Level 3 Engineering Report

Stormwater Treatment
Best Management Practices
Selection and Design

Fitesa - Washougal
3720 Grant Street
Washougal, Washington, USA 98671

Permitee:	Fitesa Washougal Inc.
Permit Number:	WAR000503
Permit Type:	Industrial Stormwater - General Permit
County:	Clark

May 2016
Project No. 17306.009

Prepared By:

PBS Engineering + Environmental

4412 SW Corbett Avenue, Portland, OR 97239
503.248.1939 Main
866.727.0140 Fax
888.248.1939 Toll-Free
www.pbsenv.com

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INDUSTRIAL STORMWATER GENERAL PERMIT S8.D.3.a REFERENCES

S8.D.3.a The engineering report must include:	Report Sections
i. Brief summary of the treatment alternatives considered and why the proposed option was selected. Include cost estimates of ongoing operation and maintenance, including disposal of any spent media;	Sections 3.3 and 3.4
ii. The basic design data, including characterization of stormwater influent, and sizing calculations of the treatment units;	Sections 3.1, 3.2, and 4.1
iii. A description of the treatment process and operation, including a flow diagram;	Section 4.2
iv. The amount and kind of chemicals used in the treatment process, if any. Note: Use of stormwater treatment chemicals requires submittal of Request for Chemical Treatment Form;	Section 4.3
v. Results to be expected from the treatment process including the predicted stormwater discharge characteristics;	Sections 3.4 and 4.4
vi. A statement, expressing sound engineering justification through the use of pilot plant data, results from similar installations, and/or scientific evidence that the proposed treatment is reasonably expected to meet the permit benchmarks; and	Section 5
vii. Certification by a licensed professional engineer.	Section 5

GENERAL INFORMATION

NAME OF FACILITY:	Fitesa - Washougal
LOCATION OF FACILITY:	3720 Grant Street Washougal, Washington 98671
TYPE OF FACILITY:	Non-woven Fiber Manufacturing
SITE ID CODE:	SIC Code 2297
TYPE OF PERMIT:	Industrial Stormwater – General Permit
PERMIT NUMBER:	WAR000503
COUNTY:	Clark County
SITE AREA:	308,406 square feet (ft^2) (7.08 acres)
IMPERVIOUS AREA:	248,336 ft^2 (5.7 acres)
CHIEF OFFICIAL:	Michael Dolan
TITLE:	Plant Manager
SITE CONTACT NAME:	JD Hisey
SITE CONTACT TITLE:	Environmental Manager
TELEPHONE NO:	360.835.9505
FAX NO:	360.835.2546

1.0 INTRODUCTION

PBS Engineering and Environmental, Inc. has prepared this engineering report to present the selection and design of stormwater best management practices (BMPs) at the Fitesa -Washougal Facility (Fitesa or Facility) in Washougal, Washington. The facility was issued an Industrial Stormwater General Permit (Permit) by the Washington State Department of Ecology (Ecology) on August 21, 2002, and was reissued the permit on December 3, 2014. During the 2015 calendar year, total zinc concentrations of stormwater samples collected in four of the quarters exceeded the respective permit benchmark. Fitesa is required to complete a Level 3 corrective action as a result of these exceedances. This engineering report is consistent with the requirements set forth in S8.D.3.a. of the Level 3 corrective action in the Permit.

2.0 FACILITY ASSESSMENT

2.1 Facility Description

The facility is located at 3720 Grant Street, Washougal, Washington, 98671 (Section 21, Township 1 North, Range 4 East of the Willamette Base and Meridian) and occupies a rectangular site of approximately 7.08 acres in size. Figure 1 illustrates the vicinity map. Land uses within a one-mile radius are predominantly industrial or undeveloped land and waterways.

The site is bordered on the west by 37th Street, on the north by Grant Street, and on the east by a manufacturing facility. To the south is a public access walkway along the Columbia River.

The facility produces non-woven fiber products from polyethylene and polypropylene feedstock. The manufacturing facility was constructed in 1982. The Facility operates continuously on a 24 hours a day, 7 days per week basis.

Approximately 80 percent of the facility's 7.08 acres is impervious. The asphalt paved areas include roads for ingress and egress routes and parking. Impervious areas also include manufacturing building and loading docks, maintenance area, well pump house, and storage silos. Pervious areas include gravel lots and landscape.

2.2 Surface Water Drainage

The facility has one drainage basin from which stormwater is collected. Stormwater falling on the roof or pavement is collected by a series of 10 catch basins that are conveyed through the stormwater system to one collection manhole prior to discharge into the offsite stormwater system. The collection manhole is identified as the discharge point for the facility where stormwater samples are collected. Two paved areas of the facility are graded to discharge toward the property boundary and are not collected by the site stormwater system and sheet flow off site. These areas serve as entrances and parking off of 37th Street and Grant Street. The majority of the eastern portion of the facility is comprised of compacted gravel, and stormwater either infiltrates into the ground or discharges off site as sheet flow. Runoff from a small portion of the manufacturing building’s roof located on the southeast side of the facility is directed to gravel surface on the east side of the facility.

In 2011, Clean Way catch basin filter inserts were installed at catch basins CB-1 through CB-7 and a Clean Way downspout filter unit was installed at a downspout on the south side of the building. Each filter unit includes a three stage filter system: the first stage is a rigid removable strainer, the second is a nonwoven fabric filter, and the third is an adsorption media filter (Metal Zorb). These treatment BMPs are currently in use.

Figure 2 details the general configuration of the stormwater system, catch basin IDs, sub-catchment areas, and locations of the treatment BMPs.

3.0 TREATMENT ALTERNATIVE EVALUATION

Section 3 presents the treatment alternative evaluation for the Level 3 corrective action. Included in this section is the hydrologic analysis and water quality characterization used to size and select the treatment alternatives as required of S8.D.3.a.ii of the Permit. This section also presents the treatment alternatives considered and their corresponding capital and ongoing maintenance and operation costs as required of S8.D.3.a.i.

3.1 Hydrologic Analysis

The hydrologic analysis performed is in accordance with the criteria and guidelines set forth by the Stormwater Management Manual for Western Washington (SWMMWW). Section 4.1.2 of Volume 5 of the SWMMWW requires that stormwater treatment facilities are sized to treat at least 91 percent of the runoff volume as estimated by an approved continuous runoff model. The Western Washington Hydrology Model (WWHM) is a continuous simulation hydrologic model developed and approved by Ecology and was used to size the stormwater treatment system for the facility. The WWHM used 60 years of precipitation data from the National Weather Service's Troutdale, Oregon rain gauge station (KTTD) in Multnomah County. Precipitation data from this rain gauge were imported into the model to represent the local historical rainfall.

The WWHM evaluates both pre- and post-development scenarios where changes in the contributing pervious and impervious areas from the predevelopment scenario are compared to the post development scenario. None of the treatment alternatives considered were expected to significantly change the existing pervious and impervious conditions (i.e., increase the impervious area by more than 0.5 percent) of the facility; therefore, the impervious and pervious contributing areas in pre- and post-development scenarios were the same.

The portion of the facility's manufacturing building's roof that is received by the stormwater system was modeled in WWHM as a 1.794 acre flat top roof. The remaining impervious areas including asphalt paved parking areas and driveways and concrete pads were modeled as a 2.03 acre flat parking area. The facility's landscaped areas and small graveled area along the railroad spurs were modeled as a 0.39 acre flat lawn.

The water quality analysis tool of the WWHM was used to estimate the design flow rates or water quality flow rates corresponding to treating 91 percent of the runoff volume. The water quality analysis tool used the simulated precipitation data and the surface area characterization to estimate the water quality flow rate. The water quality analysis tool estimates water quality flow rates for offline and online facilities. An offline facility is sized to receive and treat the water quality design flow rate to the applicable performance goal. The higher incremental portion of flow rates are bypassed around a treatment facility. Online facilities are sized to route flow rates in excess of the design flow rate provided a net pollutant reduction is maintained. The WWHM-estimated online and offline water quality flow rates are 0.8444 cubic feet per second (cfs) and 0.4763 cfs, respectively. The offline water quality flow rate was used to size the treatment alternatives because the bypassed flows will include peaks of large storm events that are not considered representative of typical stormwater discharges from the site. The WWHM output results are presented in Appendix A.

3.2 Water Quality Characterization

Stormwater samples have been collected from the facility's sample point and analyzed for zinc and other permit-required analytes from the third quarter of 2004 to the second quarter of 2016. These results are presented in Appendix B. Samples collected prior to the second quarter of 2011 reflect untreated stormwater before the Clean Way downspout and catch basin filters were installed. Fitesa will be removing the non-woven Metal Zorb filled filters when the new treatment system is installed to reduce the overall maintenances costs they incur, so data from samples collected prior to the second quarter of 2011 is considered the most representative of the influent water quality and was used to size and select treatment alternatives. Table 1 presents the average concentrations of the parameters analyzed as required of the permit from 2004 to 2011.

Table 1. Water Quality Characterization of Fitesa - Washougal Stormwater

Parameter Statistics	Turbidity (NTU)	Field pH (S.U.)	Total Zinc (ug/L)	Total Copper (ug/L)
Average Concentration	12	NA	271	34

Notes:
NA, Not Applicable

3.3 Preliminary Alternatives

Onsite management of stormwater via infiltration was initially considered as a treatment alternative but based on a preliminary review of the site's soil conditions, available footprint, and Ecology's design requirements for infiltration facilities, this option would have a low probability of success. The on-site soil contains soil group Sauvie silt loam (hydrologic group C/D) per the NRCS Soil Survey provided in Appendix C. Hydrologic soil groups (HSG) C and D have very slow infiltration rates. The capacity of this soil type to transmit water ranges from 0.20 to 0.57 inches per hour (in/hr).

