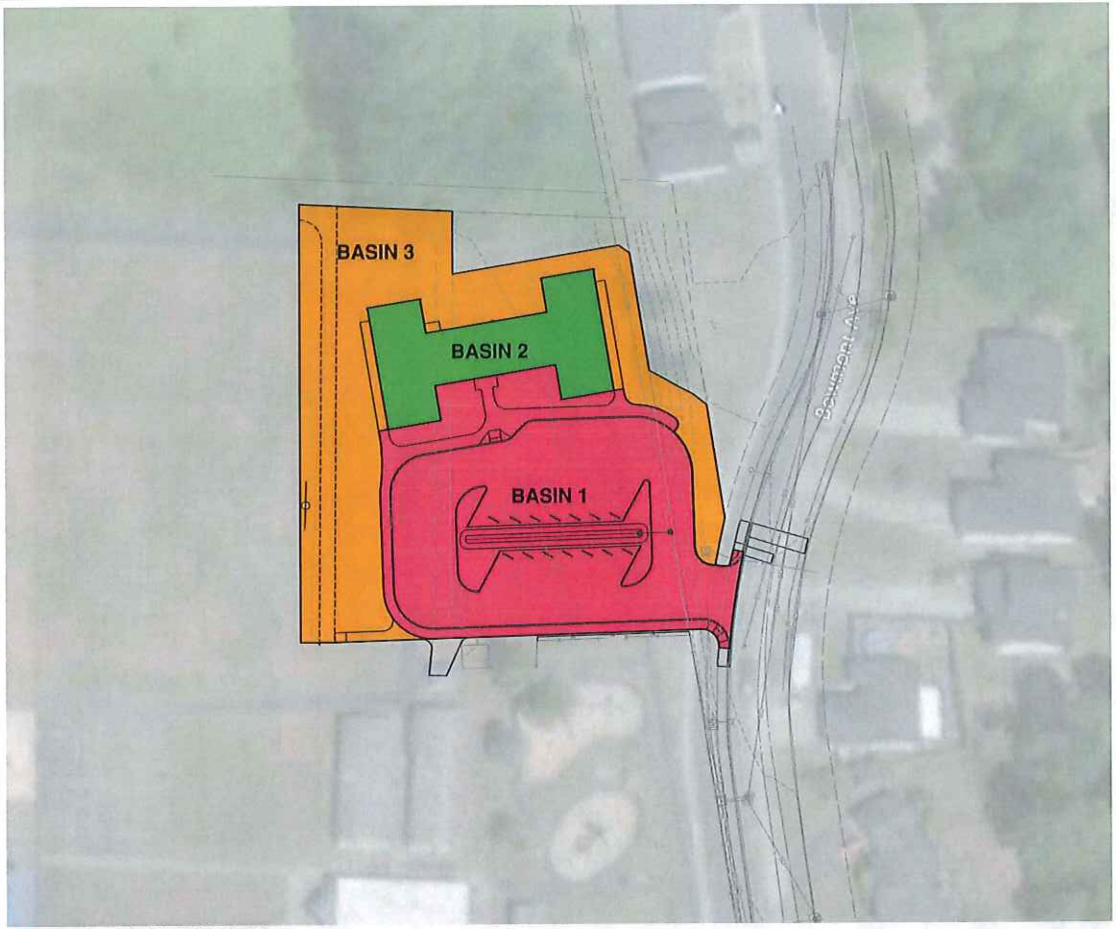
Lower Columbia College
New Head Start Bldg at Barnes School
Pre-Developed Basin Map



DEVELOPED BASIN INFORMATION

TOTAL AREA:	0.98 ACRES
BASIN 1:	0.48 ACRES
ASPHALT:	0.32 ACRES
SIDEWALK:	0.07 ACRES
LANDSCAPING:	0.07 ACRES
BIORETENTION:	0.02 ACRES
BASIN 2:	0.12 ACRES
ROOF:	0.12 ACRES
BASIN 3:	0.38 ACRES
SIDEWALK:	0.03 ACRES
LAWN:	0.29 ACRES
NEW GRAVEL TRACK	0.06 ACRES

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Lower Columbia College
New Head Start Bldg at Barnes School
Developed Basin Map

SHORELINE MAP

National Flood Hazard Layer FIRMette

FEMA

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	🟦	Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth
	▨	Regulatory Floodway Zone AE, AO, AH, VE,
OTHER AREAS OF FLOOD HAZARD	🟧	0.2% Annual Chance Flood Hazard, Are of 1% annual chance flood with averag depth less than one foot or with dralna, areas of less than one square mile Zone
	▨	Future Conditions 1% Annual Chance Flood Hazard Zone X
	▨	Area with Reduced Flood Risk due to Levee. See Notes. Zone X
	▨	Area with Flood Risk due to Levee Zone
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard Zone X
	▭	Effective LOMRs
	🟧	Area of Undetermined Flood Hazard Zo
GENERAL STRUCTURES	– — – –	Channel, Culvert, or Storm Sewer
	IIIIIIIIIII	Levee, Dike, or Floodwall
OTHER FEATURES	(B) 20.2	Cross Sections with 1% Annual Chance
	17.5	Water Surface Elevation
	(8) – – –	Coastal Transect
	~~ 513 ~~~	Base Flood Elevation Line (BFE)
	═	Limit of Study
	—	Jurisdiction Boundary
	--- ---	Coastal Transect Baseline
	- —	Profile Baseline
	—	Hydrographic Feature
MAP PANELS	☐	Digital Data Available
	⊡	No Digital Data Available
	☒	Unmapped

N

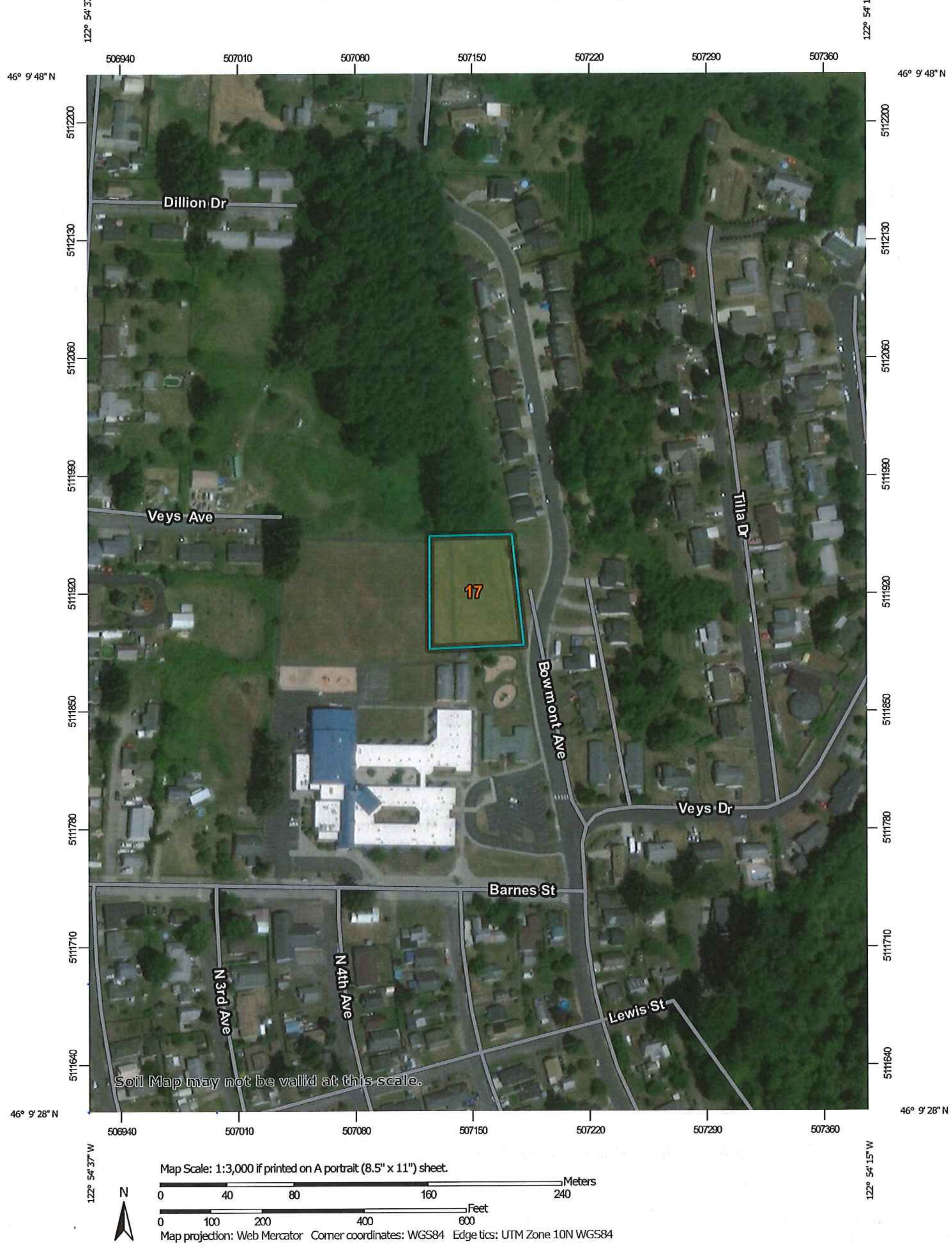
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The base map shown complies with FEMA's base map accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 2/26/2018 at 6:46:27 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: base map imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

AQUIFER RECHARGE MAP

Hydrologic Soil Group—Cowlitz County, Washington



Map Scale: 1:3,000 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Cowlitz County, Washington (WA015)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
17	Caples silty clay loam, 0 to 3 percent slopes	C/D	0.9	100.0%
Totals for Area of Interest			**0.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Appendix B

Flow Charts

Flow Control-Exempt Surface Waters
Flow Chart for Determining Minimum Requirements
Flow Chart for Determining LID MR #5 Requirements

Appendix I-E Flow Control-Exempt Surface Waters

Stormwater discharges, that are otherwise subject to Minimum Requirement #7 – Flow Control, to waters on this list must meet the following restrictions to be exempt from Minimum Requirement #7.

- Direct discharge to the exempt receiving water does not result in the diversion of drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types "S", "F", or "Np" in the Permanent Water Typing System, or from any category I, II, or III wetland; and
- Flow splitting devices or drainage BMP's are applied to route natural runoff volumes from the project site to any downstream Type 5 stream or category IV wetland:
    - Design of flow splitting devices or drainage BMP's will be based on continuous hydrologic modeling analysis. The design will assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50% of the 2-year to the 50-year peak flow.
    - Flow splitting devices or drainage BMP's that deliver flow to category IV wetlands will also be designed using continuous hydrologic modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with permitting jurisdiction; and
- The project site must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water mark of the exempt receiving water; and
- The conveyance system between the project site and the exempt receiving water shall have a hydraulic capacity sufficient to convey discharges from future build-out conditions (under current zoning) of the site, and the existing condition from non-project areas from which runoff is or will be collected; and
- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

Exempt Surface Waters List.

Water Body	Upstream Point/Reach for Exemption (if applicable)
Alder Lake	
Baker Lake	
Baker River	Baker River/Baker Lake downstream of the confluence with Noisy Creek
Bogachiel River	0.4 miles downstream of Dowans Creek
Calawah River	Downstream of confluence with South Fork Calawah River
Capital Lake / Deschutes River	Downstream of Tumwater Falls
Carbon River	Downstream of confluence with South Prairie Creek
Cascade River	Downstream of Found Creek
Cedar River	Downstream of confluence with Taylor Creek
Chehalis River	1,500 feet downstream of confluence with Stowe Creek
Chehalis River, South Fork	1,000 feet upstream of confluence with Lake Creek
Cispus River	Downstream of confluence with Cat Creek
Clearwater River	Downstream of confluence with Christmas Creek
Coal Creek Slough	Boundary of Consolidated Diking and Irrigation District #1 to confluence with the Columbia River.
Columbia River	Downstream of Canadian border
Consolidated Diking and Irrigations District #1	Waters that lie within the area bounded by the Columbia River on the south, the Cowlitz River on the east, Ditch No. 10 to the west, and Ditch No. 6 to the north.
Consolidated Diking and Irrigation District #3	Ditches served by these pump stations: Tam O'Shanter #1 and #2, Coweeman, Baker Way, Elk's
Coweman River	Downstream of confluence with Gobble Creek
Cowlitz River	Downstream of confluence of Ohanapecosh River and Clear Fork Cowlitz River
Crescent Lake	
Dickey River	Downstream of confluence with Coal Creek
Dosewallips River	Downstream of confluence with Rocky Brook
Dungeness River	Downstream of confluence with Gray Wolf River
Duwamish / Green River	Downstream River Mile 6 (S. Boeing Access Road)
Elwha River	Downstream of confluence with Goldie River
Erdahl Ditch in Fife	Downstream of pump station
First Creek in Tacoma	
Grays River	Downstream of confluence with Hull Creek
Green River (WRIA 26 – Cowlitz)	3.5 miles upstream of Devils Creek
Hoh River	1.2 miles downstream of Jackson Creek
Humptulips River	Downstream of confluence with West and East Forks
Johns Creek	Downstream of Interstate-405 East Right-of-way
Kalama River	2.0 miles downstream of Jacks Creek
Lacamas Lake	
Lake Cushman	
Lake Quinault	
Lake River (Clark County)	
Lake Shannon	
Lake Sammamish	
Lake Union & Union Bay	King County
Lake Washington, Montlake Cut, Ship Canal, & Salmon Bay	

Water Body	**Upstream Point/Reach for Exemption** (if applicable)
Lake Whatcom	
Lewis River	Downstream of confluence with Quartz Creek
Lewis River, East Fork	Downstream of confluence with Big Tree Creek
Lightning Creek	Downstream of confluence with Three Fools Creek
Little White Salmon River	Downstream of confluence with Lava Creek
Mayfield Lake	
Mercer Slough	
Muddy River	Downstream of confluence with Clear Creek
Naselle River	Downstream of confluence with Johnson Creek
Newaukum River	Downstream of confluence with South Fork Newaukum River
Nisqually River	Downstream of confluence with Big Creek
Nooksack River	Downstream of confluence of North Fork and Middle Forks
Nooksack River, North Fork	Downstream of confluence with Glacier Creek, at USGS gauge 12205000
Nooksack River, South Fork	0.1 miles upstream of confluence with Skookum Creek
North River	Downstream of confluence with Vesta Creek
Ohanapecosh River	Downstream of confluence with Summit Creek
Puyallup River	Half-mile downstream of confluence with Kellog Creek
Queets River	Downstream of confluence with Tshletshy Creek
Quillayute River	Downstream of Bogachiel River
Quinault River	Downstream of confluence with North Fork Quinault River
Riffe Lake	
Round Lake	
Ruby Creek	Ruby Creek at SR-20 crossing downstream of Granite and Canyon Creeks
Sammamish River	Downstream of Lake Sammamish
Satsop River	Downstream of confluence of Middle and East Forks
Satsop River, East Fork	Downstream of confluence with Decker Creek
Sauk River	Downstream of confluence of South Fork and North Fork
Sauk River, North Fork	North Fork Sauk River at Bedal Campground
Silver Lake	Cowlitz County
Skagit River	Downstream of Canadian border
Skokomish River	Downstream of confluence of North and South Fork
Skokomish River, South Fork	Downstream of confluence with Vance Creek
Skokomish River, North Fork	Downstream of confluence with McTaggert Creek
Skookumchuck River	1 mile upstream of Bucoda at SR 507 mile post 11.0
Skykomish River	Downstream of South Fork
Skykomish River, South Fork	Downstream of confluence of Tye and Foss Rivers
Snohomish River	Down stream of confluence of Snoqualmie and Skykomish Rivers
Snohomish River Estuary	
Snoqualmie River	Downstream of confluence of the Middle Fork
Snoqualmie River, Middle Fork	Downstream of confluence with Rainy Creek
Sol Duc River	Downstream of confluence of North and South Fork Soleduck River
Stillaguamish River	Downstream of confluence of North and South Fork
Stillaguamish River, North Fork	7.7 highway miles west of Darrington on SR530, downstream of confluence with French Creek.
Stillaguamish River, South Fork	Downstream of confluence of Cranberry Creek and South Fork
Suiattle River	Downstream of confluence with Milk Creek
Sultan River	0.4 miles upstream of SR2
Swift Creek Reservoir	
Thunder Creek	Downstream of the confluence with Neve Creek

Water Body	**Upstream Point/Reach for Exemption** (if applicable)
Tilton River	Downstream of confluence with North Fork Tilton River
Toutle River	North and South Fork Confluence
Toutle River, North Fork	Downstream of confluence with Hoffstadt Creek
Toutle River, South Fork	Downstream of confluence with Thirteen Creek
Union Bay	
Vancouver Lake	
White River	Downstream of confluence with Huckleberry Creek
Willapa River	Downstream of confluence with Mill Creek
Wind River	Downstream of confluence with Cold Creek
Wynochee Lake	
Wynoochee River	Downstream of confluence with Schafer Creek

