Draft

Stormwater Level 3 Response Engineering Report

Boat Haven Boatyard at 2790 Washington Street Port Townsend, WA

Prepared for

PORT OF PORT TOWNSEND

December 2016

Prepared by

Parametrix

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CERTIFICATION

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

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KEY TERMS

AKART	all known, available, and reasonable methods of treatment
Aquip®	StormwateRx® Aquip®
bgs	below ground surface
BMP	Best Management Practice
Boatyard	Port Townsend Boat Haven Boatyard
BSM	bioretention soil mix
CESF	Chitosan Enhanced Sand Filtration
cfs	cubic feet per second
CPFC	Chemical Precipitation/Flocculation/ Clarification
Cu	copper
CULD	Conditional Use Level Designation
Ecology	Department of Ecology
EOPC	engineer's opinion of probable cost
EPA	Environmental Protection Agency
gpm	gallons per minute
HDPE	high density polyethylene
HPA	Hydraulic Project Approval
HSPF	Hydrological Simulation Program-Fortran
I&I	infiltration and inflow
in/hr	inches/hour
MGS	MGS Engineering Consultants, Inc.
MODRET	Computer MODel to Design RETention Ponds
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NSBB	Nutrient Separating Baffle Box
PCBs	polychlorinated biphenyls
Permit	Boatyard General Permit
PIT	pilot infiltration test
Port	Port of Port Townsend
PTMTA	Port Townsend Marine Trades Association
SEPA	State Environmental Policy Act

KEY TERMS (CONTINUED)

SIC	Standard Industrial Code
SWMMWW	Stormwater Management Manual for Western Washington
SWPPP	Stormwater Pollution Prevention Plan
TP	test pit
TSS	total suspended solids
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WWHM12	Western Washington Hydrology Model 2012
WWTP	Wastewater Treatment Plant
Zn	zinc

1. INTRODUCTION

This Engineering Report has been prepared for the Port of Port Townsend's Boat Haven Boatyard property (Boatyard). An Administrative Order (Order Docket No. 13279), issued by the Department of Ecology (Ecology) on June 17, 2016, requires the Port of Port Townsend (Port) to complete an engineering report per Washington Administrative Code (WAC) 173-240-130 addressing the requirements for a Level Three Response under the Boatyard General Permit. The purpose of this report is to evaluate, select, and design (conceptually) stormwater Best Management Practice (BMP) improvements and identify a preferred option that represents all known, available, and reasonable methods of treatment (AKART) for pollution prevention and control.

This report follows WAC 173-240-130 and the General Boatyard Permit Level Three Response requirements which include:

- Background information, including summary of previous studies and engineering reports.
- Description of Boatyard facilities and operations.
- Description of existing stormwater drainage, conveyance, and treatment systems.
- Stormwater sources and characteristics.
- Evaluation, comparison, and selection of stormwater BMPs.
- Stormwater flow modeling and design analysis.
- Proposed stormwater improvements and discharge location.
- Biofiltration basin modelling, sizing, and conceptual design.
- Stormwater improvement implementation plan.

The WAC 173-240-130 checklist is included in Appendix A. Not all requirements listed are applicable because this Engineering Report addresses the treatment of stormwater, not wastewater.

2. BACKGROUND

The Port Townsend Boat Haven Boatyard is located at 2790 Washington Street in Port Townsend, Washington. A vicinity map is provided in Figure 1 (all figures are included at the end of the report). The approximately 20-acre Boatyard is Washington State's largest open and publicly accessible yard and hosts businesses that employ more than 400 skilled marine trade workers. The existing Boatyard stormwater collection and treatment system employs a combination of vaults, perimeter sand filters, StormwateRx® Aquip® (Aquip®) treatment units, experimental biochar downspout units, and in-ground treatment trenches to treat stormwater before discharging it to Port Townsend Bay. Figure 2 provides a site plan showing drainage basins and outfall locations.

The current Boatyard General Permit (Permit) was issued by Ecology on July 6, 2016, in accordance with the National Pollutant Discharge Elimination System (NPDES) and went into effect on August 8, 2016. The Permit requires that water quality sampling of qualifying storm events be conducted during 5 months of the year at the point of discharge. The Boatyard Permit also establishes "benchmark" concentrations for total copper and total zinc, with increasing levels of response actions (i.e., Level One, Level Two, and Level Three) being required based on the number of times the benchmarks are

exceeded. A Level Three response action was triggered by the Boatyard under the previous Boatyard Permit (effective date of June 1, 2011) due to seven exceedances of the zinc benchmark at Outfall A.

A Level Three Response Engineering Report was developed and submitted to Ecology in December 2013 in response to benchmark exceedances (Landau 2013). The engineering report recommended improvements to the existing perimeter sand filters to maximize the volume of treated stormwater and increase metals removal. The engineering report also recommended that improvements be made to the four existing sedimentation vaults through removal of existing orifice restrictions and/or addition of oyster shell filtration media. The Port subsequently implemented improvements to the sand filters and initiated other enhancements to source control BMPs. However, despite these efforts, the Boatyard continues to exceed benchmarks for both copper and zinc.

In June 2016, Ecology issued an Administrative Order (Order Docket No. 13279) requiring a revised engineering report to further evaluate improvements to stormwater BMPs with the objective of attaining permit benchmarks for regulated constituents (i.e., copper and zinc). The Administrative Order requires implementation of the preferred stormwater BMPs identified in the engineering report (and approved by Ecology) by September 30, 2017.

3. DESCRIPTION OF FACILITY AND OPERATION

3.1 Boatyard Facilities

Activities at the Boatyard include marine vessel repairs and new marine vessel construction conducted by both boat owners and by marine trade industries. These activities fall under the Standard Industrial Code (SIC) No. 3732, Boat Building and Repairing. The Boatyard also includes marine supply and equipment businesses and small restaurants.

Most of the Boatyard ground surface is covered with crushed gravel and ballast material. Some boat repair and maintenance occurs in buildings or under temporary covers, but most work is conducted outdoors on the gravel surface. Two wash-down areas are used for bottom-hull pressure washing: the 75-ton wash-down pad and the 300-ton wash-down pad (see Figure 2). These areas are paved with reinforced concrete and drain to the sanitary sewer as required under the Permit.

3.2 Existing Stormwater Drainage, Conveyance, and Treatment Systems

The Port installed a stormwater collection and conveyance system in 1996 that included stormwater treatment elements such as oil/water separator vaults (which also allow settling and removal of suspended solids) and sand filters. Additional stormwater treatment features were installed in 2011 as part of a stormwater improvement project partially funded by Ecology. A brief description of the current stormwater treatment elements at the Boatyard is provided below.

Stormwater at the Boatyard is collected in a stormwater system consisting of catch basins, vaults, and underground pipelines, and is discharged to Port Townsend Bay. A portion of the stormwater from the Boatyard is treated in four perimeter sand filters, in two Aquip® adsorptive media filtration systems, and in downspout treatment cells. The stormwater drainage system, treatment facilities, and outfall points of discharge are shown in Figure 2. Stormwater runoff from areas where boat-hull work is performed

drains to Outfall A. The area that drains to Outfall B is limited to buildings and roadways, where boats are not stored and where boat maintenance activities are not conducted. Boat repairs, construction, cleaning, and maintenance are conducted in all six of the main Boatyard drainage areas identified as Vaults 1, 2, 3, and 4; West Sims; and East Sims (Figure 2).

The Aquip® systems are passive adsorptive media filtration systems specifically designed for treatment of stormwater pollutants such as suspended solids and metals from industrial sites, including boatyards. In the Aquip® system, stormwater first passes through a pretreatment chamber for pH buffering and gravity settling of sediment (and associated pollutants), and then into a treatment chamber that contains a series of inert and adsorptive filtration media. The filtration media trap pollutants and remove total, dissolved, and ionized pollutants by chemical precipitation, adsorption, microsedimentation, and filtration. A StormwateRx® Aquip® Model 210SBE unit is located adjacent to Vault 1, and a Model 160SBE unit is located adjacent to Vault 4. The Port refers to the 210SBE system at Vault 1 as the "Boatyard" Aquip® and the 160SBE system at Vault 4 as the "West End" Aquip®. The systems are placed above ground on level concrete pads. Stormwater is pumped out of the effluent chambers of the vaults by dual sump pump systems in each vault and pumped to the StormwateRx® Aquip® inlets. The treated stormwater then discharges by gravity to catch basins and ultimately to Outfall A.

There are four existing perimeter sand filters at the Boatyard, one filter in each of the East Sims and West Sims drainage areas and Filters B5 and B6 in the Vault 4 drainage area as shown in Figure 2. These four sand filters provide capacity to filter some of the stormwater runoff from these drainage basins. These sand filters ultimately discharge to Outfall A. In 2014, the West Sims and East Sims filters were retrofitted to include biochar media for enhanced adsorption of metals.

The Port has successfully installed adsorption media filtration on roof downspouts on most of the metal buildings. The downspouts are connected to plastic totes containing biochar media to effectively remove zinc and copper from rooftop runoff. The treated downspouts ultimately flow to Outfall A. Biochar is charcoal created by pyrolysis of biomass, and studies conducted by the Port in association with Oregon State University have indicated that this material is effective at removing metals in stormwater runoff (Gray et al. 2015).

4. STORMWATER CHARACTERISTICS

Potential sources of zinc and copper at the Boatyard include boat-bottom paint and particulates generated during boat-bottom maintenance and repair. Other potential sources of metals include galvanized roofs and fencing, leaks or spills of motor oil or hydraulic fluid, and wear of vehicle and boat travel lift tires. It is also possible that solids accumulated in gravel surfacing material and in storm drain structures at the Boatyard are sources of zinc and copper through re-entrainment into stormwater.

In accordance with the Boatyard Permit, stormwater grab samples are collected at the point-of-compliance (Outfall A) once in each of the months of October, November, January, April, and May and analyzed for total copper and total zinc. Table 1 shows the Permit benchmark values, historic concentrations from 2011 through 2013, and seasonal average and maximum daily values for copper and zinc. As shown in Table 1, stormwater from the Boatyard periodically exceeds both seasonal average and maximum daily benchmarks for zinc and copper.

Table 1. Summary Outfall A Stormwater Sampling Results for Copper and Zinc[a]

	Outfall A	
	Zinc (µg/L)	**Copper (µg/L)**
Maximum Daily Benchmark	**90**	**147**
Seasonal Average Benchmark	**85**	**50**
Monitoring Results[b]:		
October 2011	NQSE	NQSE
November 2011	NQSE	NQSE
January 2012	NQSE	NQSE
April 2012	519	1,380
May 2012	140	93.5
2011-2012 Seasonal Average	**330**	**737**
October 2012	133	129
November 2012	NQSE	NQSE
January 2013	184	536
April 2013	122	70.3
May 2013	67	300
2012-2013 Seasonal Average	**127**	**259**
2013-2014 Seasonal Average	See Note c	
2014-2015 Seasonal Average	See Note d	
2015-2016 Seasonal Average	See Note d	

Notes:

[a] Outfall A stormwater discharge monitoring results collected prior to October 2011 are not included.

[b] Monitoring for zinc and copper is not required during months of February, March, June, July, August, September, and December.

[c] Monitoring at outfall A was discontinued in fall of 2013 due to concerns with seawater backflow and impairment of Outfall A sample quality.

[d] Monitoring at Outfall A replaced with upstream drainage basin composite samples. See Table 2.

NQSE = No qualifying storm event.

Red = Benchmark Exceedance

Sampling and reporting of results from Outfall A were discontinued in 2014 due to concerns that the tide gate at the outfall was leaking and allowing seawater to backflow and co-mingle with stormwater samples. With approval from Ecology, the Port initiated a new sampling program beginning in the 2015/2016 season involving collection of stormwater samples from flows at each of the stormwater basins (Vaults 1, 2, 3, and 4). Specific sampling locations are shown on Figure 2. Sampling at these combined locations provides representative data for all of the stormwater discharged from the site and addresses concerns about co-mingling stormwater with seawater backflow.

Results of individual stormwater basin sampling are presented in Table 2 and show that concentrations of copper and zinc at all basin locations are higher than benchmark values. Exceptions are noted for the most recent samples from Vault 1 and Vault 3 drainage areas where results were below benchmarks. The Port will continue monitoring these locations as well as others to provide additional data to support selection and design of stormwater improvements.

Table 2. Summary Result for Upstream Basin Stormwater Composite Sampling

	Zinc (µg/L)	Copper (µg/L)
Maximum Daily Benchmark	**90**	**147**
Seasonal Average Benchmark	**85**	**50**

Sampling Date[b]	Parameter	CB22, Vault 1 Drainage	CB32, Vault 2 Drainage	CB40, Vault 3 Drainage	CB57, Vault 4 Drainage
11/13/2015	Copper	509	1,250	663	803
11/13/2015	Zinc	179	508	516	661
11/20/2015	Copper	327	2,750	1,250	612
11/20/2015	Zinc	113	93.8	652	310
1/29/2016	Copper	410	2,000	405	480
1/29/2016	Zinc	139	976	246	265
2/12/2016	Copper	55.7	1,290	13.2	71.6
2/12/2016	Zinc	40.7	723	32.5	214
6/24/2016	Copper	133.0	796	5.7	252
6/24/2016	Zinc	51.8	390	5.4	303

5. EVALUATION OF STORMWATER BMPS

This section provides an evaluation of potential stormwater BMPs and covers applicable pollution prevention, operational source control, structural controls, and treatment alternatives. The guiding technical manual for stormwater BMPs in Washington is the Stormwater Management Manual for Western Washington (SWMMWW) (Ecology 2012). Accordingly, this evaluation reviews applicable BMPs in the SWMMWW, as well as industry-specific BMP guidance documents referenced in the SWMMWW to show that all known, available, and reasonable methods of prevention, control, and treatment have been considered. The initially identified BMPs are then screened to identify those that are appropriate to the site and implementable. The screening is performed for pretreatment and treatment BMPs and also for structural, pollution prevention, and operational source control BMPs.

The current SWMMWW does not include all active chemical/mechanical treatment methods. To address active chemical/mechanical technologies, Parametrix reviewed information in the Industrial Stormwater General Permit, the General Construction Stormwater Permit, Boatyard General Permit, and other treatment technologies known to have been employed by other industries. These technologies include Electrocoagulation, Chemical Precipitation/Flocculation/ Clarification (CPFC), Chitosan Enhanced Sand Filtration (CESF), and Specialty Adsorption Media.

5.1 Screening Review of Stormwater BMPs

This section provides a screening review of stormwater BMPs. Alternative BMPs are screened on the basis of performance implementability, cost, and other factors. The results of source control BMP screening (i.e., structural and operational pollution prevention methods) are shown in Table 3 and treatment BMP screening results are shown in Table 4. BMPs that are already being implemented at the Boatyard are shown in italics. The results of the screening evaluation are discussed further in Sections 5.1.1 through 5.1.4

Table 3. Screening of Pollution Prevention, Operational Source Control, and Structural BMPs[a]

BMP Description	BMP Type	Performance	Implementation	Relative Cost	Disadvantages	Advantages
Buildings or Covers over all Industrial Process Areas	Structural Source Control	Effective source control.	Buildings or covers currently used by limited number of tenants. Implementation of buildings and covers over full facility not practical, economically infeasible.	Very High	Covering the entire 20-acre facility would be cost prohibitive and would limit flexibility of Boatyard operation.	Conducting operations indoors or under cover prevents contact with stormwater and reduces pollutants in stormwater.
Wind-Break at Wash-Down Pads		Reduces overspray.	Technically very difficult to design and anchor large structure to shield large vessels and sustain anticipated wind loads of >100 mph.	Very High	Cost and design challenges.	Provides a wind-break at wash-down pad to reduce pollutant transport by wind-blown spray.
Boatyard Permit Mandatory BMPs, Permit Section S3	*Pollution Prevention/ Source Control*	*Effective pollution prevention and source control.*	*Mandatory BMPs are being implemented at the Boatyard, including vacuum sanders, limits on in-water vessel repair, containment and collection of debris from painting and paint removal, waste management, paint and solvent use, wash pad decontamination, oversight and education of tenants, and others.*	*Moderate*	*None*	*Reduces source concentrations of stormwater pollutants.*
Site Cleaning/ Housekeeping	*Pollution Prevention/ Maintenance*	*Effective pollution prevention and source control.*	*Included in Stormwater Pollution Prevention Plan (SWPPP) and mandatory BMPs. Routine housekeeping and maintenance of work areas. Routine cleaning of sediments from catch basins and vaults. Signage to reduce traffic speed and reduce dust.*	*Moderate*	*None*	*Reduces potential sources of stormwater pollutants.*
Stormwater Pollution Prevention Plan	*Pollution Prevention*	*Effective pollution prevention and source control.*	*Currently implemented. Will require updating following issuance of Engineering Report.*	*Low*	*None*	*Provides comprehensive plan for pollution prevention and stormwater management.*

(Table Continues)

Table 3. Screening of Pollution Prevention, Operational Source Control, and Structural BMPs[a] (Continued)

BMP Description	BMP Type	Performance	Implementation	Cost	Disadvantages	Advantages
Spill Prevention and Containment Plan	*Structural Source Control, Pollution Prevention*	*Effective pollution prevention and source control.*	*Currently implemented as part of the SWPPP.*	*Low*	*None*	*Prevents hazardous pollutants and spills from potentially entering stormwater.*
Pave or Cap Working Yard and Material Storage and Handling Areas	Structural Source Control	Reduces turbidity in stormwater runoff.	Reduces ability to easily access and modify underground utilities. Requires considerable quantities of subgrade and paving material and reinforcement due to heavy loading from boat lift and other heavy equipment.	High	Cost. Paving the entire Boatyard would be cost prohibitive (Engineer Opinion of Probable Cost: +$8MM).	Easy to clean and maintain surface. Reduces erosion and transport of gravel fines into stormwater system.
Secondary Containment of Hazardous Liquids	*Structural Source Control*	*Effective in preventing release of pollutants into stormwater.*	*Currently Implemented.*	*Low/ Moderate*	*None*	*Prevents hazardous pollutants from potentially entering stormwater.*
Stormwater Containment and Control Curb	*Structural Source Control*	*Effective in preventing stormwater run-off and run-on.*	*Currently implemented in select areas. Stormwater collects in catch basins, vaults, and perimeter filters. The southern shoreline boundary is contained by a bulkhead wall to prevent stormwater run-off into Port Townsend Bay.*	*Moderate*	*Cost*	*Prevents untreated stormwater from leaving site untreated. Prevents run-on of stormwater from adjacent properties.*
Excavate, Remove, and Replace Contaminated Surface Soil	*Pollution Prevention*	*Effective means of removing elevated levels of metals in gravel surfacing material and preventing transport of contaminated material into storm drains.*	*Currently implemented in focused areas where concentrations of copper and zinc are known to be high based on soil sample results. Additional replacement of crushed surface in areas of high copper and zinc concentration are likely to follow after additional testing of suspect areas.*	*Moderate*	*Cost*	*Reduces concentrations of total suspended solids (TSS), copper (Cu), and zinc (Zn) mobilized in stormwater run-off.*
Site Grading	*Structural Source Control*	*Effective in preventing stormwater from leaving the site untreated.*	*Currently implemented. Graveled surface areas slope toward collection catch basins and vault.*	*Moderate/ High*	*Cost*	*Prevents untreated stormwater from leaving site.*

Notes:

Items in *italics* are currently being implemented at the Boatyard.

[a] BMPs from SWMMWW (Ecology 2012) and other Ecology guidance documents.

Table 4. Initial Screening of Treatment BMPs[a]

Technology Process	Process Type	Performance	Implementation	Cost	Disadvantages	Advantages
Biological	Stormwater Treatment Wetland	Moderately effective for TSS, metals, and organics.	Requires excavation of a very large area; pond liner would be required.	Medium	Requires very large land area, setbacks, and mitigation of impacted wetlands. Not feasible. Soils, drainage and topography of wetlands to the west of Boatyard unfavorable for stormwater treatment.	Passive treatment method.
Biological	Wet Pond	Moderately effective for TSS, metals, and organics.	Requires excavation of a very large area; pond liner would be required.	Medium	Requires very large land area and setbacks. Not expected to meet benchmarks as a stand-alone alternative.	Passive treatment method.
Biological	Bioretention with Infiltration	Very effective for TSS, metals, and organics when coupled with pre-settling and infiltration.	Implementable. Requires moderate footprint area when coupled with infiltration. Proven technology for treating urban and industrial stormwater.	Medium	Requires moderate land area and setbacks. Can be constructed in above-ground basins to accommodate shallow groundwater conditions.	Passive treatment method. Infiltration removes the need to discharge to Outfall.
Biological	Bioswale	Somewhat effective for TSS, metals, and organics.	Requires large area and sloping grade.	Medium	Generally not as effective as bioretention for metals removal. Not expected to meet benchmarks as a stand-alone alternative.	Passive treatment method.
Biological	Discharge to City of Port Townsend Wastewater Treatment Plant (WWTP)	The City's WWTP employs standard physical, mechanical, and biological treatment processes, which, in combination, can be effective in treating metals and organic pollutants.	Not implementable. WWTP lacks sufficient capacity.	High	Not feasible due to limited wet-weather WWTP capacity.	Avoids or limits construction of on-site treatment BMPs.

(Table Continues)

Table 4. Initial Screening of Treatment BMPs[a] (Continued)

Technology Process	Process Type	Performance	Implementation	Cost	Disadvantages	Advantages
Physical	*Oil/Water Separator*	*Effective treatment for free oils. Prevents release of oil to the stormwater system.*	*Vaults in each basin (Vaults 1, 2, 3, and 4) are equipped with oil/water separation baffles.*	*Low*	*None*	*Very effective, low cost treatment to remove oil and grease and prevents release of oil to discharge.*
Physical	Pre-settling Basin	Effective pretreatment for TSS and metals	Readily implementable in above- or below- ground tanks or basins. Can be coupled with chemical flocculant to enhance TSS and metals removal.	Low/ Medium	Requires maintenance to remove build-up of sediments.	Effective treatment to remove settleable solids and particulate-bound pollutants.
Physical	Hydrodynamic Separator	Effective pretreatment for TSS and metals.	A vault-type unit requires excavation.	Medium	Effective for reducing high TSS loading and generally occupies less space than gravity settling basins.	Effective treatment to remove settleable solids and particulate-bound pollutants.
Physical	Sand Filtration	Effective for TSS removal.	Requires large gravity filter beds or pressurized filter vessels.	Medium	Effective for reducing high TSS loading, but will not remove dissolved metals.	Effective for TSS removal. Effective for other pollutants when used in combination with other treatment (see Chitosan Enhanced Filtration).
Physical	Infiltration Pond/Basin	Effective for TSS and metals removal; coupled with bioretention enhanced pollutant removal	Implementable where soils and groundwater table are favorable for infiltration.	Medium	Requires moderate land area and soil characteristics conducive for infiltration.	Passive treatment. Infiltration removes the need to discharge to Outfall.
Mechanical /Chemical	Chitosan Enhanced Filtration	Effective for TSS, metals, some organics.	Mobile and versatile. Used typically to meet surface water discharge requirements.	Very High	Relatively high capital and operating costs. Requires moderate footprint area for equalization, pre-settling tanks, reaction tanks, filters, and other equipment.	Equipment can be mobilized. Provides high level of treatment.

(Table Continues)

Table 4. Initial Screening of Treatment BMPsa (Continued)

Technology Process	Process Type	Performance	Implementation	Cost	Disadvantages	Advantages
Mechanical /Chemical	Electro-coagulation	Effective for TSS, metals, some organics.	Mobile and versatile. Used typically to meet surface water discharge requirements.	Very High	Relatively high capital and operating costs. Requires moderate footprint area for equalization, pre-settling tanks, reaction tanks, filters, and other equipment.	Equipment can be mobilized. Provides high level of treatment.
Mechanical /Chemical	Chemical Precipitation/ Flocculation/ Clarification (CPFC)	Effective for TSS, metals, polychlorinated biphenyl (PCBs), organics.	Mobile and versatile. Used typically to meet surface water discharge requirements.	Very High	Relatively high capital and operating costs. Requires moderate footprint area for equalization, pre-settling tanks, reaction tanks, filters, and other equipment.	Equipment can be mobilized. Provides high level of treatment.
Mechanical /Chemical	*Specialty Adsorption Media*	*Effective for metals and organics.*	*Mobile and versatile. Used typically to meet surface water discharge requirements.*	*Very High*	*Requires extensive pretreatment to remove competing non-target pollutants. Media disposal volumes and cost can be high. Media are sensitive to plugging and fouling. Existing Aquip® units are undersized for flow and loading.*	*Equipment can be mobilized. Provides high level of treatment.*

Notes: Items in italics are currently being implemented at the Boatyard.
BMP = Best Management Practice
CPFC = Chemical Precipitation Flocculation/Clarification
O/G = Oil and Grease
FOG = Fats, Oils, and Grease
TPH = Total Petroleum Hydrocarbons
TSS = Total Suspended Solids

[a] BMPs per SWMMWW (Ecology 2012) or industry-specific guidance.

5.1.1 Screening of Pollution Prevention and Operational Source Control BMPs

Pollution prevention and operational source control BMPs are evaluated and screened in Table 3. As shown, the Boatyard is already employing many of the BMPs listed in the table. The Boatyard SWPPP includes source control BMPs required by the Permit. SWPPP enforcement and training is administered by the Port. Below is a list of BMPs included in the SWPPP:

- Requirement to use a vacuum sander (meeting minimum requirements) for paint removal.
- Prohibition of in-water vessel hull cleaning, repair, modification, surface preparation, or coating.
- Management and collection of solids (from stripping, sanding, etc.) to prevent release into the environment, including specific procedures for tarping, sweeping, double-bagging, and disposal of solids.
- Management of paints and solvents to prevent release into the environment.
- Prohibition of bilge water discharge to waters of the state, bilge water evacuation prior to blocking in the yard, and provision of intermediate bulk containers for bilge water storage and appropriate disposal.
- Management of sacrificial anodes (zincs) to prevent release into the environment.
- Prohibition and elimination of illicit discharges, including sump isolation and cleanout when Port personnel suspect contaminants have entered a wash-down sump.
- Providing tenants/customers a waste facility to bring paint, solvents, oils, wastewater, other hazardous materials, and recyclable materials for appropriate disposal.
- Regular removal of oils, debris, sludge, etc., from storm drain structures.
- Requirement to store solid wastes contaminated with potential pollutants under cover.
- Requirement to prevent the spread of wind-blown materials from sanding, sandblasting, and spray-painting.
- Wash pad decontamination.
- Requirement to store hazardous materials in secondary containment and provision of weather-tight containers to all customers.
- Oversight of do-it-yourselfers and independent contractors including issuance of fees for BMP non-compliance and ejection from facility for repeated non-compliance.
- Additional facility monitoring for BMP compliance, including Saturday and Sunday patrols.
- Issuance of a simple tri-fold BMP handout for haul-out customers based on feedback from the Port Townsend Marine Trades Association (PTMTA) and customers.
- Development of a team approach with the PTMTA regarding BMP development, implementation, and monitoring.
- Using various media outlets to educate customers about BMPs, including the quarterly Port newsletter and the local newspaper.
- Additional staffing of up to one full-time employee for BMP administration and enforcement.