The WWHM was used to determine if the available footprint for the basin would provide enough space for 100 percent infiltration of stormwater on the site. The parking area located on the northeast corner of the site is rarely used by the facility and would be available to site an infiltration basin. The available parking area, an assumed infiltration rate of 0.5 in/hr, and the infiltration basin design criteria specified in Section 3.3.10 of Volume III of the SWMMWW were used to model the infiltration basin. The model results indicated that only 74 percent of runoff from the site could be infiltrated. Appendix A presents the WWHM results. The infiltration basin would either have to be expanded beyond what space is available at the site or the infiltration rate of the soils would have to be two orders of magnitude greater than 0.5 in/hr, which is unlikely given their HSG. On site infiltration testing could provide a field measured infiltration rate if desired; although this is not believed to be necessary at this time.

The infiltration basin must also meet the eight site suitability criteria (SSC) listed in the SWMMWW for infiltration facilities. Based on a preliminary review of the eight SSC, the infiltration basin may not meet the requirements of SSC-6. SSC-6 requires that the base of all infiltration basins or trench systems be greater than or equal to five feet above the groundwater table. A geotechnical investigation performed by URS Corporation for the construction of the nearby Washougal Transfer Station in 2006 measured the groundwater elevation at 13.5 feet mean sea level (MSL). As-built drawings of the Fitesa facility's original construction indicate that the parking area has land elevations ranging between 23 to 19 feet MSL. Consequently, groundwater is expected to be found at a depth of 9.5 to 5.5 feet below ground surface (bgs). In order to maintain a minimum vertical separation of 5 feet, the basin could only be 4.5 to 0.5 feet deep. This would not be sufficient to adequately manage stormwater runoff on-site. Based on these findings, infiltration was not considered for further evaluation.

A gravity flow biofiltration swale (without a pump station) was also initially considered but based on a preliminary review of the design and historical as-built drawings, sufficient elevation drop is not provided on site prior to discharge to the City of Washougal stormwater system. A total elevation drop of approximately four feet would be required for this option assuming the bioswale would be sited along the northern corner of the site along Grant Street. The bioswale design considered was the Washington Department of Transportation (WDOT) Compost Amended Biofiltration Swale (CABS). The current elevation drop available is 0.47 feet from the invert elevation of the existing sampling manhole's outlet pipe to the connection with the Port of Camas Washougal stormwater system. Considering the lack of elevation drop available, this option was not considered for further evaluation.

3.4 Final Alternatives

A total of six final treatment alternatives were considered as possible Level 3 corrective actions for the facility. Alternative 1 would be a multifaceted approach in which the coating of galvanized roof materials and replacement of the galvanized walkways with fiberglass walkways would be completed as a source control measure in addition to installation of Contech StormFilter cartridge catch basin inserts as a treatment BMP.

The remaining alternatives considered are exclusively treatment-based approaches. Alternatives 2 and 3 would pump stormwater to the Aquip above-ground media bed treatment system offered by StormwateRx and differ in how much of the facility's stormwater they each would treat. Alternative 2 would treat all flows from the facility and alternative 3 would only treat stormwater from the west portion of the facility. Alternatives 4 and 5 would pump stormwater to the MWS-Linear biofiltration vault offered by Modular Wetland Systems, Inc (MWS), but would differ in the same manner as alternatives 2 and 3. Alternative 6 would pump stormwater to the WDOT CABS.

Table 2 presents the pollutant reduction analysis used to evaluate the projected treatment performance of alternatives 2, 4, and 6. These three alternatives are centralized treatment options treating runoff from 100 percent of the contributing area from the facility. The total zinc concentration of the stormwater influent was assumed to be the average total zinc concentration of 0.271 mg/L presented in Table 1.

The net total zinc removal for each alternative was researched using data available through the Technology Assessment Protocol - Ecology (TAPE) program. The program provides a peer-reviewed certification process for emerging stormwater treatment technologies. As part of the TAPE certification process, laboratory and field tests are performed on these technologies and the findings from these experiments are made available to the public. The net total zinc removal was estimated using the findings from these TAPE field and laboratory tests performed on the Aquip, MWS, and WDOT CAB treatment systems. All of these alternatives are projected to reduce the total zinc concentration to levels well below the zinc benchmark of 0.117 mg/L.

Table 2. Summary of Projected Pollutant Reduction for Alternatives Treating All On-Site Runoff

Alternative Number	Portion of Facility's Runoff Treated (%)	Total Zinc Concentration (mg/L)[1]	Net Total Zinc Removal (%)	Projected Total Zinc Concentration (mg/L)
2	100%	0.271	76.5%	0.064
4	100%	0.271	73.0%	0.073
6	100%	0.271	82.0%	0.049

Notes:
1. The total zinc concentration for untreated stormwater at the site was estimated by calculating an area-weighted average of zinc concentrations measured from samples collected upstream of existing treatment BMPs.

Table 3 presents the projected pollutant reduction analyses for the remaining alternatives that would only treat a portion of runoff from the facility: alternatives 1, 3, and 5. Alternative 1 is projected to treat runoff from approximately 73 percent of the facility’s contributing area assuming the source control measure will impact the entire roof and the four catch basin filter inserts will treat runoff from their respective sub-catchments. The remaining two alternatives are expected to treat runoff from approximately 50 percent of the facility’s contributing area assuming the treatment systems will only receive influent from the western portion of the facility. The total zinc concentration of the stormwater influent for the treated and untreated portions of the facility was estimated by calculating a weighted average of zinc concentrations measured from stormwater collected upstream of the existing treatment BMPs in each of the site’s eight sub-catchments. Each measured concentration was weighted by the contributing area of the sub-catchment where it was measured. The net total zinc removal for alternatives 3 and 5, and the treatment measure of alternative 1, were estimated using data from the TAPE program.

The estimated reduction associated with the source control measures for alternative 1 was estimated by reviewing two studies: one was published by the Pacific Northwest Pollution Prevention Resource Center (PPRC) and the other by Ecology. The study by PPRC showed that a reduction in zinc from coating galvanized roofing resulted in an average of 96.6 percent reduction in zinc ("Emerging Best Management Practices in Stormwater: Addressing Galvanized Roofing," PPRC, undated). The report "Roofing Materials Assessment: Investigation of Toxic Chemicals in Roof Runoff" produced by Ecology (February 2014, Publication No. 14-03-003) simulated the release of toxins from small pieces (i.e., coupons) of roofing material by coating them and tumbling them in simulated rainwater. Results of the testing for zinc saw that reductions from galvanized roofing ranged from 47 to 91 percent for the various coatings used.

The report identified that the testing methodology was less than perfect. There were problems coating the tabs to the recommended thickness and no primer system was used. The coating thickness averaged 38 percent of the manufacture recommended thickness. Also, the tumbling action caused physical damage to the tabs. Conservatively, PBS has chosen to apply an 80 percent reduction factor after consideration of the results of the two studies and the methods used by the studies to determine the coating’s effectiveness on reduction of zinc levels in roof run-off. The cumulative total zinc removal for alternative 1 was estimated as an average between the level of removal provided by treatment and the level of removal provided by the source control measure.

The projected total zinc concentration after treatment for alternatives 1, 3, and 5, was estimated assuming that zinc would only be reduced in the treated portions of the site. Out of these three alternatives, only alternative 1 is projected to successfully reduce the total zinc concentration to below the benchmark. Table 3 summarizes the projected pollutant removal for alternatives 1, 3, and 5.

Table 3. Summary of Projected Pollutant Reduction for Alternatives Treating a Portion of On-Site Runoff

Alt. Number	Portion of Facility's Runoff Treated (%)	Total Zinc Concentration (mg/L)		Net Total Zinc Removal (%)	Projected Total Zinc Concentration (mg/L)		
		Treated Portion	Untreated Portion		Treated Portion	Untreated Portion	Total Site
1	72.7%	0.363	0.141	73.0%	0.098	0.141	0.110
3	49.8%	0.340	0.265	76.5%	0.080	0.265	0.173
5	49.8%	0.340	0.265	73.0%	0.092	0.265	0.179

Note:
1. The total zinc concentration for untreated stormwater for treated and untreated portions of the facility was estimated by calculating an area-weighted average of zinc concentrations measured from samples collected upstream of existing treatment BMPs.

Table 4 provides the estimated preliminary capital and annual operation and maintenance (O&M) costs for each alternative. The capital costs include both construction and non-construction related costs. Engineering, contractor selection support, permitting, construction support, and contingency funds are included in the non-construction cost estimates for each alternative. Alternatives 2, 3, 4, and 5 would require disposal of spent media and are included in the O&M costs.

Table 4. Treatment Technology Estimated Preliminary Cost Estimates

Alternative	Construction Costs	Non-Construction Costs[1]	Total Capital Costs[2]	Annual O&M Costs[3]
1. *Treatment BMP:* Contech StormFilter Catch Basin Cartridge Treatment Filters *Source Control BMP:* Roof Material Coating and Galvanized Walkway Replacement	$160,000	$50,000	$210,000	$3,000
2. StormwateRx Aquip Above-Ground Media Bed Treatment System (All Site Runoff) with Pump Station	$275,000	$80,000	$355,000	$6,200
3. StormwateRx Aquip Above-Ground Media Bed Treatment System (50% of Site Runoff) with Pump Station[4]	$170,000	$50,000	$220,000	$4,100

Alternative	Construction Costs	Non-Construction Costs[1]	Total Capital Costs[2]	Annual O&M Costs[3]
4. Modular Wetland Systems Linear Biofiltration Vault (All Site Runoff) with Pump Station	$125,000	$35,000	$160,000	$1,200
5. Modular Wetland Systems Linear Biofiltration Vault (50% Site Runoff) with Pump Station[4]	$100,000	$30,000	$130,000	$1,000
6. WDOT Compost Amended Biofiltration Swale with Pump Station	$110,000	$50,000	$160,000	$3,000

Notes:
1. Non-construction costs include construction management, general and administrative expenses, contractor profit, overhead, mechanical and electrical work, engineering, permitting, and survey work, and were estimated as 30 percent of the construction costs.
2. Capital costs were rounded up to the nearest $5,000.
3. Annual operation and maintenance costs were rounded to the nearest $100.
4. Options 3 and 5 are not expected to treat stormwater zinc concentration to below benchmark values.