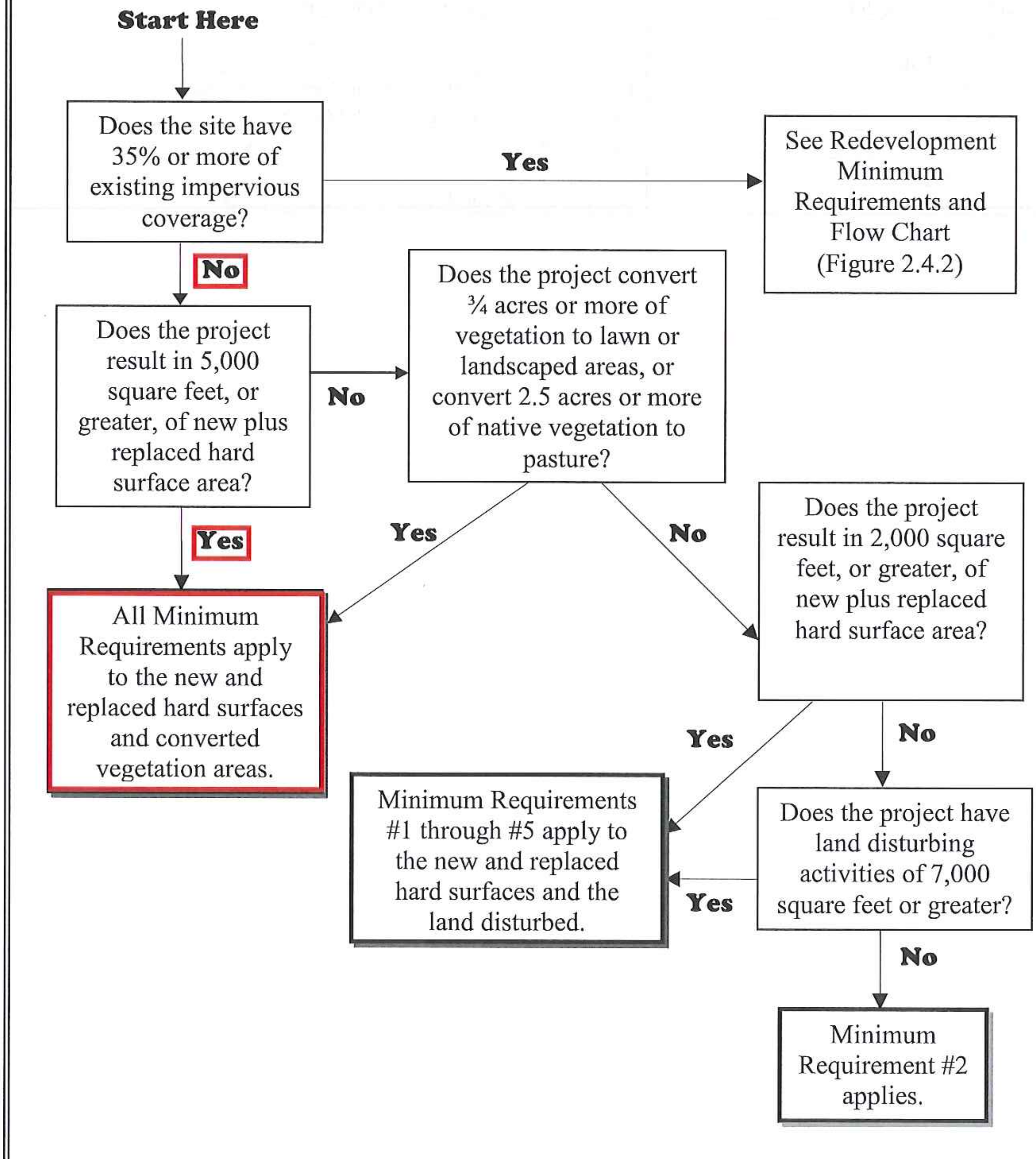
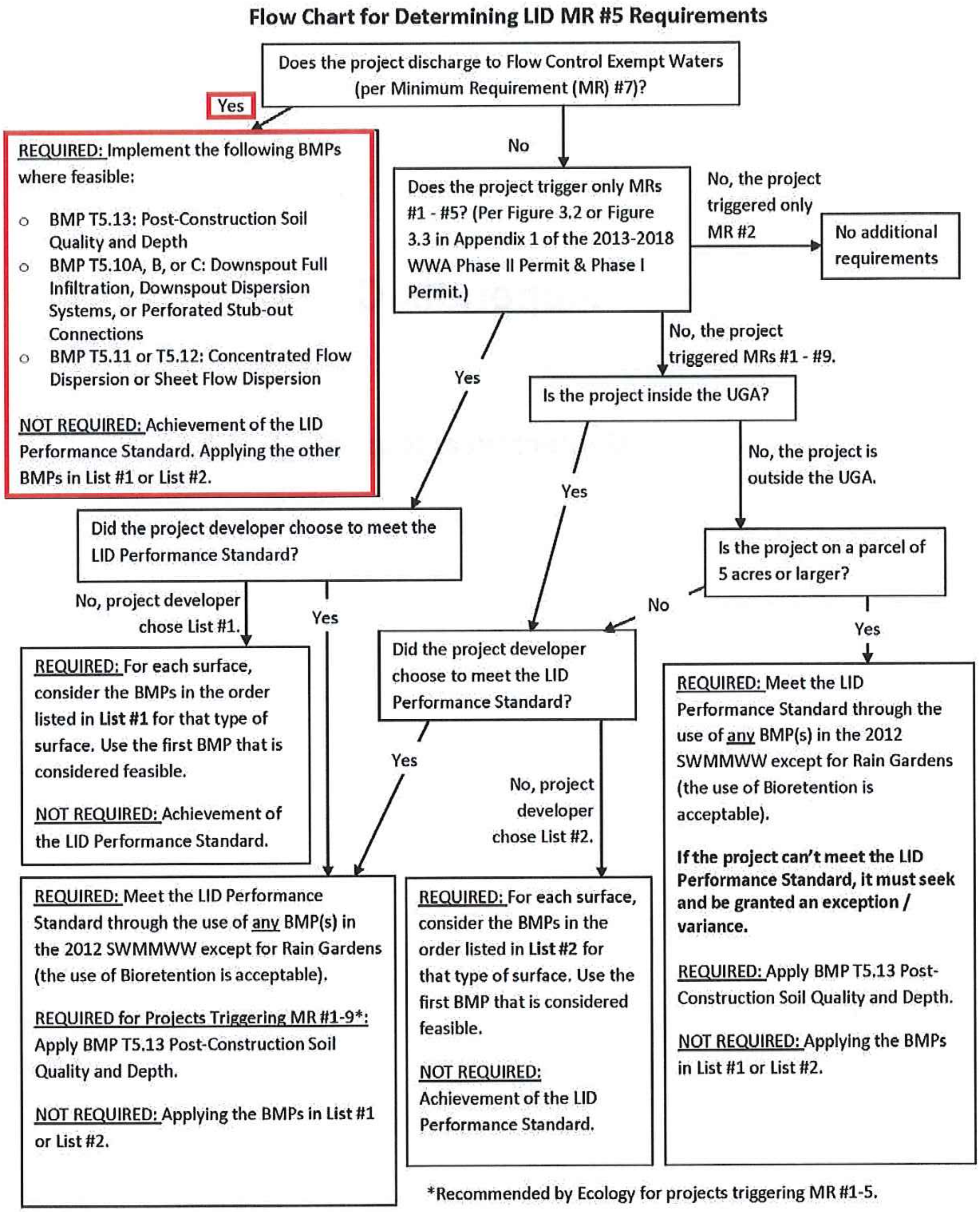


Figure 2.4.1 – Flow Chart for Determining Requirements for New Development



*Recommended by Ecology for projects triggering MR #1-5.

Figure 2.5.1 – Flow Chart for Determining LID MR #5 Requirements

Appendix C

Geotechnical Report

Geotechnical Engineering Report

Barnes Elementary School Modular
401 Barnes Street
Kelso, Washington 98626

Prepared for:

Department of Enterprise Services
c/o Richard Hamilton
Lower Columbia College
1600 Maple Street
Longview, Washington 98632

December 20, 2017
PBS Project No. 73200.003

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December 20, 2017
PBS Project No. 73200.003

Prepared by:

Cory Van Fosson, EIT
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Reviewed by:

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12/20/2017

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1 INTRODUCTION

1.1 General

This report presents results of PBS Engineering and Environmental Inc. (PBS) geotechnical engineering services for the proposed new Barnes Elementary School Modular located at 401 Barnes Street in Kelso, Washington (site). The general site location is shown on the Vicinity Map, Figure 1. The locations of PBS' explorations in relation to existing and proposed site features are shown on the Site Plan, Figure 2.

1.2 Purpose and Scope

The purpose of PBS' services was to develop geotechnical design and construction recommendations in support of the planned site development. This was accomplished by performing the following scope of services.

1.2.1 Literature and Records Review

PBS reviewed various published geologic maps of the area for information regarding geologic conditions and hazards at or near the site.

1.2.2 Subsurface Explorations

Five borings were advanced to depths ranging from approximately 11.5 to 31.5 feet below the existing ground surface (bgs) within the development footprint. The test pits were logged and representative soil samples collected by a member of the PBS geotechnical engineering staff. The approximate boring locations are shown on the Site Plan, Figure 2. The interpreted boring logs are presented as Figures A1 through A5 in Appendix A, Field Explorations.

1.2.3 Field Infiltration Testing

One cased-hole, falling-head field infiltration test was completed in boring B-1 at a depth of 4 feet bgs. Infiltration testing was observed by PBS geotechnical engineering staff.

1.2.4 Soils Testing

Soil samples were returned to our laboratory and classified in general accordance with the Unified Soil Classification System, Visual-Manual Procedure. Laboratory tests included natural moisture contents, grain-size analyses, and Atterberg limits. Laboratory test results are included in the boring logs in Appendix A, Field Explorations; and in Appendix B, Laboratory Testing.

1.2.5 Geotechnical Engineering Analysis

Data collected during the subsurface exploration, literature research, and testing were used to develop site-specific geotechnical design parameters and construction recommendations.

1.2.6 Report Preparation

This Geotechnical Engineering Report summarizes the results of our explorations, testing, and analyses, including information relating to the following:

- Field exploration logs and site plan showing approximate exploration locations
- Laboratory test results
- Infiltration test results
- Groundwater levels and considerations

- Shallow foundation recommendations:
  - Allowable bearing pressure
  - Minimum embedment
  - Estimated settlement
  - Sliding coefficient
- Earthwork and grading, cut, and fill recommendations:
  - Structural fill materials and preparation
  - Wet weather considerations
  - Utility trench excavation and backfill requirements
  - Suitability of existing on-site fill, if observed
- Seismic design criteria in accordance with the 2015 International Building Code (IBC) with Washington amendments
- Slab-on-grade and pavement subgrade preparation recommendations
- Suggested pavement thickness sections

1.3 Project Understanding

Based on the site plan provided by Collins Architectural Group (Collins), the proposed development includes construction of a modular building, new parking lot, and drive lanes north of the existing Barnes Elementary School.

Based on our conversations with Collins, the proposed development could include fills of approximately 3 feet in the building and parking lot area. Based on existing modular structures on the school campus, we anticipate the proposed structure will be one-story wood-framed with slab-on-grade floors. We estimate column loads of less than 25 kips, wall loads of less than 2 kips per linear foot, and slab loads of up to 150 pounds per square foot (psf). We understand the proposed building is not considered an essential facility (Risk Category IV) with regard to seismic design code.

The proposed development will be constructed in an existing sports field northeast of the Barnes Elementary campus, which is generally covered by grass lawn.

2 SITE CONDITIONS

2.1 Surface Description

The Barnes Elementary School is located on a flat river terrace within the north-south trending Cowlitz River valley, between the Cowlitz River and Interstate 5, in the town of Kelso, Washington. The school is embedded within medium density residential parcels sparsely populated with large trees at an elevation of 20 feet above mean sea level (amsl), approximately 6 feet higher than the Cowlitz River. To the east, the river terrace gives rise to the toe of Mount Brynion, the local topographic high point at a summit elevation of 1352 feet amsl, and to the west, Columbia and Longview Heights.

2.2 Geologic Setting

Geologic map review (Livingston, 1966) indicates the site is located on Quaternary alluvium consisting of sand, gravel, silt, and peat deposits associated with the Cowlitz River (see Figure 3). Higher elevation Pleistocene river terraces are found along the periphery of the Cowlitz River valley before giving rise on either side of the valley to Cowlitz Formation sedimentary and volcanic rocks and Troutdale formation sedimentary rocks. The Columbia and Longview hills are composed of western sedimentary and volcanic rocks deformed by the southeast plunging Columbia Heights Anticline. The eastern portion of the Cowlitz River valley is structurally bounded by the inactive north-south trending Kelso fault.

2.3 Subsurface Conditions

The site was explored by advancing five borings, designated B-1 through B-5, to depths of up to 31.5 feet bgs. Drilling was conducted by Western States Soil Conservation, Inc., using mud-rotary and hollow-stem auger drilling techniques.

PBS has summarized the subsurface units as follows:

SURFACE MATERIALS (TOPSOIL):	The site is a grass athletic field underlain by low to medium plasticity brown silt, containing grass rootlets to approximately 12 inches bgs.
SILT and CLAY:	Beneath the topsoil, silt and clay extends to a depth of approximately 3 to 5 feet bgs. The silt and clay are low to medium plasticity and soft, with SPT N-values of less than 3.
SILT and SAND:	Very loose to loose dark gray silt and sand underlies the silt and clay. These materials have no to low plasticity, SPT N-values of 0 to 2, and extend to a depth of approximately 20 feet bgs where they become increasingly stiff.
SAND and GRAVEL:	Loose to medium dense sand and gravel, with SPT N-values of 5 to 15, was encountered at a depth of approximately 20 feet bgs in B-5.

2.4 Groundwater

Groundwater was not measured during our explorations. However, the moisture content of collected samples suggests groundwater was present at about 5 feet bgs at the time of our drilling. Please note that groundwater levels can fluctuate during the year depending on climate, irrigation season, extended periods of precipitation, drought, melting snow/ice, and other factors. We recommend that the contractor determine the actual groundwater levels at the time of construction to determine the potential for groundwater to impact construction.

2.5 Infiltration Testing

Field infiltration testing was completed in boring B-1 within the 6.25-inch inside diameter hollow-stem auger used to drill the boring. The auger was filled with water to achieve a minimum 1-foot-high column of water. After the saturation period, the height of the water column in the pipe was then measured initially and at regular, timed intervals. Results of our field infiltration testing are presented in Table 1.

Table 1. Infiltration Test Results

Test Location	Depth (feet bgs)	Field Measured Infiltration Rate (in/hr)	Soil Classification
B-1	4	0.3	Poorly graded SAND (SP-SM) with silt

The infiltration rate listed in Table 1 is not a permeability/hydraulic conductivity, but a field-measured rate, and does not include correction factors related to long-term infiltration rates. The design engineer should determine the appropriate correction factors to account for the planned level of pre-treatment, maintenance, vegetation, siltation, etc. Field-measured infiltration rates are typically reduced by a minimum factor of 2 to 4 for use in design.

Soil types can vary significantly over relatively short distances. The infiltration rates noted above are representative of one discrete location and depth. Installation of infiltration systems within the layer in which the field rate was measured is considered critical to proper performance of the systems.

3 CONCLUSIONS AND RECOMMENDATIONS

3.1 Geotechnical Design Considerations

The project site is underlain by 3 to 5 feet of silt and clay, which is underlain by loose sand and sandy silt with gravel. Due to the presence of loose, saturated sand and non-plastic silt, the site is susceptible to liquefaction during a code-based earthquake. However, based on our observations and analyses, conventional foundation support on shallow spread footings is feasible, with some consideration of risk, provided spread footings are tied together with grade beams.

PBS understands this site will be raised 3 feet at the building location a minimum of two months prior to beginning construction for building foundations. Prior to placing fill, we recommend removing the upper 12 inches of topsoil and compacting the exposed subgrade using a large, smooth-drum non-vibratory roller. Following preparation of the subgrade imported structural fill (crushed rock) should be placed in lifts and compacted.

Excavation with conventional equipment is feasible at the site. Fine-grained soils, such as the silt encountered in upper 4 feet of our explorations, can be easily disturbed, particularly when wet; we recommend earthwork be completed during the drier summer months.

3.2 Shallow Foundations

3.2.1 Minimum Footing Widths / Design Bearing Pressure

Continuous wall and spread footings should be at least 18 and 24 inches wide, respectively. Independent footings are not allowed and should be connected to adjacent footings with grade beams. Footings should be sized using a maximum allowable bearing pressure of 2,000 pounds per square foot (psf). This bearing pressure is based on our understanding that at least 2 feet of crushed rock fill will be present beneath the footings. The recommended allowable bearing pressure applies to the total of dead plus long-term live loads. Allowable bearing pressures may be increased by one-third for seismic and wind loads.