The Port is also considering or implementing the following additional enhancements to BMPs:

- Requiring tenants to submit a formal work plan detailing activities, schedule, BMPs, contacts, and other information.
- Requiring that all bottom painting and paint removal be performed during normal working hours by approved/licensed contractors and under close supervision by the Port.
- Limiting bottom painting to be performed only in designated areas to limit the footprint of this activity.
- Development of a brief (10 minute) training video to demonstrate proper adherence to BMPs. The training video would be required for viewing by all tenants during intake and contract signing.
- Initiating a metal recycling program with covered containers provided for customer use.
- Replacing standard ground tarps with greater millimeter thickness covers for certain activities.
- Requiring fire blankets for hot work to maintain integrity of ground tarps.
- Utilizing a pre-haul-out inspection checklist for use of boatlift staff to identify potential pollutants aboard vessels and ensure that bilge pumps are de-energized.
- Posting BMP signage in the yard office.
- Requiring inspection of vacuum sanders prior to use.
- Site inspection prior to start of work to ensure adequate pollutant controls are in place.
- Locking yard hydrants to ensure water use is consistent with BMPs.
- Annual spill response drill with Yard staff to maintain knowledge of emergency shut-off devices on equipment and within stormwater system.

Another source control measure recently implemented by the Port is the focused removal of discrete areas of soil contamination (soil hot-spot areas). Elevated levels of copper and zinc were identified through chemical analysis of soil/gravel samples from the upper surface material (upper 3 inches) and through sampling of sheet flow into catch basins. Deeper samples of up to 6 inches below ground surface have also been collected but have been found to contain relatively low concentrations of metals. Areas found to contain elevated concentrations of copper or zinc were remediated by removing the upper 3-inch layer of gravel and replacing with new, clean gravel material. Contaminated gravel was removed and disposed in a permitted off-site disposal facility. The Port recently remediated approximately 1 acre of area in the east end of the Boatyard and a smaller area in the north-central part of the Boatyard.

These increased source control efforts are intended to reduce the concentrations of zinc and copper in stormwater that enter the treatment BMPs described in Section 5 and thereby help ensure that metals concentrations in stormwater discharge consistently achieve Permit benchmark levels.

5.1.2 Screening of Structural BMPs

Portions of the Boatyard are currently paved and some operations are conducted in buildings or under temporary covers. Covers or encapsulation helps to reduce stormwater pollutants, but covering the entire Boatyard area would be cost-prohibitive and would reduce the flexibility of operations. Similarly,

paving the entire facility would be very costly as it would require considerable quantities of subgrade and paving material and reinforcement to accommodate heavy loading from boat lifts and other heavy equipment. Paving would also reduce flexibility to access and modify underground utilities. Operational source controls combined with treatment BMPs discussed in the next section can be implemented more effectively to meet benchmarks at a more reasonable cost.

5.1.3 Screening of Stormwater Treatment BMPs

An initial screening and comparison of stormwater treatment BMPs is provided in Table 4. The table also includes typical BMPs used for pretreatment such as settling basins, oil/water separators, and other methods. In general, stormwater treatment BMPs can be defined in one of the following categories of pollutant removal processes:

- **Biological**: The biological process uses biological and/or organic components as the primary pollutant capturing or filtration agent. In some cases, the pollutant is broken down organically into inert components. Metals may be removed to a certain extent by physical filtration or adsorption to sediments. The biological processes recommended under the SWMMWW include bioretention, biofiltration, wet ponds, and stormwater treatment wetlands as the primary biological methods of pollutant removal.
- **Physical**: Physical treatment involves filtering or gravity settling of particulate material in processes such as sand filters, settling basins, and infiltration ponds. Physical treatment also includes gravity oil/water separation and hydrodynamic separation.
- **Mechanical/Chemical:** Mechanical and/or chemical processes use chemical reagents to precipitate and flocculate (or coagulate) stormwater pollutants. Separation of solids formed during the precipitation process is usually removed by gravity settling and/or sand filtration. Chitosan or polymer enhanced filtration is a mechanical/chemical process commonly implemented under the Construction Stormwater General Permit. Also, electrocoagulation, a non-chemical means of precipitating and coagulating pollutants, falls into this category. These treatment systems are usually modular in construction with most of the process controls and equipment housed within intermodal containers.
- **Specialty Adsorption Media:** A variety of adsorption media have been used for stormwater treatment, including ion exchange resins, activated carbon, leaf compost filter, bone apatite mineral, and other proprietary mixtures of adsorption materials. Organic and metal stormwater pollutants are removed by chemical/physical adsorption to the media. Adsorption media can be operated under gravity flow conditions or in pressure adsorption vessels where the stormwater is pumped through the media under pressure. StormwateRx® is a preferred treatment BMP under the Boatyard General Permit and uses a blend of sand, activated carbon, and ion exchange media. The media is operated passively in a fixed bed with stormwater flowing through the bed under gravity conditions.

5.1.3.1 Biological Treatment BMPs

Biological treatment BMPs typically require relatively large areas of open land to provide the contact area and retention time necessary for successful stormwater treatment. Bioretention combined with infiltration (bioinfiltration/infiltration) is an effective means of treating stormwater. Bioretention facilities are treatment systems that remove stormwater pollutants by passing stormwater through an engineered bioretention soil mix (BSM) vegetated with moisture tolerant plants. Treatment occurs by means of sedimentation, filtration, adsorption, and plant uptake. When stormwater is infiltrated after

passing through the BSM, further treatment is achieved through soil adsorption. Accordingly, bioretention/infiltration combines three technologies: bioretention, infiltration, and adsorption.

Bioretention/infiltration requires soil conditions favorable for infiltration. In areas with shallow groundwater, bioretention/infiltration can be implemented in above-ground basins to provide the necessary separation from groundwater and provide enough vertical space for BSM media and pond level. Bioretention/infiltration meets the Permit requirements for "facilities discharging stormwater to an infiltration basin lined with adsorption media". Bioretention/infiltration is retained as a preferred treatment alternative.

Another particularly important advantage with bioretention/infiltration is that it requires very little maintenance, especially when the system is preceded by pre-settling as described in the next section. The longevity of BSM media may be up to 25 years (Johnston 2014) when combined with pre-settling ahead of the system to remove the bulk of sediment and particulate-bound metals. Typical maintenance includes semi-annually raking debris and plant litter from the surface of the media, replacement of plants as needed, and removing and disposing sediment material in the pre-settling unit.

In summary, bioretention/infiltration meets AKART and is retained as a preferred treatment alternative.

5.1.3.2 Physical Treatment BMPs

Physical stormwater treatment technologies are commonly employed at industrial facilities and can be very effective for removal of stormwater pollutants. The existing Boatyard stormwater system includes gravity settling and oil-water separation in each of the vaults (Vaults 1 through 4). These vaults receive drainage from each basin of the Boatyard. In addition, physical separation of solids is provided for portions of stormwater flow by perimeter sand filters and Aquip® units. However, these treatment units have not been able to consistently meet Permit benchmarks.

Pre-settling of solids in clarifiers, tanks, or hydrodynamic separators is another effective physical treatment method. A large percentage of copper and zinc in Boatyard stormwater is in the particulate form (see Section 6.1) and may be removed by gravity settling or by gravity settling enhanced with polymer flocculation. In addition, pre-settling can remove the bulk of TSS in stormwater and reduce the load of material and subsequent maintenance of downstream treatment units. However, it is important to note that pre-settling alone will not meet Permit benchmarks. Pre-settling will need to be combined with bioretention/infiltration or active treatment (described below).

Therefore, physical treatment BMPs, including oil-water separation and pre-settling (either gravity settling or hydrodynamic separator), are retained and included in the proposed stormwater treatment improvements. These pretreatment BMPs are the best available alternatives and meet AKART requirements.

5.1.3.3 Active Stormwater Treatment BMPs

As shown in Table 4, a number of active treatment technologies are identified. These technologies include Chemical Precipitation/Flocculation/Clarification, Electrocoagulation, Chitosan Enhanced Sand Filtration, and Specialty Adsorption Media. These treatment technologies are relatively costly and are generally only employed when other options are not technically feasible. The footprint area required for a modular treatment system is approximately 8,000 square feet. This is in addition to the area occupied by pre-settling tanks (approximately 4,000 square feet). The tanks are required ahead of modular treatment for flow equalization and pre-settling. Therefore, the total footprint area occupied by the treatment system is approximately 12,000 square feet.

The Boatyard currently employs two Aquip® units containing specialty adsorption media. The Aquip® technology fits into the category of active treatment. However, these units have not been able to consistently meet stormwater benchmarks and are not providing the expected design-level removal of copper and zinc (Landau 2013). The level of cost and maintenance required for providing adequate active treatment capacity for the full stormwater flow is relatively high compared to the bioretention/infiltration alternative. In summary, while many active stormwater treatment devices are effective, these devices are similar in performance to other devices that have other benefits and have not performed at the Port. Stormwater treatment devices are, therefore, excluded as a preferred treatment alternative.

5.1.4 Discharge to WWTP

The City of Port Townsend operates a municipal WWTP. The Boatyard currently discharges domestic wastewater to the WWTP through a 6-inch pumped force main. The City was contacted with regard to receiving stormwater flows from the Boatyard. However, the City indicated the WWTP does not have adequate wet-weather capacity to receive additional stormwater flows due to present capacity issues from infiltration and inflow (I&I) (Merchant 2016).

5.2 Summary of BMPs Selected for Preferred Alternative

Based on the BMP screening, the Port will continue to execute a suite of BMPs and will add measures to the existing system to improve overall performance and attainment of benchmarks.

The Port will continue with pollution prevention and operational source control BMPs described in Section 5.1.1 and make enhancements to operational BMPs discussed in Section 5.1.1.

The Port will also continue providing biochar treatment on building downspouts. The biochar totes have proven to be very effective, removing greater than 90 percent zinc and copper and meeting benchmark limits. The discharge point for treated rooftop flows will be Outfall A, downstream of a new lift station constructed as part of the preferred alternative as discussed below. The modified conveyance and discharge for treated rooftop flows will be further developed during detailed design.

Bioretention/infiltration combined with pre-settling is retained as the preferred treatment alternative. Bioretention/infiltration combines the technologies of bioretention and infiltration to effectively treat stormwater pollutants. Bioretention is a proven and effective technology and is recognized as an applicable treatment BMP in the SWMMWW. Bioretention/infiltration meets AKART and when coupled with pre-settling is a reliable, low-maintenance technology capable of meeting Permit benchmarks. The level of cost and maintenance required for bioretention/infiltration is lower compared to active treatment alternatives. Continuance with operational source control BMPs will help ensure the new biorentention/infiltration system meets Permit benchmarks. The Permit limits for infiltration are significantly less stringent than the current benchmarks for discharge to marine waters (Outfall A). Table 5 provides limits for discharge to ground infiltration.

A new lift station upstream of Outfall A will be included to pump and return stormwater flows to the upland bioretention/infiltration basin. In addition, a new tide-flex control check valve will be installed on the end of Outfall A to replace the existing leaking tide-gate and prevent backflow of seawater into the storm drainage system. Design elements of this alternative are further developed and described in the next section.

The Port's Boatyard SWPPP will be modified to include enhancements to operational and treatment BMPs discussed in this section.

6. DESIGN EVALUATION

This section presents design criteria, design analysis, and sizing of the bioretention/infiltration system and other components of the selected alternative. Design analysis includes stormwater flow modelling, infiltration modelling, and field testing of soils and infiltration rates.

6.1 Description of Selected Treatment Alternative

Bioretention facilities are treatment systems that remove stormwater pollutants by passing stormwater through an engineered BSM, vegetated with moisture tolerant plants. Treatment occurs by means of sedimentation, filtration, adsorption, and plant uptake. If stormwater is infiltrated after passing through the BSM, further treatment is achieved through soil adsorption. This combined treatment approach is referred to as bioretention/infiltration in this report. Bioretention and biofiltration are described in detail in Volume V, Chapter 7, of the SWMMWW (Ecology 2012). This treatment approach provides enhanced treatment, a requirement for industrial facilities such as the Boatyard. Combined with infiltration, this method meets the facility's NPDES Boatyard General Permit Section S2.D.4 requirement for "Facilities discharging stormwater to an infiltration basin lined with adsorptive media."

6.2 Design Criteria

This section summarizes basic design criteria applicable to the new proposed bioretention/infiltration system.

Per the Boatyard Permit, the infiltration basin must be at least 200 feet from shoreline and lined with adsorptive media. The system will need to treat 91 percent of the total stormwater flow, and the infiltration basin is required have a minimum of 3 feet of separation from the bottom of the basin to the highest expected groundwater table elevation. The 91-percent stormwater flow criteria and minimum 3-foot separation from groundwater are required by the SWMMWW for treatment facilities. A new lift station will be designed to discharge the treatment flow rate to the biofiltration basin. Excess flow will bypass to Outfall A through a new tide-flex check valve. Other design criteria and sizing of the new stormwater improvements are described below.

Benchmarks applicable to flows entering the new bioretention/infiltration system are provided in the Permit in Section S2.D6 and summarized in Table 5 below.

Table 5. Limits for Discharge to the Ground of Stormwater Runoff from Areas with Industrial Activities

Parameter	Seasonal Average Limit	Maximum Daily Limit
Copper, Total (µg/L)	1,000	1,000
Zinc, Total (µg/L)	1,020	1,020

Operational source controls, combined with pretreatment in pre-settling units, will help minimize the potential that these benchmarks will be exceeded. Table 6 shows results of stormwater sampling that included analysis of both total and dissolved copper and zinc. Results are shown for samples collected at each stormwater basin and Outfall A. Dissolved metals were analyzed with standard Environmental

Protection Agency (EPA) methods by passing the stormwater through a 0.45-µm filter. As shown, a large percentage of copper and zinc exists in the particulate phase (i.e., is removed by the filtration). In addition, stormwater from each basin and Outfall A contains significant concentrations of TSS (>1,000 µg/L). These results suggest that significant removal of TSS and particulate-bound metals may be removed by pre-settling. The dissolved phase concentrations of metals shown in the table are well below Permit benchmarks for discharge to the ground (i.e., infiltration), suggesting that stormwater, following pre-treatment by settling, should readily meet the benchmarks for infiltration. These results will be confirmed with additional sampling and testing during the fall of 2016 (see Section 8).

Table 6. Comparison of Total and Dissolved Metals in Stormwater Composite Samples

		Sample Location, Drainage Area[a]				
Sampling Date	Parameter	CB22, Vault 1 Drainage	CB32, Vault 2 Drainage	CB40, Vault 3 Drainage	CB57, Vault 4 Drainage	Outfall A
April 3, 2012	Total Copper					1,380
April 3, 2012	Dissolved Copper					174
April 3, 2012	% Particulate Copper					87%
April 3, 2012	Total Zinc					519
April 3, 2012	Dissolved Zinc					203
April 3, 2012	% Particulate Zinc					61%
June 24, 2016	Total Copper	133.0	796	5.71	252	427
June 24, 2016	Dissolved Copper	53.9	139	<2.0	59.5	60.2
June 24, 2016	% Particulate Copper	59%	83%	>65%	76%	86%
June 24, 2016	Total Zinc	51.8	390	8.92	303	239
June 24, 2016	Dissolved Zinc	35.9	147	5.42	214	93.2
June 24, 2016	% Particulate Zinc	31%	62%	39%	29%	61%
June 24, 2016	TSS	1,000	35,000	4,000	10,000	124,000

Notes:

[a] All results reported in (µg/L).

6.3 Site Investigations

Site investigations were performed to provide site-specific soils and groundwater information for use in alternatives development and preliminary design. Site investigation procedures and results are described below.

6.3.1 Test Pits

Three test pits (TP) (TP-1, TP-2, and TP-3) were excavated at the site on June 27, 2016. Test pit locations (see Figure 2) were selected to explore three areas selected by Port staff as having desirable characteristics for siting new bioretention/infiltration facilities. The primary criteria used was to minimize encroachment onto permitted space currently used for boat maintenance. A secondary criteria is that the infiltration facilities be located at least 200 feet from ordinary high water line, which is a

requirement of the Boatyard Permit. Test pits were excavated to depths of up to 11 feet using a rubber-tired backhoe. Test pit logs and associated photographs are provided in Appendix B.

In general, soils observed in the test pits consist of native beach deposits overlain by 4.5 to 6 feet plus of clean sands. The clean sands likely consist of dredge spoils placed during Boat Haven construction. A 1-foot-thick surficial layer of sandy gravel with quarry spalls was observed at the ground surface in TP-2. This surficial "ballast" layer is present throughout the interior of the boatyard and was installed during site-wide redevelopment activities in 1996. According to record drawings, the ballast is generally 1- to 3-feet thick.

Groundwater levels in the test pits were visually observed during digging at depths ranging from 4 to 5 feet below ground surface (bgs). A 2-inch inside diameter piezometer was installed and backfilled in each of the test pits for the purpose of monitoring groundwater levels. Hand measurements of groundwater levels within the piezometers were used to select TP-2 and TP-3 for monitoring using transducers. Shallow groundwater at TP-1 (2 feet bgs) makes this location infeasible for infiltration. Groundwater levels were continuously monitored for approximately 8 days in July 2016 using transducers installed in TP-2 and TP-3. Transducer output is provided in Appendix C. Depth to groundwater in TP-2 was observed to vary from 4.2 to 4.4 feet. Depth to groundwater in TP-3 was observed to vary from 4.5 to 4.6 feet bgs. Groundwater levels did not appear to fluctuate with tidal fluctuations in nearby Port Townsend Bay.

Groundwater levels were also observed in the wet season in piezometers installed by the Port for the 1996 construction activities. One piezometer located near TP-3 indicated a groundwater level consistent with the level observed by Parametrix in July 2016. Therefore, groundwater level may remain relatively consistent throughout the year. Piezometers in TP-2 and TP-3 will be monitored during the 2016/2017 wet season to provide additional data for design.

6.3.2 Infiltration Testing

Small-scale pilot infiltration tests (PIT) were performed at each of the three test pit locations in general accordance with Sections 3.3 and 3.4, Volume III, of the SWMMWW. All three PIT tests were excavated to depths matching the anticipated bottom elevation of associated bioretention/infiltration facilities (15 to 22 inches bgs). Standing water test depth for each test was selected at 12 inches. PIT test results are summarized in the spreadsheets in Appendix D. Results for the PIT test at the TP-1 location is not provided since this PIT test infiltrated very slowly during the test period and infiltration in the TP-1 test area is not considered feasible.

A total correction factor of 0.30 was applied to the measured initial infiltration rates at the PIT-2 and PIT-3 locations according to the procedure guidance. Calculated design infiltration rates are 1.25 inches/hour (in/hr) for PIT-2 and 8.93 in/hr for PIT-2. Rate calculations were conducted according to the example provided in the guidelines. The results of this testing indicate that the TP-3/PIT-3 area is a good candidate for stormwater infiltration. Infiltration does not appear to be feasible at the TP-2/PIT-2 area at this time. However, the surface of the PIT test excavation was observed to be plugged with fines at the completion of the PIT test. It is possible that this plugging reduced the observed infiltration rate and that future testing may show improved results.

Infiltration rates were also calculated using sieve analysis results in accordance with Section 3.3, Volume III, of the SWMMWW. Infiltration rate calculation worksheets are included in Appendix C. A summary of infiltration rates developed for this study is provided in Table 7 below.

Table 7. Infiltration Rates

Location	Method	Long Term Infiltration Rate (in/hr)
TP-2	PIT Test	1.25
TP-2	Sieve Analysis	10.4
TP-3	PIT Test	8.9
TP-3	Sieve Analysis	16.6

6.4 Hydrologic Analysis

Stormwater runoff at the Boatyard was modeled using the Western Washington Hydrology Model 2012 (WWHM12) version approved for use in treatment facility design in accordance with Chapter 2.1, Volume III, of the SWMMWW.

6.4.1 Land Use

Boatyard areas falling under the NPDES permit consist of six tributary basins that currently discharge stormwater runoff to Outfall A (Vault 1, Vault 2, Vault 3, Vault 4, West Sims, and East Sims basins as shown in Figure 2). Combined, these basins consist of a total of 19.6 acres of, gravel surfacing, and asphalt pavement. Basins that bypass Outfall A and discharge at the "Bypass Outfall" consist of Vault 3 Basin Building Bypass, SK Building Bypass Area, and Bypass Area (Figure 2). Stormwater runoff from the Outfall A tributary basins is captured and conveyed via a piping network, including four oil/water separator vaults to treat runoff from Vault 1, Vault 2, Vault 3, and Vault 4 basins.

6.4.2 Stormwater Conveyance

Conveyance is largely by gravity with the exception of a lift station located near Vault 3 that was installed to pump water from the relatively low-lying basin during high-flow events. The conveyance system is protected from marine water intrusion by three separate tide-gate valves. Port maintenance personnel report that the tide gates are subject to failure, allowing backflow, particularly Tide Gate 2 located near Outfall A.

6.4.3 Water and Storm Event Flow Rates

Basin information was input into WWHM12 software to develop water quality treatment and storm event flow rates for use in bioretention/infiltration sizing and design. WWHM was created by Ecology for the specific purpose of sizing stormwater control facilities for new development and redevelopment projects in Western Washington. WWHM12 is a general, continuous, rainfall-runoff computer model using long-term (61 years) precipitation data to simulate the potential impacts of land-use development.

The primary purpose for developing the water quality treatment flow rate was for preliminary design of pumping and conveyance facilities. Flow rates for water quality and predicted major storm events are provided in Table 8 below. An off-line, water-quality flow rate of 1.4 cubic feet per second (cfs) or,

equivalently, 628 gallons per minute (gpm) was used for preliminary design of conveyance and treatment features. The term "off line" refers to a facility that receives only the treatment flow rate. Flows in excess of this rate are bypassed to a discharge point such as a stormwater outfall. An "on line" facility would receive all flows and bypass flows in excess of the treatment flow rate. WWHM12 output is provided in Appendix E.

Table 8. Major Storm Event Flow Rates

Flow Event	Flow (cfs)
Off Line Water Quality Treatment Flow Rate	1.4
On Line Water Quality Treatment Flow Rate	2.58
2-Year Storm Event	5.4
25-Year Storm Event	10.47
100-Year Storm Event	13.2

6.5 Bioretention/Infiltration Basin Sizing

Preliminary sizing for bioretention/infiltration basins was conducted using a combination of MGS Engineering Consultants, Inc. (MGS) Flood and MODRET (Computer MODel to Design RETention Ponds) software in accordance with Chapters 2.1 and 3.3.8, Volume III, of the SWMMWW.

MGS Flood is a continuous, rainfall-runoff computer model developed for stormwater facility design in Western Washington. The program uses the Hydrological Simulation Program-Fortran (HSPF) routine for computing runoff from rainfall and then routes runoff volumes using stage-storage-discharge routines to define a stormwater retention/detention facility or reservoir. MODRET is generally used to calculate infiltration losses from stormwater retention ponds in unconfined shallow aquifers. MODRET allows generation of runoff hydrographs with various methods, calculation of infiltration losses from a retention pond, discharge (overflow) through various types of weirs and orifices, and generation of groundwater elevations around the retention pond which can be used for evaluation of groundwater mounding beneath the pond.

6.5.1 Model Input

The TP-3/PIT-3 area was selected as the preferred location for siting new bioretention/infiltration basins. Two scenarios were selected for the development of preliminary alternatives: Scenario 1 consists of a relatively long and narrow (20 feet nominal) basin with a minimum of 3 feet of separation from the bottom of the basin to the highest expected groundwater table elevation. Three feet of separation was selected as a minimum according to Section 3.3.7, Volume III, of the SWMMWW. The area targeted for the long and narrow basin is the strip of property located between the existing Boatyard perimeter fence and Sims Way (Figure 3).

Scenario 2 consists of a wider facility (50 feet nominal) with a minimum of 5 feet of separation between the bottom of the facility and the highest expected groundwater table elevation. This facility would be located in the interior of the Boatyard and area currently used for boat maintenance. All basins were assumed to have modular block walls instead of soil berms to save space. Treatment will be provided using 18 inches of BSM in accordance with the bioretention design guidelines in the SWMMWW. Stormwater will be collected at a single point located near Outfall A and pumped to the

bioretention/infiltration basins using a lift station. Pretreatment of stormwater before it reaches the bioretention/infiltration basins is a requirement and will be achieved using a Suntree Technologies, Inc. Nutrient Separating Baffle Box (NSBB) possessing Conditional Use Level Designation (CULD) from Ecology. The NSBB is a hydrodynamic separator devised to remove TSS and particulate-bound metals (Figure 6).

Basins were initially modelled using MGS Flood (with Massmann Infiltration) to determine basin dimensions required so that 91 percent of stormwater reaching the facility is infiltrated through the BSM and into the underlying soil. The 91 percent criteria is required by the SWMMWW for treatment facilities. Basins with these dimensions were then used as input to the MODRET software to assess whether or not groundwater mounding beneath the basins limits performance of the basin. A third step was then conducted using MODRET to size minimum basin dimensions considering only groundwater mounding as the limiting factor.

Design input and output results are provided in Table 9 and Table 10 below.

Table 9. Model Inputs for MGS Flood

Input Parameters	Input Values	Basis for Value
General Data		
Basin area	19.60 acres	Total area of boatyard, minus building rooftops.
SCS Curve Number	95	User-selected: Based on the gravel surface of the basin area.
Rainfall Depth	2.22 inches	Based on coordinates of the site and scaled from the Port Angeles Station Data.
Pond Data		
Maximum Pond Elevation	19.0 feet	Site topography and basin location and sizing.
Side Slopes (ZH:1V)	0	Assumes block wall construction of side slopes
Pond Bottom Length	Calculated	
Pond Bottom Widths	20[a] / 50[b] feet	Depends on scenario/facility location.
Pond Floor Elevation	17.0 feet	Site topography and basin location and sizing.
Outlet Structure		
Riser Structure	Circular Overflow Riser	
Crest Elevation	18.5 feet	Site topography and basin location and sizing.
Diameter	24 inches	Site topography and basin location and sizing.
Infiltration Input		
Infiltration Option	Massmann Infiltration	
Hydraulic Conductivity	29.62 in/hr	TP-3 initial measured rate.
Depth to Water Table	3[a] / 5[b] feet	Depends on scenario/facility location.

[a] Scenario 1, 20-foot-wide facility with 3 feet depth to groundwater.