Alternative 2 is the most expensive option with respect to the capital cost and O&M costs. The equipment cost for the StormwateRx 400S model is the primary factor in this alternative's high cost. Alternative 1 is the second most expensive option and its high cost is primarily due to the source control measures (i.e., coating of galvanized roof ducting and piping and replacement of galvanized walkways). Alternative 5 presents the lowest capital cost and annual O&M costs largely due to the low equipment cost. The lack of proprietary equipment needed to construct the WDOT CABS presents alternative 6 as a low-cost option as well. Fitesa and PBS identified Alternative 4 as the preferred alternative as it is one of the lowest in capital costs, the lowest in O&M costs, is predicted to treat the stormwater to below the permit benchmark, and would have less impact to the parking area due to its smaller footprint when compared to Alternative 6.

4.0 PROPOSED STORMWATER SYSTEM IMPROVEMENTS

Section 4 presents the design of the preferred treatment alternative selected for the Level 3 corrective action.

4.1 Selected Treatment BMP and Sizing Calculations

The MWS Linear treatment system was selected as the treatment BMP for the Level 3 corrective action. The MWS Linear is a biofiltration vault comprised of a pretreatment vault with pretreatment cartridges containing BioMediaGreen media followed by the main chamber containing WetlandMedia. As part of Ecology's findings from the TAPE study, they have recommended the following hydraulic loading rates for the MWS Linear:

- A hydraulic loading rate of 2.1 gallons per minute (gpm) per square foot (sf) of cartridge surface area for pretreatment cartridges.
- A hydraulic loading rate of 1 gpm per sf of wetland media surface area.

Using the offline water quality flow rate of 214 gpm, a MWS that would provide a pretreatment cartridge surface area of approximately 102 square feet and a wetland media surface area of 214 square feet is required. Each pretreatment cartridge housing contains eight individual media filters, each of which provides a surface area of 3.2 square feet. A total of 32 individual media filters are required translating to a total of four cartridge housings. The MWS Linear Model MWS-L-8-16-V would provide a wetland media surface area of 214 square feet (assuming wetland media surface area dimensions of 7.4 feet in width, 15.4 feet in length, and 5.1 feet in height). The MWS Model MWS-L-8-16-V is sized for four pretreatment cartridge housings.

4.2 Treatment Process and Operation

The MWS Linear system requires 16 inches of hydraulic drop to ensure solids are adequately settled in the pretreatment chamber of the treatment system. The site's existing stormwater collection system provides 7.5 inches of hydraulic drop from the outlet of the stormwater manhole to the downstream catch basin, which is not sufficient for operation of the MWS Linear system. A pump station shall be used to lift the stormwater to an elevation that will provide the 16 inch hydraulic drop required of the MWS and is included as part of the stormwater system improvements that will be installed.

The MWS will be preceded by a pump station. The wet well of the pump station will replace the facility's existing sampling manhole. Stormwater collected by the facility's 10 catch basins would enter a 6-foot diameter by 15-foot tall wet well. Stormwater from the wet well would be pumped by one of two 1.5 horsepower (hp) submersible pumps via 3-inch pipes to a valve vault. Each pump will be sized to pump a maximum fixed flow of 220 gpm and a total dynamic head of 19 feet. The pumps will be operated alternately. Stormwater exceeding this flow rate will bypass the treatment system and discharge from the wet well via the existing 15-inch outlet pipe to a manhole downstream of the MWS treatment system. The pump station will include an outdoor rated control panel enclosure and floats to control the level when the pumps are turned off and on.

The valve vault will house the two pump's discharge piping, each of which will be equipped with a check valve and gate valve. Stormwater from the two pipes will combine into a tee fitting and discharge into a single 4-inch pipe. Stormwater from the pumped 4-inch discharge pipe will enter the pretreatment chamber of the MWS treatment system. Stormwater in the pretreatment chamber will be filtered through the four cartridge housings and will discharge into the main chamber of the vault via a 1-inch pipe exiting each cartridge housing. Stormwater will fill the 7-inch void space along the perimeter of the wetland media in the main chamber and will filter through the media towards perforated manifold piping located in the center of the media. Stormwater collected by the manifold piping will discharge to an outlet chamber where discharge flows are restricted by a flow-control riser, ensuring flows do not exceed the designed water quality flow rate. Treated stormwater from the MWS will discharge into the manhole collecting bypassed stormwater flows via the 15-inch pipe. The manhole will connect to the existing piping that discharges offsite and will become the new sampling point for the facility.

Figure 3 provides a plan view of the proposed stormwater improvements for Level 3 corrective action. Figure 4 provides the treatment process flow diagram of the proposed stormwater improvements.

4.3 Use of Chemicals in the Treatment Process

The ISGP requires that the amount and kind of any chemicals used in the proposed treatment process are described in the engineering report for the Level 3 corrective action. The proposed treatment BMP for Fitesa does not use any treatment chemicals.

4.4 Expected Treatment Performance

Modular Wetlands Systems Inc. provided results from pilot plant studies and field tests performed on full scale systems at various locations throughout the United States. These results were from studies performed on three full scale and one pilot study application. The three full scale studies were completed at the City of Oceanside boat wash facility in Oceanside, California, a recycling facility in Kileen Texas, and a City of Portland maintenance yard in Portland, Oregon. Average influent total zinc concentrations between the three facilities ranged from 0.120 ug/L to 0.425 ug/L and effluent ranged from below detection to 0.061 mg/L, respectively. The corresponding percent removals of total zinc ranged between 69 to 86 percent. The influent total zinc concentrations from these facilities are similar to the range of concentrations historically observed at Fitesa; therefore, the range of removal is expected to be similar. Appendix D provides the results from these studies.

Table 5 presents the projected pollutant reduction analyses for the proposed treatment system. Using the total zinc removals presented in the MWS-provided studies, the MWS is projected to reduce total zinc concentrations between 69 to 86 percent. When considering the average total zinc concentration as estimated in Table 1, the MWS would reduce total zinc to below the benchmark at the lower end of the projected removal range.

Table 5. Summary of Projected Pollutant Reduction for the Modular Wetland System Linear Treating Fitesa Stormwater

Parameter Statistics	Total Zinc Concentration (mg/L)	Minimum Projected Total Zinc Removal (%)	Maximum Projected Total Zinc Removal (%)	Projected Maximum Total Zinc Concentration (mg/L)	Projected Minimum Total Zinc Concentration (mg/L)
Average Concentration	0.271	69%	86%	0.084	0.038

5.0 CERTIFICATION BY A LICENSED PROFESSIONAL ENGINEER

The undersigned registered professional engineer (PE) is familiar with the current engineering report requirements set forth in S8.D.a of the Industrial Stormwater Permit issued by the State of Washington Department of Ecology in response to a trigger of Level 3 corrective action. The professional engineer (PE) attests that the necessary treatment BMP that is suited to remove zinc from stormwater runoff with the goal of attaining the zinc benchmark value specified under Section 5 of the Permit, was selected in consultation with the professional engineer (PE).

Name: Sean Hanrahan, PE

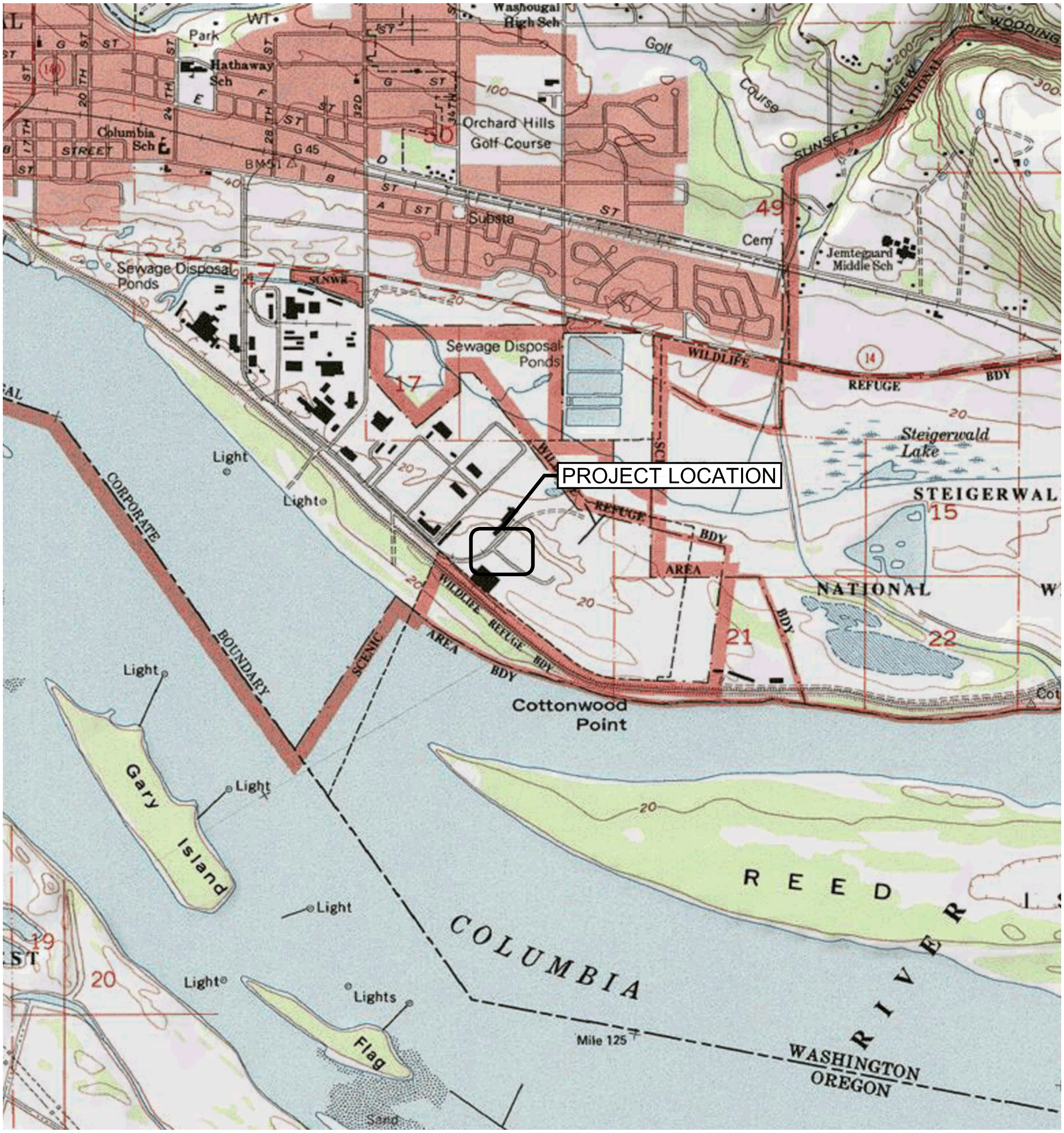
Registration Number: 50726

State: Washington

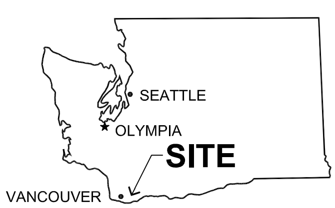
Title, Company: Environmental Engineer
PBS Engineering and Environmental Inc.