Footings will settle in response to column and wall loads. Based on our evaluation of the subsurface conditions and our analysis, we estimate post-construction static settlement will be less than 1 inch for the column and perimeter foundation loads. Differential settlement will be on the order of one-half of the total settlement. Seismic settlement will be more than 12 inches.

3.2.2 Footing Embedment Depths

PBS recommends that all footings be founded a minimum of 18 inches below the lowest adjacent grade. The footings should be founded below an imaginary line projecting upward at a 1H:1V (horizontal to vertical) slope from the base of any adjacent, parallel utility trenches or deeper excavations.

3.2.3 Footing Preparation

Shallow spread footings bearing on a minimum of 2 feet of crushed rock structural fill may be used to support loads associated with the proposed construction provided the recommendations in this report are followed. Footings should be supported on properly compacted structural fill only.

Excavations for footings should be carefully prepared to a dense and unyielding state with compacted base rock (structural fill). A representative from PBS should confirm suitable bearing conditions and evaluate all exposed footing subgrades. Observations should also confirm that loose or soft materials have been removed from new footing excavations and concrete slab-on-grade areas. In the event that loose, wet, or deleterious materials are encountered, PBS may require additional over excavation and backfilling with compacted base rock.

3.2.4 Lateral Resistance

Lateral loads can be resisted by passive earth pressure on the sides of footings and grade beams and by friction at the base of the footings. A passive earth pressure of 150 pounds per cubic foot (pcf) may be used for footings confined by native soils and new structural fills. The allowable passive pressure has been reduced by half to account for the large amount of deformation required to mobilize full passive resistance. Adjacent floor slabs, pavements, or the upper 12-inch depth of adjacent unpaved areas should not be considered when calculating passive resistance. For footings in contact with native granular soils, use a coefficient of friction equal to 0.35 when calculating resistance to sliding. These values do not include a factor of safety.

3.2.5 Grade Beams

Grade beams are not intended to vertically support column footings, but to help hold the facility structure together during a design-level earthquake. Grade beams between footings should be designed in accordance with the requirements of section 1810.3.12 of the 2015 IBC.

3.3 Seismic Design Considerations

3.3.1 Code-Based Seismic Design Parameters

The current seismic design criteria for this project are based on the 2015 IBC. Due to the potential for liquefaction of site soils, the site should be considered Site Class F. However, in accordance with ASCE 7-10, for structures having a fundamental period of less than 0.5 seconds, a site-response analysis is not required to determine the spectral accelerations of liquefied soils and seismic design parameters can be determined using the pre-liquefaction site class, Site Class E. The seismic design criteria, in accordance with the 2015 IBC, are summarized in Table 2.

Table 2. 2015 IBC Seismic Design Parameters

Parameter	Short Period	1 Second
Maximum Credible Earthquake Spectral Acceleration	S_s = 0.95 g	S_1 = 0.44 g
Site Class	E*	
Site Coefficient	F_a = 0.97	F_v = 2.40
Adjusted Spectral Acceleration	S_{MS} = 0.91 g	S_{M1} = 1.05 g
Design Spectral Response Acceleration Parameters	S_{DS} = 0.61 g	S_{D1} = 0.70 g
Design Spectral Peak Ground Acceleration	**0.24 g**	

g= Acceleration due to gravity
* Site Class E can be used if the fundamental period of the new structure is less than 0.5 seconds

3.3.2 Liquefaction Potential

Liquefaction is defined as a decrease in the shear resistance of loose, saturated, cohesionless soil (e.g., sand) or low plasticity silt soils, due to the buildup of excess pore pressures generated during an earthquake. This results in a temporary transformation of the soil deposit into a viscous fluid. Liquefaction can result in ground settlement, foundation bearing capacity failure, and lateral spreading of ground.

Based on review of the liquefaction susceptibility map for Cowlitz County (Palmer et al., 2004; see Figure 4), the site is shown as having a high liquefaction hazard. Based on the soil types and relative density of site soils encountered in our explorations, our current opinion is that the risk of structurally damaging liquefaction settlement at the site is high. Based on the results of our analyses, we expect over 12 inches of liquefaction settlement may occur following a code-based earthquake.

3.4 Ground Moisture Considerations

3.4.1 General

The perimeter ground surface and hard-scaping should be sloped to drain away from all structures and away from adjacent slopes. Gutters should be tight-lined to a suitable discharge and maintained as free-flowing. All crawl spaces should be adequately ventilated and sloped to drain to a suitable, exterior discharge.

3.4.2 Perimeter Footing Drains

Due to the relatively low permeability of near-surface soils and the potential for perched groundwater at the site, we recommend perimeter foundation drains be installed around all proposed structures, unless the entire building envelope is raised 3 feet above the existing ground surface. In this case the foundation drain is not necessary.

If needed, the foundation subdrainage system should include a minimum 4-inch-diameter perforated pipe in a drain rock envelope. A non-woven geotextile filter fabric, such as Mirafi 140N or equivalent, should be used to completely wrap the drain rock envelope, separating it from the native soil and footing backfill materials. The invert of the perimeter drain lines should be placed approximately at the bottom of footing elevation. Also, the subdrainage system should be sealed at the ground surface. The perforated subdrainage pipe should be laid to drain by gravity into a non-perforated solid pipe and finally connected to the site drainage system at a suitable location. Water from downspouts and surface water should be independently collected and routed to a storm sewer or other positive outlet. This water must not be allowed to enter the bearing soils.

3.5 Pavement Design

The provided pavement section thicknesses were developed based on our experience with similar types of projects and construction. The minimum recommended pavement sections are provided in Table 3. These are the minimum acceptable pavement section thicknesses. Depending on weather conditions at the time of construction, a thicker aggregate base course section could be required to support construction traffic during preparation and placement of the pavement section.

Table 3. Minimum AC Pavement Sections

Traffic Loading	AC (inches)	Base Course (inches)	Subgrade*
Pull-in Car Parking	3	12	Firm subgrade as verified by PBS personnel
Access Roads	4	12	Firm subgrade as verified by PBS personnel

* Subgrade must pass proofroll

The asphalt binder should be performance graded according to WSDOT SS 9-02.1(4) – Performance Graded Asphalt Binder. The AC should consist of ½-inch hot mix asphalt (HMA) with a maximum lift thickness of 3.0 inches. The AC should conform to WSDOT SS 5-04.3(7)A – Mix Design, WSDOT SS 9-03.8(2) – HMA Test Requirements, and WSDOT SS 9-03.8(6) – HMA Proportions of Materials. The AC should be compacted to 91 percent of the maximum theoretical density (Rice value) of the mix, as determined in accordance with ASTM D 2041, following the guidelines set in WSDOT SS 5-04.3(10) – Compaction.

Heavy construction traffic on new pavements or partial pavement sections (such as base course over the prepared subgrade) will likely exceed the design loads and could potentially damage or shorten the pavement life; therefore, we recommend construction traffic not be allowed on new pavements, or that the contractor take appropriate precautions to protect the subgrade and pavement during construction.

If construction traffic is to be allowed on newly constructed road sections, an allowance for this additional traffic will need to be made in the design pavement section. If construction occurs during wet conditions, thicker aggregate base sections may be required.

4 CONSTRUCTION RECOMMENDATIONS

4.1 Site Preparation

Construction of the proposed development will require removal of topsoil (upper 12-inches) and clearing and grubbing of the existing vegetation (deeper than 12-inches in some localized areas).

As discussed in previous sections of this report, all organic material beneath the proposed buildings and its perimeter should be removed (approximately the top 12 inches), backfilled with structural fill.

4.1.1 Proofrolling/Subgrade Verification

Following site preparation and prior to placing aggregate base for the access drives (pavement sections), shallow foundations, building pads, and slab subgrade sections, the recompacted subgrade should be evaluated either by proofrolling or another method of subgrade verification. The subgrade should be proofrolled with a fully loaded dump truck or similar heavy, rubber-tire construction equipment to identify unsuitable areas. If evaluation of the subgrades occurs during wet conditions, or if proofrolling the subgrades will result in disturbance, they should be evaluated by PBS using a steel foundation probe. We recommend that PBS be retained to observe the proofrolling and perform the subgrade verifications. Unsuitable areas identified during the field evaluation should be compacted to a firm condition or be excavated and replaced with structural fill.

4.1.2 Wet/Freezing Weather and Wet Soil Conditions

Due to the presence of fine-grained silt in the near-surface materials at the site, construction equipment may have difficulty operating on the near-surface soils when the moisture content of the surface soil is more than a few percentage points above the optimum moisture required for compaction. Soils disturbed during site preparation activities, or unsuitable areas identified during proofrolling or probing, should be removed and replaced with compacted structural fill.

Site earthwork and subgrade preparation should not be completed during freezing conditions, except for mass excavation to the subgrade design elevations.

Protection of the subgrade is the responsibility of the contractor. Track-mounted excavating equipment may be required during wet weather. The thickness of the haul roads to access the site for excavation and staging areas will depend on the amount and type of construction traffic. The material used for haul roads or site access drives should be stabilization material described below. A 12- to 18-inch-thick mat of stabilization material should be sufficient for light staging areas. The stabilization material for haul roads and areas with repeated heavy construction traffic typically needs to be increased to between 18 to 24 inches. The actual thickness of haul roads and staging areas should be based on the contractor's approach to site work and the amount and type of construction traffic, and is the contractor's responsibility. The stabilization material should be placed in one lift over the prepared, undisturbed subgrade and compacted using a smooth-drum, non-vibratory roller. Additionally, a geotextile fabric should be placed as a barrier between the subgrade and stabilization material. The geotextile should meet specifications and be installed in conformance with WSDOT SS Section 2-12.3.

4.2 Excavation

The near-surface soils at the site can be excavated with conventional earthwork equipment. All excavations should be made in accordance with applicable Occupational Safety and Health Administration (OSHA) and state regulations. The contractor is solely responsible for adherence to the OSHA requirements. Trench cuts should stand relatively vertical to a depth of approximately 4 feet bgs, provided no groundwater seepage is present in the trench walls. Open excavation techniques may be used provided the excavation is configured in accordance with the OSHA requirements, groundwater seepage is not present, and with the understanding that some sloughing may occur. Trenches/excavations should be flattened if sloughing occurs or seepage is present. Use of a trench shield or other approved temporary shoring is recommended if vertical walls are desired for cuts deeper than 4 feet bgs.

4.3 Structural Fill

The extent of site grading is currently unknown; however, PBS estimates that cuts will be 12 inches or more to remove the existing topsoil and fills will be on the order of up to 3 feet within the proposed development beneath the modular building. Structural fill should be placed over subgrade that has been prepared in conformance with the Site Preparation and Wet/Freezing Weather and Wet Soil Conditions sections of this report. Structural fill material should consist of relatively well-graded soil, or an approved rock product that is free of organic material and debris, and contains particles not greater than 3 inches nominal dimension.

The suitability of soil for use as compacted structural fill will depend on the gradation and moisture content of the soil when it is placed. As the amount of fines (material finer than the US Standard No. 200 Sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and compaction becomes more difficult to achieve. Soils containing more than about 5 percent fines cannot consistently be compacted to a dense, non-yielding condition when the water content is significantly greater (or significantly less) than optimum.

If fill and excavated material will be placed on slopes steeper than 5H:1V, these must be keyed/benched into the existing slopes and installed in horizontal lifts. Vertical steps between benches should be approximately 2 feet.

4.3.1 On-Site Soil

The on-site soils encountered in our explorations are generally suitable for placement as structural fill during dry weather when moisture content can be maintained by air drying and/or addition of water. The fine-grained fraction of the site soils are moisture sensitive, and during wet weather, may become unworkable because of excess moisture content. In order to reduce moisture content, some aerating and drying of fine-grained soils may be required. The material should be placed in lifts with a maximum uncompacted thickness of approximately 8 inches and compacted to at least 92 percent of the maximum dry density, as determined by ASTM D1557 (modified proctor). We do not suggest using the onsite silt as structural fill.

4.3.2 Borrow Material

Selected granular backfill used during periods of wet weather for structural fill construction should meet the specifications provided in WSDOT SS 9-03.14(2) – Select Borrow. The imported granular material should be uniformly moisture conditioned to within about 2 percent of the optimum moisture content and compacted in relatively thin lifts using suitable mechanical compaction equipment. Selected granular backfill should be placed in lifts with a maximum uncompacted thickness of 8 to 12 inches and be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D 1557.

4.3.3 Select Granular Fill

Imported granular material used during periods of wet weather or for haul roads, building pad subgrades, staging areas, etc., should be pit or quarry run rock, crushed rock, or crushed gravel and sand, and should meet the specifications provided in WSDOT SS 9-03.14(2) – Select Borrow. In addition, the imported granular material should be fairly well graded between coarse and fine, and of the fraction passing the US Standard No. 4 Sieve, less than 5 percent by dry weight should pass the US Standard No. 200 Sieve.

Imported granular material should be placed in lifts with a maximum uncompacted thickness of 9 inches, and be compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

During wet conditions, where imported granular material is placed over potentially soft-soil subgrades, we recommend a geotextile be placed between the subgrade and imported granular material. Depending on site conditions, the geotextile should meet WSDOT SS 9-33.2 – Geosynthetic Properties for soil separation or stabilization. The geotextile should be installed in conformance with WSDOT SS 2-12.3 – Construction Geosynthetic (Construction Requirements) and, as applicable, WSDOT SS 2-12.3(2) – Separation or WSDOT SS 2-12.3(3) – Stabilization.

4.3.4 Crushed Aggregate Base

Crushed aggregate base course below floor slabs, spread footings, and asphalt concrete pavements should be clean, crushed rock or crushed gravel that contains no deleterious materials and meets the specifications provided in WSDOT SS 9-03.9(3) – Crushed Surfacing, and have less than 7.5 percent by dry weight passing the US Standard No. 200 Sieve. The crushed aggregate base course should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D 1557.

4.3.5 Utility Trench Backfill

Due to the difficulty in moisture conditioning and compacting silt or soils containing silt, we recommend on-site silt only be used as trench backfill in non-structural areas such as landscaping and sports fields. Use of silt as trench backfill may result in settlement in the trench over time and may require on-going maintenance to provide flat sports fields.

Trench backfill in structural areas should be composed of suitable granular soils such as sand, gravel, and crushed rock. Pipe bedding placed to uniformly support and surround the barrel of pipe should meet specifications provided in WSDOT SS 9-03.12(3) – Gravel Fill for Pipe Zone Bedding. The pipe zone extends at least 6 inches above and below utility lines. The pipe zone backfill material should be compacted to at least 90 percent of the maximum dry density, as determined by ASTM D1557, or as required by the pipe manufacturer.

The remainder of the trench backfill should consist of well-graded granular material with less than 10 percent by dry weight passing the US Standard No. 200 Sieve, and should meet standards prescribed by WSDOT SS 9-03.19 – Bank Run Material for Trench Backfill. This material should be compacted to at least 92 percent of the maximum dry density, as determined by ASTM D 1557, or as required by the pipe manufacturer. The upper 2 feet of the trench backfill should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D1557. Controlled low-strength material (CLSM), WSDOT SS 2-09.3(1)E – Backfilling, can be used as an alternative.

5 ADDITIONAL SERVICES AND CONSTRUCTION OBSERVATIONS

In most cases, other services beyond completion of a final geotechnical engineering report are necessary or desirable to complete the project. Occasionally, conditions or circumstances arise that require additional work that was not anticipated when the geotechnical report was written. PBS offers a range of environmental, geological, geotechnical, and construction services to suit the varying needs of our clients.

PBS should be retained to review the plans and specifications for this project before they are finalized. Such a review allows us to verify that our recommendations and concerns have been adequately addressed in the design.

Satisfactory earthwork performance depends on the quality of construction. Sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings and specifications. We recommend that PBS be retained to observe general excavation, stripping, fill placement, footing subgrades, and/or pile installation. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions requires experience; therefore, qualified personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated.

6 LIMITATIONS

This report has been prepared for the exclusive use of the addressee, and their architects and engineers, for aiding in the design and construction of the proposed development and is not to be relied upon by other parties. It is not to be photographed, photocopied, or similarly reproduced, in total or in part, without express written consent of the client and PBS. It is the addressee's responsibility to provide this report to the appropriate design professionals, building officials, and contractors to ensure correct implementation of the recommendations.

The opinions, comments, and conclusions presented in this report are based upon information derived from our literature review, field explorations, laboratory testing, and engineering analyses. It is possible that soil, rock, or groundwater conditions could vary between or beyond the points explored. If soil, rock, or groundwater conditions are encountered during construction that differ from those described herein, the client is responsible for ensuring that PBS is notified immediately so that we may reevaluate the recommendations of this report.

Unanticipated fill, soil and rock conditions, and seasonal soil moisture and groundwater variations are commonly encountered and cannot be fully determined by merely taking soil samples or completing explorations such as soil borings or test pits. Such variations may result in changes to our recommendations and may require additional funds for expenses to attain a properly constructed project; therefore, we recommend a contingency fund to accommodate such potential extra costs.