[b] Scenario 2, 50-foot-wide facility with 5 feet depth to groundwater.

Table 10. Scenarios Run Through MODRET

	Pond Length (ft)	Pond Width (ft)	Depth to Water Table (ft)	Area at Starting Water Level (ft^2)	Volume Between Starting Water Level and Estimated High Water Level (ft^3)	Pond length to width ratio (L/W)	Percent Treated	Elevation of GW mound (ft)
Scenario 1	1,020[a]	20	3	20,400	42,840	51	91.0	Below Basin Bottom
Scenario 2	380[a]	50	5	19,000	39,900	7.6	91.4	Below Basin Bottom

[a] Calculated based on MGS Flood.

6.5.2 Results and Summary

MGS Flood model results indicate that the 20-foot-wide linear facility of Scenario 1 requires a length of 1,020 feet to meet the 91 percent treatment criteria. The Scenario 2 facility requires 380 feet of length to meet the treatment criteria. MODRET predicts that groundwater mounding is not a limiting factor for either scenario. Basins sized using MODRET were significantly smaller than those sized using MGS Flood. This is due to differences between the software used; MGS Flood using the Massmann Infiltration approach is more conservative than MODRET. For shallow groundwater sites, the Massmann Infiltration approach assumes groundwater mounding reduces the hydraulic gradient and the adjusted infiltration rate is significantly less than the initial hydraulic conductivity. Infiltration basin sizing in this Engineering Report is based on the MGS Flood model to provide a degree of conservatism appropriate for the preliminary nature of this evaluation.

7. EVALUATION OF PROPOSED BIORETENTION/INFILTRATION CONFIGURATIONS

The results of the hydrologic and basin modelling studies were used to develop three potential locations and configurations for treatment using bioretention/infiltration. Proposed configurations and details are provided in Figures 3 through 6.

7.1 Configuration/Location Options

Three preliminary layouts were developed using the biofiltration basin approach for stormwater treatment (Options 1, 2, and 3). These options are illustrated in Figures 3, 4, and 5, respectively. Each option uses a lift station installed near Outfall A to collect and pump stormwater at the treatment flow rate (1.4 cfs) to up to three bioretention/infiltration basins. The lift station would be equipped with a minimum of two pumps. A simplified control system would power the pumps on and off based on float switches and water levels in the lift station structure. A 480-volt, three-phase service would be required. Pumped stormwater would be conveyed to the basins using high density polyethylene (HDPE) force main. Pretreatment would be achieved using an NSBB hydrodynamic separator.

Infiltration/treatment basins would be constructed using modular concrete block walls in order to reduce the overall basin footprint compared to soil berms. Treatment would be achieved by passing stormwater through 18 inches of vegetated BSM. Stormwater would then infiltrate into native soils and recharge groundwater. Each basin would be equipped with an overflow structure to provide for emergency overflows.

The elongated configuration along Sims Way in Option 1 would have the least amount of impact on current Boatyard operating space. Options 2 and 3 are located within the interior of the Boatyard and would occupy space that is currently used primarily by noncommercial tenants. However, as described in the next section, the probable cost for Option 1 is significantly greater than Options 2 and 3.

7.2 Engineering Opinion of Probable Cost

Table 11 shows an engineer's opinion of probable cost (EOPC) for construction of each option. The EOPC for each option was developed using a combination of existing bid information, vendor quotes, and engineering judgment. The costs include construction of a lift station, force main, hydrodynamic separator, and bioretention/infiltration basins. The cost also includes engineering, permitting, construction management, contingency, and taxes. Detailed EOPC spreadsheets are provided in Appendix F.

As shown, the EOPC for Option 1 is the greatest and Option 3 is the least. The primary reason for this is that Option 3 is a single, rectangular structure and requires fewer modular blocks and other materials to construct. Options 1 and 2 include multiple infiltration structures and longer configurations requiring more construction materials and are a greater cost. However, as discussed previously, Options 2 and 3 occupy Boatyard operating space, whereas Option 1 does not. The Port and Parametrix will further review the cost-benefit of the three options and select a preferred option during detailed design.

It is important to note that costs presented in Table 11 are preliminary and include a sizable contingency and safety factor. The size and cost of bioretention/infiltration may be reduced significantly upon collection of additional pit test data described in Section 8 and upon further engineering and optimization of system design.

Table 11. Summary of Engineer's Opinion of Probable Cost for Bioretention/Infiltration

Location/Configuration	Preliminary Engineer's Opinion of Probable Cost
Option 1	$1,846,000
Option 2	$1,450,000
Option 3	$1,218,000

8. IMPLEMENTATION PLAN

This section summarizes an implementation plan for proposed stormwater improvements. The implementation plan describes supplemental data collection, treatment system monitoring, waste management, engineering design, permitting, and preliminary implementation schedule. The Port, as a public agency, is expected to use public and enterprise funds effectively and efficiently and does not operate under a for-profit business model. Consequently, the proposed implementation plan is phased over a 3-year period to minimize disruption of the facility area operations (and business) for construction, collect additional seasonal groundwater and data per Ecology requirements to optimize the system, and align the project costs with annual Port budget cycles. The Port also needs to seek financial assistance and accumulate matching contributions to fund the range of probable project costs identified in Section 7.2. The Port has initiated research on potential grant/loan opportunities and has identified several for which the Port may be eligible and can provide matching funds if needed over a 3-year period.

8.1 Summary of Preferred Alternatives and Proposed Improvements

Bioretention/infiltration is the preferred treatment alternative. Pre-settling will be included ahead of biofiltration to remove suspended solids and particulate-bound metals. A new lift station upstream of Outfall A will be included to pump and return stormwater flows to the upland bioretention/infiltration basin. In addition, a new tide-flex check valve will be installed on the end of Outfall A to replace the existing leaking tide-gate valve and prevent backflow of seawater into the stormwater system. Alternative locations and configurations for bioretention/infiltration have been preliminarily reviewed in this report. A final location/configuration will be selected in final design.

The Port will also continue providing biochar treatment on building downspouts. The biochar totes have proven to be very effective, removing greater than 90 percent of zinc and copper and meeting benchmark limits. The discharge point for treated rooftop flows will be Outfall A, downstream of the new lift station. The modified conveyance and discharge connection for treated rooftop flows will be further developed during detailed design.

The Port will also continue with pollution prevention and operational source control BMPs, and the Boatyard SWPPP will be modified to include enhancements to operational BMPs identified in Section 5.1.1. These operational source control BMPs will help the new bioretention/infiltration treatment system operate under preferred conditions and meet performance expectations.

8.2 Monitoring and Waste Management

Monitoring of pre-treated influent stormwater to the bioretention/infiltration system will be performed in accordance with monitoring requirements in Section S6 of the Permit. Typical maintenance will include semi-annually raking debris and plant litter from the surface of the bioretention media, replacing plants, and removing and disposing sediment material in the pre-settling unit. Sediment wastes from pre-settling units, as well as depleted biochar from downspout totes, will be characterized appropriately (e.g., toxicity characteristic leaching procedure and total metals) and the waste material will be hauled off-site and disposed in a permitted disposal facility.

8.3 Supplemental Data Needs

This section summarizes additional data that will be collected during the remainder of the 2016 wet season to provide additional information to support engineering design and analysis.

8.3.1 Pre-Settling Tests

Existing stormwater data summarized in Section 6.2 suggest that significant removal of TSS and particulate-bound metals may be provided by pre-settling. The results indicate that stormwater, following pre-treatment by settling, should readily meet the benchmarks for infiltration. These results will be confirmed through additional stormwater sampling and analysis.

Stormwater samples during qualifying storm events will be collected from the effluent of each vault (Vaults 1, 2, 3, and 4) and the effluent from East Sims and West Sims filters. The samples will be composited in proportion to drainage basin size and will be analyzed for TSS and total and dissolved coper and zinc before and following gravity settling in bench-top beaker tests. The testing will be repeated using polymer flocculant to examine any increases in settling rates. Testing results will be used to determine settling rates and polymer doses for final design of the pre-settling units.

8.3.2 Additional Test Pits

Additional test pits will be excavated in the preferred location of the biofiltration system. Test pit soils will be examined and logged according to the same procedures used for the previous test pits described in this report. Approximately six additional test pits will be excavated and examined. Small-scale pit tests will be performed in up to four of the test pits. The data will be used to confirm results from the previous test pits and infiltration tests, and to adjust and optimize infiltration design.

8.3.3 Field Piezometer Measurements

The piezometers previously installed with TP-2 and TP-3 will be measured again during the 2016 wet season to confirm groundwater depths per Ecology guidance. Quality and complete data are needed to confirm expected performance and provide information to inform an efficient and optimized treatment system. Continuous level readings with installed transducers will be measured and recorded and compared to results obtained in June 2016.

8.4 Engineering and Permitting

Engineering design and permitting will proceed following Ecology's review and acceptance of this Engineering Report. Design will include detailed plans and specifications and construction bid documents. Design documents will be prepared for new lift station, tide-flex check valve, force main, pre-settling units, and bioretention/infiltration basins.

Permits will be required for excavation and grading work and for in-water work associated with installation of the new tide-flex check valve on the end of Outfall A. The following permits are anticipated to be required prior to construction of the proposed stormwater improvements:

- Grading Permit from City of Port Townsend.
- Construction Stormwater Notice of Intent (NOI) and SWPPP per Ecology requirements.
- United States Corps of Engineers Nationwide Abbreviated Review Programmatic Permit (for maintenance in-water work associated with installation of the tide-flex check valve).
- Washington Department of Fish and Wildlife (WDFW) Hydraulic Project Approval (HPA) Application (for in-water work associated with installation of tide-flex check valve).
- State Environmental Policy Act (SEPA) Determination of Non-Significance.
- Shoreline Permit from City of Port Townsend.

This preliminary list of permits may require modification based on further detailed review of permitting requirements.

8.5 Implementation Schedule

A preliminary, phased implementation schedule is shown in Table 12. The proposed implementation schedule is phased over a 3-year period to allow the Port time to align data collection, construction scheduling, and funding stream to design an effective and adaptable system that will comply with discharge limits.

Table 12. Implementation Schedule

Phase	Project Elements	Completion Date
I	• Supplemental Data Collection. • Initiate enhancements to operational source control BMPs identified in Section 5.1.1. • Construct Phase I infiltration basin. • Connect Vault 1 Lift Station to Phase I Infiltration Basin. • Relocate Boatyard Aquip unit to Vault 2 and replace media. • Engineering design and permitting.	September 30, 2017
II	• Complete enhancements to operational source control BMPs identified in Section 5.1.1. • Construct return flow Lift Station at Outfall A. • Install Tide-Flex valve on Outfall A. • Run force main from Lift Station to Phase I Infiltration Basin. • Connect treated downspouts to Outfall A. • Engineering design and permitting.	September 30, 2018
III	• Construct Phase II Infiltration Basin. • Engineering design and permitting.	September 30, 2019

8.5.1 Phase I Stormwater Improvements

Phase I project elements are identified in Table 12. The bioretention/infiltration basin will be constructed in two phases. The Phase I basin will infiltrate stormwater flows (approximately 200 gpm – 300 gpm) from the existing Vault 1 lift station. The Aquip unit currently connected to Vault 1 will be relocated to treat stormwater flows at the Vault 2 lift station. The media in the Aquip unit will be replaced with new media. Phase I will also include initiation of operational BMP enhancements identified in Section 5.1.1, including implementation of formal work plan and training video.

The Phase I improvements are expected to lower discharge concentrations of copper and zinc by providing treatment of a significant portion of stormwater flow (Vault 1 drainage) through biorention/infiltration. Additional treatment of Vault 2 drainage will be provided by the relocated Aquip unit. Treatment will occur up to the pump flow rate and through-put rates of the infiltration and Aquip systems. Only a large storm will possibly exceed the treatment capacity of the Phase I system. Operational and performance data from Phase I infiltration will be useful for design and optimization of the full build-out bioretention/infiltration basin in Phase III.

8.5.2 Phase II Stormwater Improvements

Phase II will include construction of a new lift station at Outfall A and a new force-main to return flows to the bioretention/infiltration basin. Phase II will also include installation of a tide-flex check valve on Outfall A and a new connection to convey treated roof-top downspout flows to Outfall A. The new lift station will be designed to accommodate variable flow rates to allow a controlled portion of the flow to be routed to the Phase I bioretention/infiltration basin. Phase II will also include completion of operational BMP enhancements identified in Section 5.1.1, including limitations on bottom painting.

8.5.3 Phase III Stormwater Improvements

Phase III will include final completion of stormwater improvements identified in the Engineering Report. Operation and performance data from Phase I bioretention/infiltration will be used to size and design

the final bioretention/infiltration system. Phase III will likely involve expansion of the Phase I bioretention/infiltration basin or construction of a new basin to provide capacity for infiltration of the full design stormwater flow, if needed, to confirm full design flow compliance.

9. REFERENCES

Ecology (Washington Department of Ecology). 2006. Vehicle recyclers – A guide for implementing the industrial stormwater general national pollutant discharge elimination system (NPDES) permit requirements. Publication Number 94-146, 2006.

Ecology. 2010. AKART analysis: Draft national pollutant discharge elimination system (NPDES) wastewater discharge general permit for boatyards. April 2010.

Ecology. 2012. Stormwater management manual for Western Washington, as amended in December 2014.

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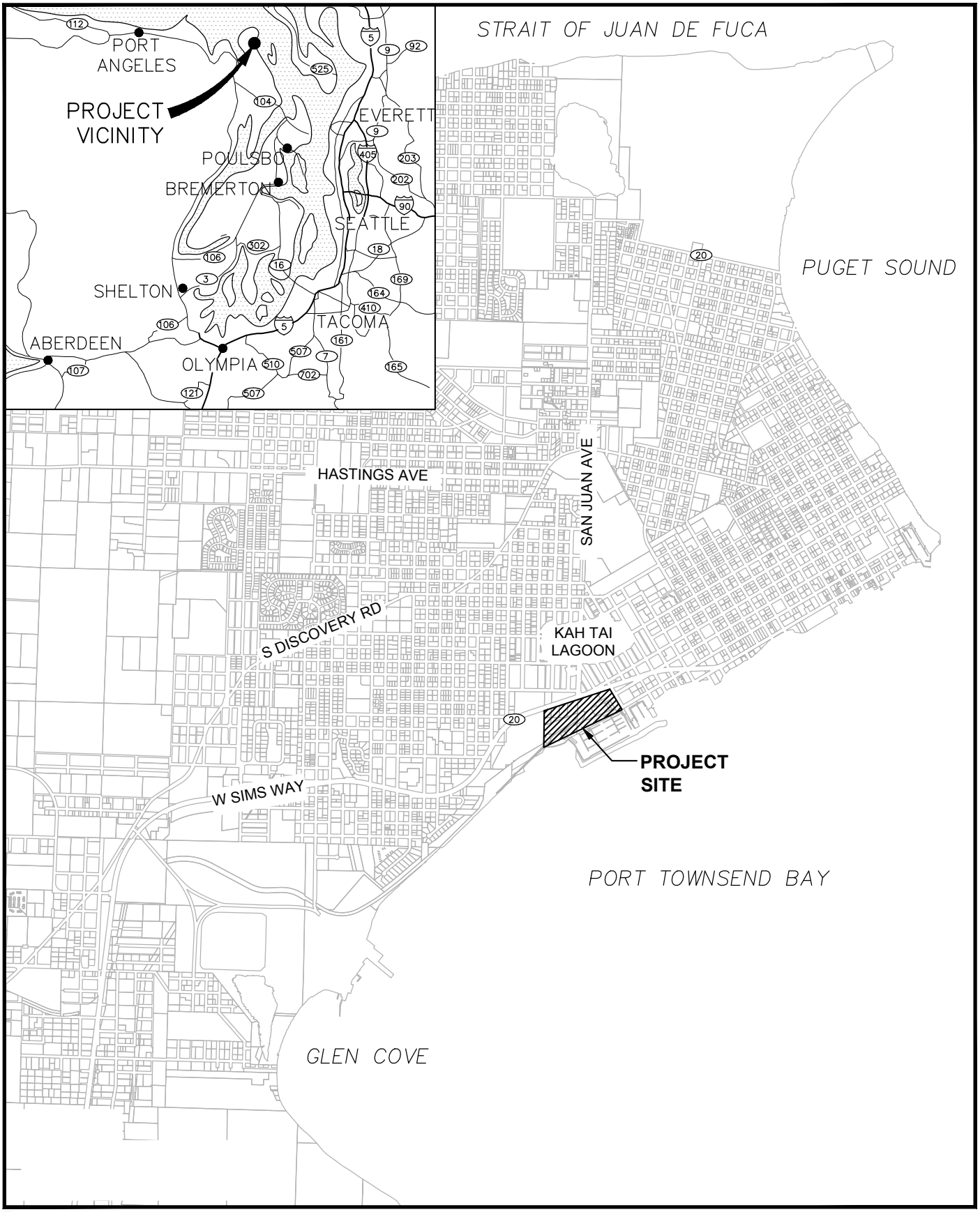
Johnston, Matt. 2014. Consideration of BMP lifespans. University of Maryland. October 20, 2014.

Landau and Associates. 2013. Revised level three response engineering report. Prepared for Port of Port Townsend. December 18, 2013.

Merchant, John. 2016. Personal communication with John Merchant, City of Port Townsend, September 2016.

Figures



Parametrix DATE: Oct 17, 2016 FILE: PS2170001_F01

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SCALE IN MILES

Figure 1
Vicinity Map

Port of Port Townsend
Boat Haven Boatyard
Port Townsend, WA

Parametrix DATE: Octo er 12, 2016 FILE: PS2170001_F02

0 160
N
SCALE IN FEET

NOTES

1 LOCATION OF STORM DRAIN UTILITIES AND BASIN BOUNDARIES PROVIDED BY LANDAU 2011 THE AERIAL PHOTO WAS PROVIDED BY USGS EARTHSTAR GEOGRAPHICS SIO 2016 MICROSOFT CORPORATION

2 PROPERTY BOUNDARIES WERE OBTAINED FROM JEFFERSON COUNTY GIS MAPS

LEGEND

- PROPERTY BOUNDARY
- DRAINAGE BASIN BOUNDARY APPRO IMATE
- STORM DRAIN LINE AND FLOW DIRECTION
- TEST PIT
- BUILDING ROOF TOP STORMWATER TREATED WITH BIOCHAR MEDIA
- STORMWATER MONITORING LOCATIONS

Figure 2
Site Plan and Drainage Basin Map
Port of Port Townsend
Boat Haven Boatyard
Port Townsend, WA

Parametrix DATE: Octo□er 17, 2016 FILE: PS2170001_F0□

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SCALE IN FEET

NOTES

1□ LOCATION OF STORM DRAIN UTILITIES AND BASIN BOUNDARIES PROVIDED BY LANDAU 2011□THE AERIAL PHOTO WAS PROVIDED BY USGS EARTHSTAR GEOGRAPHICS SIO 2016 MICROSOFT CORPORATION□

2□ PROPERTY BOUNDARIES WERE OBTAINED FROM JEFFERSON COUNTY GIS MAPS□

LEGEND

- PROPERTY BOUNDARY
- STORM DRAIN LINE AND FLOW DIRECTION
- TEST PIT
- CATCH BASIN
- INLET

ABBREVIATIONS

CPEP	CORRUGATED POLYETHYLENE PIPE
HDPE	HIGH□DENSITY POLYETHYLENE PIPE
NSBB	NUTRIENT SEPARATING BAFFLE BO□ □HYDRODYNAMIC SEPARATOR□

Figure 3 : Site Plan - Option 1 Bioretention/Infiltration Basin (Multiple Cells Along Sims Way)

Port of Port Townsend
Boat Haven Boatyard
Port Townsend, WA

Parametrix DATE: Octo□er 17, 2016 FILE: PS2170001_F0□

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SCALE IN FEET

NOTES

1. □ LOCATION OF STORM DRAIN UTILITIES AND BASIN BOUNDARIES PROVIDED BY LANDAU 2011□THE AERIAL PHOTO WAS PROVIDED BY USGS EARTHSTAR GEOGRAPHICS SIO 2016 MICROSOFT CORPORATION□
2. □ PROPERTY BOUNDARIES WERE OBTAINED FROM JEFFERSON COUNTY GIS MAPS□

LEGEND

- PROPERTY BOUNDARY
- STORM DRAIN LINE AND FLOW DIRECTION
- TEST PIT
- CATCH BASIN
- INLET

ABBREVIATIONS

CPEP	CORRUGATED POLYETHYLENE PIPE
HDPE	HIGH□DENSITY POLYETHYLENE PIPE
NSBB	NUTRIENT SEPARATING BAFFLE BO□ □HYDRODYNAMIC SEPARATOR□

Figure 4 : Site Plan - Option 2 Bioretention/Infiltration Basin (Dual Basin in Boatyard Interior)

Port of Port Townsend
Boat Haven Boatyard
Port Townsend, WA

Parametrix DATE: Octo□er 17, 2016 FILE: PS2170001_F0□

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SCALE IN FEET

NOTES

1□ LOCATION OF STORM DRAIN UTILITIES AND BASIN BOUNDARIES PROVIDED BY LANDAU 2011□THE AERIAL PHOTO WAS PROVIDED BY USGS EARTHSTAR GEOGRAPHICS SIO 2016 MICROSOFT CORPORATION□

2□ PROPERTY BOUNDARIES WERE OBTAINED FROM JEFFERSON COUNTY GIS MAPS□

LEGEND

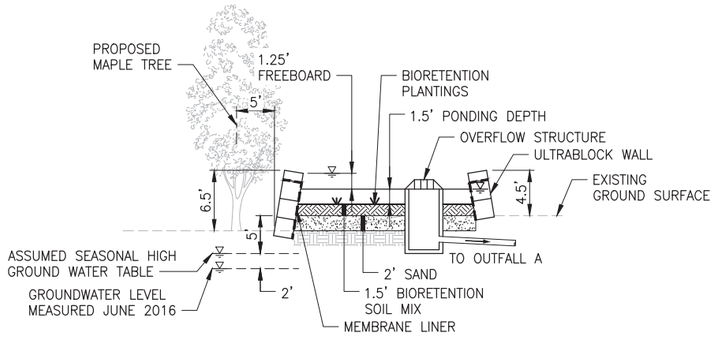
- PROPERTY BOUNDARY
- STORM DRAIN LINE AND FLOW DIRECTION
- TEST PIT
- CATCH BASIN
- INLET

ABBREVIATIONS

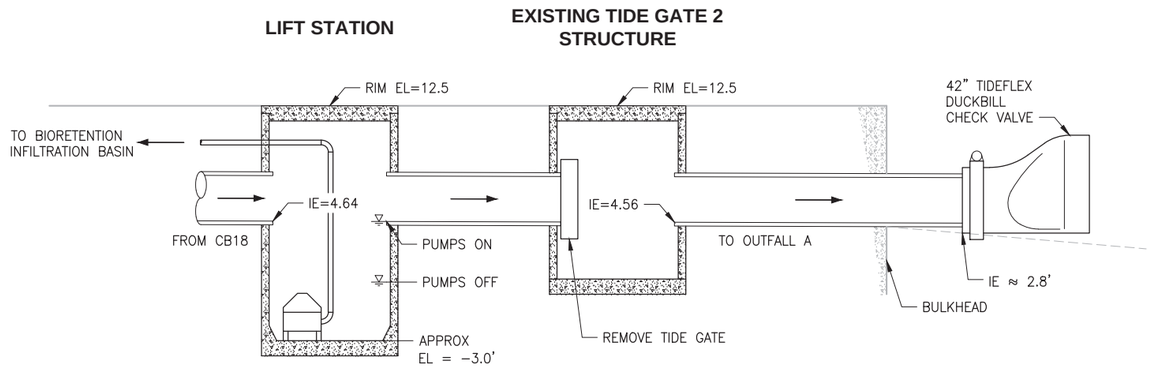
CPEP	CORRUGATED POLYETHYLENE PIPE
HDPE	HIGH□DENSITY POLYETHYLENE PIPE
NSBB	NUTRIENT SEPARATING BAFFLE BO□ □HYDRODYNAMIC SEPARATOR□

Figure 5 : Site Plan - Option 3 Bioretention/Infiltration Basin (Single Basin in Boatyard Interior)

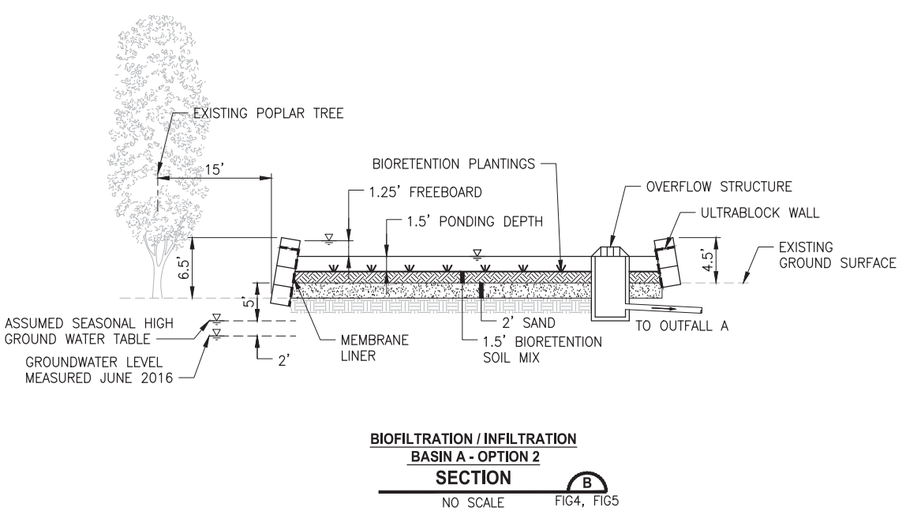
Port of Port Townsend
Boat Haven Boatyard
Port Townsend, WA



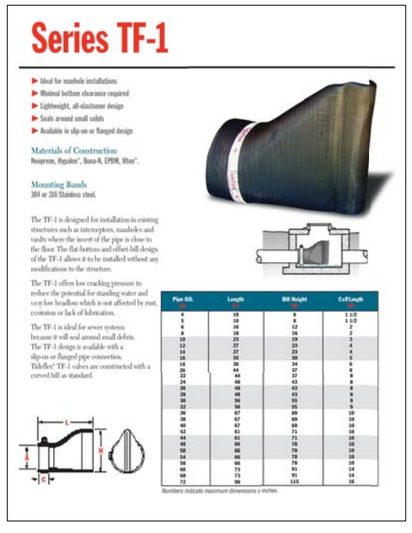
BIOFILTRATION / INFILTRATION BASIN A - OPTION 1
SECTION A FIG3
NO SCALE



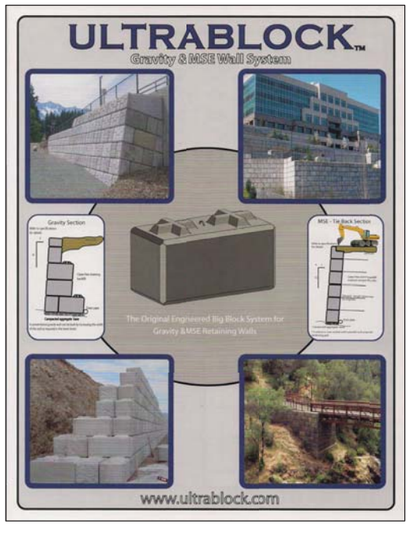
LIFTSTATION CONCEPT
SECTION B FIG3
NO SCALE



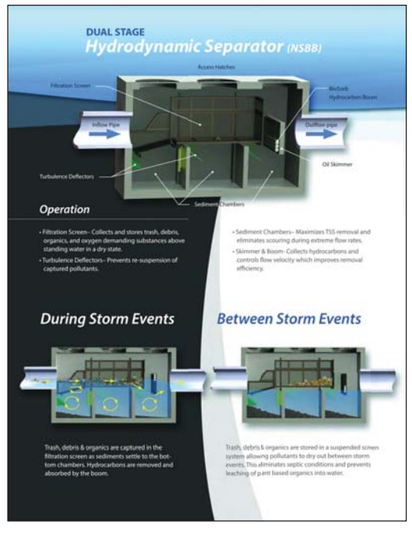
BIOFILTRATION / INFILTRATION BASIN A - OPTION 2
SECTION B FIG4, FIG5
NO SCALE



TIDEFLEX DUCKBILL CHECK VALVE



ULTRABLOCK WALL SYSTEM



HYDRODYNAMIC SEPARATOR (NSBB)

Figure 6
Details and Brochures
Bioretention and Lift Station
Port of Port Townsend
Boat Haven Boatyard
Port Townsend, WA

Appendix A

WAC 173-240-130 Checklist

APPENDIX A

WAC 173-240-130 Checklist

Section	WAC 173-240-130 Engineering Report Requirements	Stormwater Level 3 Engineering Report
2(a)	Type of industry or business.	Section 3
2(b)	The kind and quantity of finished product.	Section 3
2(c)	The quantity and quality of water used by the industry and a description of how it Is consumed or disposed of, including:	Sections 3 and 4
2(c)i	The quantity and quality of all process wastewater and method of disposal.	Section 3
2(c)ii	The quantity of domestic wastewater and how it is disposed.	Not applicable for stormwater systems.
2(c)iii	The quantity and quality of noncontact cooling water (including air conditioning) and how it is disposed.	Not applicable for stormwater systems.
2(c)iv	The quantity of water consumed or lost to evaporation.	Not applicable for stormwater systems.
2(d)	The amount and kind of chemicals used in the treatment process, if any.	None for stormwater.
2(e)	The basic design data and sizing calculations of the treatment units.	Section 6
2(f)	A discussion of the suitability of the proposed site for the facility.	Sections 5.2 and 6
2(g)	A description of the treatment process and operation, including a flow diagram.	Sections 6 and 7
2(h)	All necessary maps and layout sketches.	Figure 2 – Site Drainage Map Figures 3, 4, 5, and 6 – Flow conveyance, lift station, bioretention layout options, and details and profiles.
2(i)	Provisions for bypass, if any.	Section 6
2(j)	Physical provision for oil and hazardous material spill control or accidental discharge prevention or both.	Section 5
2(k)	Results to be expected from the treatment process including the predicted wastewater characteristics, as shown in the waste discharge permit, where applicable.	Sections 5.2 and 6.2
2(l)	A description of the receiving water, location of the point of discharge, applicable water quality standards, and how water quality standards will be met outside of any applicable dilution zone.	Sections 4 and 6.2
2(m)	Detailed outfall analysis.	Treated stormwater will be infiltrated to the ground. By-pass flows in excess of design criteria storm flow will discharge through existing Outfall A. See Sections 6 and 7.