Date: 05/11/2016

FIGURES



SOURCE: USGS WASHOUGAL QUADRANGLE, WA. 1994



WASHINGTON

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SCALE: 1" = 2,000'

PREPARED FOR: FITESA - WASHOUGAL

PBS	PROJECT # 17306.001	SITE VICINITY MAP	FIGURE
	DATE AUG 2012	3720 GRANT STREET WASHOUGAL, WASHINGTON	1

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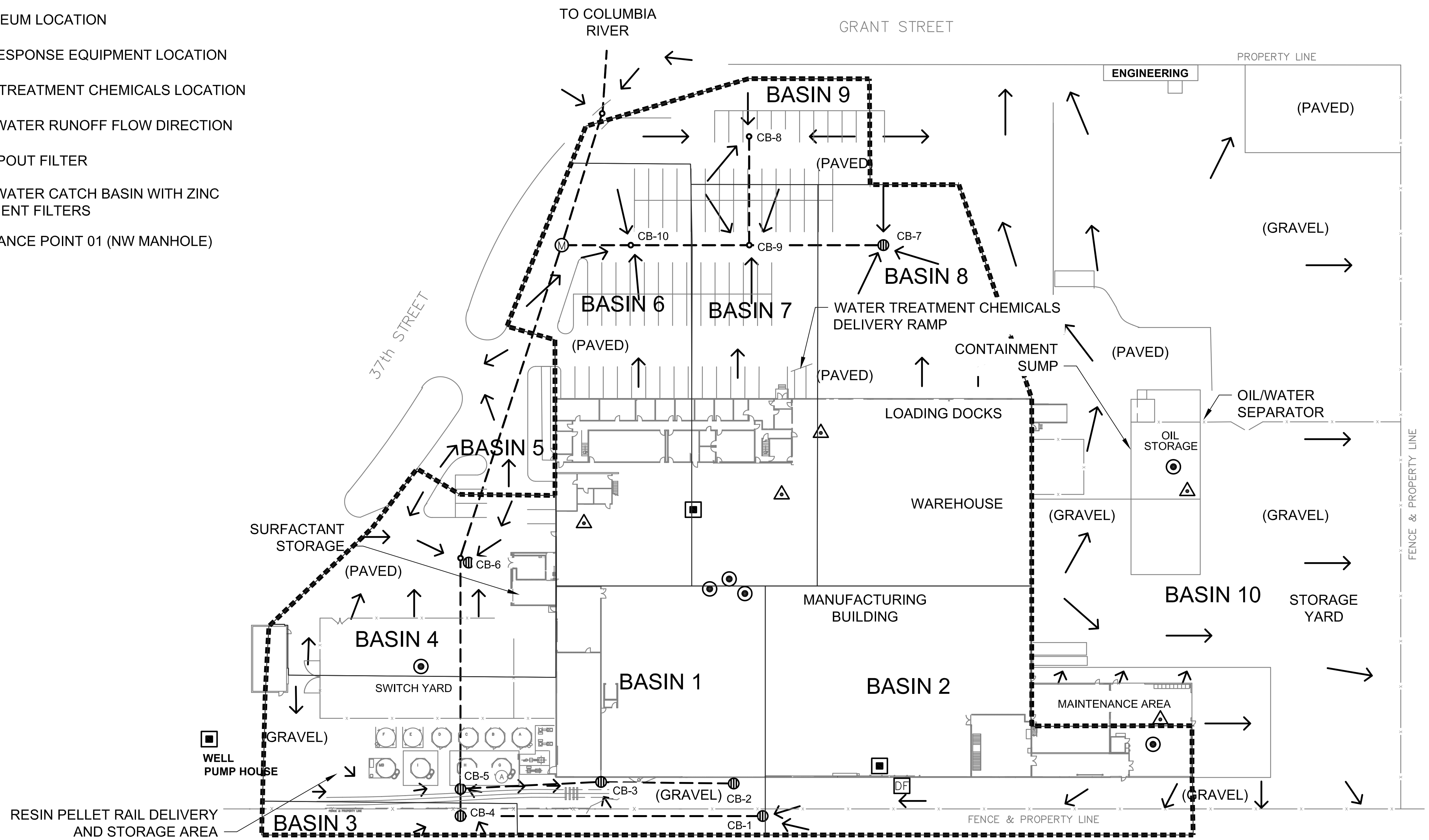
LEGEND

- STORMWATER LINE
- DRAINAGE BASIN BOUNDARY
- SUB-CATCHMENT BOUNDARY
- STORMWATER CATCH BASINS
- PETROLEUM LOCATION
- SPILL RESPONSE EQUIPMENT LOCATION
- WATER TREATMENT CHEMICALS LOCATION
- STORMWATER RUNOFF FLOW DIRECTION
- DF DOWNSPOUT FILTER
- STORMWATER CATCH BASIN WITH ZINC TREATMENT FILTERS
- M COMPLIANCE POINT 01 (NW MANHOLE)



0' 40' 80' 160'

SCALE: 1" = 80'

PREPARED FOR: FITESA - WASHOUGAL

PBS
Engineering + Environmental
4412 SW Corbett Ave
Portland, OR 97239
503.248.1939 Main
866.727.0140 Fax
www.pbsenv.com

FITESA - WASHOUGAL

3720 GRANT STREET
WASHOUGAL, WASHINGTON

STORMWATER DIAGRAM

PROJECT: 17306.009

DATE: MAY 2016

FIGURE: 2

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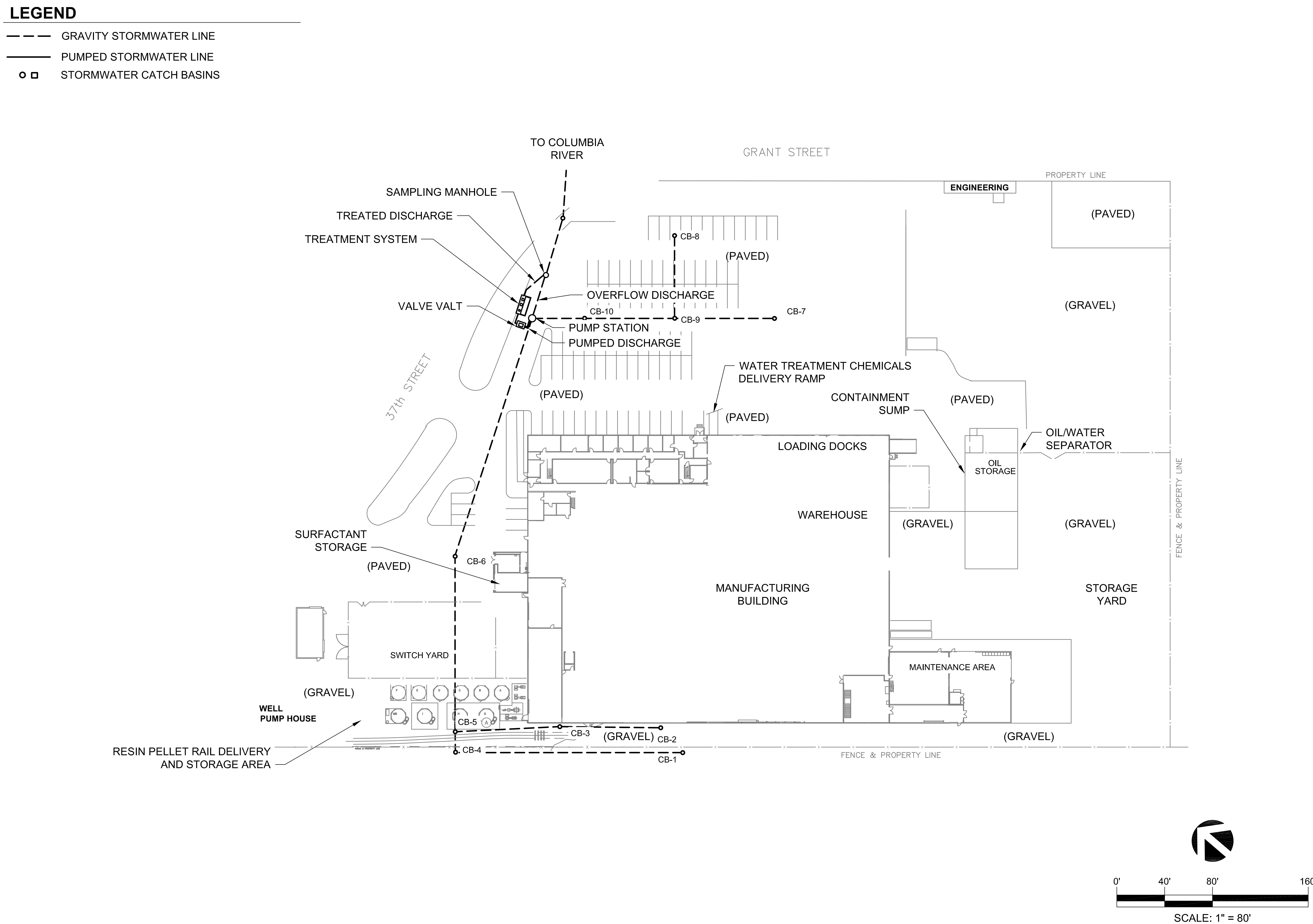