The scope of work for this subsurface exploration and geotechnical report did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous substances in the soil, surface water, or groundwater at this site.

If there is a substantial lapse of time between the submission of this report and the start of work at the site, if conditions have changed due to natural causes or construction operations at or adjacent to the site, or if the basic project scheme is significantly modified from that assumed, this report should be reviewed to determine the applicability of the conclusions and recommendations presented herein. Land use, site conditions (both on and off site), or other factors may change over time and could materially affect our findings; therefore, this report should not be relied upon after three years from its issue, or in the event that the site conditions change.

7 REFERENCES

WSDOT SS (2018). Standard Specifications for Road, Bridge, and Municipal Construction, M 41-10 Olympia, WA: Washington State Department of Transportation.

International Building Code (IBC). (2015). International Building Code. Country Club Hills, IL: International Code Council, Inc. Washington State Amendments to the International Building Code 2009 Edition, Effective July 1, 2010.

Livingston, V. E. (1966). [Map] Geology and mineral resources of the Kelso-Cathlamet area, Cowlitz and Wahkiakim Counties, Washington. Washington Division of Mines and Geology, Bulletin 54, scale 1:24,000.

Palmer, S. P., Magsino, S. L., Bilderback, E. L., Poelstra, J. L., Folger, D. S., and Niggemann, R. A. (2004). [Map] Liquefaction Susceptibility Map of Cowlitz County, Washington. Washington Division of Geology and Earth Resources, Open File Report 2004-20, scale 1:100,000.

FIGURES

VICINITY MAP

BARNES ELEMENTARY
SCHOOL MODULAR
401 BARNES ST
KELSO, WASHINGTON

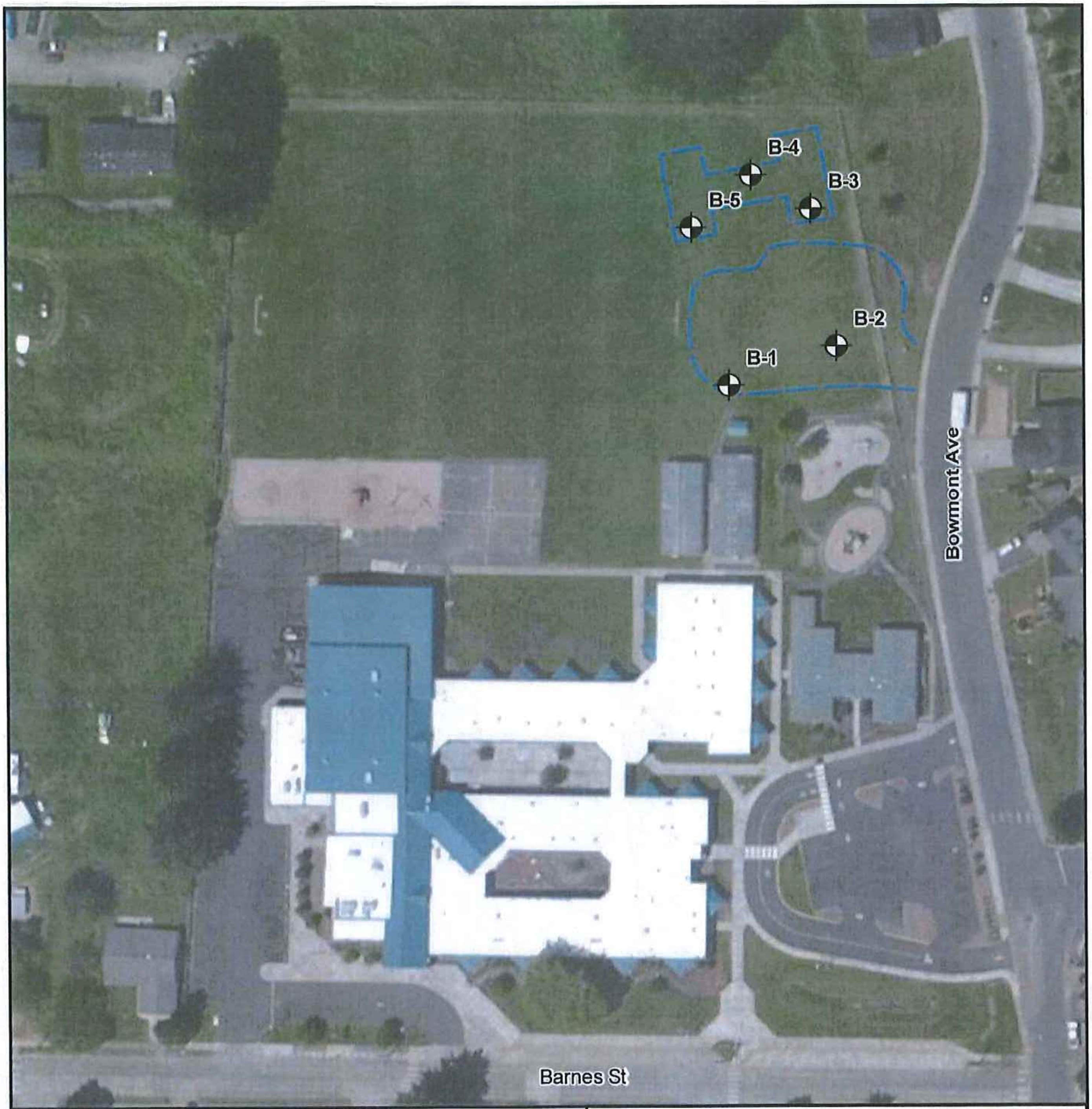
DATE: DEC 2017 · PROJECT: 0073200.003

PBS

FIGURE

1

L:\Projects\73000\73200-73299\73200_WA STATE 2015-810C\73200.003\gis\fig_01.mxd



EXPLANATION

⊕	B-1 - Approximate boring location
– – –	Approximate proposed building location

SITE PLAN

BARNES ELEMENTARY
SCHOOL MODULAR
KELSO, WASHINGTON

DATE: DEC 2017 · PROJECT: 0073200.003

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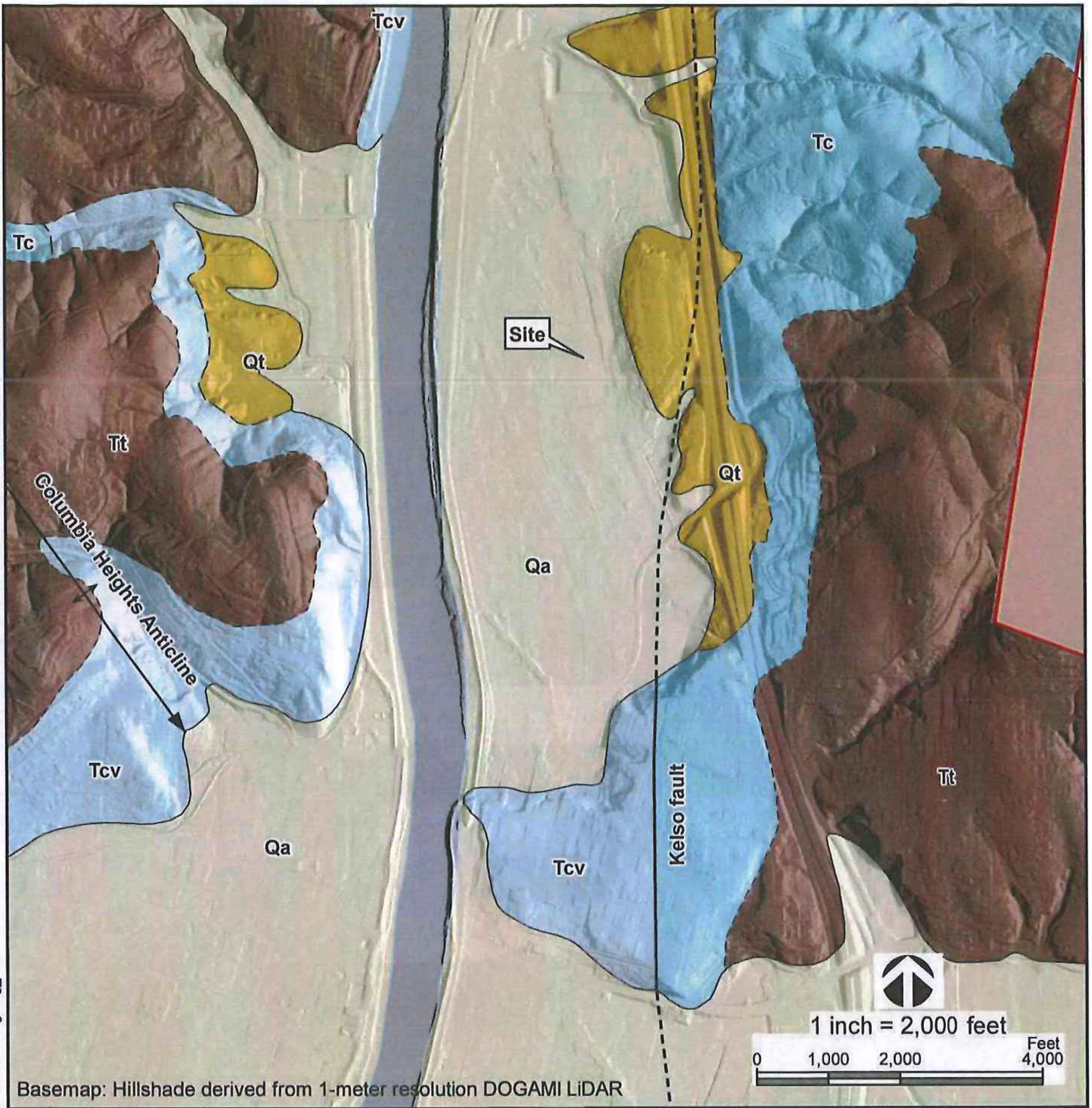
FIGURE

2

L:\Projects\73000\73200-73299\73200_WA STATE 2015-810C\73200.003\gis\fig_02.mxd



Basemap: Hillshade derived from 1-meter resolution DOGAMI LiDAR

EXPLANATION

Qa	Alluvium - sand, gravel, silt, and peat deposits along stream courses
Qt	Terrace deposits - silt and fine sand along valley walls
Tc	Cowlitz Formation - sedimentary rocks
Tcv	Cowlitz Formation - volcanic rocks
Tt	Troutdale Formation - sedimentary rocks

Contact - solid where known; dashed where inferred

Fault - solid where known; dashed where inferred

Extent of DOGAMI LiDAR coverage

Anticline with arrow indicating direction of plunge

GEOLOGIC MAP

BARNES ELEMENTARY
SCHOOL MODULAR
KELSO, WASHINGTON

DATE: DEC 2017 · PROJECT: 0073200.003

PBS

FIGURE

3

L:\Projects\73000\73200-73299\73200_WA STATE 2015-810C\73200.003\gis\fig_03.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

EXPLANATION

- 🟥 Liquefaction susceptibility: Moderate to high
- 🟨 Liquefaction susceptibility: Very low to low
- 🟨 Liquefaction susceptibility: Very low
- 🟩 Liquefaction susceptibility: Bedrock

Notes:

1. Sourced from: Liquefaction Susceptibility Map of Cowlitz County, Washington by Palmer et al. (2004)
2. Boundaries are approximate

LIQUEFACTION SUSCEPTIBILITY MAP

BARNES ELEMENTARY
SCHOOL MODULAR
KELSO, WASHINGTON

DATE: DEC 2017 · PROJECT: 0073200.003

PBS

FIGURE

4

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APPENDIX A

Field Explorations

APPENDIX A: FIELD EXPLORATIONS

A1 GENERAL

PBS explored subsurface conditions at the project site by advancing five borings to depths of up to 31.5 feet bgs on November 21, 2017. The approximate locations of the explorations are shown on Figure 2, Site Plan. The procedures used to advance the borings, collect samples, and other field techniques are described in detail in the following paragraphs. Unless otherwise noted, all soil sampling and classification procedures followed engineering practices in general accordance with relevant ASTM procedures. "General accordance" means that certain local drilling/excavation and descriptive practices and methodologies have been followed.

A2 BORINGS

A2.1 Drilling

Borings were advanced using a track-mounted CME-55 drill rig provided and operated by Western States Soil Conservation, Inc., of Hubbard, Oregon. Borings B-1 through B-3 were advanced using hollow-stem auger drilling techniques. Borings B-4 and B-5 were advanced using mud-rotary drilling techniques. The borings were observed by a member of the PBS geotechnical staff, who maintained a detailed log of the subsurface conditions and materials encountered during the course of the work.

A2.2 Sampling

Disturbed soil samples were taken in the borings at selected depth intervals. The samples were obtained using a standard 2-inch outside diameter (OD), split-spoon sampler following procedures prescribed for the standard penetration test (SPT). Using the SPT, the sampler is driven 18 inches into the soil using a 140-pound hammer dropped 30 inches. The number of blows required to drive the sampler the last 12 inches is defined as the standard penetration resistance (N-value). The N-value provides a measure of the relative density of granular soils such as sands and gravels, and the consistency of cohesive soils such as clays and plastic silts. The disturbed soil samples were examined by a member of the PBS geotechnical staff and then sealed in plastic bags for further examination and physical testing in our laboratory.

A2.3 Boring Logs

The boring logs show the various types of materials that were encountered in the borings and the depths where the materials and/or characteristics of these materials changed, although the changes may be gradual. Where material types and descriptions changed between samples, the contacts were interpreted. The types of samples taken during drilling, along with their sample identification number, are shown to the right of the classification of materials. The N-values and natural water (moisture) contents are shown further to the right.

A3 MATERIAL DESCRIPTION

Initially, samples were classified visually in the field. Consistency, color, relative moisture, degree of plasticity, and other distinguishing characteristics of the soil samples were noted. Afterward, the samples were reexamined in the PBS laboratory and the field classifications were modified where necessary. The terminology used in the soil classifications and other modifiers are defined in Table A-1, Terminology Used to Describe Soil.

PBS

Table A-1
Terminology Used to Describe Soil

Soil Descriptions

Soils exist in mixtures with varying proportions of components. The predominant soil, i.e., greater than 50 percent based on total dry weight, is the primary soil type and is capitalized in our log descriptions (SAND, GRAVEL, SILT, or CLAY). Smaller percentages of other constituents in the soil mixture are indicated by use of modifier words in general accordance with the ASTM D2488-06 Visual-Manual Procedure. "General Accordance" means that certain local and common descriptive practices may have been followed. In accordance with ASTM D2488-06, group symbols (such as GP or CH) are applied on the portion of soil passing the 3-inch (75mm) sieve based on visual examination. The following describes the use of soil names and modifying terms used to describe fine- and coarse-grained soils.

Fine-Grained Soils (50% or greater fines passing 0.075 mm, No. 200 sieve)

The primary soil type, i.e., SILT or CLAY is designated through visual-manual procedures to evaluate soil toughness, dilatency, dry strength, and plasticity. The following outlines the terminology used to describe fine-grained soils, and varies from ASTM D2488 terminology in the use of some common terms.

Primary soil NAME, Symbols, and Adjectives			Plasticity Description	Plasticity Index (PI)
SILT (ML & MH)	**CLAY (CL & CH)**	**ORGANIC SOIL (OL & OH)**		
SILT		Organic SILT	Non-plastic	0 – 3
SILT		Organic SILT	Low plasticity	4 – 10
SILT/Elastic SILT	Lean CLAY	Organic SILT/ Organic CLAY	Medium Plasticity	10 – 20
Elastic SILT	Lean/Fat CLAY	Organic CLAY	High Plasticity	20 – 40
Elastic SILT	Fat CLAY	Organic CLAY	Very Plastic	>40

Modifying terms describing secondary constituents, estimated to 5 percent increments, are applied as follows:

Description	% Composition	
With Sand	% Sand ≥ % Gravel	15% to 25% plus No. 200
With Gravel	% Sand < % Gravel	
Sandy	% Sand ≥ % Gravel	≤30% to 50% plus No. 200
Gravelly	% Sand < % Gravel	

Borderline Symbols, for example CH/MH, are used when soils are not distinctly in one category or when variable soil units contain more than one soil type. **Dual Symbols,** for example CL-ML, are used when two symbols are required in accordance with ASTM D2488.

Soil Consistency terms are applied to fine-grained, plastic soils (i.e., PI ≥ 7). Descriptive terms are based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84, as follows. SILT soils with low to non-plastic behavior (i.e., PI < 7) may be classified using relative density.