Section	WAC 173-240-130 Engineering Report Requirements	Stormwater Level 3 Engineering Report
2(n)	The relationship to existing treatment facilities, if any.	Existing OWS vaults and perimeter filters will continue to be used for pre-treatment for the new bioretention/infiltration system. Section 3.
2(o)	Where discharge is to a municipal sewerage system, a discussion of the ability of that system to transport and treat the proposed industrial waste discharge without exceeding the municipality's allocated industrial capacity. Also, a discussion on the effects of the proposed industrial discharge on the use or disposal of municipal sludge.	Section 5.1.4. There will be no stormwater discharge to the WWTP, other than the current discharges from the two wash-down pads.
2(p)	Where discharge is through land application, including seepage lagoons, irrigation, and subsurface disposal, a geohydrologic evaluation of factors such as:	Section 6
2(p)i	Depth to groundwater and groundwater movement during different times of the year.	Section 6
2(p)ii	Water balance analysis of the proposed discharge area.	Section 6
2(p)iii	Overall effects of the proposed facility upon the groundwater in conjunction with any other land application facilities that may be present.	Section 6
2(q)	A statement expressing sound engineering justification through the use of pilot plant data, results from other similar installations, or scientific evidence from literature, or both, that the effluent from the proposed facility will meet applicable permit effluent limitations or pretreatment standards or both.	Section 5.2
2(r)	A discussion of the method of final sludge disposal selected and any alternatives considered with reason for rejection.	Section 8
2(s)	A statement regarding who will own, operate, and maintain the system after construction.	Section 8
2(t)	A statement regarding compliance with any state or local water quality management plan or any plan adopted under the Federal Water Pollution Control ACT as amended.	Section 8
2(u)	Provisions for any committed future plans.	Section 8
2(v)	A discussion of the various alternatives evaluated, if any, and reasons they are unacceptable.	Section 5
2(w)	A timetable for final design and construction.	Section 8
2(x)	A statement regarding compliance with the State Environmental Policy Act (SEPA) and NEPA, if applicable.	See Implementation Plan in Section 8.

Appendix B

Field Test Pit Results

HWA GEOSCIENCES INC.
Geotechnical & Pavement Engineering • Hydrogeology • Geoenvironmental • Inspection & Testing

July 20, 2016
HWA Project No. 2013-017-23 T300

Parametrix
60 Washington Avenue, Suite 390
Bremerton, Washington 98337

Attention: Brandon Ball, P.E.

Subject: **Materials Laboratory Report**
Particle Size, Organic Content, and CEC Testing
Boatyard Project

Dear Mr. Ball;

In accordance with your request, HWA GeoSciences Inc. (HWA) performed laboratory testing for the above referenced project. Herein we present the results of our laboratory analyses, which are summarized on the attached reports and table. The laboratory testing program was performed in general accordance with your instructions and appropriate ASTM Standards as outlined below.

SAMPLE DESCRIPTION: The subject samples were delivered to our laboratory on June 30, 2016 UPS. The samples were delivered in re-sealable 1-gallon plastic bags and were designated with exploration ID and depth of sampling. The soil was classified for engineering purposes using visual-manual methods and the descriptions can be found on the attached Figures 1 and 2.

PARTICLE SIZE ANALYSIS OF SOILS: The samples were tested to determine the particle size distribution in general accordance with ASTM D422, using sieve and hydrometer analysis. The results are plotted on the attached Particle Size Analysis of Soil Reports, Figures 1 and 2 which also indicates the moisture content of the soil samples at the time of testing.

MOISTURE CONTENT, ASH, AND ORGANIC MATTER: Selected samples were tested in general accordance with method ASTM D 2974, using moisture content method 'A' (oven dried at 1050 C) and ash content method 'C' (burned at 4400 C). The test results are summarized on the Table below. The results are percent by weight of dry soil.

21312 30th Drive SE
Suite 110
Bothell, WA 98021-7010
Tel: 425.774.0106
Fax: 425.774.2714
www.hwageo.com

Moisture Content, Ash, and Organic Matter			
Sample	Moisture Content (%)	Ash Content (%)	Organic Content (%)
TP-1, 1.0-1.5 ft.	8	98.7	1.3
TP-2, 1.0-1.5 ft.	5	99.1	0.9
TP-3, 1.0-1.5 ft.	2	99.4	0.6
TP-3, 4.5-5.0 ft.	38	97.1	2.9

CATION-EXCHANGE CAPACITY: The Cation-Exchange Capacity of the samples was determined in accordance with EPA method 9081. Analytical Resources Inc. of Tukwila, Washington performed these analyses under subcontract to HWA. The results are presented Appendix A.

CLOSURE: Experience has shown that test values on soil and other natural materials vary with each representative sample. As such, HWA has no knowledge as to the extent and quantity of material the tested samples may represent. HWA also makes no warranty as to how representative either the samples tested or the test results obtained are to actual field conditions. It is a well established fact that sampling methods present varying degrees of disturbance that affect sample representativeness.

No copy should be made of this report except in its entirety.

We appreciate the opportunity to provide laboratory testing services on this project. Should you have any questions or comments, or if we may be of further service, please call.

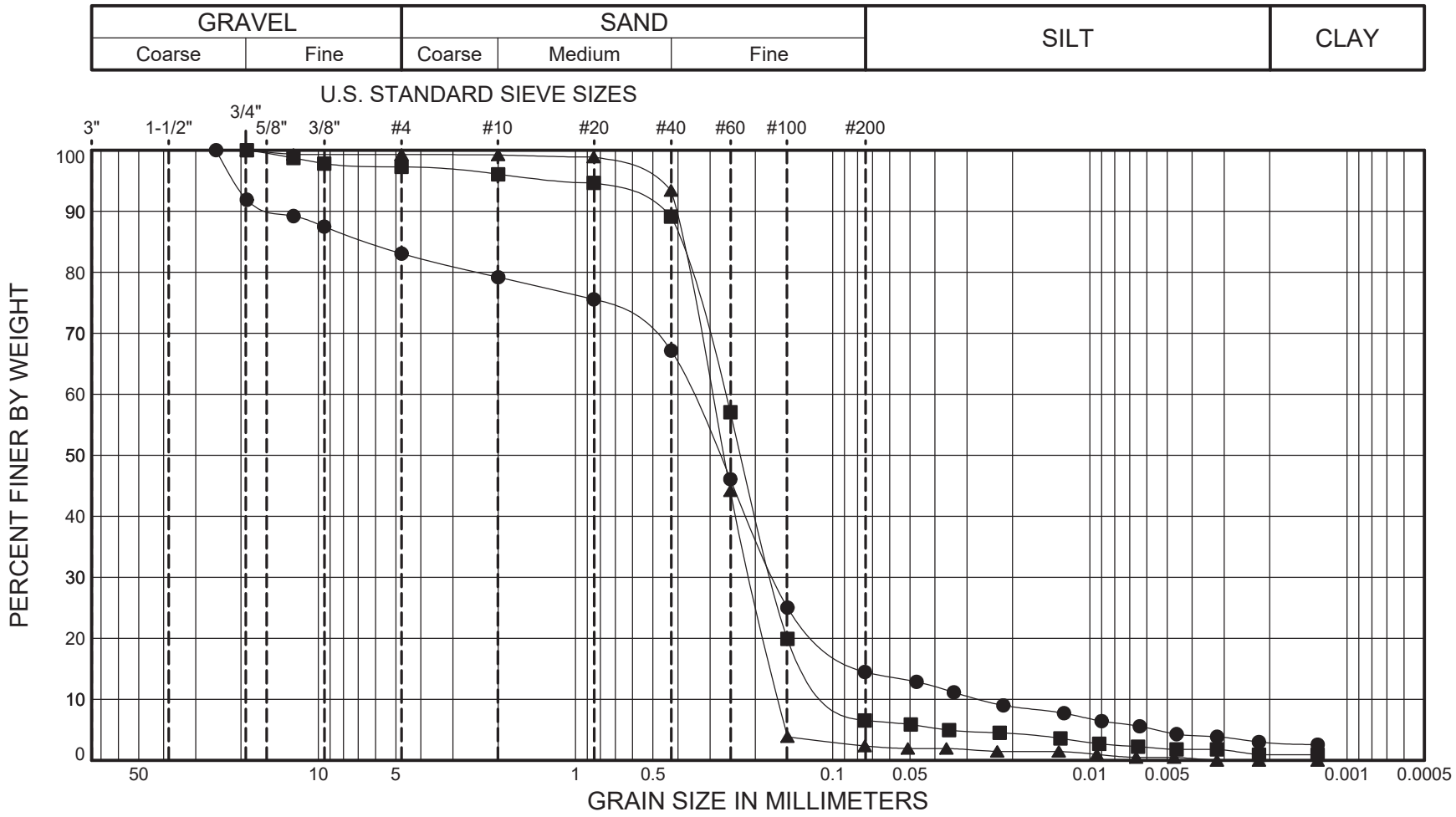
HWA GEOSCIENCES INC.

Jessica Herrera
Materials Laboratory Manager

Steven E. Greene, L.G., L.E.G.
Principal Engineering Geologist
Vice President

Attachments:

Figures 1 and 2 Particle Size Analysis of Soils
Appendix A Testing Performed by Analytical Resources Inc.



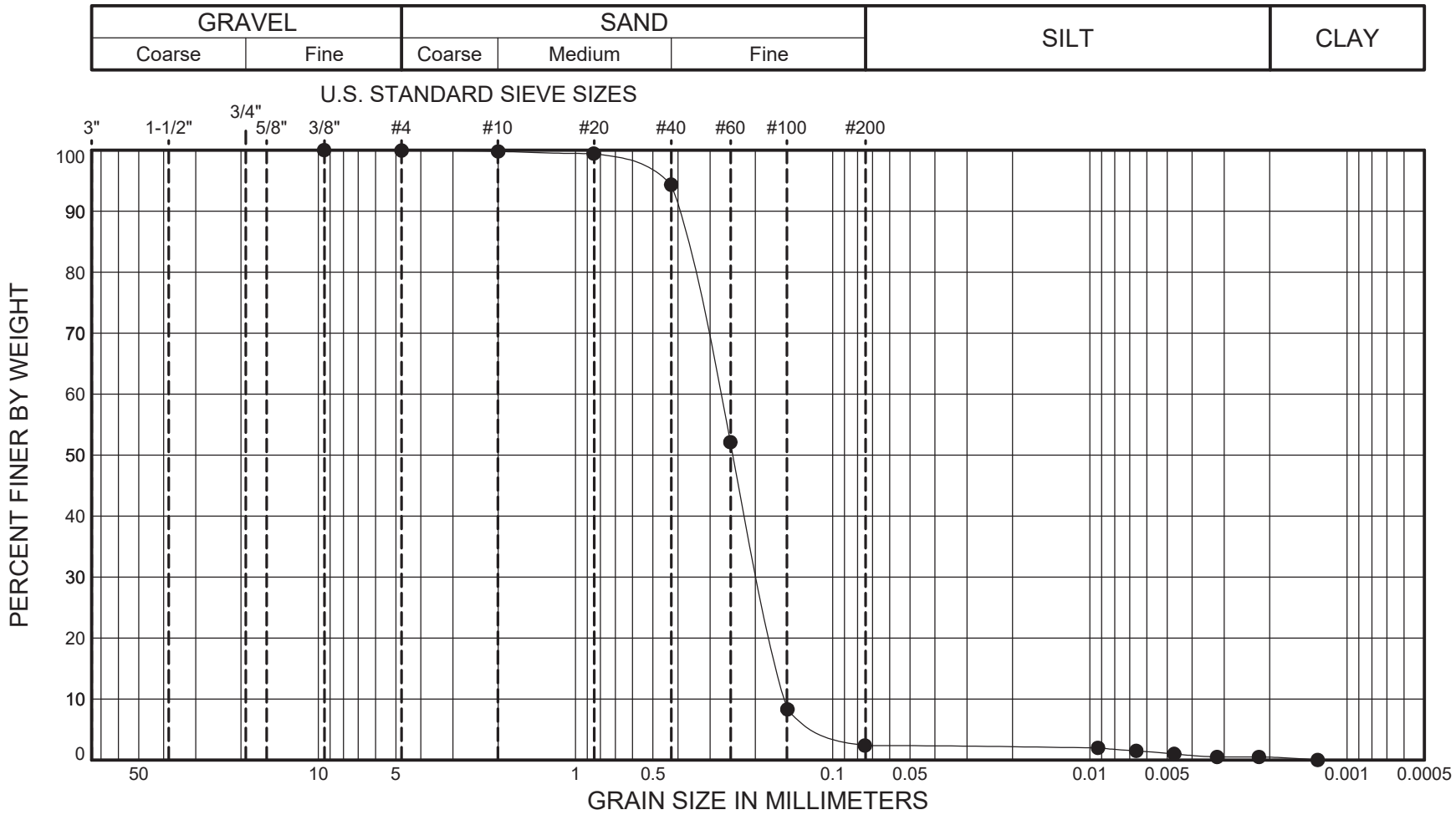
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	D90	D60	D10	Gravel %	Sand %	Silt %	Clay %
●	TP-1		1.0 - 1.5	(SM) Dark olive brown, silty SAND with gravel and organics	8	14.16	0.35	0.0267	16.9	68.6	11.6	2.9
■	TP-2		1.0 - 1.5	(SP-SM) Light olive brown, poorly graded SAND with silt	5	0.48	0.26	0.0898	2.7	90.7	5.6	0.9
▲	TP-3		1.0 - 1.5	(SP) Light olive brown, poorly graded SAND	2	0.41	0.30	0.1621	0.7	96.9	2.4	0.0

HWA GEOSCIENCES INC.

Laboratory Testing for Parametrix
Boatyard
Parametrix Project #2170

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2013-017 T300 FIGURE: 1



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION OF SOIL- ASTM D2487 Group Symbol and Name	% MC	D90	D60	D10	Gravel %	Sand %	Silt %	Clay %
●	TP-3		4.5 - 5.0	(SP) Dark grayish brown, poorly graded SAND with organics	38	0.40	0.28	0.1530	0.1	97.6	2.0	0.4

HWA GEOSCIENCES INC.

Laboratory Testing for Parametrix
Boatyard
Parametrix Project #2170

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D422

PROJECT NO.: 2013-017 T300 FIGURE: 2

APPENDIX A
Testing Performed by Analytical Resources Incorporated

Analytical Resources, Incorporated
Analytical Chemists and Consultants

19 July 2016

Jessica Herrera
HWA Geosciences
21312 30th Drive SE, Suite 110
Bothell, WA 98021

RE: Client Project: Boatyard
ARI Job No: BCW7

Dear Jessica:

Please find enclosed the original 'chain of custody record and the final results for the samples from the project referenced above. Four soil samples were received on July 15, 2016. The samples were analyzed for CEC as requested.

There were no incidents of note associated with these analyses.

A copy of these reports and all raw data will be kept of file at ARI. If you have any questions or require additional information, please contact me at your convenience.

Sincerely,

ANALYTICAL RESOURCES, INC.

Mark Harris
Project Manager
markh@arilabs.com
206/695-6210

Enclosures

cc: eFile BCW7

MDH/mdh

4611 South 134th Place, Suite 100 • Tukwila WA 98168 • **206-695-6200** • **206-695-6201** fax

BCW7

2013-017

HWA GeoSciences Inc.

21312 30th Drive SE, Suite 110, Bothell, Washington 98021-7010
Tel 425.774.0106 Fax 425.774.2714 www.hwageo.com

Chain of Custody and Laboratory Anaylsis Request

DATE: 6/28
PAGE: 1 of 1

PROJECT NAME: Boat Yard #: 2170
SAMPLERS NAME: Brannon Gall PHONE: 360 805 5346
SAMPLERS SIGNATURE: B Gall DATE: 6/28/16
HWA CONTACT: _____ PHONE: _____

HWA SAMPLE ID	DATE	TIME	MATRIX	LAB ID	# OF BOTTLE	ASTM D422	EPA 9081	ASTM D2974	EDD	REMARKS
TP1 12"-18"	6/27/16	9:00 AM	Soil		1	X	X	X		Gradation,
TP2 12"-18"	"	"	"		1	X	X	X		CEC, and
TP3 12"-18"	"	"	"		1	X	X	X		Organic
TP3 45"-5"	"	"	"		1	X	X	X		Content on
										each BAG.

ANALYSIS REQUESTED

TURNAROUND TIME
☐ DAYS
☒ STANDARD

PRINT NAME	SIGNATURE	COMPANY	DATE	TIME	REMARKS
Relinquished by: B. Gall	B Gall	PM x Parametrix	6/28/16	5:00 PM	
Received by: M. Wray	Melody Wray	Parametrix	6/29/16	2:10 pm	Sentrica UPS
Relinquished by: J. Herrera	J Herrera	HWA	7/5/16	11:00 AM	Sent to ALS
Received by: J. Meyer		ARI	7/5/16	1130	

DISTRIBUTION: WHITE - Return to HWA GeoSciences; YELLOW - Retain by Lab; PINK - Retain by Sampler

2013-017 BOAT YARD

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Cooler Receipt Form

ARI Client: HWA Geosciences Project Name: Boatyard

COC No(s): _____ NA Delivered by: Fed-Ex UPS Courier Hand Delivered Other: _____

Assigned ARI Job No: BCW7 Tracking No: _____ NA

Preliminary Examination Phase:

Were intact, properly signed and dated custody seals attached to the outside of to cooler?	YES	NO
Were custody papers included with the cooler?	YES	NO
Were custody papers properly filled out (ink, signed, etc.)	YES	NO

Temperature of Cooler(s) (°C) (recommended 2.0-6.0 °C for chemistry) 2.5

Time: _____

If cooler temperature is out of compliance fill out form 00070F Temp Gun ID#: D0052Z6

Cooler Accepted by: JM Date: 7-5-16 Time: 1250

Complete custody forms and attach all shipping documents

Log-In Phase:

Was a temperature blank included in the cooler?		YES	NO
What kind of packing material was used? ... Bubble Wrap Wet Ice Gel Packs Baggies Foam Block Paper Other:			
Was sufficient ice used (if appropriate)?	NA	YES	NO
Were all bottles sealed in individual plastic bags?		YES	NO
Did all bottles arrive in good condition (unbroken)?		YES	NO
Were all bottle labels complete and legible?		YES	NO
Did the number of containers listed on COC match with the number of containers received?		YES	NO
Did all bottle labels and tags agree with custody papers?		YES	NO
Were all bottles used correct for the requested analyses?		YES	NO
Do any of the analyses (bottles) require preservation? (attach preservation sheet, excluding VOCs)...	NA	YES	NO
Were all VOC vials free of air bubbles?	NA	YES	NO
Was sufficient amount of sample sent in each bottle?		YES	NO
Date VOC Trip Blank was made at ARI	NA		

Was Sample Split by ARI : NA YES Date/Time:_____ Equipment:_____ Split by:_____

Samples Logged by: JM Date: 7-5-16 Time: 1250

***** Notify Project Manager of discrepancies or concerns *****

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Additional Notes, Discrepancies, & Resolutions:

By: Date:

Small Air Bubbles ~2mm	Peabubbles 2-4 mm	LARGE Air Bubbles > 4 mm
• • •	• • • •	● ● ●

Small → "sm" (< 2 mm)
Peabubbles → "pb" (2 to < 4 mm)
Large → "lg" (4 to < 6 mm)
Headspace → "hs" (> 6 mm)

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Cooler Temperature Compliance Form

Cooler#: 1 Temperature(°C): 22.5

Sample ID	Bottle Count	Bottle Type
All samples over	6 °C	

Cooler#: _____ Temperature(°C): _____

Sample ID	Bottle Count	Bottle Type

Cooler#: _____ Temperature(°C): _____

Sample ID	Bottle Count	Bottle Type

Cooler#: _____ Temperature(°C): _____

Sample ID	Bottle Count	Bottle Type

Completed by: JM Date: 7-5-16 Time: 1250

HWA GEOSCIENCES INC.
Geotechnical & Pavement Engineering • Hydrogeology • Geoenvironmental • Inspection & Testing

Analytical Resources, Inc.
4611 S. 134th Place
Tukwila, WA 98168

Attention:	**Mark Harris**
From:	**Jessica Herrera / HWA GeoSciences Inc.**
Subject:	**Soil Analyses** **Parametrix/Boatyard**
Date:	**July 5, 2016**
Project Number:	**2013-017 Task 300**

Dear Mark:

Please conduct analyses for Cation Exchange Capacity EPA Method 9081 (or similar) on the enclosed four soil samples listed below. A standard turnaround of 14 days is assumed.

Samples:

TP1	12"-18"
TP2	12"-18"
TP3	12"-18"
TP3	4.5"-5"

Thank you for effort in this matter. If you have any questions do not hesitate to call me at (425) 774-0106.

Sincerely;

Jessica Herrera
Materials Laboratory
jherrera@hwageo.com

21312 30th Drive SE
Suite 110
Bothell, WA 98021-7010
Tel: 425.774.0106
Fax: 425.774.2714
www.hwageo.com

Sample ID Cross Reference Report

ANALYTICAL RESOURCES INCORPORATED

ARI Job No: BCW7

Client: HWa Geosciences Inc.
Project Event: 2170
Project Name: Boat Yard

	Sample ID	ARI Lab ID	ARI LIMS ID	Matrix	Sample Date/Time	VTSR
1.	TP1 12"-18"	BCW7A	16-10111	Soil	06/27/16 09:00	07/05/16 12:50
2.	TP2 12"-18"	BCW7B	16-10112	Soil	06/27/16 09:00	07/05/16 12:50
3.	TP3 12"-18"	BCW7C	16-10113	Soil	06/27/16 09:00	07/05/16 12:50
4.	TP3 4.5"-5"	BCW7D	16-10114	Soil	06/27/16 09:00	07/05/16 12:50

Analytical Resources, Incorporated
Analytical Chemists and Consultants

Data Reporting Qualifiers

Effective 12/31/13

Inorganic Data

U	Indicates that the target analyte was not detected at the reported concentration
*	Duplicate RPD is not within established control limits
B	Reported value is less than the CRDL but ≥ the Reporting Limit
N	Matrix Spike recovery not within established control limits
NA	Not Applicable, analyte not spiked
H	The natural concentration of the spiked element is so much greater than the concentration spiked that an accurate determination of spike recovery is not possible
L	Analyte concentration is ≤5 times the Reporting Limit and the replicate control limit defaults to ±1 RL instead of the normal 20% RPD

Organic Data

U	Indicates that the target analyte was not detected at the reported concentration
*	Flagged value is not within established control limits
B	Analyte detected in an associated Method Blank at a concentration greater than one-half of ARI's Reporting Limit or 5% of the regulatory limit or 5% of the analyte concentration in the sample.
J	Estimated concentration when the value is less than ARI's established reporting limits
D	The spiked compound was not detected due to sample extract dilution
E	Estimated concentration calculated for an analyte response above the valid instrument calibration range. A dilution is required to obtain an accurate quantification of the analyte.