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Engineering + Environmental
4412 SW Corbett Ave
Portland, OR 97239
503.248.1939 Main
866.727.0140 Fax
www.pbsenv.com

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3720 GRANT STREET
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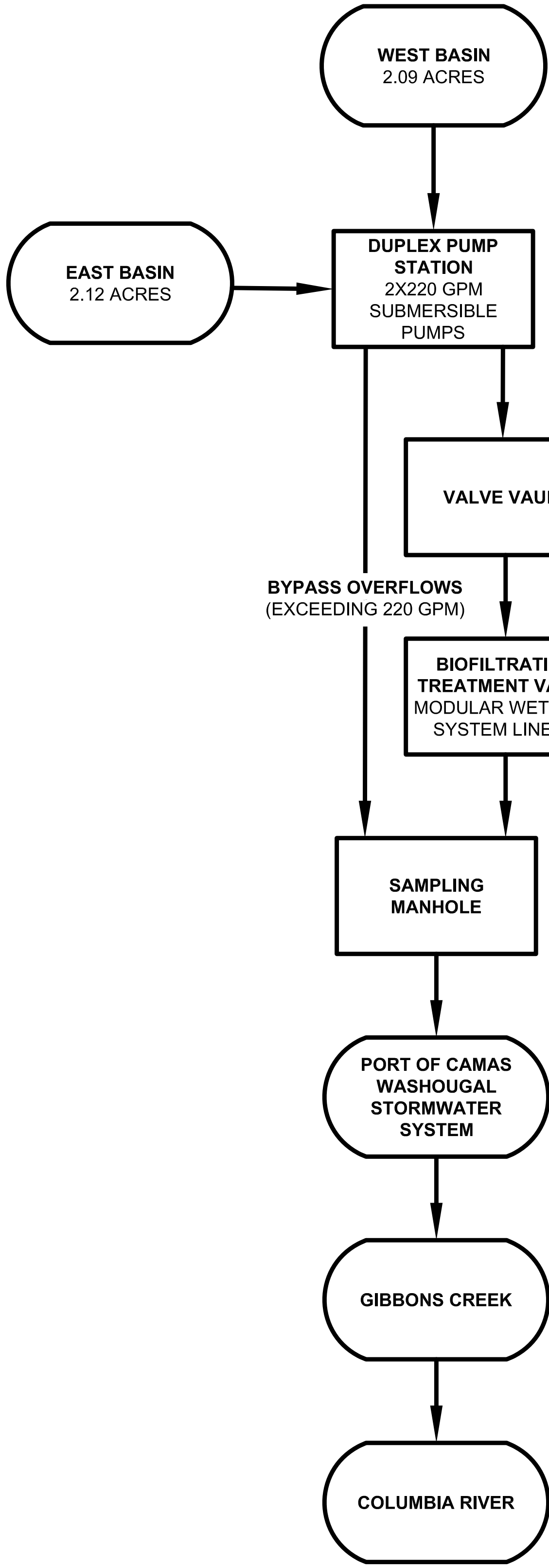
PROPOSED STORMWATER IMPROVEMENTS

PROJECT: 17306.009

DATE: MAY 2016

FIGURE: 3



STORMWATER TREATMENT PROCESS FLOW DIAGRAM

PREPARED FOR: FITESA WASHOUGAL, INC.

PBS	PROJECT # 17306.009	STORMWATER TREATMENT PROCESS	FIGURE
	DATE MAY 2016	FITESA - WASHOUGAL 3720 GRANT STREET WASHOUGAL, WASHINGTON	4

APPENDIX A

Western Washington Hydrology Model Results

WWHM2012
PROJECT REPORT

Project Name: Fitesa_030116
Site Name: Fitesa Washougal
Site Address: 3720 Grant St.
City : Washougal
Report Date: 3/3/2016
Gage : Troutdale
Data Start : 1948/10/01
Data End : 2008/09/30
Precip Scale: 1.37
Version Date: 2015/11/13
Version : 4.2.11

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	.39
Pervious Total	0.39

Impervious Land Use	acre
ROOF TOPS FLAT	1.794
PARKING FLAT	2.03
Impervious Total	3.824
Basin Total	4.214

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Lawn, Flat	**.39**
Pervious Total	**0.39**

Impervious Land Use	**acre**
ROOF TOPS FLAT	**1.794**
PARKING FLAT	**2.03**
Impervious Total	**3.824**
Basin Total	**4.214**

Element Flows To:

Surface	**Interflow**	**Groundwater**

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:0.39
Total Impervious Area:3.824

Mitigated Landuse Totals for POC #1
Total Pervious Area:0.39
Total Impervious Area:3.824

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	2.222192
5 year	2.924345
10 year	3.447491
25 year	4.177567
50 year	4.773774
100 year	5.416824

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	2.222192
5 year	2.924345
10 year	3.447491
25 year	4.177567

50 year	4.773774
100 year	5.416824

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	3.412	3.412
1950	2.041	2.041
1951	1.766	1.766
1952	2.727	2.727
1953	1.833	1.833
1954	2.875	2.875
1955	1.695	1.695
1956	2.564	2.564
1957	1.570	1.570
1958	2.111	2.111
1959	1.563	1.563
1960	2.128	2.128
1961	1.763	1.763
1962	1.768	1.768
1963	2.059	2.059
1964	1.964	1.964
1965	1.831	1.831
1966	1.965	1.965
1967	1.923	1.923
1968	4.152	4.152
1969	3.594	3.594
1970	5.816	5.816
1971	2.814	2.814
1972	2.454	2.454
1973	2.586	2.586
1974	2.091	2.091
1975	1.816	1.816
1976	2.522	2.522
1977	1.527	1.527
1978	2.542	2.542
1979	2.446	2.446
1980	1.655	1.655
1981	1.987	1.987
1982	2.413	2.413
1983	2.470	2.470
1984	2.115	2.115
1985	2.313	2.313
1986	2.364	2.364
1987	1.732	1.732
1988	2.996	2.996
1989	2.241	2.241
1990	1.973	1.973
1991	2.218	2.218
1992	1.650	1.650
1993	3.319	3.319
1994	2.043	2.043
1995	2.518	2.518
1996	3.289	3.289
1997	3.497	3.497
1998	2.713	2.713

1999	1.911	1.911
2000	1.430	1.430
2001	1.658	1.658
2002	2.533	2.533
2003	2.089	2.089
2004	2.710	2.710
2005	2.536	2.536
2006	2.452	2.452
2007	1.778	1.778
2008	6.938	6.938

Stream Protection Duration

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	6.9382	6.9382
2	5.8159	5.8159
3	4.1524	4.1524
4	3.5943	3.5943
5	3.4967	3.4967
6	3.4121	3.4121
7	3.3185	3.3185
8	3.2894	3.2894
9	2.9961	2.9961
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14	2.7104	2.7104
15	2.5859	2.5859
16	2.5637	2.5637
17	2.5416	2.5416
18	2.5362	2.5362
19	2.5327	2.5327
20	2.5216	2.5216
21	2.5179	2.5179
22	2.4696	2.4696
23	2.4540	2.4540
24	2.4524	2.4524
25	2.4459	2.4459
26	2.4135	2.4135
27	2.3642	2.3642
28	2.3134	2.3134
29	2.2409	2.2409
30	2.2184	2.2184
31	2.1278	2.1278
32	2.1146	2.1146
33	2.1112	2.1112
34	2.0913	2.0913
35	2.0888	2.0888
36	2.0587	2.0587
37	2.0433	2.0433
38	2.0413	2.0413
39	1.9873	1.9873
40	1.9732	1.9732
41	1.9651	1.9651
42	1.9640	1.9640

43	1.9228	1.9228
44	1.9111	1.9111
45	1.8326	1.8326
46	1.8312	1.8312
47	1.8163	1.8163
48	1.7785	1.7785
49	1.7680	1.7680
50	1.7661	1.7661
51	1.7629	1.7629
52	1.7320	1.7320
53	1.6952	1.6952
54	1.6583	1.6583
55	1.6550	1.6550
56	1.6500	1.6500
57	1.5699	1.5699
58	1.5631	1.5631
59	1.5272	1.5272
60	1.4300	1.4300

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	**Predev**	**Mit**	**Percentage**	**Pass/Fail**
1.1111	1193	1193	100	Pass
1.1481	1051	1051	100	Pass
1.1851	941	941	100	Pass
1.2221	838	838	100	Pass
1.2591	764	764	100	Pass
1.2961	697	697	100	Pass
1.3331	626	626	100	Pass
1.3701	575	575	100	Pass
1.4071	513	513	100	Pass
1.4441	472	472	100	Pass
1.4811	421	421	100	Pass
1.5181	383	383	100	Pass
1.5551	347	347	100	Pass
1.5921	329	329	100	Pass
1.6291	303	303	100	Pass
1.6660	270	270	100	Pass
1.7030	236	236	100	Pass
1.7400	216	216	100	Pass
1.7770	197	197	100	Pass
1.8140	183	183	100	Pass
1.8510	169	169	100	Pass
1.8880	154	154	100	Pass
1.9250	141	141	100	Pass
1.9620	129	129	100	Pass
1.9990	114	114	100	Pass
2.0360	108	108	100	Pass
2.0730	100	100	100	Pass
2.1100	91	91	100	Pass
2.1470	79	79	100	Pass
2.1840	76	76	100	Pass