Consistency Term	SPT N-value	Unconfined Compressive Strength	
		tsf	kPa
Very soft	Less than 2	Less than 0.25	Less than 24
Soft	2 – 4	0.25 – 0.5	24 – 48
Medium stiff	5 – 8	0.5 – 1.0	48 – 96
Stiff	9 – 15	1.0 – 2.0	96 – 192
Very stiff	16 – 30	2.0 – 4.0	192 – 383
Hard	Over 30	Over 4.0	Over 383

Table A-1
Terminology Used to Describe Soil

Soil Descriptions

Coarse - Grained Soils (less than 50% fines)

Coarse-grained soil descriptions, i.e., SAND or GRAVEL, are based on the portion of materials passing a 3-inch (75mm) sieve. Coarse-grained soil group symbols are applied in accordance with ASTM D2488-06 based on the degree of grading, or distribution of grain sizes of the soil. For example, well-graded sand containing a wide range of grain sizes is designated SW; poorly graded gravel, GP, contains high percentages of only certain grain sizes. Terms applied to grain sizes follow.

Material NAME	Particle Diameter	
	Inches	Millimeters
SAND (SW or SP)	0.003 – 0.19	0.075 – 4.8
GRAVEL (GW or GP)	0.19 – 3	4.8 – 75
Additional Constituents:		
Cobble	3 – 12	75 – 300
Boulder	12 – 120	300 – 3050

The primary soil type is capitalized, and the fines content in the soil are described as indicated by the following examples. Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 percent. Other soil mixtures will have similar descriptive names.

Example: Coarse-Grained Soil Descriptions with Fines

>5% to < 15% fines (Dual Symbols)	≥15% to < 50% fines
Well graded GRAVEL with silt: GW-GM	Silty GRAVEL: GM
Poorly graded SAND with clay: SP-SC	Silty SAND: SM

Additional descriptive terminology applied to coarse-grained soils follow.

Example: Coarse-Grained Soil Descriptions with Other Coarse-Grained Constituents

Coarse-Grained Soil Containing Secondary Constituents	
With sand or with gravel	≥ 15% sand or gravel
With cobbles; with boulders	Any amount of cobbles or boulders.

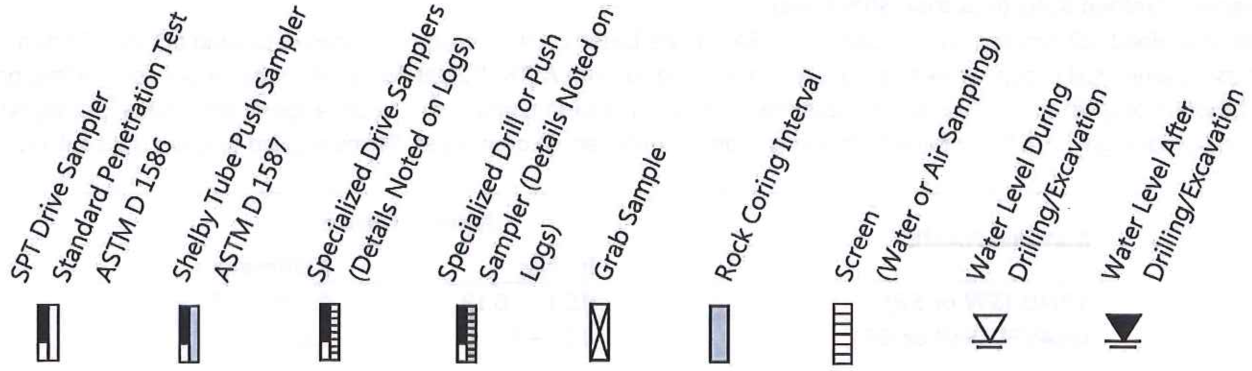
Cobble and boulder deposits may include a description of the matrix soils, as defined above.

Relative Density terms are applied to granular, non-plastic soils based on direct measure or correlation to the Standard Penetration Test N-value as determined by ASTM D1586-84.

Relative Density Term	SPT N-value
Very loose	0 – 4
Loose	5 – 10
Medium dense	11 – 30
Dense	31 – 50
Very dense	> 50

Table A-2
Key To Test Pit and Boring Log Symbols

SAMPLING DESCRIPTIONS

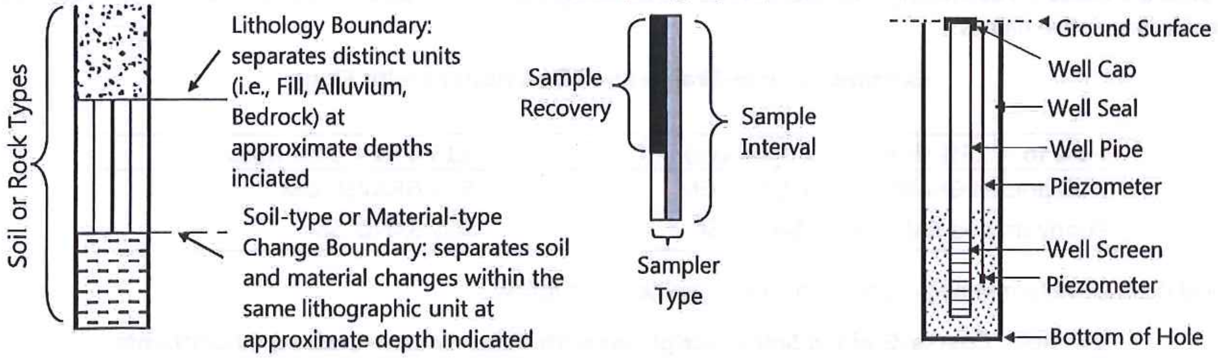


LOG GRAPHICS

Soil and Rock

Sampling Symbols

Instrumentation Detail



Geotechnical Testing Acronym Explanations

PP	Pocket Penetrometer	HYD	Hydrometer Gradation
TOR	Torvane	SIEV	Sieve Gradation
DCP	Dynamic Cone Penetrometer	DS	Direct Shear
ATT	Atterberg Limits	DD	Dry Density
PL	Plasticity Limit	CBR	California Bearing Ratio
LL	Liquid Limit	RES	Resilient Modulus
PI	Plasticity Index	VS	Vane Shear
P200	Percent Passing US Standard No. 200 Sieve	bgs	Below ground surface
OC	Organic Content	MSL	Mean Sea Level
CON	Consolidation	HCL	Hydrochloric Acid
UC	Unconfined Compressive Strength		

Details of soil and rock classification systems are available on request.

Rev. 02/2017

BARNES ELEMENTARY SCHOOL
KELSO, WASHINGTON

BORING B-1

PBS PROJECT NUMBER:
73200.003

APPROX. BORING B-1 LOCATION:
46.160613, -122.907432

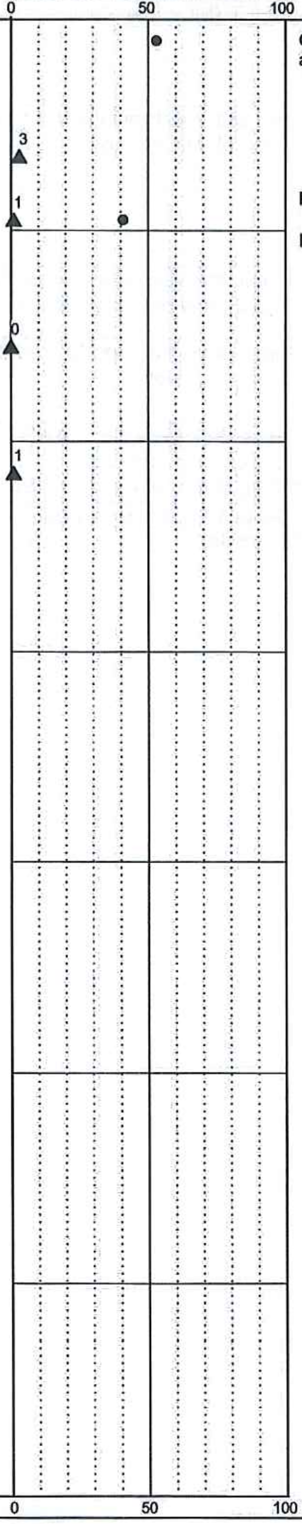
MATERIAL DESCRIPTION

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

▲ UNCORRECTED N-VALUE
◆ DYNAMIC CONE PENETROMETER
● MOISTURE CONTENT %
▥ RQD% ▨ CORE REC%

Surface Conditions: Grass

DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	N-VALUE	INSTALLATION AND COMMENTS
0.0	Brown SILT (ML); low to medium plasticity; moist	0.0		S-1		Grass roollets to approximately 12 inches bgs
	Soft brown Lean CLAY (CL); medium plasticity; moist	2.6		S-2	3	
	Very loose gray with brown mottles poorly graded SAND (SP-SM) with silt; non-plastic; fine sand; moist	3.0	P200	S-3	1	P200 = 14% Infiltration testing at 4 feet bgs
5.0	becomes brown; fine to medium sand; wet			S-4	0	
10.0	becomes dark gray; increase in fines content			S-5	1	
	Final depth 11.5 feet bgs; boring backfilled with bentonite.	11.5				
15.0						
20.0						
25.0						
30.0						
35.0						



DRILLING METHOD: Hollow-Stem Auger
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Cordes

BIT DIAMETER: 4 ¼ inches
HAMMER EFFICIENCY PERCENT: 74.4
LOGGING COMPLETED: 11/21/17

FIGURE A1

BARNES ELEMENTARY SCHOOL
KELSO, WASHINGTON

BORING B-2

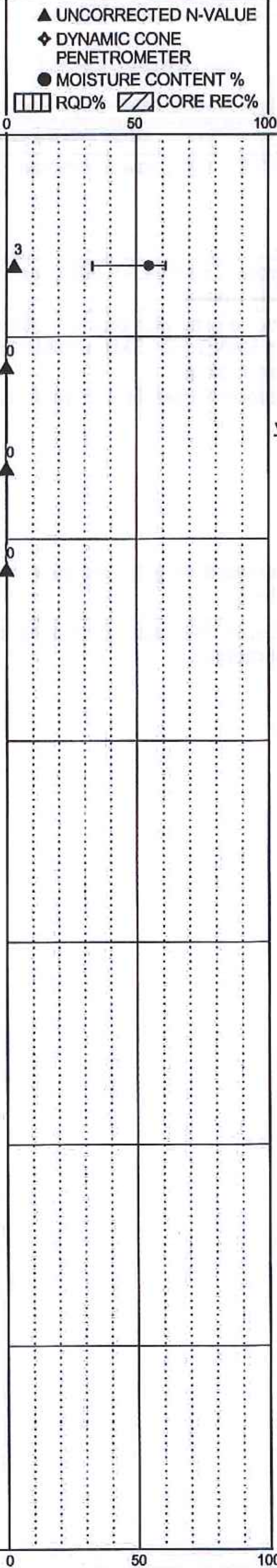
PBS PROJECT NUMBER:
73200.003

APPROX. BORING B-2 LOCATION:
46.160688, -122.907129

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Surface Conditions: Grass

DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE ID	UNCORRECTED N-VALUE	INSTALLATION AND COMMENTS
0.0	Brown SILT (ML); low plasticity; moist	0.0		S-1		Grass rootlets to approximately 12 inches bgs
	Soft gray with red-brown mottles Elastic SILT (MH); high plasticity; moist	2.5	ATT	S-2	3	LL = 61 PL = 33 PI = 28
5.0				S-3	0	
	Very loose dark gray with red mottles silty SAND (SM); low plasticity; fine sand; wet	6.3				▽ 11/21/17
	Very loose dark gray poorly graded SAND (SP); fine sand; wet	8.0		S-4	0	
10.0	Very loose dark gray silty SAND (SM); non-plastic; fine sand; wet stratified layers of dark gray SILT (ML)	10.0		S-5	0	
	Final depth 11.5 feet bgs; boring backfilled with bentonite.	11.5				



DRILLING METHOD: Hollow-Stem Auger
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Cordes

BIT DIAMETER: 4 ¼ inches
HAMMER EFFICIENCY PERCENT: 74.4
LOGGING COMPLETED: 11/21/17

FIGURE A2

BARNES ELEMENTARY SCHOOL
KELSO, WASHINGTON

BORING B-3

PBS PROJECT NUMBER:
73200.003

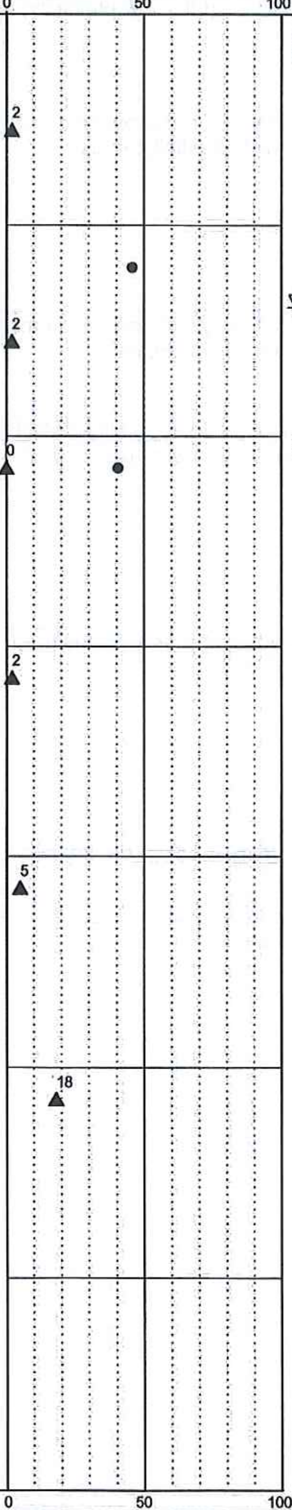
APPROX. BORING B-3 LOCATION:
46.160925, -122.907191

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

▲ UNCORRECTED N-VALUE
✦ DYNAMIC CONE PENETROMETER
● MOISTURE CONTENT %
▥ RQD% ▨ CORE REC%

Surface Conditions: Grass

DEPTH	MATERIAL DESCRIPTION	TESTING	SAMPLE ID	UNCORRECTED N-VALUE	INSTALLATION AND COMMENTS
0.0	Brown SILT (ML); low plasticity; moist				Grass rootlets to approximately 12 inches bgs
2.0	Very loose brown poorly graded SAND (SP); fine to medium sand; moist		S-1	2	
2.8	Very soft gray with red-brown mottles Lean CLAY (CL); low to medium plasticity; moist		S-2		▽ 11/21/17
7.0	Very loose dark gray poorly graded SAND (SP); fine to medium sand; wet		S-3	2	
8.5	Very loose dark gray sandy SILT (ML); non-plastic; fine sand; wet	P200	S-4	0	P200 = 68%
15.0	Very loose dark gray poorly graded SAND (SP); fine to medium sand; wet				
15.5	Very loose dark gray silty SAND (SM); non-plastic; fine sand; wet stratified layers of dark gray SILT (ML)		S-5	2	
20.0	Loose dark gray poorly graded SAND (SP); fine to medium sand; wet		S-6	5	
	becomes medium dense, olive brown		S-7	18	
26.5	Final depth 26.5 feet bgs; boring backfilled with bentonite.				



DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Cordes

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT: 74.4
LOGGING COMPLETED: 11/21/17

FIGURE A3

PBS

BARNES ELEMENTARY SCHOOL
KELSO, WASHINGTON

BORING B-4

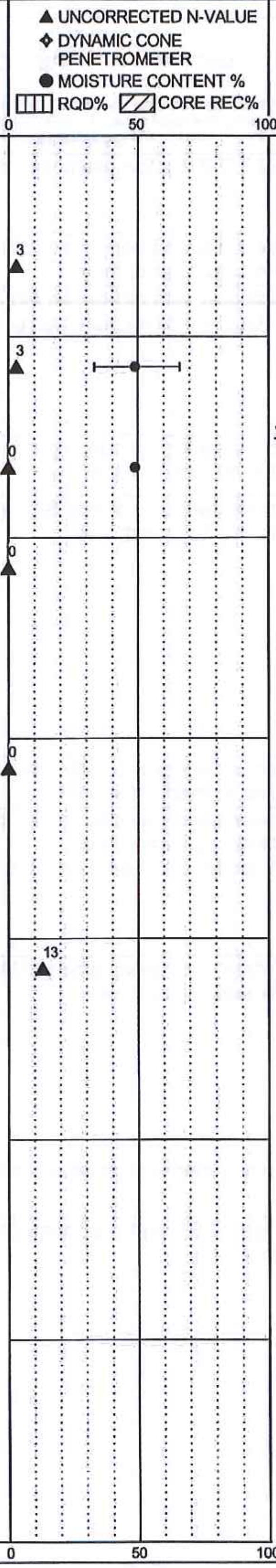
PBS PROJECT NUMBER:
73200.003

APPROX. BORING B-4 LOCATION:
46.161054, -122.907366

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

Surface Conditions: Grass

DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	TESTING	SAMPLE TYPE SAMPLE ID	UNCORRECTED N-VALUE	INSTALLATION AND COMMENTS
0.0	Brown SILT (ML); low plasticity; moist	0.0				Grass rootlets to approximately 12 inches bgs
	Soft gray with red-brown mottles Elastic SILT (MH); high plasticity; moist	2.7		S-1	3	
5.0			ATT	S-2	3	LL = 66 PL = 33 PI = 33
	Very soft gray with red-brown mottles SILT (ML); low plasticity; wet	7.5		S-3	0	▽ 11/21/17
10.0	Very loose dark gray silty SAND (SM); non-plastic to low plasticity; fine sand; wet	10.0		S-4	0	
15.0	Very loose dark gray poorly graded SAND (SP); fine sand; wet	15.0		S-5	0	
20.0	becomes medium dense; fine to medium sand			S-6	13	
	Final depth 21.5 feet bgs; boring backfilled with bentonite.	21.5				
25.0						
30.0						
35.0						

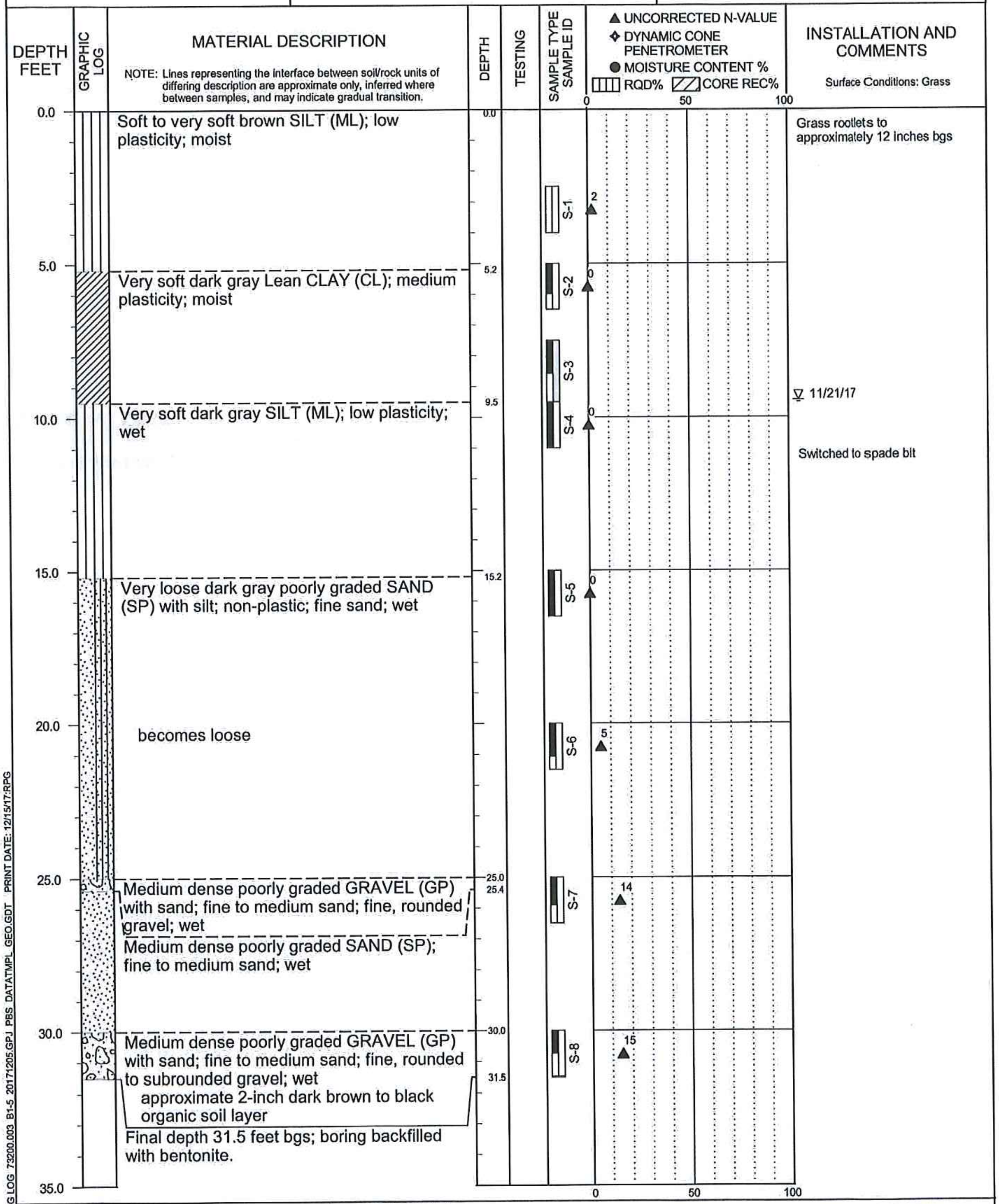


DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Cordes

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT: 74.4
LOGGING COMPLETED: 11/21/17

FIGURE A4

PBS	BARNES ELEMENTARY SCHOOL KELSO, WASHINGTON	**BORING B-5**
	PBS PROJECT NUMBER: 73200.003	APPROX. BORING B-5 LOCATION: 46.160906, -122.907533



MATERIAL DESCRIPTION

NOTE: Lines representing the interface between soil/rock units of differing description are approximate only, inferred where between samples, and may indicate gradual transition.

INSTALLATION AND COMMENTS

Surface Conditions: Grass

DEPTH FEET	MATERIAL DESCRIPTION	DEPTH	SAMPLE ID	UNCORRECTED N-VALUE	INSTALLATION AND COMMENTS
0.0	Soft to very soft brown SILT (ML); low plasticity; moist	0.0	S-1	2	Grass rootlets to approximately 12 inches bgs
5.0	Very soft dark gray Lean CLAY (CL); medium plasticity; moist	5.2	S-2	0	
			S-3		∇ 11/21/17
10.0	Very soft dark gray SILT (ML); low plasticity; wet	9.5	S-4	0	Switched to spade bit
15.0	Very loose dark gray poorly graded SAND (SP) with silt; non-plastic; fine sand; wet	15.2	S-5	0	
20.0	becomes loose		S-6	5	
25.0	Medium dense poorly graded GRAVEL (GP) with sand; fine to medium sand; fine, rounded gravel; wet	25.0	S-7	14	
	Medium dense poorly graded SAND (SP); fine to medium sand; wet	25.4			
30.0	Medium dense poorly graded GRAVEL (GP) with sand; fine to medium sand; fine, rounded to subrounded gravel; wet approximate 2-inch dark brown to black organic soil layer	30.0	S-8	15	
	Final depth 31.5 feet bgs; boring backfilled with bentonite.	31.5			
35.0					

DRILLING METHOD: Mud Rotary
DRILLED BY: Western States Soil Conservation, Inc.
LOGGED BY: S. Cordes

BIT DIAMETER: 4 7/8 inches
HAMMER EFFICIENCY PERCENT: 74.4
LOGGING COMPLETED: 11/21/17

FIGURE A5

APPENDIX B

Laboratory Testing

APPENDIX B: LABORATORY TESTING

B1 GENERAL

Samples obtained during the field explorations were examined in the PBS laboratory. The physical characteristics of the samples were noted and field classifications were modified where necessary. During the course of examination, representative samples were selected for further testing. The testing program for the soil samples included standard classification tests, which yield certain index properties of the soils important to an evaluation of soil behavior. The testing procedures are described in the following paragraphs. Unless noted otherwise, all test procedures are in general accordance with applicable ASTM standards. "General accordance" means that certain local and common descriptive practices and methodologies have been followed.

B2 CLASSIFICATION TESTS

B2.1 Visual Classification

The soils were classified in accordance with the Unified Soil Classification System with certain other terminology, such as the relative density or consistency of the soil deposits, in general accordance with engineering practice. In determining the soil type (that is, gravel, sand, silt, or clay) the term that best described the major portion of the sample is used. Modifying terminology to further describe the samples is defined in Table A-1, Terminology Used to Describe Soil, in Appendix A.

B2.2 Atterberg Limits

Atterberg limits were determined on select samples for the purpose of classifying soils into various groups for correlation. The results of the Atterberg limits test, which included liquid and plastic limits, are plotted on Figure B1, Atterberg Limits Test Results, and on the explorations logs in Appendix A where applicable.

B2.3 Grain-Size Analyses (P200 Wash)

No. 200 wash (P200) analyses were completed on samples to determine the portion of soil samples passing the No. 200 Sieve (i.e., silt and clay). The results of the P200 test results are presented on the exploration logs in Appendix A and on Figure B1, Summary of Laboratory Data, in Appendix B.

B2.4 Moisture (Water) Contents

Natural moisture content determinations were made on samples of the fine-grained soils (that is, silts, clays, and silty sands). The natural moisture content is defined as the ratio of the weight of water to dry weight of soil, expressed as a percentage. The results of the moisture content determinations are presented on the logs of the borings in Appendix A and on Figure B1, Summary of Laboratory Data, in Appendix B.

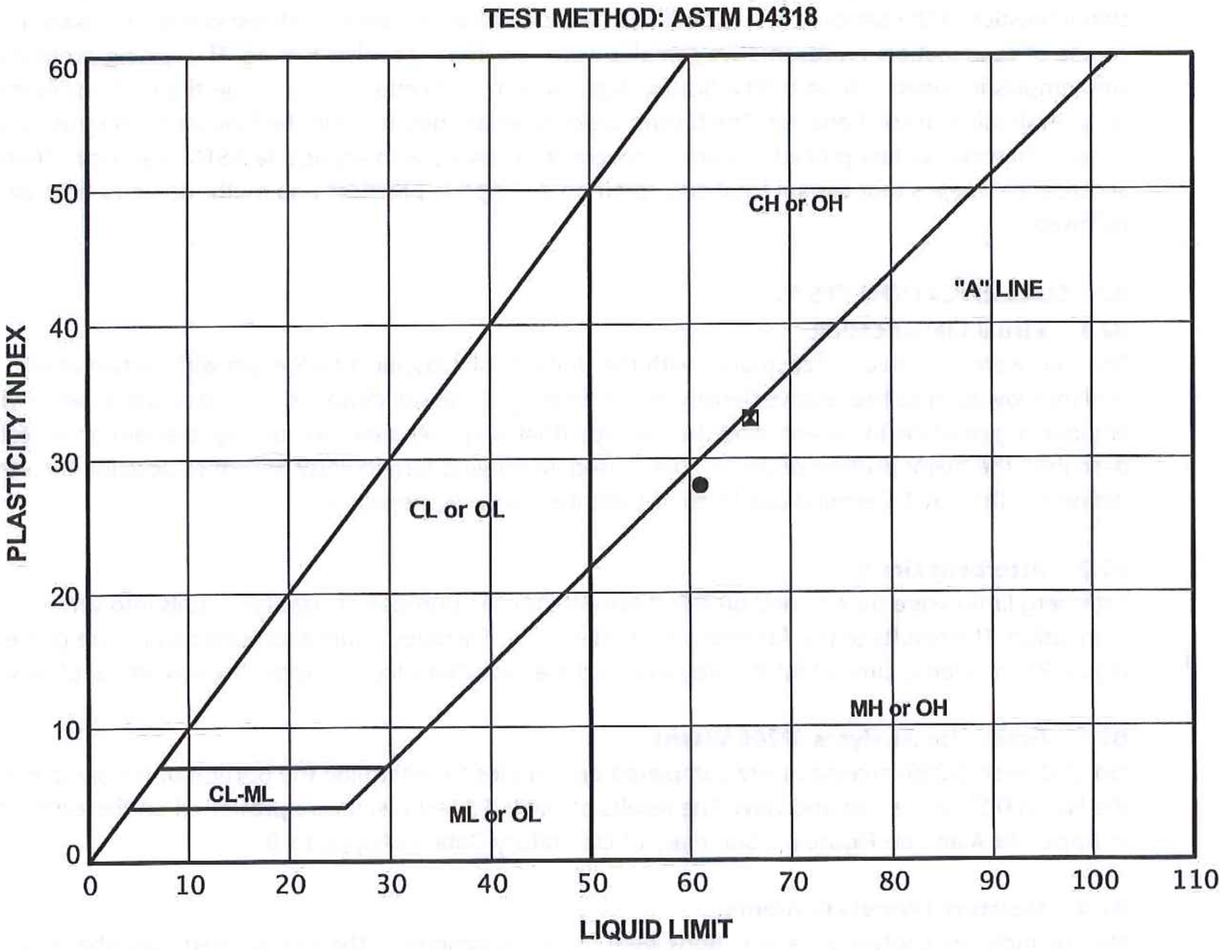
PBS

ATTERBERG LIMITS TEST RESULTS

BARNES ELEMENTARY SCHOOL
KELSO, WASHINGTON

PBS PROJECT NUMBER:
73200.003

TEST METHOD: ASTM D4318



KEY	EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	NATURAL MOISTURE CONTENT (PERCENT)	PERCENT PASSING NO. 40 SIEVE (PERCENT)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
●	B-2	S-2	2.5	54.8	NA	61	33	28
☒	B-4	S-2	5.0	48.8	NA	66	33	33

ATTERBERG LIMITS 73200.003_B1-5_20171205.GPJ PBS_DATATMPL_GEO.GDT PRINT DATE: 12/7/17:RPG

FIGURE B1

PBS

SUMMARY OF LABORATORY DATA

BARNES ELEMENTARY SCHOOL
KELSO, WASHINGTON

PBS PROJECT NUMBER:
73200.003

SAMPLE INFORMATION				MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	SIEVE			ATTERBERG LIMITS		
EXPLORATION NUMBER	SAMPLE NUMBER	SAMPLE DEPTH (FEET)	ELEVATION (FEET)			GRAVEL (PERCENT)	SAND (PERCENT)	P200 (PERCENT)	LIQUID LIMIT (PERCENT)	PLASTIC LIMIT (PERCENT)	PLASTICITY INDEX (PERCENT)
B-1	S-1	0		52.9							
B-1	S-3	4		40.8				14			
B-2	S-2	2.5		54.8					61	33	28
B-3	S-2	5		45.6	75						
B-3	S-4	10		40.5				68			
B-4	S-2	5		48.8					66	33	33
B-4	S-3	7.5		48.8							

Appendix D

Modeling Results
Technical Data

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Barnes Headstart
Site Name:	Barnes Headstart
Site Address:	401 Barnes
City:	Kelso
Report Date:	3/1/2018
Gage:	Longview
Data Start:	1955/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.143
Version Date:	2017/04/14
Version:	4.2.13

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year
Low Flow Threshold for POC2:	50 Percent of the 2 Year
High Flow Threshold for POC2:	50 Year

Landuse Basin Data

Predeveloped Land Use

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.07
Pervious Total	0.07
Impervious Land Use	acre
SIDEWALKS FLAT	0.07
PARKING FLAT	0.32
Impervious Total	0.39
Basin Total	0.46

Element Flows To:

Surface	Interflow	Groundwater
Surface retention 1	Surface retention 1	

Basin 2

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROOF TOPS FLAT	0.12
Impervious Total	0.12
Basin Total	0.12

Element Flows To:

Surface	Interflow	Groundwater

Routing Elements

Predeveloped Routing

Mitigated Routing

Bioretention 1

Bottom Length:	85.00 ft.
Bottom Width:	4.00 ft.
Material thickness of first layer:	0.25
Material type for first layer:	ASTM 100
Material thickness of second layer:	1.5
Material type for second layer:	SMMWW 12 in/hr
Material thickness of third layer:	1.33
Material type for third layer:	GRAVEL
Underdrain used	
Underdrain Diameter (feet):	0.34
Orifice Diameter (in.):	4
Offset (in.):	4
Flow Through Underdrain (ac-ft.):	80.283
Total Outflow (ac-ft.):	81.701
Percent Through Underdrain:	98.26

Discharge Structure

Riser Height:	0.5 ft.
Riser Diameter:	8 in.