Q Indicates a detected analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20%Drift or minimum RRF).

S Indicates an analyte response that has saturated the detector. The calculated concentration is not valid; a dilution is required to obtain valid quantification of the analyte

NA The flagged analyte was not analyzed for

NR Spiked compound recovery is not reported due to chromatographic interference

NS The flagged analyte was not spiked into the sample

M Estimated value for an analyte detected and confirmed by an analyst but with low spectral match parameters. This flag is used only for GC-MS analyses

N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification"

Y The analyte is not detected at or above the reported concentration. The reporting limit is raised due to chromatographic interference. The Y flag is equivalent to the U flag with a raised reporting limit.

EMPC Estimated Maximum Possible Concentration (EMPC) defined in EPA Statement of Work DLM02.2 as a value "calculated for 2,3,7,8-substituted isomers for which the quantitation and /or confirmation ion(s) has signal to noise in excess of 2.5, but does not meet identification criteria" **(Dioxin/Furan analysis only)**

C The analyte was positively identified on only one of two chromatographic columns. Chromatographic interference prevented a positive identification on the second column

P The analyte was detected on both chromatographic columns but the quantified values differ by ≥40% RPD with no obvious chromatographic interference

X Analyte signal includes interference from polychlorinated diphenyl ethers. **(Dioxin/Furan analysis only)**

Z Analyte signal includes interference from the sample matrix or perfluorokerosene ions. **(Dioxin/Furan analysis only)**

Geotechnical Data

A The total of all fines fractions. This flag is used to report total fines when only sieve analysis is requested and balances total grain size with sample weight.

F Samples were frozen prior to particle size determination

SM Sample matrix was not appropriate for the requested analysis. This normally refers to samples contaminated with an organic product that interferes with the sieving process and/or moisture content, porosity and saturation calculations

SS Sample did not contain the proportion of "fines" required to perform the pipette portion of the grain size analysis

W Weight of sample in some pipette aliquots was below the level required for accurate weighting

SAMPLE RESULTS-CONVENTIONALS
BCW7-HWa Geosciences Inc.

ANALYTICAL RESOURCES INCORPORATED

Matrix: Soil
Data Release Authorized:
Reported: 07/18/16

Project: Boat Yard
Event: 2170
Date Sampled: 06/27/16
Date Received: 07/05/16

Client ID: TP1 12"-18"
ARI ID: 16-10111 BCW7A

Analyte	Date	Method	Units	RL	Sample
Total Solids	07/05/16 070516#1	SM2540G	Percent	0.01	91.96
Cation Exchange Capacity	07/08/16 070816#1	9080	meq/100 g	0.05	3.43

RL Analytical reporting limit
U Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
BCW7-HWa Geosciences Inc.

ANALYTICAL RESOURCES INCORPORATED

Matrix: Soil
Data Release Authorized:
Reported: 07/18/16

Project: Boat Yard
Event: 2170
Date Sampled: 06/27/16
Date Received: 07/05/16

Client ID: TP2 12"-18"
ARI ID: 16-10112 BCW7B

Analyte	Date	Method	Units	RL	Sample
Total Solids	07/05/16 070516#1	SM2540G	Percent	0.01	96.27
Cation Exchange Capacity	07/08/16 070816#1	9080	meq/100 g	0.05	1.66

RL Analytical reporting limit
U Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
BCW7-HWa Geosciences Inc.

ANALYTICAL RESOURCES INCORPORATED

Matrix: Soil
Data Release Authorized: CJ
Reported: 07/18/16

Project: Boat Yard
Event: 2170
Date Sampled: 06/27/16
Date Received: 07/05/16

Client ID: TP3 12"-18"
ARI ID: 16-10113 BCW7C

Analyte	Date	Method	Units	RL	Sample
Total Solids	07/05/16 070516#1	SM2540G	Percent	0.01	98.06
Cation Exchange Capacity	07/08/16 070816#1	9080	meq/100 g	0.05	1.24

RL Analytical reporting limit
U Undetected at reported detection limit

SAMPLE RESULTS-CONVENTIONALS
BCW7-HWa Geosciences Inc.

ANALYTICAL RESOURCES INCORPORATED

Matrix: Soil
Data Release Authorized:
Reported: 07/18/16

Project: Boat Yard
Event: 2170
Date Sampled: 06/27/16
Date Received: 07/05/16

Client ID: TP3 4.5"-5"
ARI ID: 16-10114 BCW7D

Analyte	Date	Method	Units	RL	Sample
Total Solids	07/05/16 070516#1	SM2540G	Percent	0.01	66.73
Cation Exchange Capacity	07/08/16 070816#1	9080	meq/100 g	0.07	9.26

RL Analytical reporting limit
U Undetected at reported detection limit

METHOD BLANK RESULTS-CONVENTIONALS
BCW7-HWa Geosciences Inc.

ANALYTICAL RESOURCES INCORPORATED

Matrix: Soil
Data Release Authorized: J
Reported: 07/18/16

Project: Boat Yard
Event: 2170
Date Sampled: NA
Date Received: NA

Analyte	Date	Units	Blank	QC ID
Total Solids	07/05/16	Percent	< 0.01 U	ICB
Cation Exchange Capacity	07/08/16	meq/100 g	< 0.05 U	PREP

REPLICATE RESULTS-CONVENTIONALS
BCW7-HWa Geosciences Inc.

ANALYTICAL RESOURCES INCORPORATED

Matrix: Soil
Data Release Authorized: w
Reported: 07/18/16

Project: Boat Yard
Event: 2170
Date Sampled: 06/27/16
Date Received: 07/05/16

Analyte	Date	Units	Sample	Replicate(s)	RPD/RSD
ARI ID: BCW7A Client ID: TP1 12"-18"					
Total Solids	07/05/16	Percent	91.96	91.84	0.1%
Cation Exchange Capacity	07/08/16	meq/100 g	3.43	3.50	2.0%

Parametrix

Test Pit Log

Project Number 233-2170-001
Project Name PoPT Stormwater Planning
Location Boat Haven Boatyard
Excavation Equipment Case Backhoe
Coordinates

Test Pit Number TP-1
Date Completed 6/27/2016
Total Depth of Test Pit 11 ft
Water Level 2 feet bgs (piezometer)
Logged By David Dinkuhn

Depth (ft)	USCS SYMBOL	Description	Remarks
1	GW	Gray, slightly silty, gravelly SAND, damp, some organics (fill)	Piezometer installed in test pit Piezo. depth = 8 feet bgs Screen interval = 3 to 8 feet bgs Dtw = 2 feet bgs (measured 06/27/16)
2			
3	SW	Gray, medium SAND, damp to wet (fill) GW observed at 4 feet bgs during excavation	
4			
5			
6			
7			
8			
9	SM	Gray-black, silty SAND, numerous shell fragments, wet (beach sediment)	
10			
11			
		Bottom of Excavation at 11 feet	

Notes:
bgs = below ground surface
dtw = depth to water

Parametrix

Test Pit Log

Project Number 233-2170-001
Project Name PoPT Stormwater Planning
Location Boat Haven Boatyard
Excavation Equipment Case Backhoe
Coordinates

Test Pit Number TP-2
Date Completed 6/27/2016
Total Depth of Test Pit 10 ft
Water Level 4.2 feet bgs (piezometer)
Logged By David Dinkuhn

Depth (ft)	USCS SYMBOL	Description	Remarks
1	GW	Gray, sandy GRAVEL with quarry spalls, damp (fill)	Piezometer installed in test pit Piezo. depth = 9.7 feet bgs Screen interval = 4.7 to 9.7 feet Dtw = 4.2 feet bgs (measured 06/29/16)
2	SW	Gray, medium SAND, damp to wet (fill)	
3			
4		GW observed at 4.5 feet bgs during excavation	
5			
6	SW	Black, gravelly SAND, numerous shell fragments, wet (beach sediment)	
7			
8			
9			
10		Bottom of excavation at 10 feet	
11			

Notes:
bgs = below ground surface
dtw = depth to water

Parametrix

Test Pit Log

Project Number 233-2170-001
Project Name PoPT Stormwater Planning
Location Boat Haven Boatyard
Excavation Equipment Case Backhoe
Coordinates

Test Pit Number TP-3
Date Completed 6/27/2016
Total Depth of Test Pit 10 ft
Water Level 4.5 feet bgs (piezometer)
Logged By David Dinkuhn

Depth (ft)	USCS SYMBOL	Description	Remarks
1	SW	Gray, medium SAND, damp (fill)	Piezometer installed in test pit Piezo. depth = 8.7 feet bgs Screen interval = 3.7 to 8.7 feet Dtw = 4.5 feet bgs (measured 06/29/16)
2			
3			
4			
5	SW	Dark grey medium sand, damp to wet (fill) GW observed at 5 feet bgs during excavation	
6			
7			
8			
9			
10			
11		Bottom of excavation at 10 feet	

Notes:
bgs = below ground surface
dtw = depth to water

Appendix C

Water Level Measurements

Report Date:	7/8/2016 9:55
Report User Name	dinkudav
Report Computer I	BREMLT4750
Application:	WinSitu.exe
Application Versio	5.6.27.1

Log File Properties

File Name	Log 1_Append_2016-07-08_07-23-06-291.wsl
Create Date	7/8/2016 7:23

Device Properties

Device	Level TROLL 700			
Site	TP2			
Device Name				
Serial Number	416036			
Firmware Version	3.03			
Hardware Version	5			
Device Address	1			
Device Comm Cfg	19200	8 Even	1	(Modbus-RTU)
Used Memory	0			
Used Battery	8			

Log Configuration

Log Name	Log 1
Created By	dinkudav
Computer Name	BREMLT4750
Application	WinSitu.exe
Application Versi	5.6.27.1
Create Date	6/29/2016 11:38:14 AM Pacific Daylight Time
Log Setup Time Z	Pacific Daylight Time
Notes Size(bytes)	4096
Overwrite when f	Disabled
Scheduled Start T	6/29/2016 12:00:00 PM Pacific Daylight Time
Scheduled Stop T	7/7/2016 12:00:00 PM Pacific Daylight Time
Type	Linear
Duration	Days: 8 hrs: 00 mins: 00 secs: 00
Interval	Days: 0 hrs: 00 mins: 15 secs: 00

Level Reference Settings At Log Creation

Level Measu	Depth
Specific G	0.999

Other Log Settings

Depth of Probe: 3.859 (ft)
Head Pressure: 1.67131 (PSI)
Temperature: 16.2517 (C)

Log Notes:

Date and Time	Note
6/29/2016 11:38	Used Battery: 8% Used Memory: 1% User Name: dinkudav
7/2/2016 11:49	Log Download - Used Battery: 8% Used Memory: 1% User Name: dinkudav

Log Data:

Record Count	769		
Sensors	1		
	1	416036	Pressure/Temp 5 PSIG (3.5m/11.5ft)

Time Zone: Pacific Daylight Time GW Depth = 8.06' - Transducer Depth

	Elapsed Time	Sensor: Pres(G) 11.5ft SN#: 416036	GW Depth
Date and Time	Seconds	Depth (ft)	BGS
6/29/2016 12:00	0	3.851	4.209
6/29/2016 12:15	900.001	3.854	4.206
6/29/2016 12:30	1800.001	3.847	4.213
6/29/2016 12:45	2700.001	3.847	4.213
6/29/2016 13:00	3600.001	3.847	4.213
6/29/2016 13:15	4500.001	3.845	4.215
6/29/2016 13:30	5400.001	3.844	4.216
6/29/2016 13:45	6300.001	3.844	4.216
6/29/2016 14:00	7200.001	3.843	4.217
6/29/2016 14:15	8100.001	3.841	4.219
6/29/2016 14:30	9000.001	3.842	4.218
6/29/2016 14:45	9900.001	3.842	4.218
6/29/2016 15:00	10800.001	3.841	4.219
6/29/2016 15:15	11700.001	3.843	4.217
6/29/2016 15:30	12600.001	3.844	4.216
6/29/2016 15:45	13500.001	3.84	4.22
6/29/2016 16:00	14400.001	3.837	4.223
6/29/2016 16:15	15300.001	3.837	4.223
6/29/2016 16:30	16200.001	3.836	4.224
6/29/2016 16:45	17100.001	3.837	4.223
6/29/2016 17:00	18000.001	3.837	4.223
6/29/2016 17:15	18900.001	3.84	4.22
6/29/2016 17:30	19800.001	3.833	4.227

6/29/2016 17:45	20700.001	3.833	4.227
6/29/2016 18:00	21600.001	3.831	4.229
6/29/2016 18:15	22500.001	3.834	4.226
6/29/2016 18:30	23400.001	3.832	4.228
6/29/2016 18:45	24300.001	3.832	4.228
6/29/2016 19:00	25200.001	3.831	4.229
6/29/2016 19:15	26100.001	3.826	4.234
6/29/2016 19:30	27000.001	3.83	4.23
6/29/2016 19:45	27900.001	3.828	4.232
6/29/2016 20:00	28800.001	3.825	4.235
6/29/2016 20:15	29700.001	3.823	4.237
6/29/2016 20:30	30600.001	3.823	4.237
6/29/2016 20:45	31500.001	3.819	4.241
6/29/2016 21:00	32400.001	3.822	4.238
6/29/2016 21:15	33300.001	3.825	4.235
6/29/2016 21:30	34200.001	3.822	4.238
6/29/2016 21:45	35100.001	3.82	4.24
6/29/2016 22:00	36000.001	3.821	4.239
6/29/2016 22:15	36900.001	3.821	4.239
6/29/2016 22:30	37800.001	3.824	4.236
6/29/2016 22:45	38700.001	3.82	4.24
6/29/2016 23:00	39600.001	3.825	4.235
6/29/2016 23:15	40500.001	3.823	4.237
6/29/2016 23:30	41400.001	3.826	4.234
6/29/2016 23:45	42300.001	3.825	4.235
6/30/2016 0:00	43200.001	3.825	4.235
6/30/2016 0:15	44100.001	3.823	4.237
6/30/2016 0:30	45000.001	3.826	4.234
6/30/2016 0:45	45900.001	3.823	4.237
6/30/2016 1:00	46800.001	3.823	4.237
6/30/2016 1:15	47700.001	3.824	4.236
6/30/2016 1:30	48600.001	3.824	4.236
6/30/2016 1:45	49500.001	3.823	4.237
6/30/2016 2:00	50400.001	3.826	4.234
6/30/2016 2:15	51300.001	3.823	4.237
6/30/2016 2:30	52200.001	3.819	4.241
6/30/2016 2:45	53100.001	3.819	4.241
6/30/2016 3:00	54000.001	3.816	4.244
6/30/2016 3:15	54900.001	3.814	4.246
6/30/2016 3:30	55800.001	3.81	4.25
6/30/2016 3:45	56700.001	3.807	4.253
6/30/2016 4:00	57600.001	3.806	4.254
6/30/2016 4:15	58500.001	3.803	4.257
6/30/2016 4:30	59400.001	3.798	4.262
6/30/2016 4:45	60300.001	3.8	4.26
6/30/2016 5:00	61200.001	3.797	4.263
6/30/2016 5:15	62100.001	3.795	4.265

6/30/2016 5:30	63000.001	3.793	4.267
6/30/2016 5:45	63900.001	3.792	4.268
6/30/2016 6:00	64800.001	3.794	4.266
6/30/2016 6:15	65700.001	3.792	4.268
6/30/2016 6:30	66600.001	3.791	4.269
6/30/2016 6:45	67500.001	3.788	4.272
6/30/2016 7:00	68400.001	3.786	4.274
6/30/2016 7:15	69300.001	3.787	4.273
6/30/2016 7:30	70200.001	3.79	4.27
6/30/2016 7:45	71100.001	3.789	4.271
6/30/2016 8:00	72000.001	3.786	4.274
6/30/2016 8:15	72900.001	3.785	4.275
6/30/2016 8:30	73800.001	3.786	4.274
6/30/2016 8:45	74700.001	3.786	4.274
6/30/2016 9:00	75600.001	3.784	4.276
6/30/2016 9:15	76500.001	3.785	4.275
6/30/2016 9:30	77400.001	3.785	4.275
6/30/2016 9:45	78300.001	3.783	4.277
6/30/2016 10:00	79200.001	3.783	4.277
6/30/2016 10:15	80100.001	3.782	4.278
6/30/2016 10:30	81000.001	3.782	4.278
6/30/2016 10:45	81900.001	3.782	4.278
6/30/2016 11:00	82800.001	3.783	4.277
6/30/2016 11:15	83700.001	3.781	4.279
6/30/2016 11:30	84600.001	3.783	4.277
6/30/2016 11:45	85500.001	3.783	4.277
6/30/2016 12:00	86400.001	3.782	4.278
6/30/2016 12:15	87300.001	3.78	4.28
6/30/2016 12:30	88200.001	3.782	4.278
6/30/2016 12:45	89100.001	3.783	4.277
6/30/2016 13:00	90000.001	3.783	4.277
6/30/2016 13:15	90900.001	3.781	4.279
6/30/2016 13:30	91800.001	3.786	4.274
6/30/2016 13:45	92700.001	3.787	4.273
6/30/2016 14:00	93600.001	3.787	4.273
6/30/2016 14:15	94500.001	3.788	4.272
6/30/2016 14:30	95400.001	3.783	4.277
6/30/2016 14:45	96300.001	3.784	4.276
6/30/2016 15:00	97200.001	3.779	4.281
6/30/2016 15:15	98100.001	3.782	4.278
6/30/2016 15:30	99000.001	3.782	4.278
6/30/2016 15:45	99900.001	3.781	4.279
6/30/2016 16:00	100800.001	3.784	4.276
6/30/2016 16:15	101700.001	3.78	4.28
6/30/2016 16:30	102600.001	3.782	4.278
6/30/2016 16:45	103500.001	3.783	4.277
6/30/2016 17:00	104400.001	3.785	4.275

6/30/2016 17:15	105300.001	3.782	4.278
6/30/2016 17:30	106200.001	3.784	4.276
6/30/2016 17:45	107100.001	3.784	4.276
6/30/2016 18:00	108000.001	3.785	4.275
6/30/2016 18:15	108900.001	3.785	4.275
6/30/2016 18:30	109800.001	3.779	4.281
6/30/2016 18:45	110700.001	3.78	4.28
6/30/2016 19:00	111600.001	3.777	4.283
6/30/2016 19:15	112500.001	3.779	4.281
6/30/2016 19:30	113400.001	3.778	4.282
6/30/2016 19:45	114300.001	3.779	4.281
6/30/2016 20:00	115200.001	3.78	4.28
6/30/2016 20:15	116100.001	3.781	4.279
6/30/2016 20:30	117000.001	3.778	4.282
6/30/2016 20:45	117900.001	3.779	4.281
6/30/2016 21:00	118800.001	3.78	4.28
6/30/2016 21:15	119700.001	3.784	4.276
6/30/2016 21:30	120600.001	3.778	4.282
6/30/2016 21:45	121500.001	3.778	4.282
6/30/2016 22:00	122400.001	3.775	4.285
6/30/2016 22:15	123300.001	3.777	4.283
6/30/2016 22:30	124200.001	3.775	4.285
6/30/2016 22:45	125100.001	3.778	4.282
6/30/2016 23:00	126000.001	3.78	4.28
6/30/2016 23:15	126900.001	3.783	4.277
6/30/2016 23:30	127800.001	3.785	4.275
6/30/2016 23:45	128700.001	3.779	4.281
7/1/2016 0:00	129600.001	3.78	4.28
7/1/2016 0:15	130500.001	3.785	4.275
7/1/2016 0:30	131400.001	3.784	4.276
7/1/2016 0:45	132300.001	3.783	4.277
7/1/2016 1:00	133200.001	3.789	4.271
7/1/2016 1:15	134100.001	3.789	4.271
7/1/2016 1:30	135000.001	3.795	4.265
7/1/2016 1:45	135900.001	3.791	4.269
7/1/2016 2:00	136800.001	3.791	4.269
7/1/2016 2:15	137700.001	3.791	4.269
7/1/2016 2:30	138600.001	3.792	4.268
7/1/2016 2:45	139500.001	3.786	4.274
7/1/2016 3:00	140400.001	3.787	4.273
7/1/2016 3:15	141300.001	3.785	4.275
7/1/2016 3:30	142200.001	3.784	4.276
7/1/2016 3:45	143100.001	3.784	4.276
7/1/2016 4:00	144000.001	3.782	4.278
7/1/2016 4:15	144900.001	3.78	4.28
7/1/2016 4:30	145800.001	3.779	4.281
7/1/2016 4:45	146700.001	3.778	4.282

7/1/2016 5:00	147600.001	3.778	4.282
7/1/2016 5:15	148500.001	3.779	4.281
7/1/2016 5:30	149400.001	3.774	4.286
7/1/2016 5:45	150300.001	3.771	4.289
7/1/2016 6:00	151200.001	3.769	4.291
7/1/2016 6:15	152100.001	3.774	4.286
7/1/2016 6:30	153000.001	3.766	4.294
7/1/2016 6:45	153900.001	3.765	4.295
7/1/2016 7:00	154800.001	3.763	4.297
7/1/2016 7:15	155700.001	3.765	4.295
7/1/2016 7:30	156600.001	3.762	4.298
7/1/2016 7:45	157500.001	3.762	4.298
7/1/2016 8:00	158400.001	3.76	4.3
7/1/2016 8:15	159300.001	3.758	4.302
7/1/2016 8:30	160200.001	3.758	4.302
7/1/2016 8:45	161100.001	3.758	4.302
7/1/2016 9:00	162000.001	3.758	4.302
7/1/2016 9:15	162900.001	3.755	4.305
7/1/2016 9:30	163800.001	3.758	4.302
7/1/2016 9:45	164700.001	3.76	4.3
7/1/2016 10:00	165600.001	3.758	4.302
7/1/2016 10:15	166500.001	3.759	4.301
7/1/2016 10:30	167400.001	3.757	4.303
7/1/2016 10:45	168300.001	3.755	4.305
7/1/2016 11:00	169200.001	3.754	4.306
7/1/2016 11:15	170100.001	3.754	4.306
7/1/2016 11:30	171000.001	3.751	4.309
7/1/2016 11:45	171900.001	3.754	4.306
7/1/2016 12:00	172800.001	3.756	4.304
7/1/2016 12:15	173700.001	3.755	4.305
7/1/2016 12:30	174600.001	3.756	4.304
7/1/2016 12:45	175500.001	3.757	4.303
7/1/2016 13:00	176400.001	3.757	4.303
7/1/2016 13:15	177300.001	3.758	4.302
7/1/2016 13:30	178200.001	3.756	4.304
7/1/2016 13:45	179100.001	3.755	4.305
7/1/2016 14:00	180000.001	3.756	4.304
7/1/2016 14:15	180900.001	3.76	4.3
7/1/2016 14:30	181800.001	3.758	4.302
7/1/2016 14:45	182700.001	3.754	4.306
7/1/2016 15:00	183600.001	3.755	4.305
7/1/2016 15:15	184500.001	3.754	4.306
7/1/2016 15:30	185400.001	3.749	4.311
7/1/2016 15:45	186300.001	3.75	4.31
7/1/2016 16:00	187200.001	3.751	4.309
7/1/2016 16:15	188100.001	3.75	4.31
7/1/2016 16:30	189000.001	3.753	4.307

7/1/2016 16:45	189900.001	3.752	4.308
7/1/2016 17:00	190800.001	3.751	4.309
7/1/2016 17:15	191700.001	3.751	4.309
7/1/2016 17:30	192600.001	3.751	4.309
7/1/2016 17:45	193500.001	3.752	4.308
7/1/2016 18:00	194400.001	3.752	4.308
7/1/2016 18:15	195300.001	3.749	4.311
7/1/2016 18:30	196200.001	3.752	4.308
7/1/2016 18:45	197100.001	3.751	4.309
7/1/2016 19:00	198000.001	3.749	4.311
7/1/2016 19:15	198900.001	3.75	4.31
7/1/2016 19:30	199800.001	3.751	4.309
7/1/2016 19:45	200700.001	3.751	4.309
7/1/2016 20:00	201600.001	3.748	4.312
7/1/2016 20:15	202500.001	3.75	4.31
7/1/2016 20:30	203400.001	3.753	4.307
7/1/2016 20:45	204300.001	3.75	4.31
7/1/2016 21:00	205200.001	3.75	4.31
7/1/2016 21:15	206100.001	3.751	4.309
7/1/2016 21:30	207000.001	3.755	4.305
7/1/2016 21:45	207900.001	3.754	4.306
7/1/2016 22:00	208800.001	3.751	4.309
7/1/2016 22:15	209700.001	3.753	4.307
7/1/2016 22:30	210600.001	3.752	4.308
7/1/2016 22:45	211500.001	3.755	4.305
7/1/2016 23:00	212400.001	3.755	4.305
7/1/2016 23:15	213300.001	3.756	4.304
7/1/2016 23:30	214200.001	3.758	4.302
7/1/2016 23:45	215100.001	3.758	4.302
7/2/2016 0:00	216000.001	3.759	4.301
7/2/2016 0:15	216900.001	3.765	4.295
7/2/2016 0:30	217800.001	3.766	4.294
7/2/2016 0:45	218700.001	3.767	4.293
7/2/2016 1:00	219600.001	3.768	4.292
7/2/2016 1:15	220500.001	3.771	4.289
7/2/2016 1:30	221400.001	3.771	4.289
7/2/2016 1:45	222300.001	3.769	4.291
7/2/2016 2:00	223200.001	3.772	4.288
7/2/2016 2:15	224100.001	3.771	4.289
7/2/2016 2:30	225000.001	3.77	4.29
7/2/2016 2:45	225900.001	3.771	4.289
7/2/2016 3:00	226800.001	3.766	4.294
7/2/2016 3:15	227700.001	3.771	4.289
7/2/2016 3:30	228600.001	3.769	4.291
7/2/2016 3:45	229500.001	3.77	4.29
7/2/2016 4:00	230400.001	3.768	4.292
7/2/2016 4:15	231300.001	3.767	4.293