2.2210	71	71	100	Pass
2.2580	65	65	100	Pass
2.2950	62	62	100	Pass
2.3320	54	54	100	Pass
2.3690	50	50	100	Pass
2.4060	48	48	100	Pass
2.4430	45	45	100	Pass
2.4800	38	38	100	Pass
2.5170	38	38	100	Pass
2.5540	33	33	100	Pass
2.5910	31	31	100	Pass
2.6280	30	30	100	Pass
2.6650	28	28	100	Pass
2.7020	27	27	100	Pass
2.7390	23	23	100	Pass
2.7759	23	23	100	Pass
2.8129	22	22	100	Pass
2.8499	19	19	100	Pass
2.8869	18	18	100	Pass
2.9239	18	18	100	Pass
2.9609	18	18	100	Pass
2.9979	17	17	100	Pass
3.0349	16	16	100	Pass
3.0719	16	16	100	Pass
3.1089	16	16	100	Pass
3.1459	16	16	100	Pass
3.1829	15	15	100	Pass
3.2199	14	14	100	Pass
3.2569	13	13	100	Pass
3.2939	12	12	100	Pass
3.3309	11	11	100	Pass
3.3679	11	11	100	Pass
3.4049	11	11	100	Pass
3.4419	9	9	100	Pass
3.4789	9	9	100	Pass
3.5159	8	8	100	Pass
3.5529	8	8	100	Pass
3.5899	8	8	100	Pass
3.6269	7	7	100	Pass
3.6639	7	7	100	Pass
3.7009	7	7	100	Pass
3.7379	7	7	100	Pass
3.7749	6	6	100	Pass
3.8119	5	5	100	Pass
3.8489	4	4	100	Pass
3.8859	4	4	100	Pass
3.9228	4	4	100	Pass
3.9598	4	4	100	Pass
3.9968	4	4	100	Pass
4.0338	4	4	100	Pass
4.0708	4	4	100	Pass
4.1078	4	4	100	Pass
4.1448	4	4	100	Pass
4.1818	3	3	100	Pass
4.2188	3	3	100	Pass
4.2558	3	3	100	Pass
4.2928	3	3	100	Pass

4.3298	3	3	100	Pass
4.3668	3	3	100	Pass
4.4038	3	3	100	Pass
4.4408	3	3	100	Pass
4.4778	3	3	100	Pass
4.5148	3	3	100	Pass
4.5518	3	3	100	Pass
4.5888	3	3	100	Pass
4.6258	3	3	100	Pass
4.6628	3	3	100	Pass
4.6998	3	3	100	Pass
4.7368	3	3	100	Pass
4.7738	3	3	100	Pass

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0.5751 **acre-feet**
On-line facility target flow: 0.8444 **cfs.**
Adjusted for 15 min: 0.8444 **cfs.**
Off-line facility target flow: 0.4763 **cfs.**
Adjusted for 15 min: 0.4763 **cfs.**

LID Report

LID Technique	Used for Treatment?	Total Volumn Needs Treatment (ac-ft)	Volumn Through Facility (ac-ft)	Infiltration Volumn (ac-ft.)	Cumulative Volumn Infiltration Credit	Percent Volumn Infiltrated	Water Quality	Percent Water Quality Treated	Comment

Perlnd and Implnd Changes

No changes have been made.

WWHM2012
PROJECT REPORT

Project Name: Fitesa_030116_total winfiltration
Site Name: Fitesa Washougal
Site Address: 3720 Grant St.
City : Washougal
Report Date: 3/15/2016
Gage : Troutdale
Data Start : 1948/10/01
Data End : 2008/09/30
Precip Scale: 1.37
Version Date: 2015/11/13
Version : 4.2.11

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	.39

Pervious Total 0.39

Impervious Land Use	acre
ROOF TOPS FLAT	1.794
PARKING FLAT	2.03

Impervious Total 3.824

Basin Total 4.214

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Lawn, Flat	**.39**

Pervious Total **0.39**

Impervious Land Use	**acre**
ROOF TOPS FLAT	**1.794**
PARKING FLAT	**2.03**

Impervious Total **3.824**

Basin Total **4.214**

Element Flows To:

Surface	**Interflow**	**Groundwater**
Trapezoidal Pond 1	Trapezoidal Pond 1	

Name : Trapezoidal Pond 1
Bottom Length: 300.00 ft.
Bottom Width: 300.00 ft.
Depth: 7 ft.
Volume at riser head: 11.5371 acre-feet.
Infiltration On
Infiltration rate: 0.5
Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft.): 596.628
Total Volume Through Riser (ac-ft.): 208.156
Total Volume Through Facility (ac-ft.): 804.784
Percent Infiltrated: 74.14
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure
Riser Height: 5 ft.
Riser Diameter: 48 in.
Notch Type: Rectangular
Notch Width: 1.000 ft.
Notch Height: 4.500 ft.
Orifice 1 Diameter: 4 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 4 in. **Elevation:** 0 ft.
Orifice 3 Diameter: 4 in. **Elevation:** 0 ft.

Element Flows To:

Outlet 1	**Outlet 2**

Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	2.066	0.000	0.000	0.000
0.0778	2.072	0.160	0.363	1.041
0.1556	2.079	0.322	0.513	1.041
0.2333	2.085	0.484	0.629	1.041
0.3111	2.091	0.646	0.726	1.041
0.3889	2.098	0.809	0.812	1.041
0.4667	2.104	0.973	0.889	1.041
0.5444	2.111	1.137	0.992	1.041
0.6222	2.117	1.301	1.166	1.041
0.7000	2.124	1.466	1.375	1.041
0.7778	2.130	1.632	1.609	1.041
0.8556	2.137	1.798	1.860	1.041
0.9333	2.144	1.964	2.126	1.041
1.0111	2.150	2.131	2.402	1.041
1.0889	2.157	2.299	2.686	1.041
1.1667	2.163	2.467	2.977	1.041
1.2444	2.170	2.635	3.273	1.041
1.3222	2.176	2.804	3.572	1.041
1.4000	2.183	2.974	3.872	1.041
1.4778	2.190	3.144	4.173	1.041
1.5556	2.196	3.315	4.513	1.041
1.6333	2.203	3.486	4.878	1.041
1.7111	2.209	3.657	5.254	1.041
1.7889	2.216	3.829	5.640	1.041
1.8667	2.223	4.002	6.035	1.041
1.9444	2.229	4.175	7.922	1.041
2.0222	2.236	4.349	8.457	1.041
2.1000	2.243	4.523	9.005	1.041
2.1778	2.250	4.698	9.565	1.041
2.2556	2.256	4.873	10.13	1.041
2.3333	2.263	5.049	10.72	1.041
2.4111	2.270	5.225	11.31	1.041
2.4889	2.276	5.402	11.92	1.041
2.5667	2.283	5.579	12.53	1.041
2.6444	2.290	5.757	13.16	1.041
2.7222	2.297	5.936	13.80	1.041
2.8000	2.304	6.115	14.44	1.041
2.8778	2.310	6.294	15.10	1.041
2.9556	2.317	6.474	15.77	1.041
3.0333	2.324	6.655	16.45	1.041
3.1111	2.331	6.836	17.13	1.041
3.1889	2.338	7.017	17.83	1.041
3.2667	2.344	7.199	18.54	1.041
3.3444	2.351	7.382	19.25	1.041
3.4222	2.358	7.565	19.97	1.041
3.5000	2.365	7.749	20.71	1.041
3.5778	2.372	7.933	21.45	1.041
3.6556	2.379	8.118	22.20	1.041
3.7333	2.386	8.303	22.96	1.041
3.8111	2.393	8.489	23.73	1.041
3.8889	2.400	8.676	24.51	1.041
3.9667	2.406	8.863	25.29	1.041
4.0444	2.413	9.050	26.08	1.041

4.1222	2.420	9.238	26.89	1.041
4.2000	2.427	9.427	27.70	1.041
4.2778	2.434	9.616	28.51	1.041
4.3556	2.441	9.805	29.34	1.041
4.4333	2.448	9.996	30.17	1.041
4.5111	2.455	10.18	31.02	1.041
4.5889	2.462	10.37	31.87	1.041
4.6667	2.469	10.57	32.72	1.041
4.7444	2.476	10.76	33.59	1.041
4.8222	2.483	10.95	34.46	1.041
4.9000	2.490	11.14	35.34	1.041
4.9778	2.498	11.34	36.23	1.041
5.0556	2.505	11.53	37.05	1.041
5.1333	2.512	11.73	38.59	1.041
5.2111	2.519	11.92	40.65	1.041
5.2889	2.526	12.12	43.14	1.041
5.3667	2.533	12.32	45.97	1.041
5.4444	2.540	12.51	49.08	1.041
5.5222	2.547	12.71	52.45	1.041
5.6000	2.554	12.91	56.01	1.041
5.6778	2.562	13.11	59.72	1.041
5.7556	2.569	13.31	63.54	1.041
5.8333	2.576	13.51	67.42	1.041
5.9111	2.583	13.71	71.31	1.041
5.9889	2.590	13.91	75.18	1.041
6.0667	2.597	14.11	78.96	1.041
6.1444	2.605	14.31	82.61	1.041
6.2222	2.612	14.52	86.10	1.041
6.3000	2.619	14.72	89.38	1.041
6.3778	2.626	14.93	92.43	1.041
6.4556	2.634	15.13	95.21	1.041
6.5333	2.641	15.33	97.72	1.041
6.6111	2.648	15.54	99.94	1.041
6.6889	2.655	15.75	101.8	1.041
6.7667	2.663	15.95	103.5	1.041
6.8444	2.670	16.16	105.0	1.041
6.9222	2.677	16.37	106.3	1.041
7.0000	2.685	16.58	107.5	1.041
7.0778	2.692	16.79	109.6	1.041

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:0.39
Total Impervious Area:3.824

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

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	2.222192
5 year	2.924345
10 year	3.447491
25 year	4.177567
50 year	4.773774
100 year	5.416824