Element Flows To:

Outlet 1	Outlet 2

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.0534	0.0000	0.0000	0.0000
0.0448	0.0529	0.0002	0.0000	0.0000
0.0897	0.0521	0.0004	0.0000	0.0000
0.1345	0.0513	0.0006	0.0000	0.0000
0.1793	0.0506	0.0008	0.0000	0.0000
0.2242	0.0498	0.0010	0.0000	0.0000
0.2690	0.0490	0.0013	0.0000	0.0000
0.3138	0.0483	0.0015	0.0000	0.0000
0.3587	0.0475	0.0017	0.0000	0.0000
0.4035	0.0468	0.0020	0.0000	0.0000
0.4484	0.0460	0.0023	0.0000	0.0000
0.4932	0.0453	0.0026	0.0000	0.0000
0.5380	0.0445	0.0028	0.0000	0.0000
0.5829	0.0438	0.0032	0.0000	0.0000
0.6277	0.0431	0.0035	0.0000	0.0000
0.6725	0.0423	0.0038	0.0000	0.0000
0.7174	0.0416	0.0041	0.0000	0.0000
0.7622	0.0409	0.0045	0.0000	0.0000
0.8070	0.0402	0.0049	0.0000	0.0000
0.8519	0.0394	0.0053	0.0000	0.0000
0.8967	0.0387	0.0056	0.0000	0.0000
0.9415	0.0380	0.0060	0.0000	0.0000
0.9864	0.0373	0.0065	0.0000	0.0000
1.0312	0.0366	0.0069	0.0000	0.0000
1.0760	0.0359	0.0073	0.0000	0.0000
1.1209	0.0352	0.0078	0.0000	0.0000
1.1657	0.0345	0.0083	0.0000	0.0000
1.2105	0.0338	0.0088	0.0000	0.0000
1.2554	0.0331	0.0092	0.0000	0.0000

1.3002	0.0324	0.0098	0.0000	0.0000
1.3451	0.0318	0.0103	0.0066	0.0000
1.3899	0.0311	0.0108	0.0074	0.0000
1.4347	0.0304	0.0114	0.0083	0.0000
1.4796	0.0297	0.0119	0.0086	0.0000
1.5244	0.0291	0.0125	0.0093	0.0000
1.5692	0.0284	0.0131	0.0103	0.0000
1.6141	0.0278	0.0137	0.0114	0.0000
1.6589	0.0271	0.0143	0.0126	0.0000
1.7037	0.0264	0.0149	0.0139	0.0000
1.7486	0.0258	0.0156	0.0152	0.0000
1.7934	0.0251	0.0162	0.0166	0.0000
1.8382	0.0245	0.0168	0.0180	0.0000
1.8831	0.0239	0.0174	0.0187	0.0000
1.9279	0.0232	0.0180	0.0190	0.0000
1.9727	0.0226	0.0187	0.0220	0.0000
2.0176	0.0220	0.0194	0.0236	0.0000
2.0624	0.0213	0.0200	0.0236	0.0000
2.1073	0.0207	0.0207	0.0236	0.0000
2.1521	0.0201	0.0214	0.0236	0.0000
2.1969	0.0195	0.0221	0.0236	0.0000
2.2418	0.0188	0.0229	0.0236	0.0000
2.2866	0.0182	0.0236	0.0236	0.0000
2.3314	0.0176	0.0244	0.0236	0.0000
2.3763	0.0170	0.0251	0.0236	0.0000
2.4211	0.0164	0.0259	0.0236	0.0000
2.4659	0.0158	0.0267	0.0236	0.0000
2.5108	0.0152	0.0275	0.0236	0.0000
2.5556	0.0146	0.0283	0.0236	0.0000
2.6004	0.0141	0.0292	0.0236	0.0000
2.6453	0.0135	0.0300	0.0236	0.0000
2.6901	0.0129	0.0309	0.0236	0.0000
2.7349	0.0123	0.0318	0.0236	0.0000
2.7798	0.0117	0.0326	0.0236	0.0000
2.8246	0.0112	0.0336	0.0236	0.0000
2.8695	0.0106	0.0345	0.0236	0.0000
2.9143	0.0100	0.0354	0.0236	0.0000
2.9591	0.0095	0.0364	0.0236	0.0000
3.0040	0.0089	0.0373	0.0236	0.0000
3.0488	0.0084	0.0383	0.0236	0.0000
3.0800	0.0078	0.0390	0.0236	0.0000

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Infilt(cfs)
3.0800	0.0534	0.0390	0.0000	0.0969	0.0000
3.1248	0.0542	0.0414	0.0000	0.0969	0.0000
3.1697	0.0550	0.0438	0.0000	0.0993	0.0000
3.2145	0.0558	0.0463	0.0000	0.1017	0.0000
3.2593	0.0565	0.0488	0.0000	0.1041	0.0000
3.3042	0.0573	0.0514	0.0000	0.1065	0.0000
3.3490	0.0581	0.0540	0.0000	0.1090	0.0000
3.3938	0.0589	0.0566	0.0000	0.1114	0.0000
3.4387	0.0597	0.0593	0.0000	0.1138	0.0000
3.4835	0.0605	0.0620	0.0000	0.1162	0.0000
3.5284	0.0613	0.0647	0.0000	0.1186	0.0000
3.5732	0.0622	0.0675	0.0000	0.1211	0.0000
3.6180	0.0630	0.0703	0.0524	0.1235	0.0000
3.6629	0.0638	0.0731	0.1669	0.1259	0.0000

3.7077	0.0646	0.0760	0.3104	0.1283	0.0000
3.7525	0.0654	0.0789	0.4612	0.1307	0.0000
3.7974	0.0663	0.0819	0.5978	0.1332	0.0000
3.8422	0.0671	0.0848	0.7029	0.1356	0.0000
3.8870	0.0679	0.0879	0.7712	0.1380	0.0000
3.9319	0.0688	0.0909	0.8304	0.1404	0.0000
3.9767	0.0696	0.0940	0.8817	0.1428	0.0000
4.0215	0.0705	0.0972	0.9302	0.1453	0.0000
4.0664	0.0713	0.1004	0.9763	0.1477	0.0000
4.0800	0.0716	0.1013	1.0203	0.1484	0.0000

Surface retention 1

Element Flows To:

Outlet 1	Outlet 2
	Bioretention 1

Analysis Results

POC 1

POC #1 was not reported because POC must exist in both scenarios and both scenarios must have been run.

POC 2

POC #2 was not reported because POC must exist in both scenarios and both scenarios must have been run.

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

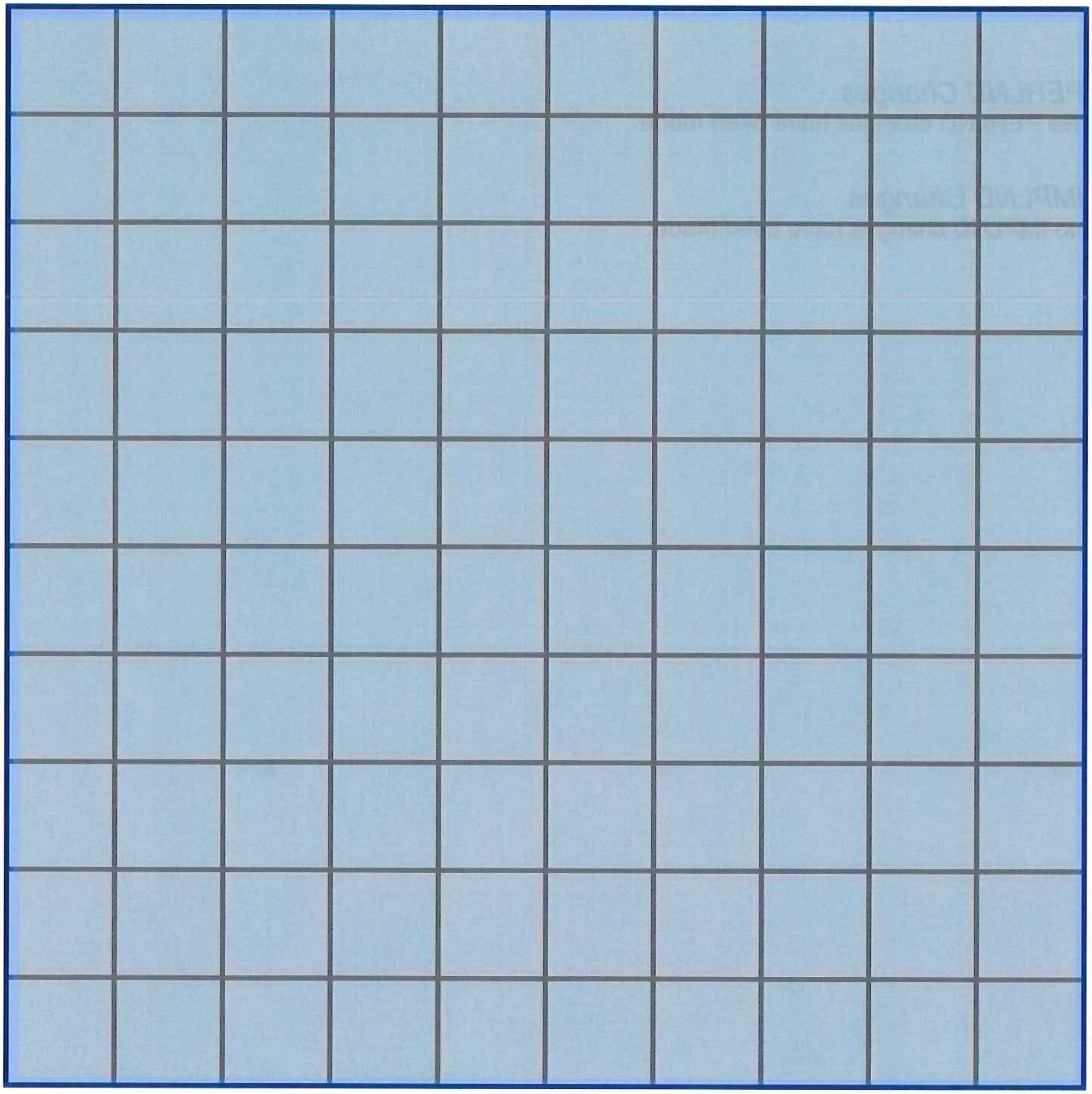
No PERLND changes have been made.

IMPLND Changes

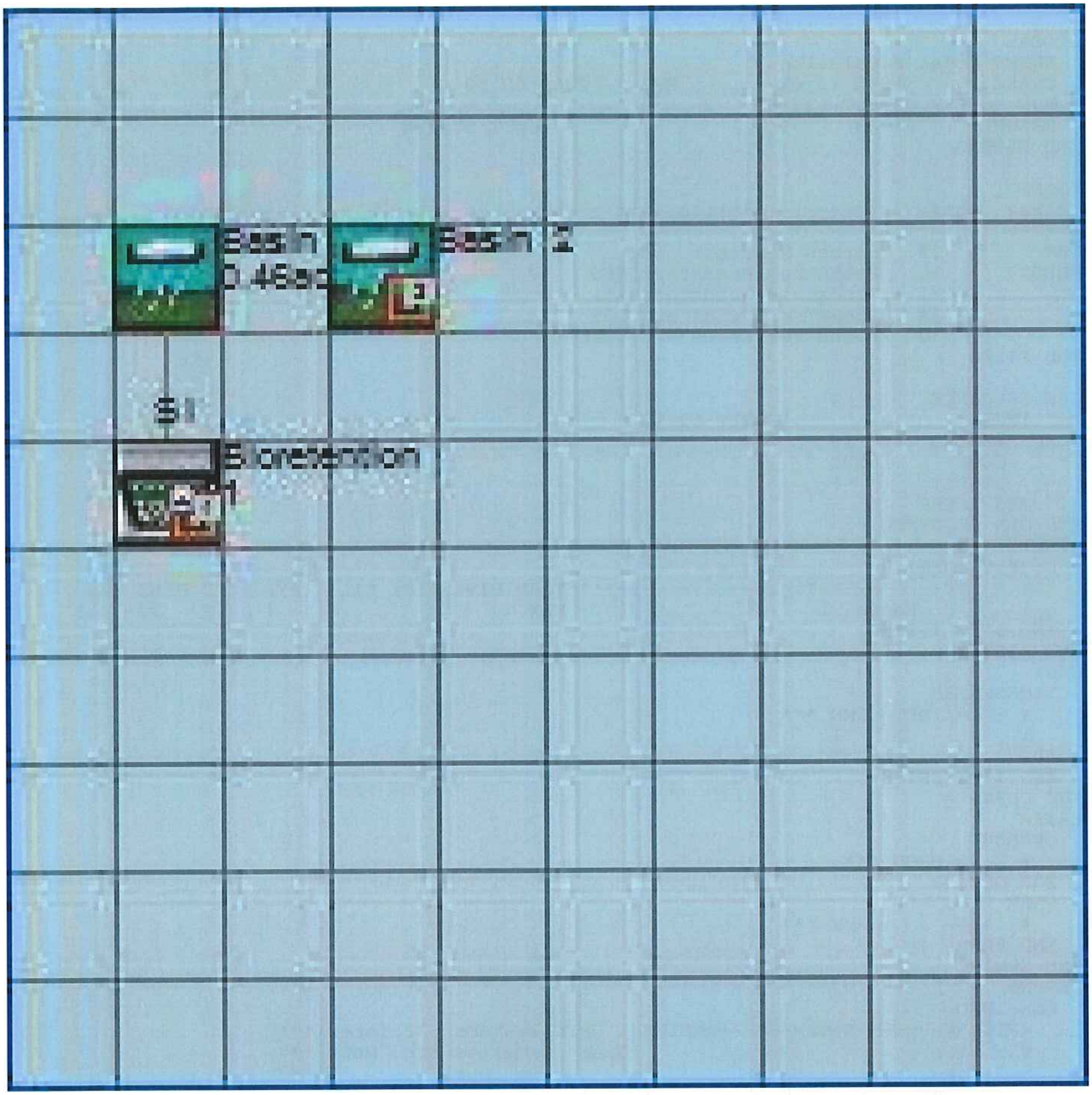
No IMPLND changes have been made.

Appendix

Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1955 10 01        END    2009 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   Barnes Headstart.wdm
MESSU      25   PreBarnes Headstart.MES
           27   PreBarnes Headstart.L61
           28   PreBarnes Headstart.L62
           30   POCBarnes Headstart1.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      SAT, 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         4         2       100     0.001       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   19              0         0        10         2         0         0       0.7
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   19            0.2         3       0.5         1       0.7       0.8
  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       4.2         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                        0.47     COPY   501     12
PERLND  19                        0.47     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    1.143          PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1.143          IMPLND   1 999 EXTNL  PREC
```

```
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           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       1955 10 01        END    2009 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   Barnes Headstart.wdm
MESSU      25   MitBarnes Headstart.MES
           27   MitBarnes Headstart.L61
           28   MitBarnes Headstart.L62
           31   POCBarnes Headstart2.dat
           30   POCBarnes Headstart1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      16
      IMPLND       8
      IMPLND      11
      IMPLND       4
      GENER        2
      RCHRES       1
      RCHRES       2
      COPY       502
      COPY         1
      COPY       501
      DISPLY       2
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    2        Basin  2                    MAX                     1    2   31    9
    1        Surface retention  1        MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  502         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
    2        24
  END OPCODE
  PARM
    #    #         K ***
    2             0.
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out            ***
   16      C, Lawn, 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 ***
   16         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  *********
   16         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 ***
   16         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
   16              0       4.5      0.03       400      0.05       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3           ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   16              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   16            0.1      0.25      0.25         6       0.5      0.25
  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
   16                  0         0         0         0       2.5         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                         User  t-series Engl Metr ***
                                         in  out            ***
    8      SIDEWALKS/FLAT          1    1    1   27    0
   11      PARKING/FLAT            1    1    1   27    0
    4      ROOF TOPS/FLAT          1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    8         0    0    1    0    0    0
   11         0    0    1    0    0    0
    4         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   *********
    8         0    0    4    0    0    0    1    9
   11         0    0    4    0    0    0    1    9
```

```
    4         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     ***
    8         0    0    0    0    0
   11         0    0    0    0    0
    4         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***   LSUR     SLSUR      NSUR     RETSC
    8            400      0.01       0.1       0.1
   11            400      0.01       0.1       0.1
    4            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    8              0         0
   11              0         0
    4              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    8              0         0
   11              0         0
    4              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin   1***
PERLND  16                        0.07     RCHRES   1      2
PERLND  16                        0.07     RCHRES   1      3
IMPLND   8                        0.07     RCHRES   1      5
IMPLND  11                        0.32     RCHRES   1      5
Basin   2***
IMPLND   4                        0.12     COPY   502     15

******Routing******
PERLND  16                        0.07     COPY     1     12
IMPLND   8                        0.07     COPY     1     15
IMPLND  11                        0.32     COPY     1     15
PERLND  16                        0.07     COPY     1     13
RCHRES   1                           1     RCHRES   2      8
RCHRES   2                           1     COPY   501     16
RCHRES   1                           1     COPY   501     17
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   502 OUTPUT MEAN   1 1   48.4        DISPLY   2     INPUT  TIMSER 1
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1
GENER    2 OUTPUT TIMSER      .0011111     RCHRES   1     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 retentio-008   3    1    1    1   28    0    1
    2     Bioretention  1        1    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
  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
  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
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50           ***
  <------><--------><--------><--------><--------><--------><-------->           ***
    1             1      0.01       0.0       0.0       0.5       0.0
    2             2      0.02       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
  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 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
*** opt foplop dcdts  yr mo dy hr mn d t   vnam  s1 s2 s3 ac quantity  tc  ts rp
  <****><-><--><><-><--> <> <> <> <><><>  <----><-><-><-><-><--------> <> <-><->
```