7/2/2016 4:30	232200.001	3.766	4.294
7/2/2016 4:45	233100.001	3.763	4.297
7/2/2016 5:00	234000.001	3.762	4.298
7/2/2016 5:15	234900.001	3.761	4.299
7/2/2016 5:30	235800.001	3.758	4.302
7/2/2016 5:45	236700.001	3.756	4.304
7/2/2016 6:00	237600.001	3.752	4.308
7/2/2016 6:15	238500.001	3.752	4.308
7/2/2016 6:30	239400.001	3.747	4.313
7/2/2016 6:45	240300.001	3.746	4.314
7/2/2016 7:00	241200.001	3.746	4.314
7/2/2016 7:15	242100.001	3.743	4.317
7/2/2016 7:30	243000.001	3.744	4.316
7/2/2016 7:45	243900.001	3.742	4.318
7/2/2016 8:00	244800.001	3.741	4.319
7/2/2016 8:15	245700.001	3.735	4.325
7/2/2016 8:30	246600.001	3.738	4.322
7/2/2016 8:45	247500.001	3.735	4.325
7/2/2016 9:00	248400.001	3.737	4.323
7/2/2016 9:15	249300.001	3.735	4.325
7/2/2016 9:30	250200.001	3.734	4.326
7/2/2016 9:45	251100.001	3.739	4.321
7/2/2016 10:00	252000.001	3.74	4.32
7/2/2016 10:15	252900.001	3.742	4.318
7/2/2016 10:30	253800.001	3.741	4.319
7/2/2016 10:45	254700.001	3.741	4.319
7/2/2016 11:00	255600.001	3.74	4.32
7/2/2016 11:15	256500.001	3.738	4.322
7/2/2016 11:30	257400.001	3.737	4.323
7/2/2016 11:45	258300.001	3.737	4.323
7/2/2016 12:00	259200.001	3.727	4.333
7/2/2016 12:15	260100.001	3.733	4.327
7/2/2016 12:30	261000.001	3.732	4.328
7/2/2016 12:45	261900.001	3.736	4.324
7/2/2016 13:00	262800.001	3.739	4.321
7/2/2016 13:15	263700.001	3.737	4.323
7/2/2016 13:30	264600.001	3.734	4.326
7/2/2016 13:45	265500.001	3.732	4.328
7/2/2016 14:00	266400.001	3.737	4.323
7/2/2016 14:15	267300.001	3.735	4.325
7/2/2016 14:30	268200.001	3.731	4.329
7/2/2016 14:45	269100.001	3.737	4.323
7/2/2016 15:00	270000.001	3.739	4.321
7/2/2016 15:15	270900.001	3.731	4.329
7/2/2016 15:30	271800.001	3.733	4.327
7/2/2016 15:45	272700.001	3.73	4.33
7/2/2016 16:00	273600.001	3.732	4.328

7/2/2016 16:15	274500.001	3.739	4.321
7/2/2016 16:30	275400.001	3.733	4.327
7/2/2016 16:45	276300.001	3.726	4.334
7/2/2016 17:00	277200.001	3.733	4.327
7/2/2016 17:15	278100.001	3.73	4.33
7/2/2016 17:30	279000.001	3.732	4.328
7/2/2016 17:45	279900.001	3.731	4.329
7/2/2016 18:00	280800.001	3.733	4.327
7/2/2016 18:15	281700.001	3.738	4.322
7/2/2016 18:30	282600.001	3.734	4.326
7/2/2016 18:45	283500.001	3.733	4.327
7/2/2016 19:00	284400.001	3.736	4.324
7/2/2016 19:15	285300.001	3.733	4.327
7/2/2016 19:30	286200.001	3.731	4.329
7/2/2016 19:45	287100.001	3.729	4.331
7/2/2016 20:00	288000.001	3.726	4.334
7/2/2016 20:15	288900.001	3.729	4.331
7/2/2016 20:30	289800.001	3.727	4.333
7/2/2016 20:45	290700.001	3.726	4.334
7/2/2016 21:00	291600.001	3.727	4.333
7/2/2016 21:15	292500.001	3.726	4.334
7/2/2016 21:30	293400.001	3.725	4.335
7/2/2016 21:45	294300.001	3.726	4.334
7/2/2016 22:00	295200.001	3.725	4.335
7/2/2016 22:15	296100.001	3.725	4.335
7/2/2016 22:30	297000.001	3.726	4.334
7/2/2016 22:45	297900.001	3.73	4.33
7/2/2016 23:00	298800.001	3.731	4.329
7/2/2016 23:15	299700.001	3.73	4.33
7/2/2016 23:30	300600.001	3.73	4.33
7/2/2016 23:45	301500.001	3.73	4.33
7/3/2016 0:00	302400.001	3.734	4.326
7/3/2016 0:15	303300.001	3.734	4.326
7/3/2016 0:30	304200.001	3.733	4.327
7/3/2016 0:45	305100.001	3.73	4.33
7/3/2016 1:00	306000.001	3.733	4.327
7/3/2016 1:15	306900.001	3.73	4.33
7/3/2016 1:30	307800.001	3.727	4.333
7/3/2016 1:45	308700.001	3.726	4.334
7/3/2016 2:00	309600.001	3.727	4.333
7/3/2016 2:15	310500.001	3.731	4.329
7/3/2016 2:30	311400.001	3.729	4.331
7/3/2016 2:45	312300.001	3.732	4.328
7/3/2016 3:00	313200.001	3.73	4.33
7/3/2016 3:15	314100.001	3.73	4.33
7/3/2016 3:30	315000.001	3.726	4.334
7/3/2016 3:45	315900.001	3.728	4.332

7/3/2016 4:00	316800.001	3.729	4.331
7/3/2016 4:15	317700.001	3.726	4.334
7/3/2016 4:30	318600.001	3.723	4.337
7/3/2016 4:45	319500.001	3.724	4.336
7/3/2016 5:00	320400.001	3.719	4.341
7/3/2016 5:15	321300.001	3.717	4.343
7/3/2016 5:30	322200.001	3.714	4.346
7/3/2016 5:45	323100.001	3.716	4.344
7/3/2016 6:00	324000.001	3.711	4.349
7/3/2016 6:15	324900.001	3.712	4.348
7/3/2016 6:30	325800.001	3.71	4.35
7/3/2016 6:45	326700.001	3.708	4.352
7/3/2016 7:00	327600.001	3.705	4.355
7/3/2016 7:15	328500.001	3.704	4.356
7/3/2016 7:30	329400.001	3.705	4.355
7/3/2016 7:45	330300.001	3.704	4.356
7/3/2016 8:00	331200.001	3.698	4.362
7/3/2016 8:15	332100.001	3.694	4.366
7/3/2016 8:30	333000.001	3.693	4.367
7/3/2016 8:45	333900.001	3.692	4.368
7/3/2016 9:00	334800.001	3.692	4.368
7/3/2016 9:15	335700.001	3.691	4.369
7/3/2016 9:30	336600.001	3.687	4.373
7/3/2016 9:45	337500.001	3.69	4.37
7/3/2016 10:00	338400.001	3.688	4.372
7/3/2016 10:15	339300.001	3.687	4.373
7/3/2016 10:30	340200.001	3.687	4.373
7/3/2016 10:45	341100.001	3.687	4.373
7/3/2016 11:00	342000.001	3.69	4.37
7/3/2016 11:15	342900.001	3.685	4.375
7/3/2016 11:30	343800.001	3.686	4.374
7/3/2016 11:45	344700.001	3.686	4.374
7/3/2016 12:00	345600.001	3.687	4.373
7/3/2016 12:15	346500.001	3.685	4.375
7/3/2016 12:30	347400.001	3.683	4.377
7/3/2016 12:45	348300.001	3.688	4.372
7/3/2016 13:00	349200.001	3.688	4.372
7/3/2016 13:15	350100.001	3.688	4.372
7/3/2016 13:30	351000.001	3.682	4.378
7/3/2016 13:45	351900.001	3.679	4.381
7/3/2016 14:00	352800.001	3.682	4.378
7/3/2016 14:15	353700.001	3.686	4.374
7/3/2016 14:30	354600.001	3.684	4.376
7/3/2016 14:45	355500.001	3.688	4.372
7/3/2016 15:00	356400.001	3.688	4.372
7/3/2016 15:15	357300.001	3.684	4.376
7/3/2016 15:30	358200.001	3.689	4.371

7/3/2016 15:45	359100.001	3.688	4.372
7/3/2016 16:00	360000.001	3.683	4.377
7/3/2016 16:15	360900.001	3.687	4.373
7/3/2016 16:30	361800.001	3.686	4.374
7/3/2016 16:45	362700.001	3.687	4.373
7/3/2016 17:00	363600.001	3.684	4.376
7/3/2016 17:15	364500.001	3.683	4.377
7/3/2016 17:30	365400.001	3.687	4.373
7/3/2016 17:45	366300.001	3.686	4.374
7/3/2016 18:00	367200.001	3.69	4.37
7/3/2016 18:15	368100.001	3.69	4.37
7/3/2016 18:30	369000.001	3.689	4.371
7/3/2016 18:45	369900.001	3.691	4.369
7/3/2016 19:00	370800.001	3.686	4.374
7/3/2016 19:15	371700.001	3.684	4.376
7/3/2016 19:30	372600.001	3.684	4.376
7/3/2016 19:45	373500.001	3.686	4.374
7/3/2016 20:00	374400.001	3.686	4.374
7/3/2016 20:15	375300.001	3.687	4.373
7/3/2016 20:30	376200.001	3.687	4.373
7/3/2016 20:45	377100.001	3.687	4.373
7/3/2016 21:00	378000.001	3.69	4.37
7/3/2016 21:15	378900.001	3.687	4.373
7/3/2016 21:30	379800.001	3.688	4.372
7/3/2016 21:45	380700.001	3.684	4.376
7/3/2016 22:00	381600.001	3.683	4.377
7/3/2016 22:15	382500.001	3.684	4.376
7/3/2016 22:30	383400.001	3.682	4.378
7/3/2016 22:45	384300.001	3.684	4.376
7/3/2016 23:00	385200.001	3.69	4.37
7/3/2016 23:15	386100.001	3.69	4.37
7/3/2016 23:30	387000.001	3.689	4.371
7/3/2016 23:45	387900.001	3.693	4.367
7/4/2016 0:00	388800.001	3.693	4.367
7/4/2016 0:15	389700.001	3.693	4.367
7/4/2016 0:30	390600.001	3.692	4.368
7/4/2016 0:45	391500.001	3.692	4.368
7/4/2016 1:00	392400.001	3.69	4.37
7/4/2016 1:15	393300.001	3.691	4.369
7/4/2016 1:30	394200.001	3.693	4.367
7/4/2016 1:45	395100.001	3.697	4.363
7/4/2016 2:00	396000.001	3.699	4.361
7/4/2016 2:15	396900.001	3.698	4.362
7/4/2016 2:30	397800.001	3.696	4.364
7/4/2016 2:45	398700.001	3.698	4.362
7/4/2016 3:00	399600.001	3.697	4.363
7/4/2016 3:15	400500.001	3.701	4.359

7/4/2016 3:30	401400.001	3.7	4.36
7/4/2016 3:45	402300.001	3.698	4.362
7/4/2016 4:00	403200.001	3.701	4.359
7/4/2016 4:15	404100.001	3.698	4.362
7/4/2016 4:30	405000.001	3.7	4.36
7/4/2016 4:45	405900.001	3.7	4.36
7/4/2016 5:00	406800.001	3.701	4.359
7/4/2016 5:15	407700.001	3.701	4.359
7/4/2016 5:30	408600.001	3.7	4.36
7/4/2016 5:45	409500.001	3.695	4.365
7/4/2016 6:00	410400.001	3.694	4.366
7/4/2016 6:15	411300.001	3.692	4.368
7/4/2016 6:30	412200.001	3.695	4.365
7/4/2016 6:45	413100.001	3.689	4.371
7/4/2016 7:00	414000.001	3.689	4.371
7/4/2016 7:15	414900.001	3.686	4.374
7/4/2016 7:30	415800.001	3.688	4.372
7/4/2016 7:45	416700.001	3.686	4.374
7/4/2016 8:00	417600.001	3.686	4.374
7/4/2016 8:15	418500.001	3.681	4.379
7/4/2016 8:30	419400.001	3.678	4.382
7/4/2016 8:45	420300.001	3.674	4.386
7/4/2016 9:00	421200.001	3.674	4.386
7/4/2016 9:15	422100.001	3.667	4.393
7/4/2016 9:30	423000.001	3.669	4.391
7/4/2016 9:45	423900.001	3.667	4.393
7/4/2016 10:00	424800.001	3.672	4.388
7/4/2016 10:15	425700.001	3.671	4.389
7/4/2016 10:30	426600.001	3.669	4.391
7/4/2016 10:45	427500.001	3.67	4.39
7/4/2016 11:00	428400.001	3.666	4.394
7/4/2016 11:15	429300.001	3.671	4.389
7/4/2016 11:30	430200.001	3.668	4.392
7/4/2016 11:45	431100.001	3.673	4.387
7/4/2016 12:00	432000.001	3.67	4.39
7/4/2016 12:15	432900.001	3.672	4.388
7/4/2016 12:30	433800.001	3.67	4.39
7/4/2016 12:45	434700.001	3.67	4.39
7/4/2016 13:00	435600.001	3.67	4.39
7/4/2016 13:15	436500.001	3.67	4.39
7/4/2016 13:30	437400.001	3.668	4.392
7/4/2016 13:45	438300.001	3.666	4.394
7/4/2016 14:00	439200.001	3.664	4.396
7/4/2016 14:15	440100.001	3.664	4.396
7/4/2016 14:30	441000.001	3.665	4.395
7/4/2016 14:45	441900.001	3.669	4.391
7/4/2016 15:00	442800.001	3.666	4.394

7/4/2016 15:15	443700.001	3.667	4.393
7/4/2016 15:30	444600.001	3.668	4.392
7/4/2016 15:45	445500.001	3.67	4.39
7/4/2016 16:00	446400.001	3.671	4.389
7/4/2016 16:15	447300.001	3.67	4.39
7/4/2016 16:30	448200.001	3.673	4.387
7/4/2016 16:45	449100.001	3.673	4.387
7/4/2016 17:00	450000.001	3.673	4.387
7/4/2016 17:15	450900.001	3.676	4.384
7/4/2016 17:30	451800.001	3.674	4.386
7/4/2016 17:45	452700.001	3.674	4.386
7/4/2016 18:00	453600.001	3.675	4.385
7/4/2016 18:15	454500.001	3.678	4.382
7/4/2016 18:30	455400.001	3.679	4.381
7/4/2016 18:45	456300.001	3.68	4.38
7/4/2016 19:00	457200.001	3.68	4.38
7/4/2016 19:15	458100.001	3.681	4.379
7/4/2016 19:30	459000.001	3.679	4.381
7/4/2016 19:45	459900.001	3.679	4.381
7/4/2016 20:00	460800.001	3.677	4.383
7/4/2016 20:15	461700.001	3.675	4.385
7/4/2016 20:30	462600.001	3.674	4.386
7/4/2016 20:45	463500.001	3.676	4.384
7/4/2016 21:00	464400.001	3.672	4.388
7/4/2016 21:15	465300.001	3.671	4.389
7/4/2016 21:30	466200.001	3.669	4.391
7/4/2016 21:45	467100.001	3.669	4.391
7/4/2016 22:00	468000.001	3.67	4.39
7/4/2016 22:15	468900.001	3.669	4.391
7/4/2016 22:30	469800.001	3.671	4.389
7/4/2016 22:45	470700.001	3.671	4.389
7/4/2016 23:00	471600.001	3.673	4.387
7/4/2016 23:15	472500.001	3.674	4.386
7/4/2016 23:30	473400.001	3.676	4.384
7/4/2016 23:45	474300.001	3.673	4.387
7/5/2016 0:00	475200.001	3.675	4.385
7/5/2016 0:15	476100.001	3.678	4.382
7/5/2016 0:30	477000.001	3.675	4.385
7/5/2016 0:45	477900.001	3.678	4.382
7/5/2016 1:00	478800.001	3.679	4.381
7/5/2016 1:15	479700.001	3.678	4.382
7/5/2016 1:30	480600.001	3.68	4.38
7/5/2016 1:45	481500.001	3.682	4.378
7/5/2016 2:00	482400.001	3.686	4.374
7/5/2016 2:15	483300.001	3.69	4.37
7/5/2016 2:30	484200.001	3.687	4.373
7/5/2016 2:45	485100.001	3.687	4.373

7/5/2016 3:00	486000.001	3.689	4.371
7/5/2016 3:15	486900.001	3.691	4.369
7/5/2016 3:30	487800.001	3.693	4.367
7/5/2016 3:45	488700.001	3.692	4.368
7/5/2016 4:00	489600.001	3.692	4.368
7/5/2016 4:15	490500.001	3.692	4.368
7/5/2016 4:30	491400.001	3.694	4.366
7/5/2016 4:45	492300.001	3.692	4.368
7/5/2016 5:00	493200.001	3.693	4.367
7/5/2016 5:15	494100.001	3.697	4.363
7/5/2016 5:30	495000.001	3.69	4.37
7/5/2016 5:45	495900.001	3.692	4.368
7/5/2016 6:00	496800.001	3.688	4.372
7/5/2016 6:15	497700.001	3.689	4.371
7/5/2016 6:30	498600.001	3.685	4.375
7/5/2016 6:45	499500.001	3.687	4.373
7/5/2016 7:00	500400.001	3.683	4.377
7/5/2016 7:15	501300.001	3.685	4.375
7/5/2016 7:30	502200.001	3.682	4.378
7/5/2016 7:45	503100.001	3.674	4.386
7/5/2016 8:00	504000.001	3.678	4.382
7/5/2016 8:15	504900.001	3.674	4.386
7/5/2016 8:30	505800.001	3.671	4.389
7/5/2016 8:45	506700.001	3.669	4.391
7/5/2016 9:00	507600.001	3.667	4.393
7/5/2016 9:15	508500.001	3.666	4.394
7/5/2016 9:30	509400.001	3.666	4.394
7/5/2016 9:45	510300.001	3.659	4.401
7/5/2016 10:00	511200.001	3.663	4.397
7/5/2016 10:15	512100.001	3.669	4.391
7/5/2016 10:30	513000.001	3.666	4.394
7/5/2016 10:45	513900.001	3.665	4.395
7/5/2016 11:00	514800.001	3.668	4.392
7/5/2016 11:15	515700.001	3.667	4.393
7/5/2016 11:30	516600.001	3.664	4.396
7/5/2016 11:45	517500.001	3.66	4.4
7/5/2016 12:00	518400.001	3.657	4.403
7/5/2016 12:15	519300.001	3.66	4.4
7/5/2016 12:30	520200.001	3.657	4.403
7/5/2016 12:45	521100.001	3.664	4.396
7/5/2016 13:00	522000.001	3.663	4.397
7/5/2016 13:15	522900.001	3.663	4.397
7/5/2016 13:30	523800.001	3.662	4.398
7/5/2016 13:45	524700.001	3.661	4.399
7/5/2016 14:00	525600.001	3.663	4.397
7/5/2016 14:15	526500.001	3.663	4.397
7/5/2016 14:30	527400.001	3.665	4.395

7/5/2016 14:45	528300.001	3.666	4.394
7/5/2016 15:00	529200.001	3.66	4.4
7/5/2016 15:15	530100.001	3.663	4.397
7/5/2016 15:30	531000.001	3.663	4.397
7/5/2016 15:45	531900.001	3.665	4.395
7/5/2016 16:00	532800.001	3.666	4.394
7/5/2016 16:15	533700.001	3.665	4.395
7/5/2016 16:30	534600.001	3.669	4.391
7/5/2016 16:45	535500.001	3.67	4.39
7/5/2016 17:00	536400.001	3.674	4.386
7/5/2016 17:15	537300.001	3.671	4.389
7/5/2016 17:30	538200.001	3.67	4.39
7/5/2016 17:45	539100.001	3.669	4.391
7/5/2016 18:00	540000.001	3.669	4.391
7/5/2016 18:15	540900.001	3.669	4.391
7/5/2016 18:30	541800.001	3.667	4.393
7/5/2016 18:45	542700.001	3.667	4.393
7/5/2016 19:00	543600.001	3.666	4.394
7/5/2016 19:15	544500.001	3.665	4.395
7/5/2016 19:30	545400.001	3.665	4.395
7/5/2016 19:45	546300.001	3.667	4.393
7/5/2016 20:00	547200.001	3.668	4.392
7/5/2016 20:15	548100.001	3.669	4.391
7/5/2016 20:30	549000.001	3.668	4.392
7/5/2016 20:45	549900.001	3.665	4.395
7/5/2016 21:00	550800.001	3.669	4.391
7/5/2016 21:15	551700.001	3.665	4.395
7/5/2016 21:30	552600.001	3.668	4.392
7/5/2016 21:45	553500.001	3.665	4.395
7/5/2016 22:00	554400.001	3.665	4.395
7/5/2016 22:15	555300.001	3.666	4.394
7/5/2016 22:30	556200.001	3.663	4.397
7/5/2016 22:45	557100.001	3.668	4.392
7/5/2016 23:00	558000.001	3.666	4.394
7/5/2016 23:15	558900.001	3.666	4.394
7/5/2016 23:30	559800.001	3.664	4.396
7/5/2016 23:45	560700.001	3.663	4.397
7/6/2016 0:00	561600.001	3.664	4.396
7/6/2016 0:15	562500.001	3.665	4.395
7/6/2016 0:30	563400.001	3.664	4.396
7/6/2016 0:45	564300.001	3.664	4.396
7/6/2016 1:00	565200.001	3.665	4.395
7/6/2016 1:15	566100.001	3.665	4.395
7/6/2016 1:30	567000.001	3.668	4.392
7/6/2016 1:45	567900.001	3.67	4.39
7/6/2016 2:00	568800.001	3.67	4.39
7/6/2016 2:15	569700.001	3.672	4.388

7/6/2016 2:30	570600.001	3.672	4.388
7/6/2016 2:45	571500.001	3.674	4.386
7/6/2016 3:00	572400.001	3.673	4.387
7/6/2016 3:15	573300.001	3.675	4.385
7/6/2016 3:30	574200.001	3.673	4.387
7/6/2016 3:45	575100.001	3.675	4.385
7/6/2016 4:00	576000.001	3.678	4.382
7/6/2016 4:15	576900.001	3.678	4.382
7/6/2016 4:30	577800.001	3.677	4.383
7/6/2016 4:45	578700.001	3.68	4.38
7/6/2016 5:00	579600.001	3.677	4.383
7/6/2016 5:15	580500.001	3.679	4.381
7/6/2016 5:30	581400.001	3.679	4.381
7/6/2016 5:45	582300.001	3.678	4.382
7/6/2016 6:00	583200.001	3.676	4.384
7/6/2016 6:15	584100.001	3.679	4.381
7/6/2016 6:30	585000.001	3.675	4.385
7/6/2016 6:45	585900.001	3.674	4.386
7/6/2016 7:00	586800.001	3.672	4.388
7/6/2016 7:15	587700.001	3.669	4.391
7/6/2016 7:30	588600.001	3.667	4.393
7/6/2016 7:45	589500.001	3.664	4.396
7/6/2016 8:00	590400.001	3.663	4.397
7/6/2016 8:15	591300.001	3.663	4.397
7/6/2016 8:30	592200.001	3.665	4.395
7/6/2016 8:45	593100.001	3.661	4.399
7/6/2016 9:00	594000.001	3.661	4.399
7/6/2016 9:15	594900.001	3.664	4.396
7/6/2016 9:30	595800.001	3.66	4.4
7/6/2016 9:45	596700.001	3.656	4.404
7/6/2016 10:00	597600.001	3.658	4.402
7/6/2016 10:15	598500.001	3.653	4.407
7/6/2016 10:30	599400.001	3.658	4.402
7/6/2016 10:45	600300.001	3.655	4.405
7/6/2016 11:00	601200.001	3.649	4.411
7/6/2016 11:15	602100.001	3.653	4.407
7/6/2016 11:30	603000.001	3.651	4.409
7/6/2016 11:45	603900.001	3.653	4.407
7/6/2016 12:00	604800.001	3.653	4.407
7/6/2016 12:15	605700.001	3.656	4.404
7/6/2016 12:30	606600.001	3.657	4.403
7/6/2016 12:45	607500.001	3.653	4.407
7/6/2016 13:00	608400.001	3.652	4.408
7/6/2016 13:15	609300.001	3.654	4.406
7/6/2016 13:30	610200.001	3.654	4.406
7/6/2016 13:45	611100.001	3.655	4.405
7/6/2016 14:00	612000.001	3.657	4.403

7/6/2016 14:15	612900.001	3.659	4.401
7/6/2016 14:30	613800.001	3.656	4.404
7/6/2016 14:45	614700.001	3.654	4.406
7/6/2016 15:00	615600.001	3.655	4.405
7/6/2016 15:15	616500.001	3.658	4.402
7/6/2016 15:30	617400.001	3.658	4.402
7/6/2016 15:45	618300.001	3.66	4.4
7/6/2016 16:00	619200.001	3.658	4.402
7/6/2016 16:15	620100.001	3.658	4.402
7/6/2016 16:30	621000.001	3.657	4.403
7/6/2016 16:45	621900.001	3.662	4.398
7/6/2016 17:00	622800.001	3.663	4.397
7/6/2016 17:15	623700.001	3.666	4.394
7/6/2016 17:30	624600.001	3.666	4.394
7/6/2016 17:45	625500.001	3.665	4.395
7/6/2016 18:00	626400.001	3.665	4.395
7/6/2016 18:15	627300.001	3.67	4.39
7/6/2016 18:30	628200.001	3.671	4.389
7/6/2016 18:45	629100.001	3.666	4.394
7/6/2016 19:00	630000.001	3.663	4.397
7/6/2016 19:15	630900.001	3.662	4.398
7/6/2016 19:30	631800.001	3.666	4.394
7/6/2016 19:45	632700.001	3.663	4.397
7/6/2016 20:00	633600.001	3.662	4.398
7/6/2016 20:15	634500.001	3.659	4.401
7/6/2016 20:30	635400.001	3.664	4.396
7/6/2016 20:45	636300.001	3.667	4.393
7/6/2016 21:00	637200.001	3.664	4.396
7/6/2016 21:15	638100.001	3.664	4.396
7/6/2016 21:30	639000.001	3.665	4.395
7/6/2016 21:45	639900.001	3.663	4.397
7/6/2016 22:00	640800.001	3.665	4.395
7/6/2016 22:15	641700.001	3.663	4.397
7/6/2016 22:30	642600.001	3.665	4.395
7/6/2016 22:45	643500.001	3.661	4.399
7/6/2016 23:00	644400.001	3.665	4.395
7/6/2016 23:15	645300.001	3.669	4.391
7/6/2016 23:30	646200.001	3.672	4.388
7/6/2016 23:45	647100.001	3.669	4.391
7/7/2016 0:00	648000.001	3.667	4.393
7/7/2016 0:15	648900.001	3.67	4.39
7/7/2016 0:30	649800.001	3.669	4.391
7/7/2016 0:45	650700.001	3.67	4.39
7/7/2016 1:00	651600.001	3.672	4.388
7/7/2016 1:15	652500.001	3.675	4.385
7/7/2016 1:30	653400.001	3.675	4.385
7/7/2016 1:45	654300.001	3.678	4.382