Flow Frequency Return Periods for Mitigated. POC #1

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1955	1.695	1.695
1956	2.564	2.564
1957	1.570	1.570
1958	2.111	2.111
1959	1.563	1.563
1960	2.128	2.128
1961	1.763	1.763
1962	1.768	1.768
1963	2.059	2.059
1964	1.964	1.964
1965	1.831	1.831
1966	1.965	1.965
1967	1.923	1.923
1968	4.152	4.152
1969	3.594	3.594
1970	5.816	5.816
1971	2.814	2.814
1972	2.454	2.454
1973	2.586	2.586
1974	2.091	2.091
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1976	2.522	2.522
1977	1.527	1.527
1978	2.542	2.542
1979	2.446	2.446
1980	1.655	1.655
1981	1.987	1.987

1982	2.413	2.413
1983	2.470	2.470
1984	2.115	2.115
1985	2.313	2.313
1986	2.364	2.364
1987	1.732	1.732
1988	2.996	2.996
1989	2.241	2.241
1990	1.973	1.973
1991	2.218	2.218
1992	1.650	1.650
1993	3.319	3.319
1994	2.043	2.043
1995	2.518	2.518
1996	3.289	3.289
1997	3.497	3.497
1998	2.713	2.713
1999	1.911	1.911
2000	1.430	1.430
2001	1.658	1.658
2002	2.533	2.533
2003	2.089	2.089
2004	2.710	2.710
2005	2.536	2.536
2006	2.452	2.452
2007	1.778	1.778
2008	6.938	6.938

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
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6	3.4121	3.4121
7	3.3185	3.3185
8	3.2894	3.2894
9	2.9961	2.9961
10	2.8747	2.8747
11	2.8145	2.8145
12	2.7272	2.7272
13	2.7131	2.7131
14	2.7104	2.7104
15	2.5859	2.5859
16	2.5637	2.5637
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21	2.5179	2.5179
22	2.4696	2.4696
23	2.4540	2.4540
24	2.4524	2.4524
25	2.4459	2.4459

26	2.4135	2.4135
27	2.3642	2.3642
28	2.3134	2.3134
29	2.2409	2.2409
30	2.2184	2.2184
31	2.1278	2.1278
32	2.1146	2.1146
33	2.1112	2.1112
34	2.0913	2.0913
35	2.0888	2.0888
36	2.0587	2.0587
37	2.0433	2.0433
38	2.0413	2.0413
39	1.9873	1.9873
40	1.9732	1.9732
41	1.9651	1.9651
42	1.9640	1.9640
43	1.9228	1.9228
44	1.9111	1.9111
45	1.8326	1.8326
46	1.8312	1.8312
47	1.8163	1.8163
48	1.7785	1.7785
49	1.7680	1.7680
50	1.7661	1.7661
51	1.7629	1.7629
52	1.7320	1.7320
53	1.6952	1.6952
54	1.6583	1.6583
55	1.6550	1.6550
56	1.6500	1.6500
57	1.5699	1.5699
58	1.5631	1.5631
59	1.5272	1.5272
60	1.4300	1.4300

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
1.1111	1193	1193	100	Pass
1.1481	1051	1051	100	Pass
1.1851	941	941	100	Pass
1.2221	838	838	100	Pass
1.2591	764	764	100	Pass
1.2961	697	697	100	Pass
1.3331	626	626	100	Pass
1.3701	575	575	100	Pass
1.4071	513	513	100	Pass
1.4441	472	472	100	Pass
1.4811	421	421	100	Pass
1.5181	383	383	100	Pass
1.5551	347	347	100	Pass

1.5921	329	329	100	Pass
1.6291	303	303	100	Pass
1.6660	270	270	100	Pass
1.7030	236	236	100	Pass
1.7400	216	216	100	Pass
1.7770	197	197	100	Pass
1.8140	183	183	100	Pass
1.8510	169	169	100	Pass
1.8880	154	154	100	Pass
1.9250	141	141	100	Pass
1.9620	129	129	100	Pass
1.9990	114	114	100	Pass
2.0360	108	108	100	Pass
2.0730	100	100	100	Pass
2.1100	91	91	100	Pass
2.1470	79	79	100	Pass
2.1840	76	76	100	Pass
2.2210	71	71	100	Pass
2.2580	65	65	100	Pass
2.2950	62	62	100	Pass
2.3320	54	54	100	Pass
2.3690	50	50	100	Pass
2.4060	48	48	100	Pass
2.4430	45	45	100	Pass
2.4800	38	38	100	Pass
2.5170	38	38	100	Pass
2.5540	33	33	100	Pass
2.5910	31	31	100	Pass
2.6280	30	30	100	Pass
2.6650	28	28	100	Pass
2.7020	27	27	100	Pass
2.7390	23	23	100	Pass
2.7759	23	23	100	Pass
2.8129	22	22	100	Pass
2.8499	19	19	100	Pass
2.8869	18	18	100	Pass
2.9239	18	18	100	Pass
2.9609	18	18	100	Pass
2.9979	17	17	100	Pass
3.0349	16	16	100	Pass
3.0719	16	16	100	Pass
3.1089	16	16	100	Pass
3.1459	16	16	100	Pass
3.1829	15	15	100	Pass
3.2199	14	14	100	Pass
3.2569	13	13	100	Pass
3.2939	12	12	100	Pass
3.3309	11	11	100	Pass
3.3679	11	11	100	Pass
3.4049	11	11	100	Pass
3.4419	9	9	100	Pass
3.4789	9	9	100	Pass
3.5159	8	8	100	Pass
3.5529	8	8	100	Pass
3.5899	8	8	100	Pass
3.6269	7	7	100	Pass
3.6639	7	7	100	Pass

3.7009	7	7	100	Pass
3.7379	7	7	100	Pass
3.7749	6	6	100	Pass
3.8119	5	5	100	Pass
3.8489	4	4	100	Pass
3.8859	4	4	100	Pass
3.9228	4	4	100	Pass
3.9598	4	4	100	Pass
3.9968	4	4	100	Pass
4.0338	4	4	100	Pass
4.0708	4	4	100	Pass
4.1078	4	4	100	Pass
4.1448	4	4	100	Pass
4.1818	3	3	100	Pass
4.2188	3	3	100	Pass
4.2558	3	3	100	Pass
4.2928	3	3	100	Pass
4.3298	3	3	100	Pass
4.3668	3	3	100	Pass
4.4038	3	3	100	Pass
4.4408	3	3	100	Pass
4.4778	3	3	100	Pass
4.5148	3	3	100	Pass
4.5518	3	3	100	Pass
4.5888	3	3	100	Pass
4.6258	3	3	100	Pass
4.6628	3	3	100	Pass
4.6998	3	3	100	Pass
4.7368	3	3	100	Pass
4.7738	3	3	100	Pass

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0 **acre-feet**
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**

LID Report

LID Technique Used for Total Volumn Volumn Infiltration Cumulative
Percent Water Quality Percent Comment
Treatment? Needs Through Volumn Volumn
Volumn Water Quality
Treatment Facility (ac-ft.) Infiltration
Infiltrated Treated
(ac-ft) (ac-ft) Credit
Total Volume Infiltrated 0.00 0.00 0.00 0.00
0.00 0% No Treat. Credit
Compliance with LID Standard 8
Duration Analysis Result = Passed

Perlnd and Implnd Changes

No changes have been made.

___

APPENDIX B

Fitesa Historical Stormwater Quality Data

PBS Engineering + Environmental

Fitesa Washougal - Stormwater Results
Washington State Industrial Stormwater General Permit
Permit No. WAR-000503
PBS Project No. 17306.008
Compliance Point 01: NW Manhole

Table 1: Cumulative Stormwater Permit Monitoring Data Summary

		Turbidity (NTU)	Field pH (S.U.)	Lab pH (S.U.)	Total Zinc (ug/l)	Total Copper (ug/l)	Oil Sheen (Yes/No)	Field Temp (deg F)
	Benchmark	**25**	**5.0 - 9.0**	**5.0 - 9.0**	**117**	**14**	**No**	**-**
YEAR	QTR							
2004	3rd	3.8	6.65	6.60	**285**	NA		66.38
2004	4th	12	5.4	5.30	**140**	6.7		54.86
2005	1st	**45**	8.3	6.90	**258**	15.8		57.6
2005	2nd	3.2	7.03	6.10	**420**	18		62.2
2005	3rd	**32**	7.03	7.30	**162**	**66.6**		65.1
2005	4th	2.3	7.03	6.80	**160**	ND		50
2006	1st	3.6	7.88	6.80	110	ND		50
2006	2nd	2.87	8.65	6.79	**138**	5.03		63
2006	3rd	20.9	6.22	6.54	**589**	46.2		70.2
2006	4th	17	8.05	7.20	81.4	7.97		NA
2007	1st	5	8.4	6.97	**141**	<5		44.6
2007	2nd	5.32	10.75	6.94	**200**	10.3		55.8
2007	3rd	23	8.4	6.54	**1080**	**97.2**		71.8
2007	4th	NA	NA	6.29	109	<5		NA
2008	1st	2	7.79	6.79	**174**	5.44		47.5
2008	2nd	3.9	8.5	6.70	**203**	5.62		58.5
2008	3rd	NA	NA	NA	NA	NA		NA
2008	4th	4.7	5.72	6.65	**219**	7.99		56.5
2009	1st	6.3	9.35	6.45	**282**	1		48.4
2009	2nd	4.9	7.29	6.64	**149**	<5.00		8.3
2009	3rd	18	7.01	NA	**443**	22.4		14.3
2009	4th	15	7.00	7.00	**150**	<5.00		NA
2010	1st	10	6.00	NA	**174**	<4.0	No	NA
2010	2nd	**30**	5.80	NA	**344**	**277**	No	51.3
2010	3rd	19	6.20	NA	87.9	8.61	No	NA
2010	4th	13	6.40	NA	**349**	10	No	NA
2011	1st	5.3	6.10	NA	**589**	7.2	No	NA
2011	2nd	1.5	5.80	NA	**224**	**21.3**	No	NA
2011	3rd	NA	NA	NA	NA	NA	NA	NA
2011	4th: Nov 16	4.1	6.5	6.90	**175**	ND	No	NA
2011	4th: Dec 15	2.2	5.00	6.76	**306**	ND	No	NA
2012	1st	4.8	6.80	6.99	114	4.30	No	NA
2012	2nd	3.4	6.30	6.97	106	ND	No	NA
2012	3rd	NA	NA	NA	NA	NA	NA	NA
2012	4th	1.3	6.75	6.44	87.3	2.02	No	NA
2013	1st	13	6.20	6.80	**129**	3.34	No	NA
2013	2nd	4.4	6.78	6.61	99.3	2.26	No	56.8
2013	3rd	2.4	6.55	NA	113	5.08	No	63.7
2013	4th	NA	NA	NA	**169**	3.63	No	NA
2014	1st	NA	NA	NA	95.5	6.52	No	NA
2014	2nd	12.65	NA	NA	**153**	NA	No	NA
2014	3rd	NA	NA	NA	**145**	NA	No	NA
2014	4th	NA	NA	NA	111	NA	No	NA
2015	1st	NA	NA	NA	**135**	NA	No	NA
2015	2nd	NA	NA	NA	**221**	NA	No	NA
2015	3rd	NA	6.55	NA	**344**	NA	No	NA
2015	4th	NA	NA	NA	**189**	NA	No	NA
2016	1st	NA	NA	NA	**127**	NA	No	NA
2016	2nd	NA	NA	NA	**134**	NA	No	NA
2016	3rd							
2016	4th							