```
  GENER   2                               v2m2           =  1584.
*** 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
END SPEC-ACTIONS
FTABLES
  FTABLE      2
   70    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.053403  0.000000  0.000000
  0.044835  0.052862  0.000183  0.000000
  0.089670  0.052088  0.000378  0.000000
  0.134505  0.051318  0.000587  0.000000
  0.179341  0.050550  0.000807  0.000000
  0.224176  0.049787  0.001041  0.000000
  0.269011  0.049026  0.001264  0.000000
  0.313846  0.048269  0.001499  0.000000
  0.358681  0.047515  0.001745  0.000000
  0.403516  0.046764  0.002003  0.000000
  0.448352  0.046017  0.002274  0.000000
  0.493187  0.045273  0.002556  0.000000
  0.538022  0.044532  0.002850  0.000000
  0.582857  0.043795  0.003156  0.000000
  0.627692  0.043061  0.003474  0.000000
  0.672527  0.042330  0.003805  0.000000
  0.717363  0.041602  0.004148  0.000000
  0.762198  0.040878  0.004503  0.000000
  0.807033  0.040158  0.004871  0.000000
  0.851868  0.039440  0.005251  0.000000
  0.896703  0.038726  0.005644  0.000000
  0.941538  0.038015  0.006049  0.000000
  0.986374  0.037308  0.006467  0.000000
  1.031209  0.036604  0.006898  0.000000
  1.076044  0.035903  0.007342  0.000000
  1.120879  0.035205  0.007798  0.000000
  1.165714  0.034511  0.008268  0.000000
  1.210549  0.033820  0.008750  0.000000
  1.255385  0.033133  0.009246  0.000000
  1.300220  0.032449  0.009755  0.000000
  1.345055  0.031768  0.010277  0.006565
  1.389890  0.031090  0.010813  0.007412
  1.434725  0.030416  0.011361  0.008322
  1.479560  0.029745  0.011924  0.008570
  1.524396  0.029078  0.012499  0.009295
  1.569231  0.028413  0.013089  0.010334
  1.614066  0.027752  0.013692  0.011440
  1.658901  0.027095  0.014309  0.012614
  1.703736  0.026440  0.014939  0.013857
  1.748571  0.025789  0.015584  0.015171
  1.793407  0.025142  0.016181  0.016557
  1.838242  0.024497  0.016791  0.018015
  1.883077  0.023856  0.017414  0.018662
  1.927912  0.023219  0.018050  0.018986
  1.972747  0.022584  0.018698  0.021986
  2.017582  0.021953  0.019360  0.023611
  2.062418  0.021326  0.020034  0.023611
  2.107253  0.020701  0.020722  0.023611
  2.152088  0.020080  0.021423  0.023611
  2.196923  0.019462  0.022137  0.023611
  2.241758  0.018848  0.022864  0.023611
  2.286593  0.018237  0.023604  0.023611
  2.331429  0.017629  0.024358  0.023611
  2.376264  0.017025  0.025126  0.023611
```

```
  2.421099  0.016424  0.025907  0.023611
  2.465934  0.015826  0.026701  0.023611
  2.510769  0.015231  0.027509  0.023611
  2.555604  0.014640  0.028331  0.023611
  2.600440  0.014052  0.029166  0.023611
  2.645275  0.013468  0.030015  0.023611
  2.690110  0.012887  0.030879  0.023611
  2.734945  0.012309  0.031756  0.023611
  2.779780  0.011734  0.032647  0.023611
  2.824615  0.011163  0.033552  0.023611
  2.869451  0.010595  0.034471  0.023611
  2.914286  0.010030  0.035405  0.023611
  2.959121  0.009469  0.036352  0.023611
  3.003956  0.008911  0.037314  0.023611
  3.048791  0.008357  0.038291  0.023611
  3.080000  0.007805  0.081856  0.023611
  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  0.007805  0.000000  0.000000  0.000000  0.000000
  0.044835  0.054182  0.002412  0.000000  0.096864  0.000000
  0.089670  0.054965  0.004859  0.000000  0.099284  0.000000
  0.134505  0.055752  0.007341  0.000000  0.101704  0.000000
  0.179341  0.056541  0.009858  0.000000  0.104123  0.000000
  0.224176  0.057334  0.012411  0.000000  0.106543  0.000000
  0.269011  0.058130  0.014999  0.000000  0.108963  0.000000
  0.313846  0.058929  0.017623  0.000000  0.111382  0.000000
  0.358681  0.059732  0.020283  0.000000  0.113802  0.000000
  0.403516  0.060538  0.022980  0.000000  0.116222  0.000000
  0.448352  0.061348  0.025712  0.000000  0.118641  0.000000
  0.493187  0.062161  0.028481  0.000000  0.121061  0.000000
  0.538022  0.062977  0.031286  0.052360  0.123481  0.000000
  0.582857  0.063796  0.034128  0.166860  0.125900  0.000000
  0.627692  0.064619  0.037007  0.310356  0.128320  0.000000
  0.672527  0.065445  0.039923  0.461188  0.130740  0.000000
  0.717363  0.066274  0.042875  0.597770  0.133159  0.000000
  0.762198  0.067107  0.045865  0.702875  0.135579  0.000000
  0.807033  0.067943  0.048893  0.771234  0.137999  0.000000
  0.851868  0.068782  0.051958  0.830361  0.140418  0.000000
  0.896703  0.069625  0.055061  0.881678  0.142838  0.000000
  0.941538  0.070471  0.058201  0.930168  0.145258  0.000000
  0.986374  0.071320  0.061380  0.976252  0.147677  0.000000
  1.000000  0.071579  0.062354  1.020257  0.148413  0.000000
  END FTABLE  1
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      1.143        PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL      1.143        IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL      0.76         PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL      0.76         IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL      1.143        RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL      0.5          RCHRES   1     EXTNL  POTEV
WDM      1 EVAP     ENGL      0.76         RCHRES   2     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   2 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   2 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1002 STAG     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1003 FLOW     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
COPY      2 OUTPUT MEAN   1 1      48.4       WDM     702 FLOW      ENGL        REPL
COPY    502 OUTPUT MEAN   1 1      48.4       WDM     802 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        8
RCHRES      OFLOW  OVOL   2                   RCHRES          INFLOW IVOL
  END MASS-LINK    8

  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

  MASS-LINK       15
IMPLND      IWATER SURO        0.083333       COPY            INPUT  MEAN
  END MASS-LINK   15

  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

Disclaimer

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Olympia, WA. 98501
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Local (360)943-0304

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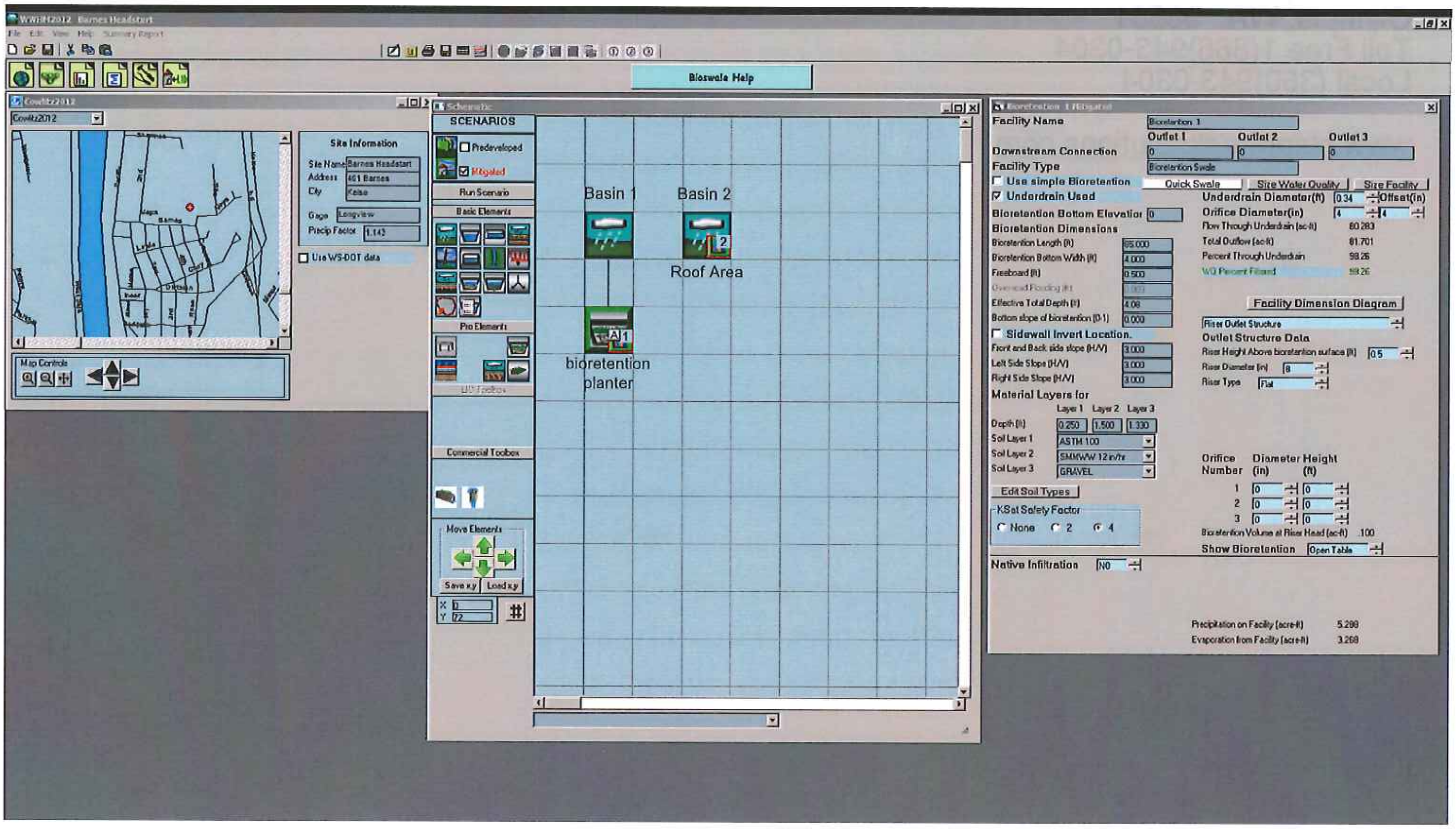
WATER QUALITY



Site Information

Site Name: Barnes Headstart
Address: 401 Barnes
City: Kelso
Gage: Longview
Precip Factor: 1.142
☐ Use WS-DOT data

Facility Name: Bioretention 1

	Outlet 1	Outlet 2	Outlet 3
Downstream Connection	0	0	0

Facility Type: Bioretention Swale
☐ Use simple Bioretention
☑ Underdrain Used
Bioretention Bottom Elevation: 0

Bioretention Dimensions

Bioretention Length (ft): 65.000
Bioretention Bottom Width (ft): 4.000
Freeboard (ft): 0.500
Effective Total Depth (ft): 4.08
Bottom slope of bioretention (0-1): 0.000
☐ Sidewall Invert Location.
Front and Back side slope (H/V): 3.000
Left Side Slope (H/V): 3.000
Right Side Slope (H/V): 3.000

Material Layers for

	Layer 1	Layer 2	Layer 3
Depth (ft)	0.250	1.500	1.330

Soil Layer 1: ASTM 100
Soil Layer 2: SMMWW 12 in/hr
Soil Layer 3: GRAVEL

KSat Safety Factor: ○ None ○ 2 ● 4

Native Infiltration: NO

Underdrain Diameter(ft): 0.34 Offset(in)
Orifice Diameter(in): 4 4
Flow Through Underdrain (ac-ft): 80.283
Total Outflow (ac-ft): 81.701
Percent Through Underdrain: 98.26
WQ Percent Filtered: 98.26

Riser Outlet Structure

Outlet Structure Data

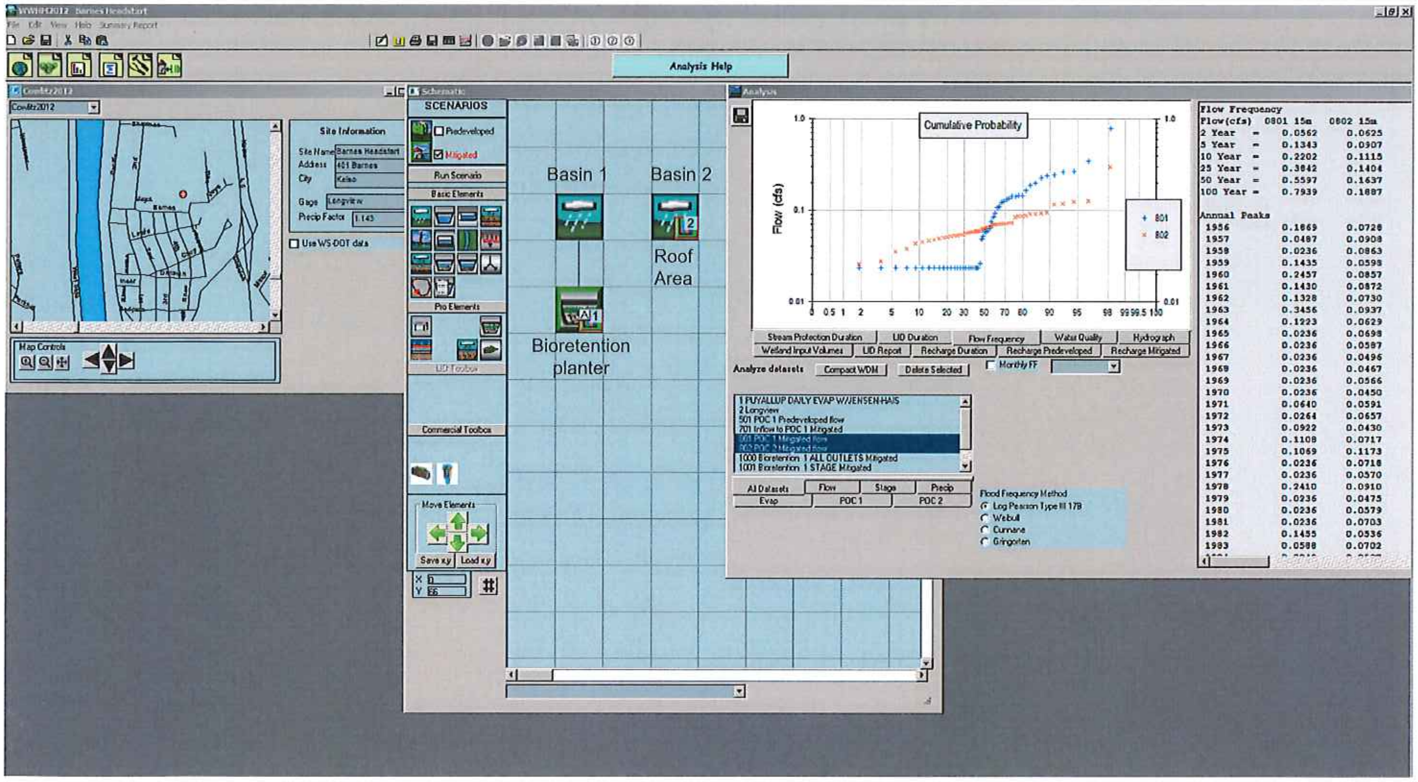
Riser Height Above bioretention surface (ft): 0.5
Riser Diameter (in): 8
Riser Type: Flat

Orifice Number	Diameter (in)	Height (ft)
1	0	0
2	0	0
3	0	0

Bioretention Volume at Riser Head (ac-ft): .100
Show Bioretention: Open Table

Precipitation on Facility (acre-ft): 5.288
Evaporation from Facility (acre-ft): 3.268

FLOW FREQUENCY



Site Information

Site Name: Barnes Headstart
Address: 401 Barnes
City: Kelso
Gage: Longview
Precip Factor: 1.143

☐ Use WS-DOT data

☐ Predeveloped
☑ Mitigated

X: 0
Y: 66

☐ Monthly FF

1 PUYALLUP DAILY EVAP W/JENSEN-HAIS
2 Longview
501 POC 1 Predeveloped flow
701 Inflow to POC 1 Mitigated
801 POC 1 Mitigated flow
802 POC 2 Mitigated flow
1000 Bioretention 1 ALL OUTLETS Mitigated
1001 Bioretention 1 STAGE Mitigated

Flood Frequency Method
● Log Pearson Type III 17B
○ Weibull
○ Cunnane
○ Gringorten

```
Flow Frequency
Flow(cfs)  0801 15m  0802 15m
2 Year   =    0.0562    0.0625
5 Year   =    0.1343    0.0907
10 Year  =    0.2202    0.1115
25 Year  =    0.3842    0.1404
50 Year  =    0.5597    0.1637
100 Year =    0.7939    0.1887

Annual Peaks
 1956         0.1869    0.0728
 1957         0.0487    0.0908
 1958         0.0236    0.0863
 1959         0.1435    0.0598
 1960         0.2457    0.0857
 1961         0.1430    0.0872
 1962         0.1328    0.0730
 1963         0.3456    0.0937
 1964         0.1223    0.0629
 1965         0.0236    0.0698
 1966         0.0236    0.0587
 1967         0.0236    0.0496
 1968         0.0236    0.0467
 1969         0.0236    0.0566
 1970         0.0236    0.0450
 1971         0.0640    0.0591
 1972         0.0264    0.0657
 1973         0.0922    0.0430
 1974         0.1108    0.0717
 1975         0.1069    0.1173
 1976         0.0236    0.0718
 1977         0.0236    0.0570
 1978         0.2410    0.0910
 1979         0.0236    0.0475
 1980         0.0236    0.0579
 1981         0.0236    0.0703
 1982         0.1455    0.0536
 1983         0.0588    0.0702
```