7/7/2016 2:00	655200.001	3.674	4.386
7/7/2016 2:15	656100.001	3.676	4.384
7/7/2016 2:30	657000.001	3.68	4.38
7/7/2016 2:45	657900.001	3.679	4.381
7/7/2016 3:00	658800.001	3.678	4.382
7/7/2016 3:15	659700.001	3.683	4.377
7/7/2016 3:30	660600.001	3.682	4.378
7/7/2016 3:45	661500.001	3.679	4.381
7/7/2016 4:00	662400.001	3.682	4.378
7/7/2016 4:15	663300.001	3.686	4.374
7/7/2016 4:30	664200.001	3.686	4.374
7/7/2016 4:45	665100.001	3.686	4.374
7/7/2016 5:00	666000.001	3.687	4.373
7/7/2016 5:15	666900.001	3.686	4.374
7/7/2016 5:30	667800.001	3.683	4.377
7/7/2016 5:45	668700.001	3.685	4.375
7/7/2016 6:00	669600.001	3.688	4.372
7/7/2016 6:15	670500.001	3.687	4.373
7/7/2016 6:30	671400.001	3.684	4.376
7/7/2016 6:45	672300.001	3.686	4.374
7/7/2016 7:00	673200.001	3.683	4.377
7/7/2016 7:15	674100.001	3.685	4.375
7/7/2016 7:30	675000.001	3.682	4.378
7/7/2016 7:45	675900.001	3.681	4.379
7/7/2016 8:00	676800.001	3.683	4.377
7/7/2016 8:15	677700.001	3.678	4.382
7/7/2016 8:30	678600.001	3.677	4.383
7/7/2016 8:45	679500.001	3.674	4.386
7/7/2016 9:00	680400.001	3.671	4.389
7/7/2016 9:15	681300.001	3.674	4.386
7/7/2016 9:30	682200.001	3.67	4.39
7/7/2016 9:45	683100.001	3.671	4.389
7/7/2016 10:00	684000.001	3.67	4.39
7/7/2016 10:15	684900.001	3.669	4.391
7/7/2016 10:30	685800.001	3.664	4.396
7/7/2016 10:45	686700.001	3.664	4.396
7/7/2016 11:00	687600.001	3.667	4.393
7/7/2016 11:15	688500.001	3.665	4.395
7/7/2016 11:30	689400.001	3.662	4.398
7/7/2016 11:45	690300.001	3.661	4.399
7/7/2016 12:00	691200.001	3.665	4.395

Report Date:	7/8/2016 9:51
Report User Name	dinkudav
Report Computer	BREMLT4750
Application:	WinSitu.exe
Application Versio	5.6.27.1

Log File Properties

File Name	Log1_Append_2016-07-08_07-33-55-885.wsl
Create Date	7/8/2016 7:33

Device Properties

Device	Level TROLL 700			
Site	TP3			
Device Name				
Serial Number	446725			
Firmware Version	3.03			
Hardware Version	5			
Device Address	1			
Device Comm Cfg	19200	8 Even	1	(Modbus-RTU)
Used Memory	0			
Used Battery	6			

Log Configuration

Log Name	Log1
Created By	dinkudav
Computer Name	BREMLT4750
Application	WinSitu.exe
Application Vers	5.6.27.1
Create Date	6/29/2016 11:55:24 AM Pacific Daylight Time
Log Setup Time Z	Pacific Daylight Time
Notes Size(bytes	4096
Overwrite when	Disabled
Scheduled Start	6/29/2016 1:00:00 PM Pacific Daylight Time
Scheduled Stop	7/7/2016 1:00:00 PM Pacific Daylight Time
Type	Linear
Duration	Days: 8 hrs: 00 mins: 00 secs: 00
Interval	Days: 0 hrs: 00 mins: 15 secs: 00

Level Reference Settings At Log Creation

Level Measu	Depth
Specific (	0.999

Other Log Settings

Depth of Probe: 3.54121 (ft)
Head Pressure: 1.53368 (PSI)
Temperature: 16.1296 (C)

Log Notes:

Date and Time	Note
6/29/2016 11:55	Used Battery: 6% Used Memory: 1% User Name: dinkudav
7/2/2016 11:56	Log Download - Used Battery: 6% Used Memory: 1% User Name: dinkudav

Log Data:

Record Count	769
Sensors	1

1 446725 Pressure/Temp 5 PSIG (3.5m/11.5ft)

Time Zone: Pacific Daylight Time GW Depth = 7.84' - Transducer Depth

		Sensor: Pres(G) 11.5ft SN#: 446725	
Date and Time	Elapsed Time Seconds	Depth (ft)	GW Depth BGS
6/29/2016 13:00	0	3.3	4.54
6/29/2016 13:15	900.001	3.301	4.539
6/29/2016 13:30	1800.001	3.301	4.539
6/29/2016 13:45	2700.001	3.304	4.536
6/29/2016 14:00	3600.001	3.3	4.54
6/29/2016 14:15	4500.001	3.299	4.541
6/29/2016 14:30	5400.001	3.3	4.54
6/29/2016 14:45	6300.001	3.299	4.541
6/29/2016 15:00	7200.001	3.297	4.543
6/29/2016 15:15	8100.001	3.295	4.545
6/29/2016 15:30	9000.001	3.293	4.547
6/29/2016 15:45	9900.001	3.293	4.547
6/29/2016 16:00	10800.001	3.292	4.548
6/29/2016 16:15	11700.001	3.287	4.553
6/29/2016 16:30	12600.001	3.289	4.551
6/29/2016 16:45	13500.001	3.29	4.55
6/29/2016 17:00	14400.001	3.29	4.55
6/29/2016 17:15	15300.001	3.29	4.55
6/29/2016 17:30	16200.001	3.287	4.553
6/29/2016 17:45	17100.001	3.287	4.553
6/29/2016 18:00	18000.001	3.285	4.555
6/29/2016 18:15	18900.001	3.284	4.556
6/29/2016 18:30	19800.001	3.281	4.559

6/29/2016 18:45	20700.001	3.281	4.559
6/29/2016 19:00	21600.001	3.283	4.557
6/29/2016 19:15	22500.001	3.282	4.558
6/29/2016 19:30	23400.001	3.279	4.561
6/29/2016 19:45	24300.001	3.277	4.563
6/29/2016 20:00	25200.001	3.278	4.562
6/29/2016 20:15	26100.001	3.279	4.561
6/29/2016 20:30	27000.001	3.278	4.562
6/29/2016 20:45	27900.001	3.276	4.564
6/29/2016 21:00	28800.001	3.279	4.561
6/29/2016 21:15	29700.001	3.278	4.562
6/29/2016 21:30	30600.001	3.279	4.561
6/29/2016 21:45	31500.001	3.28	4.56
6/29/2016 22:00	32400.001	3.279	4.561
6/29/2016 22:15	33300.001	3.281	4.559
6/29/2016 22:30	34200.001	3.282	4.558
6/29/2016 22:45	35100.001	3.282	4.558
6/29/2016 23:00	36000.001	3.284	4.556
6/29/2016 23:15	36900.001	3.284	4.556
6/29/2016 23:30	37800.001	3.284	4.556
6/29/2016 23:45	38700.001	3.284	4.556
6/30/2016 0:00	39600.001	3.285	4.555
6/30/2016 0:15	40500.001	3.287	4.553
6/30/2016 0:30	41400.001	3.288	4.552
6/30/2016 0:45	42300.001	3.286	4.554
6/30/2016 1:00	43200.001	3.288	4.552
6/30/2016 1:15	44100.001	3.288	4.552
6/30/2016 1:30	45000.001	3.288	4.552
6/30/2016 1:45	45900.001	3.29	4.55
6/30/2016 2:00	46800.001	3.287	4.553
6/30/2016 2:15	47700.001	3.289	4.551
6/30/2016 2:30	48600.001	3.292	4.548
6/30/2016 2:45	49500.001	3.288	4.552
6/30/2016 3:00	50400.001	3.291	4.549
6/30/2016 3:15	51300.001	3.289	4.551
6/30/2016 3:30	52200.001	3.289	4.551
6/30/2016 3:45	53100.001	3.287	4.553
6/30/2016 4:00	54000.001	3.285	4.555
6/30/2016 4:15	54900.001	3.289	4.551
6/30/2016 4:30	55800.001	3.285	4.555
6/30/2016 4:45	56700.001	3.286	4.554
6/30/2016 5:00	57600.001	3.285	4.555
6/30/2016 5:15	58500.001	3.282	4.558
6/30/2016 5:30	59400.001	3.284	4.556
6/30/2016 5:45	60300.001	3.283	4.557
6/30/2016 6:00	61200.001	3.284	4.556
6/30/2016 6:15	62100.001	3.284	4.556

6/30/2016 6:30	63000.001	3.281	4.559
6/30/2016 6:45	63900.001	3.284	4.556
6/30/2016 7:00	64800.001	3.282	4.558
6/30/2016 7:15	65700.001	3.283	4.557
6/30/2016 7:30	66600.001	3.284	4.556
6/30/2016 7:45	67500.001	3.28	4.56
6/30/2016 8:00	68400.001	3.282	4.558
6/30/2016 8:15	69300.001	3.278	4.562
6/30/2016 8:30	70200.001	3.278	4.562
6/30/2016 8:45	71100.001	3.278	4.562
6/30/2016 9:00	72000.001	3.278	4.562
6/30/2016 9:15	72900.001	3.278	4.562
6/30/2016 9:30	73800.001	3.277	4.563
6/30/2016 9:45	74700.001	3.276	4.564
6/30/2016 10:00	75600.001	3.277	4.563
6/30/2016 10:15	76500.001	3.279	4.561
6/30/2016 10:30	77400.001	3.275	4.565
6/30/2016 10:45	78300.001	3.275	4.565
6/30/2016 11:00	79200.001	3.277	4.563
6/30/2016 11:15	80100.001	3.275	4.565
6/30/2016 11:30	81000.001	3.274	4.566
6/30/2016 11:45	81900.001	3.273	4.567
6/30/2016 12:00	82800.001	3.275	4.565
6/30/2016 12:15	83700.001	3.275	4.565
6/30/2016 12:30	84600.001	3.273	4.567
6/30/2016 12:45	85500.001	3.273	4.567
6/30/2016 13:00	86400.001	3.273	4.567
6/30/2016 13:15	87300.001	3.272	4.568
6/30/2016 13:30	88200.001	3.269	4.571
6/30/2016 13:45	89100.001	3.27	4.57
6/30/2016 14:00	90000.001	3.269	4.571
6/30/2016 14:15	90900.001	3.269	4.571
6/30/2016 14:30	91800.001	3.269	4.571
6/30/2016 14:45	92700.001	3.265	4.575
6/30/2016 15:00	93600.001	3.266	4.574
6/30/2016 15:15	94500.001	3.264	4.576
6/30/2016 15:30	95400.001	3.262	4.578
6/30/2016 15:45	96300.001	3.261	4.579
6/30/2016 16:00	97200.001	3.262	4.578
6/30/2016 16:15	98100.001	3.261	4.579
6/30/2016 16:30	99000.001	3.259	4.581
6/30/2016 16:45	99900.001	3.261	4.579
6/30/2016 17:00	100800.001	3.259	4.581
6/30/2016 17:15	101700.001	3.258	4.582
6/30/2016 17:30	102600.001	3.257	4.583
6/30/2016 17:45	103500.001	3.257	4.583
6/30/2016 18:00	104400.001	3.258	4.582

6/30/2016 18:15	105300.001	3.255	4.585
6/30/2016 18:30	106200.001	3.255	4.585
6/30/2016 18:45	107100.001	3.254	4.586
6/30/2016 19:00	108000.001	3.255	4.585
6/30/2016 19:15	108900.001	3.253	4.587
6/30/2016 19:30	109800.001	3.253	4.587
6/30/2016 19:45	110700.001	3.254	4.586
6/30/2016 20:00	111600.001	3.254	4.586
6/30/2016 20:15	112500.001	3.253	4.587
6/30/2016 20:30	113400.001	3.251	4.589
6/30/2016 20:45	114300.001	3.253	4.587
6/30/2016 21:00	115200.001	3.253	4.587
6/30/2016 21:15	116100.001	3.254	4.586
6/30/2016 21:30	117000.001	3.254	4.586
6/30/2016 21:45	117900.001	3.251	4.589
6/30/2016 22:00	118800.001	3.255	4.585
6/30/2016 22:15	119700.001	3.255	4.585
6/30/2016 22:30	120600.001	3.256	4.584
6/30/2016 22:45	121500.001	3.259	4.581
6/30/2016 23:00	122400.001	3.258	4.582
6/30/2016 23:15	123300.001	3.259	4.581
6/30/2016 23:30	124200.001	3.261	4.579
6/30/2016 23:45	125100.001	3.261	4.579
7/1/2016 0:00	126000.001	3.262	4.578
7/1/2016 0:15	126900.001	3.262	4.578
7/1/2016 0:30	127800.001	3.263	4.577
7/1/2016 0:45	128700.001	3.265	4.575
7/1/2016 1:00	129600.001	3.266	4.574
7/1/2016 1:15	130500.001	3.266	4.574
7/1/2016 1:30	131400.001	3.266	4.574
7/1/2016 1:45	132300.001	3.269	4.571
7/1/2016 2:00	133200.001	3.27	4.57
7/1/2016 2:15	134100.001	3.271	4.569
7/1/2016 2:30	135000.001	3.271	4.569
7/1/2016 2:45	135900.001	3.271	4.569
7/1/2016 3:00	136800.001	3.271	4.569
7/1/2016 3:15	137700.001	3.276	4.564
7/1/2016 3:30	138600.001	3.272	4.568
7/1/2016 3:45	139500.001	3.273	4.567
7/1/2016 4:00	140400.001	3.274	4.566
7/1/2016 4:15	141300.001	3.272	4.568
7/1/2016 4:30	142200.001	3.272	4.568
7/1/2016 4:45	143100.001	3.273	4.567
7/1/2016 5:00	144000.001	3.272	4.568
7/1/2016 5:15	144900.001	3.272	4.568
7/1/2016 5:30	145800.001	3.273	4.567
7/1/2016 5:45	146700.001	3.271	4.569

7/1/2016 6:00	147600.001	3.271	4.569
7/1/2016 6:15	148500.001	3.272	4.568
7/1/2016 6:30	149400.001	3.271	4.569
7/1/2016 6:45	150300.001	3.272	4.568
7/1/2016 7:00	151200.001	3.269	4.571
7/1/2016 7:15	152100.001	3.269	4.571
7/1/2016 7:30	153000.001	3.269	4.571
7/1/2016 7:45	153900.001	3.267	4.573
7/1/2016 8:00	154800.001	3.269	4.571
7/1/2016 8:15	155700.001	3.269	4.571
7/1/2016 8:30	156600.001	3.268	4.572
7/1/2016 8:45	157500.001	3.266	4.574
7/1/2016 9:00	158400.001	3.266	4.574
7/1/2016 9:15	159300.001	3.266	4.574
7/1/2016 9:30	160200.001	3.265	4.575
7/1/2016 9:45	161100.001	3.264	4.576
7/1/2016 10:00	162000.001	3.264	4.576
7/1/2016 10:15	162900.001	3.264	4.576
7/1/2016 10:30	163800.001	3.26	4.58
7/1/2016 10:45	164700.001	3.258	4.582
7/1/2016 11:00	165600.001	3.258	4.582
7/1/2016 11:15	166500.001	3.255	4.585
7/1/2016 11:30	167400.001	3.254	4.586
7/1/2016 11:45	168300.001	3.253	4.587
7/1/2016 12:00	169200.001	3.253	4.587
7/1/2016 12:15	170100.001	3.249	4.591
7/1/2016 12:30	171000.001	3.25	4.59
7/1/2016 12:45	171900.001	3.249	4.591
7/1/2016 13:00	172800.001	3.249	4.591
7/1/2016 13:15	173700.001	3.247	4.593
7/1/2016 13:30	174600.001	3.248	4.592
7/1/2016 13:45	175500.001	3.246	4.594
7/1/2016 14:00	176400.001	3.243	4.597
7/1/2016 14:15	177300.001	3.244	4.596
7/1/2016 14:30	178200.001	3.244	4.596
7/1/2016 14:45	179100.001	3.243	4.597
7/1/2016 15:00	180000.001	3.242	4.598
7/1/2016 15:15	180900.001	3.242	4.598
7/1/2016 15:30	181800.001	3.238	4.602
7/1/2016 15:45	182700.001	3.237	4.603
7/1/2016 16:00	183600.001	3.24	4.6
7/1/2016 16:15	184500.001	3.237	4.603
7/1/2016 16:30	185400.001	3.236	4.604
7/1/2016 16:45	186300.001	3.236	4.604
7/1/2016 17:00	187200.001	3.237	4.603
7/1/2016 17:15	188100.001	3.236	4.604
7/1/2016 17:30	189000.001	3.234	4.606

7/1/2016 17:45	189900.001	3.236	4.604
7/1/2016 18:00	190800.001	3.234	4.606
7/1/2016 18:15	191700.001	3.236	4.604
7/1/2016 18:30	192600.001	3.237	4.603
7/1/2016 18:45	193500.001	3.237	4.603
7/1/2016 19:00	194400.001	3.236	4.604
7/1/2016 19:15	195300.001	3.237	4.603
7/1/2016 19:30	196200.001	3.237	4.603
7/1/2016 19:45	197100.001	3.237	4.603
7/1/2016 20:00	198000.001	3.239	4.601
7/1/2016 20:15	198900.001	3.24	4.6
7/1/2016 20:30	199800.001	3.241	4.599
7/1/2016 20:45	200700.001	3.242	4.598
7/1/2016 21:00	201600.001	3.241	4.599
7/1/2016 21:15	202500.001	3.241	4.599
7/1/2016 21:30	203400.001	3.242	4.598
7/1/2016 21:45	204300.001	3.242	4.598
7/1/2016 22:00	205200.001	3.244	4.596
7/1/2016 22:15	206100.001	3.244	4.596
7/1/2016 22:30	207000.001	3.246	4.594
7/1/2016 22:45	207900.001	3.247	4.593
7/1/2016 23:00	208800.001	3.246	4.594
7/1/2016 23:15	209700.001	3.248	4.592
7/1/2016 23:30	210600.001	3.249	4.591
7/1/2016 23:45	211500.001	3.25	4.59
7/2/2016 0:00	212400.001	3.251	4.589
7/2/2016 0:15	213300.001	3.254	4.586
7/2/2016 0:30	214200.001	3.253	4.587
7/2/2016 0:45	215100.001	3.255	4.585
7/2/2016 1:00	216000.001	3.257	4.583
7/2/2016 1:15	216900.001	3.258	4.582
7/2/2016 1:30	217800.001	3.257	4.583
7/2/2016 1:45	218700.001	3.259	4.581
7/2/2016 2:00	219600.001	3.26	4.58
7/2/2016 2:15	220500.001	3.26	4.58
7/2/2016 2:30	221400.001	3.263	4.577
7/2/2016 2:45	222300.001	3.264	4.576
7/2/2016 3:00	223200.001	3.263	4.577
7/2/2016 3:15	224100.001	3.264	4.576
7/2/2016 3:30	225000.001	3.264	4.576
7/2/2016 3:45	225900.001	3.266	4.574
7/2/2016 4:00	226800.001	3.266	4.574
7/2/2016 4:15	227700.001	3.266	4.574
7/2/2016 4:30	228600.001	3.265	4.575
7/2/2016 4:45	229500.001	3.268	4.572
7/2/2016 5:00	230400.001	3.267	4.573
7/2/2016 5:15	231300.001	3.267	4.573

7/2/2016 5:30	232200.001	3.267	4.573
7/2/2016 5:45	233100.001	3.266	4.574
7/2/2016 6:00	234000.001	3.265	4.575
7/2/2016 6:15	234900.001	3.266	4.574
7/2/2016 6:30	235800.001	3.263	4.577
7/2/2016 6:45	236700.001	3.265	4.575
7/2/2016 7:00	237600.001	3.265	4.575
7/2/2016 7:15	238500.001	3.264	4.576
7/2/2016 7:30	239400.001	3.265	4.575
7/2/2016 7:45	240300.001	3.263	4.577
7/2/2016 8:00	241200.001	3.263	4.577
7/2/2016 8:15	242100.001	3.261	4.579
7/2/2016 8:30	243000.001	3.26	4.58
7/2/2016 8:45	243900.001	3.259	4.581
7/2/2016 9:00	244800.001	3.26	4.58
7/2/2016 9:15	245700.001	3.257	4.583
7/2/2016 9:30	246600.001	3.258	4.582
7/2/2016 9:45	247500.001	3.258	4.582
7/2/2016 10:00	248400.001	3.257	4.583
7/2/2016 10:15	249300.001	3.257	4.583
7/2/2016 10:30	250200.001	3.253	4.587
7/2/2016 10:45	251100.001	3.252	4.588
7/2/2016 11:00	252000.001	3.252	4.588
7/2/2016 11:15	252900.001	3.251	4.589
7/2/2016 11:30	253800.001	3.248	4.592
7/2/2016 11:45	254700.001	3.245	4.595
7/2/2016 12:00	255600.001	3.244	4.596
7/2/2016 12:15	256500.001	3.242	4.598
7/2/2016 12:30	257400.001	3.244	4.596
7/2/2016 12:45	258300.001	3.24	4.6
7/2/2016 13:00	259200.001	3.239	4.601
7/2/2016 13:15	260100.001	3.238	4.602
7/2/2016 13:30	261000.001	3.236	4.604
7/2/2016 13:45	261900.001	3.236	4.604
7/2/2016 14:00	262800.001	3.236	4.604
7/2/2016 14:15	263700.001	3.233	4.607
7/2/2016 14:30	264600.001	3.231	4.609
7/2/2016 14:45	265500.001	3.231	4.609
7/2/2016 15:00	266400.001	3.23	4.61
7/2/2016 15:15	267300.001	3.228	4.612
7/2/2016 15:30	268200.001	3.229	4.611
7/2/2016 15:45	269100.001	3.225	4.615
7/2/2016 16:00	270000.001	3.225	4.615
7/2/2016 16:15	270900.001	3.223	4.617
7/2/2016 16:30	271800.001	3.227	4.613
7/2/2016 16:45	272700.001	3.226	4.614
7/2/2016 17:00	273600.001	3.223	4.617

7/2/2016 17:15	274500.001	3.224	4.616
7/2/2016 17:30	275400.001	3.225	4.615
7/2/2016 17:45	276300.001	3.225	4.615
7/2/2016 18:00	277200.001	3.223	4.617
7/2/2016 18:15	278100.001	3.226	4.614
7/2/2016 18:30	279000.001	3.224	4.616
7/2/2016 18:45	279900.001	3.224	4.616
7/2/2016 19:00	280800.001	3.225	4.615
7/2/2016 19:15	281700.001	3.225	4.615
7/2/2016 19:30	282600.001	3.225	4.615
7/2/2016 19:45	283500.001	3.223	4.617
7/2/2016 20:00	284400.001	3.226	4.614
7/2/2016 20:15	285300.001	3.223	4.617
7/2/2016 20:30	286200.001	3.224	4.616
7/2/2016 20:45	287100.001	3.226	4.614
7/2/2016 21:00	288000.001	3.226	4.614
7/2/2016 21:15	288900.001	3.227	4.613
7/2/2016 21:30	289800.001	3.228	4.612
7/2/2016 21:45	290700.001	3.228	4.612
7/2/2016 22:00	291600.001	3.231	4.609
7/2/2016 22:15	292500.001	3.23	4.61
7/2/2016 22:30	293400.001	3.232	4.608
7/2/2016 22:45	294300.001	3.233	4.607
7/2/2016 23:00	295200.001	3.234	4.606
7/2/2016 23:15	296100.001	3.235	4.605
7/2/2016 23:30	297000.001	3.237	4.603
7/2/2016 23:45	297900.001	3.235	4.605
7/3/2016 0:00	298800.001	3.239	4.601
7/3/2016 0:15	299700.001	3.238	4.602
7/3/2016 0:30	300600.001	3.238	4.602
7/3/2016 0:45	301500.001	3.239	4.601
7/3/2016 1:00	302400.001	3.24	4.6
7/3/2016 1:15	303300.001	3.239	4.601
7/3/2016 1:30	304200.001	3.24	4.6
7/3/2016 1:45	305100.001	3.241	4.599
7/3/2016 2:00	306000.001	3.243	4.597
7/3/2016 2:15	306900.001	3.243	4.597
7/3/2016 2:30	307800.001	3.246	4.594
7/3/2016 2:45	308700.001	3.244	4.596
7/3/2016 3:00	309600.001	3.245	4.595
7/3/2016 3:15	310500.001	3.248	4.592
7/3/2016 3:30	311400.001	3.248	4.592
7/3/2016 3:45	312300.001	3.251	4.589
7/3/2016 4:00	313200.001	3.247	4.593
7/3/2016 4:15	314100.001	3.25	4.59
7/3/2016 4:30	315000.001	3.25	4.59
7/3/2016 4:45	315900.001	3.253	4.587

7/3/2016 5:00	316800.001	3.249	4.591
7/3/2016 5:15	317700.001	3.25	4.59
7/3/2016 5:30	318600.001	3.249	4.591
7/3/2016 5:45	319500.001	3.25	4.59
7/3/2016 6:00	320400.001	3.252	4.588
7/3/2016 6:15	321300.001	3.253	4.587
7/3/2016 6:30	322200.001	3.25	4.59
7/3/2016 6:45	323100.001	3.251	4.589
7/3/2016 7:00	324000.001	3.25	4.59
7/3/2016 7:15	324900.001	3.251	4.589
7/3/2016 7:30	325800.001	3.249	4.591
7/3/2016 7:45	326700.001	3.252	4.588
7/3/2016 8:00	327600.001	3.25	4.59
7/3/2016 8:15	328500.001	3.251	4.589
7/3/2016 8:30	329400.001	3.248	4.592
7/3/2016 8:45	330300.001	3.249	4.591
7/3/2016 9:00	331200.001	3.247	4.593
7/3/2016 9:15	332100.001	3.247	4.593
7/3/2016 9:30	333000.001	3.242	4.598
7/3/2016 9:45	333900.001	3.24	4.6
7/3/2016 10:00	334800.001	3.237	4.603
7/3/2016 10:15	335700.001	3.236	4.604
7/3/2016 10:30	336600.001	3.234	4.606
7/3/2016 10:45	337500.001	3.233	4.607
7/3/2016 11:00	338400.001	3.229	4.611
7/3/2016 11:15	339300.001	3.225	4.615
7/3/2016 11:30	340200.001	3.224	4.616
7/3/2016 11:45	341100.001	3.221	4.619
7/3/2016 12:00	342000.001	3.221	4.619
7/3/2016 12:15	342900.001	3.217	4.623
7/3/2016 12:30	343800.001	3.218	4.622
7/3/2016 12:45	344700.001	3.213	4.627
7/3/2016 13:00	345600.001	3.214	4.626
7/3/2016 13:15	346500.001	3.213	4.627
7/3/2016 13:30	347400.001	3.213	4.627
7/3/2016 13:45	348300.001	3.211	4.629
7/3/2016 14:00	349200.001	3.21	4.63
7/3/2016 14:15	350100.001	3.21	4.63
7/3/2016 14:30	351000.001	3.21	4.63
7/3/2016 14:45	351900.001	3.208	4.632
7/3/2016 15:00	352800.001	3.207	4.633
7/3/2016 15:15	353700.001	3.206	4.634
7/3/2016 15:30	354600.001	3.205	4.635
7/3/2016 15:45	355500.001	3.207	4.633
7/3/2016 16:00	356400.001	3.204	4.636
7/3/2016 16:15	357300.001	3.204	4.636
7/3/2016 16:30	358200.001	3.205	4.635