Notes: < = Not Detected at the Specified Method Reporting Limit (MDL)
NA = Not Applicable

APPENDIX C

NRCS Soil Group Report

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

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

Custom Soil Resource Report for

Clark County, Washington

Fitesa

February 16, 2016

Preface

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

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

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

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

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

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

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Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

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

Soil Map

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

Soil Map

Map Scale: 1:2,080 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 30, 60, 120, 180

Feet: 0, 100, 200, 400, 600

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

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

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Clark County, Washington
Survey Area Data: Version 13, Sep 14, 2015

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

Date(s) aerial images were photographed: Jul 8, 2010—Sep 4, 2011

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

Map Unit Legend

Clark County, Washington (WA011)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
SnA	Sauvie silt loam, sandy substratum, 0 to 3 percent slopes	9.4	100.0%
Totals for Area of Interest		**9.4**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

Clark County, Washington

SnA—Sauvie silt loam, sandy substratum, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2dzr
Elevation: 10 to 20 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 52 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

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

Description of Sauvie

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 15 inches: silt loam
H2 - 15 to 36 inches: silty clay loam
H3 - 36 to 60 inches: stratified sandy loam to silt loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: Frequent
Frequency of ponding: None
Available water storage in profile: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: C/D
Other vegetative classification: Soils with Few Limitations (G002XV502WA)

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

APPENDIX D

Modular Wetland Systems Linear Treatment Performance Data

PERFORMANCE SUMMARY

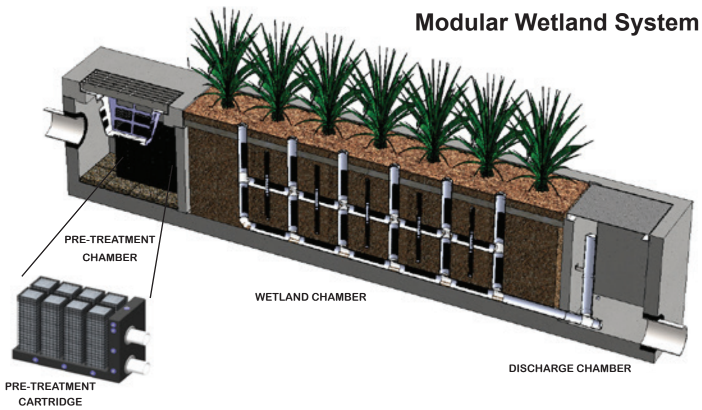
MWS-LINEAR 2.0

Application: Stand Alone Stormwater Treatment Best Management Practice
Type of Treatment: High Flow Rate Media Filtration and Biofiltration (dual-stage)

DESCRIPTION

Modular Wetland System Linear 2.0 (MWS-L 2.0) is an advanced dual-stage high flow rate media and biofiltration system for the treatment of urban stormwater runoff. Superior pollutant removal efficiencies are achieved by treating runoff through a pre-treatment chamber containing a screening device for trash and larger debris, a separation chamber for larger TSS and a series of media filter cartridges for removal of fine TSS and other particulate pollutants. Pre-treated runoff is transferred to the biofiltration chamber which contains an engineered ion exchange media designed to support an abundant plant and microbe community that captures, absorbs, transforms and uptakes pollutants through an array of physical, chemical, and biological mechanisms.

MWS-L 2.0 is a self-contained treatment train that is supplied to the job site completely assembled and ready for use. Once installed, stormwater runoff drains directly from impervious surfaces through an built-in curb inlet, drop in, or via pipe from upstream inlets or downspouts. Treated runoff is discharged from the system through an orifice control riser to assure the proper amount of flow is treated. The treated water leaving the system is connected to the storm drain system, infiltration basins, or to be re-used on site for irrigation or other uses.



Modular Wetland System Linear 2.0 (MWS-L 2.0) has been independently tested in laboratory and field conditions since 2008.

Oceanside Test Site

Portland Test Site

HEAVY METALS: Copper / Zinc

Description	Type	Avg. Influent (mg/L)	Avg. Effluent (mg/L)	Removal Efficiency	Notes
Waves Environmental - 1/4 Scale Lab Testing - 2007	Lab	.76 / .95	.06 / .19	92% / 80%	Majority Dissolved Fraction
City of Oceanside Boat Wash / Waves Environmental - 2008	Field	.04 / .24	< .02 / < .05	>50% / >79%	Effluent Concentrations Below Detectable Limits
Recycling Facility, Kileen, TX / CERL - 2011-2012	Field	.058 / .425	.032 / .061	44% / 86%	Test Unit 2
TAPE Field Testing / Portland, OR 2011/2012	Field	.017/ .120	.009 / .038	50% / 69%	Total Metals

TOTAL SUSPENDED SOLIDS:

Description	Type	Avg. Influent (mg/L)	Avg. Effluent (mg/L)	Removal Efficiency	Notes
Waves Environmental - 1/4 Scale Lab Testing - 2007	Lab	270	3	99%	Sil-co-sil 106 - 20 micron mean particle size
City of Oceanside Boat Wash / Waves Environmental - 2008	Field	45.67	8.24	82%	Mean Particle Size by Count < 8 Microns
Recycling Facility, Kileen, TX / CERL - 2011-2012	Field	676	39	94%	Test Unit 2
TAPE Field Testing / Portland, OR 2011/2012	Field	75.0	15.7	85%	Means particle size of 8 microns

Modular Wetland System, Inc.
2972 San Luis Rey Rd
Oceanside, CA 92058

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www.modularwetlands.com
P 760-433-7640
F 760-433-3179

PERFORMANCE SUMMARY

MWS-LINEAR 2.0

PHOSPHORUS:

Description	Type	Avg. Influent (mg/L)	Avg. Effluent (mg/L)	Removal Efficiency	Notes
TAPE Field Testing / Portland, OR 2011/2012	Field	.227	.074	64%	TOTAL P
TAPE Field Testing / Portland, OR 2011/2012	Field	.093	.031	67%	ORTHO P

BACTERIA:

Description	Type	Avg. Influent (MPN)	Avg. Effluent (MPN)	Removal Efficiency	Notes
Waves Environmental - 1/4 Scale Lab Testing - 2007	Lab	1600 / 1600	535 / 637	67% / 60%	Fecal / E. Coli
City of Oceanside Boat Wash / Waves Environmental - 2008	Field	31666 / 6280	8667 / 1058	73% / 83%	Fecal / E. Coli

LEAD:

Description	Type	Avg. Influent (mg/L)	Avg. Effluent (mg/L)	Removal Efficiency	Notes
Waves Environmental - 1/4 Scale Lab Testing - 2007	Lab	.54	.10	82%	Total
Recycling Facility, Kileen, TX / CERL - 2011-2012	Field	.01 / .043	.004 / .014	60% / 68%	Both Test Units
TAPE Field Testing / Portland, OR 2011/2012	Field	.011	.003	70%	Total

All removal efficiencies and concentrations rounded up for easy viewing. Please call us for more information, including full copies of the reports reference above.

NITROGEN:

Description	Type	Avg. Influent (mg/L)	Avg. Effluent (mg/L)	Removal Efficiency	Notes
City of Oceanside Boat Wash / Waves Environmental - 2008	Field	.85	.21	75%	NITRATE
TAPE Field Testing / Portland, OR 2011/2012	Field	1.40	0.77	45%	TKN

HYDROCARBONS:

Description	Type	Avg. Influent (mg/L)	Avg. Effluent (mg/L)	Removal Efficiency	Notes
Waves Environmental - 1/4 Scale Lab Testing - 2007	Lab	10	1.625	84%	Oils & Grease
City of Oceanside Boat Wash / Waves Environmental - 2008	Field	.83	0	100%	TPH Motor Oil
TAPE Field Testing / Portland, OR 2011/2012	Field	24.157	1.133	95%	Motor Oil

TURBIDITY:

Description	Type	Avg. Influent (NTU)	Avg. Effluent (NTU)	Removal Efficiency	Notes
Waves Environmental - 1/4 Scale Lab Testing - 2007	Lab	21	1.575	93%	Field Measurement
City of Oceanside Boat Wash / Waves Environmental - 2008	Field	21	6	71%	Field Measurement

COD:

Description	Type	Avg. Influent (mg/L)	Avg. Effluent (mg/L)	Removal Efficiency	Notes
Recycling Facility, Kileen, TX / CERL - 2011-2012	Field	516 / 1450	90 / 356	83% / 75%	Both Test Units

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