7/3/2016 16:45	359100.001	3.204	4.636
7/3/2016 17:00	360000.001	3.205	4.635
7/3/2016 17:15	360900.001	3.206	4.634
7/3/2016 17:30	361800.001	3.203	4.637
7/3/2016 17:45	362700.001	3.204	4.636
7/3/2016 18:00	363600.001	3.206	4.634
7/3/2016 18:15	364500.001	3.207	4.633
7/3/2016 18:30	365400.001	3.206	4.634
7/3/2016 18:45	366300.001	3.206	4.634
7/3/2016 19:00	367200.001	3.205	4.635
7/3/2016 19:15	368100.001	3.204	4.636
7/3/2016 19:30	369000.001	3.206	4.634
7/3/2016 19:45	369900.001	3.207	4.633
7/3/2016 20:00	370800.001	3.207	4.633
7/3/2016 20:15	371700.001	3.205	4.635
7/3/2016 20:30	372600.001	3.206	4.634
7/3/2016 20:45	373500.001	3.205	4.635
7/3/2016 21:00	374400.001	3.209	4.631
7/3/2016 21:15	375300.001	3.209	4.631
7/3/2016 21:30	376200.001	3.21	4.63
7/3/2016 21:45	377100.001	3.211	4.629
7/3/2016 22:00	378000.001	3.212	4.628
7/3/2016 22:15	378900.001	3.212	4.628
7/3/2016 22:30	379800.001	3.214	4.626
7/3/2016 22:45	380700.001	3.214	4.626
7/3/2016 23:00	381600.001	3.214	4.626
7/3/2016 23:15	382500.001	3.217	4.623
7/3/2016 23:30	383400.001	3.218	4.622
7/3/2016 23:45	384300.001	3.218	4.622
7/4/2016 0:00	385200.001	3.222	4.618
7/4/2016 0:15	386100.001	3.222	4.618
7/4/2016 0:30	387000.001	3.221	4.619
7/4/2016 0:45	387900.001	3.223	4.617
7/4/2016 1:00	388800.001	3.224	4.616
7/4/2016 1:15	389700.001	3.226	4.614
7/4/2016 1:30	390600.001	3.226	4.614
7/4/2016 1:45	391500.001	3.228	4.612
7/4/2016 2:00	392400.001	3.229	4.611
7/4/2016 2:15	393300.001	3.231	4.609
7/4/2016 2:30	394200.001	3.231	4.609
7/4/2016 2:45	395100.001	3.233	4.607
7/4/2016 3:00	396000.001	3.233	4.607
7/4/2016 3:15	396900.001	3.234	4.606
7/4/2016 3:30	397800.001	3.234	4.606
7/4/2016 3:45	398700.001	3.235	4.605
7/4/2016 4:00	399600.001	3.237	4.603
7/4/2016 4:15	400500.001	3.237	4.603

7/4/2016 4:30	401400.001	3.237	4.603
7/4/2016 4:45	402300.001	3.24	4.6
7/4/2016 5:00	403200.001	3.24	4.6
7/4/2016 5:15	404100.001	3.241	4.599
7/4/2016 5:30	405000.001	3.242	4.598
7/4/2016 5:45	405900.001	3.24	4.6
7/4/2016 6:00	406800.001	3.243	4.597
7/4/2016 6:15	407700.001	3.242	4.598
7/4/2016 6:30	408600.001	3.242	4.598
7/4/2016 6:45	409500.001	3.242	4.598
7/4/2016 7:00	410400.001	3.242	4.598
7/4/2016 7:15	411300.001	3.243	4.597
7/4/2016 7:30	412200.001	3.24	4.6
7/4/2016 7:45	413100.001	3.243	4.597
7/4/2016 8:00	414000.001	3.241	4.599
7/4/2016 8:15	414900.001	3.242	4.598
7/4/2016 8:30	415800.001	3.24	4.6
7/4/2016 8:45	416700.001	3.238	4.602
7/4/2016 9:00	417600.001	3.24	4.6
7/4/2016 9:15	418500.001	3.239	4.601
7/4/2016 9:30	419400.001	3.238	4.602
7/4/2016 9:45	420300.001	3.236	4.604
7/4/2016 10:00	421200.001	3.238	4.602
7/4/2016 10:15	422100.001	3.236	4.604
7/4/2016 10:30	423000.001	3.235	4.605
7/4/2016 10:45	423900.001	3.234	4.606
7/4/2016 11:00	424800.001	3.235	4.605
7/4/2016 11:15	425700.001	3.231	4.609
7/4/2016 11:30	426600.001	3.234	4.606
7/4/2016 11:45	427500.001	3.233	4.607
7/4/2016 12:00	428400.001	3.232	4.608
7/4/2016 12:15	429300.001	3.23	4.61
7/4/2016 12:30	430200.001	3.227	4.613
7/4/2016 12:45	431100.001	3.227	4.613
7/4/2016 13:00	432000.001	3.225	4.615
7/4/2016 13:15	432900.001	3.225	4.615
7/4/2016 13:30	433800.001	3.222	4.618
7/4/2016 13:45	434700.001	3.223	4.617
7/4/2016 14:00	435600.001	3.221	4.619
7/4/2016 14:15	436500.001	3.221	4.619
7/4/2016 14:30	437400.001	3.22	4.62
7/4/2016 14:45	438300.001	3.22	4.62
7/4/2016 15:00	439200.001	3.221	4.619
7/4/2016 15:15	440100.001	3.223	4.617
7/4/2016 15:30	441000.001	3.222	4.618
7/4/2016 15:45	441900.001	3.223	4.617
7/4/2016 16:00	442800.001	3.22	4.62

7/4/2016 16:15	443700.001	3.221	4.619
7/4/2016 16:30	444600.001	3.222	4.618
7/4/2016 16:45	445500.001	3.225	4.615
7/4/2016 17:00	446400.001	3.221	4.619
7/4/2016 17:15	447300.001	3.222	4.618
7/4/2016 17:30	448200.001	3.221	4.619
7/4/2016 17:45	449100.001	3.22	4.62
7/4/2016 18:00	450000.001	3.222	4.618
7/4/2016 18:15	450900.001	3.22	4.62
7/4/2016 18:30	451800.001	3.222	4.618
7/4/2016 18:45	452700.001	3.22	4.62
7/4/2016 19:00	453600.001	3.22	4.62
7/4/2016 19:15	454500.001	3.221	4.619
7/4/2016 19:30	455400.001	3.22	4.62
7/4/2016 19:45	456300.001	3.22	4.62
7/4/2016 20:00	457200.001	3.218	4.622
7/4/2016 20:15	458100.001	3.221	4.619
7/4/2016 20:30	459000.001	3.218	4.622
7/4/2016 20:45	459900.001	3.221	4.619
7/4/2016 21:00	460800.001	3.221	4.619
7/4/2016 21:15	461700.001	3.221	4.619
7/4/2016 21:30	462600.001	3.222	4.618
7/4/2016 21:45	463500.001	3.223	4.617
7/4/2016 22:00	464400.001	3.223	4.617
7/4/2016 22:15	465300.001	3.223	4.617
7/4/2016 22:30	466200.001	3.224	4.616
7/4/2016 22:45	467100.001	3.225	4.615
7/4/2016 23:00	468000.001	3.227	4.613
7/4/2016 23:15	468900.001	3.226	4.614
7/4/2016 23:30	469800.001	3.227	4.613
7/4/2016 23:45	470700.001	3.228	4.612
7/5/2016 0:00	471600.001	3.23	4.61
7/5/2016 0:15	472500.001	3.231	4.609
7/5/2016 0:30	473400.001	3.232	4.608
7/5/2016 0:45	474300.001	3.231	4.609
7/5/2016 1:00	475200.001	3.232	4.608
7/5/2016 1:15	476100.001	3.234	4.606
7/5/2016 1:30	477000.001	3.235	4.605
7/5/2016 1:45	477900.001	3.235	4.605
7/5/2016 2:00	478800.001	3.236	4.604
7/5/2016 2:15	479700.001	3.237	4.603
7/5/2016 2:30	480600.001	3.241	4.599
7/5/2016 2:45	481500.001	3.24	4.6
7/5/2016 3:00	482400.001	3.241	4.599
7/5/2016 3:15	483300.001	3.243	4.597
7/5/2016 3:30	484200.001	3.242	4.598
7/5/2016 3:45	485100.001	3.244	4.596

7/5/2016 4:00	486000.001	3.243	4.597
7/5/2016 4:15	486900.001	3.245	4.595
7/5/2016 4:30	487800.001	3.247	4.593
7/5/2016 4:45	488700.001	3.247	4.593
7/5/2016 5:00	489600.001	3.249	4.591
7/5/2016 5:15	490500.001	3.249	4.591
7/5/2016 5:30	491400.001	3.249	4.591
7/5/2016 5:45	492300.001	3.249	4.591
7/5/2016 6:00	493200.001	3.248	4.592
7/5/2016 6:15	494100.001	3.25	4.59
7/5/2016 6:30	495000.001	3.25	4.59
7/5/2016 6:45	495900.001	3.25	4.59
7/5/2016 7:00	496800.001	3.25	4.59
7/5/2016 7:15	497700.001	3.252	4.588
7/5/2016 7:30	498600.001	3.25	4.59
7/5/2016 7:45	499500.001	3.25	4.59
7/5/2016 8:00	500400.001	3.249	4.591
7/5/2016 8:15	501300.001	3.249	4.591
7/5/2016 8:30	502200.001	3.248	4.592
7/5/2016 8:45	503100.001	3.25	4.59
7/5/2016 9:00	504000.001	3.249	4.591
7/5/2016 9:15	504900.001	3.248	4.592
7/5/2016 9:30	505800.001	3.247	4.593
7/5/2016 9:45	506700.001	3.249	4.591
7/5/2016 10:00	507600.001	3.249	4.591
7/5/2016 10:15	508500.001	3.245	4.595
7/5/2016 10:30	509400.001	3.247	4.593
7/5/2016 10:45	510300.001	3.245	4.595
7/5/2016 11:00	511200.001	3.244	4.596
7/5/2016 11:15	512100.001	3.242	4.598
7/5/2016 11:30	513000.001	3.24	4.6
7/5/2016 11:45	513900.001	3.24	4.6
7/5/2016 12:00	514800.001	3.237	4.603
7/5/2016 12:15	515700.001	3.238	4.602
7/5/2016 12:30	516600.001	3.238	4.602
7/5/2016 12:45	517500.001	3.237	4.603
7/5/2016 13:00	518400.001	3.237	4.603
7/5/2016 13:15	519300.001	3.235	4.605
7/5/2016 13:30	520200.001	3.235	4.605
7/5/2016 13:45	521100.001	3.233	4.607
7/5/2016 14:00	522000.001	3.233	4.607
7/5/2016 14:15	522900.001	3.232	4.608
7/5/2016 14:30	523800.001	3.229	4.611
7/5/2016 14:45	524700.001	3.228	4.612
7/5/2016 15:00	525600.001	3.228	4.612
7/5/2016 15:15	526500.001	3.226	4.614
7/5/2016 15:30	527400.001	3.227	4.613

7/5/2016 15:45	528300.001	3.224	4.616
7/5/2016 16:00	529200.001	3.224	4.616
7/5/2016 16:15	530100.001	3.224	4.616
7/5/2016 16:30	531000.001	3.223	4.617
7/5/2016 16:45	531900.001	3.222	4.618
7/5/2016 17:00	532800.001	3.223	4.617
7/5/2016 17:15	533700.001	3.221	4.619
7/5/2016 17:30	534600.001	3.219	4.621
7/5/2016 17:45	535500.001	3.222	4.618
7/5/2016 18:00	536400.001	3.22	4.62
7/5/2016 18:15	537300.001	3.221	4.619
7/5/2016 18:30	538200.001	3.219	4.621
7/5/2016 18:45	539100.001	3.219	4.621
7/5/2016 19:00	540000.001	3.219	4.621
7/5/2016 19:15	540900.001	3.22	4.62
7/5/2016 19:30	541800.001	3.221	4.619
7/5/2016 19:45	542700.001	3.221	4.619
7/5/2016 20:00	543600.001	3.223	4.617
7/5/2016 20:15	544500.001	3.222	4.618
7/5/2016 20:30	545400.001	3.223	4.617
7/5/2016 20:45	546300.001	3.225	4.615
7/5/2016 21:00	547200.001	3.225	4.615
7/5/2016 21:15	548100.001	3.228	4.612
7/5/2016 21:30	549000.001	3.226	4.614
7/5/2016 21:45	549900.001	3.227	4.613
7/5/2016 22:00	550800.001	3.228	4.612
7/5/2016 22:15	551700.001	3.229	4.611
7/5/2016 22:30	552600.001	3.231	4.609
7/5/2016 22:45	553500.001	3.23	4.61
7/5/2016 23:00	554400.001	3.231	4.609
7/5/2016 23:15	555300.001	3.23	4.61
7/5/2016 23:30	556200.001	3.23	4.61
7/5/2016 23:45	557100.001	3.232	4.608
7/6/2016 0:00	558000.001	3.231	4.609
7/6/2016 0:15	558900.001	3.232	4.608
7/6/2016 0:30	559800.001	3.234	4.606
7/6/2016 0:45	560700.001	3.234	4.606
7/6/2016 1:00	561600.001	3.234	4.606
7/6/2016 1:15	562500.001	3.235	4.605
7/6/2016 1:30	563400.001	3.237	4.603
7/6/2016 1:45	564300.001	3.237	4.603
7/6/2016 2:00	565200.001	3.237	4.603
7/6/2016 2:15	566100.001	3.239	4.601
7/6/2016 2:30	567000.001	3.241	4.599
7/6/2016 2:45	567900.001	3.24	4.6
7/6/2016 3:00	568800.001	3.241	4.599
7/6/2016 3:15	569700.001	3.242	4.598

7/6/2016 3:30	570600.001	3.243	4.597
7/6/2016 3:45	571500.001	3.245	4.595
7/6/2016 4:00	572400.001	3.245	4.595
7/6/2016 4:15	573300.001	3.246	4.594
7/6/2016 4:30	574200.001	3.246	4.594
7/6/2016 4:45	575100.001	3.246	4.594
7/6/2016 5:00	576000.001	3.25	4.59
7/6/2016 5:15	576900.001	3.251	4.589
7/6/2016 5:30	577800.001	3.25	4.59
7/6/2016 5:45	578700.001	3.251	4.589
7/6/2016 6:00	579600.001	3.251	4.589
7/6/2016 6:15	580500.001	3.252	4.588
7/6/2016 6:30	581400.001	3.252	4.588
7/6/2016 6:45	582300.001	3.252	4.588
7/6/2016 7:00	583200.001	3.254	4.586
7/6/2016 7:15	584100.001	3.252	4.588
7/6/2016 7:30	585000.001	3.253	4.587
7/6/2016 7:45	585900.001	3.254	4.586
7/6/2016 8:00	586800.001	3.254	4.586
7/6/2016 8:15	587700.001	3.253	4.587
7/6/2016 8:30	588600.001	3.253	4.587
7/6/2016 8:45	589500.001	3.256	4.584
7/6/2016 9:00	590400.001	3.251	4.589
7/6/2016 9:15	591300.001	3.254	4.586
7/6/2016 9:30	592200.001	3.251	4.589
7/6/2016 9:45	593100.001	3.251	4.589
7/6/2016 10:00	594000.001	3.251	4.589
7/6/2016 10:15	594900.001	3.249	4.591
7/6/2016 10:30	595800.001	3.247	4.593
7/6/2016 10:45	596700.001	3.245	4.595
7/6/2016 11:00	597600.001	3.243	4.597
7/6/2016 11:15	598500.001	3.242	4.598
7/6/2016 11:30	599400.001	3.239	4.601
7/6/2016 11:45	600300.001	3.239	4.601
7/6/2016 12:00	601200.001	3.235	4.605
7/6/2016 12:15	602100.001	3.232	4.608
7/6/2016 12:30	603000.001	3.23	4.61
7/6/2016 12:45	603900.001	3.228	4.612
7/6/2016 13:00	604800.001	3.225	4.615
7/6/2016 13:15	605700.001	3.223	4.617
7/6/2016 13:30	606600.001	3.223	4.617
7/6/2016 13:45	607500.001	3.221	4.619
7/6/2016 14:00	608400.001	3.217	4.623
7/6/2016 14:15	609300.001	3.214	4.626
7/6/2016 14:30	610200.001	3.212	4.628
7/6/2016 14:45	611100.001	3.212	4.628
7/6/2016 15:00	612000.001	3.209	4.631

7/6/2016 15:15	612900.001	3.207	4.633
7/6/2016 15:30	613800.001	3.203	4.637
7/6/2016 15:45	614700.001	3.204	4.636
7/6/2016 16:00	615600.001	3.201	4.639
7/6/2016 16:15	616500.001	3.2	4.64
7/6/2016 16:30	617400.001	3.201	4.639
7/6/2016 16:45	618300.001	3.2	4.64
7/6/2016 17:00	619200.001	3.201	4.639
7/6/2016 17:15	620100.001	3.202	4.638
7/6/2016 17:30	621000.001	3.2	4.64
7/6/2016 17:45	621900.001	3.203	4.637
7/6/2016 18:00	622800.001	3.2	4.64
7/6/2016 18:15	623700.001	3.201	4.639
7/6/2016 18:30	624600.001	3.202	4.638
7/6/2016 18:45	625500.001	3.203	4.637
7/6/2016 19:00	626400.001	3.201	4.639
7/6/2016 19:15	627300.001	3.2	4.64
7/6/2016 19:30	628200.001	3.202	4.638
7/6/2016 19:45	629100.001	3.2	4.64
7/6/2016 20:00	630000.001	3.202	4.638
7/6/2016 20:15	630900.001	3.204	4.636
7/6/2016 20:30	631800.001	3.205	4.635
7/6/2016 20:45	632700.001	3.208	4.632
7/6/2016 21:00	633600.001	3.209	4.631
7/6/2016 21:15	634500.001	3.209	4.631
7/6/2016 21:30	635400.001	3.211	4.629
7/6/2016 21:45	636300.001	3.212	4.628
7/6/2016 22:00	637200.001	3.213	4.627
7/6/2016 22:15	638100.001	3.213	4.627
7/6/2016 22:30	639000.001	3.213	4.627
7/6/2016 22:45	639900.001	3.216	4.624
7/6/2016 23:00	640800.001	3.218	4.622
7/6/2016 23:15	641700.001	3.218	4.622
7/6/2016 23:30	642600.001	3.22	4.62
7/6/2016 23:45	643500.001	3.219	4.621
7/7/2016 0:00	644400.001	3.219	4.621
7/7/2016 0:15	645300.001	3.221	4.619
7/7/2016 0:30	646200.001	3.223	4.617
7/7/2016 0:45	647100.001	3.223	4.617
7/7/2016 1:00	648000.001	3.224	4.616
7/7/2016 1:15	648900.001	3.225	4.615
7/7/2016 1:30	649800.001	3.226	4.614
7/7/2016 1:45	650700.001	3.226	4.614
7/7/2016 2:00	651600.001	3.227	4.613
7/7/2016 2:15	652500.001	3.231	4.609
7/7/2016 2:30	653400.001	3.232	4.608
7/7/2016 2:45	654300.001	3.234	4.606

7/7/2016 3:00	655200.001	3.235	4.605
7/7/2016 3:15	656100.001	3.234	4.606
7/7/2016 3:30	657000.001	3.234	4.606
7/7/2016 3:45	657900.001	3.235	4.605
7/7/2016 4:00	658800.001	3.237	4.603
7/7/2016 4:15	659700.001	3.238	4.602
7/7/2016 4:30	660600.001	3.238	4.602
7/7/2016 4:45	661500.001	3.241	4.599
7/7/2016 5:00	662400.001	3.24	4.6
7/7/2016 5:15	663300.001	3.24	4.6
7/7/2016 5:30	664200.001	3.242	4.598
7/7/2016 5:45	665100.001	3.243	4.597
7/7/2016 6:00	666000.001	3.244	4.596
7/7/2016 6:15	666900.001	3.246	4.594
7/7/2016 6:30	667800.001	3.245	4.595
7/7/2016 6:45	668700.001	3.247	4.593
7/7/2016 7:00	669600.001	3.249	4.591
7/7/2016 7:15	670500.001	3.248	4.592
7/7/2016 7:30	671400.001	3.25	4.59
7/7/2016 7:45	672300.001	3.248	4.592
7/7/2016 8:00	673200.001	3.25	4.59
7/7/2016 8:15	674100.001	3.251	4.589
7/7/2016 8:30	675000.001	3.252	4.588
7/7/2016 8:45	675900.001	3.251	4.589
7/7/2016 9:00	676800.001	3.251	4.589
7/7/2016 9:15	677700.001	3.252	4.588
7/7/2016 9:30	678600.001	3.251	4.589
7/7/2016 9:45	679500.001	3.251	4.589
7/7/2016 10:00	680400.001	3.251	4.589
7/7/2016 10:15	681300.001	3.251	4.589
7/7/2016 10:30	682200.001	3.25	4.59
7/7/2016 10:45	683100.001	3.25	4.59
7/7/2016 11:00	684000.001	3.249	4.591
7/7/2016 11:15	684900.001	3.247	4.593
7/7/2016 11:30	685800.001	3.247	4.593
7/7/2016 11:45	686700.001	3.247	4.593
7/7/2016 12:00	687600.001	3.247	4.593
7/7/2016 12:15	688500.001	3.245	4.595
7/7/2016 12:30	689400.001	3.244	4.596
7/7/2016 12:45	690300.001	3.246	4.594
7/7/2016 13:00	691200.001	3.244	4.596

Appendix D

Infiltration Test Results

Grain Size Analysis Infiltration Estimation

Soil Grain Size Analysis Method (Stormwater Management Manual for Western Washington Vol III, pgs 3-79 and 3-82, Aug 2012):

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$

Where, D_{10}, D_{60} and D_{90} are the grain sizes in mm for which 10 percent, 60 percent and 90 percent of the sample is more fine and f_{fines} is the fraction of the soil (by weight) that passes the number-200 sieve (K_{sat} is in cm/s).

Table 3.3.1
Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates.

Issue	Partial Correction Factor
Site variability and number of locations tested	CF_v = 0.33 to 1.0
Test Method	
Large-scale PIT	CF_t = 0.75
Small-scale PIT	= 0.50
Other small-scale (e.g. Double ring, falling head)	= 0.40
Grain Size Method	= 0.40
Degree of influent control to prevent siltation and bio-buildup	CF_m = 0.9

Total Correction Factor, $CF_T = CF_v \times CF_t \times CF_m$

CF_T is used in step 5 of the Design of Infiltration Facilities (Section 3.3.4) to adjust the measured (initial) saturated hydraulic conductivity.

$K_{sat\ design} = K_{sat\ initial} \times CF_T$

	D10	D60	D90	Fines	Log10 (Ksat)	K(sat) (cm/s)	K(sat) (in/h)	CF(v)	CF(t)	CF(m)	Correction Factor (total)	Long Term Infiltration Rate (in/h)
Test Pit-1, 1.0-1.5 ft	0.0267	0.4	14.2	11.6%	-1.93938	0.011	16.30	0.67	0.40	0.90	0.2412	3.9
Test Pit-2, 1.0-1.5 ft	0.0898	0.26	0.5	5.6%	-1.5182	0.030	42.98	0.67	0.40	0.90	0.2412	10.4
Test Pit-3, 1.0-1.5 ft	0.1621	0.3	0.4	2.4%	-1.313176	0.049	68.91	0.67	0.40	0.90	0.24	16.6
Test Pit-3, 4.5-5.0 ft	0.153	0.28	0.4	2.0%	-1.3219	0.048	67.54	0.67	0.40	0.90	0.2412	16.3

PORT OF PORT TOWNSEND Parametrix

WORKSHEET FOR SMALL-SCALE PILOT INFILTRATION TEST Test Date: June 27, 2016

Test Loc. **Pit 2**

Width (ft)	3.5	Start Pre-Soak	1051
Length (ft)	4	End Pre-Soak	1345
Area (sf)	14	Pre-Soak Elapsed Time	2:54
Pit Depth (in)	22		
Pre-soak Depth (in)	12		
Test Depth (in)	11		

Date	Time	Elapsed Time (min)	Water Added (gal)	Water Depth (in)	Flow (gpm)	Flow (gph)	Infil. Rate (in/hr)	Notes
06/27/16	1345	0	0	11	0.00	0.00	-	Start Stabilized Flow Test
	1356	11	3.5	11	0.32	19.09	2.19	Water added using calibrated bucket
	1402	17	4	11	0.67	40.00	4.58	
	1410	25	4	11	0.50	30.00	3.44	
	1420	35	4.5	11	0.45	27.00	3.09	
	1425	40	4.5	11	0.90	54.00	6.19	
	1432	47	5	11	0.71	42.86	4.91	
	1440	55	4.5	11	0.56	33.75	3.87	
	1445	60	3.5	11	0.70	42.00	4.81	End Stabilized Flow Test
	1500	75	0	9	NA	NA	8.00	
	1515	90	0	8.25	NA	NA	3.00	
	1536	111	0	7.5	NA	NA	2.14	
	1540	115	0	7	NA	NA	7.50	
	1600	135	0	6	NA	NA	3.00	
	1640	175	0	3.5	NA	NA	3.75	
	1731	226	0	0.5	NA	NA	3.53	
	1815	270	0	0	NA	NA	0.68	End Drawdown Test

Ave. Stabilized Flow Infiltration Rate (in/hr)	4.14	K_{sat} initial
Correction Factors:		2014 SMMWW Vol. III Table 3.3.1
Site Var. and No. Locs. Tested Correction Factor (CF_v) =	0.67	Small # tests, uniform soils
Test Method Correction Factor (CF_t) =	0.5	
Degree of Influent Control to Prevent Siltation and Bio Buildup Correction Factor (CF_m) =	0.9	
Total Correction Factor (CF_T) = CF_v x CF_t x CF_m =	0.3015	
Design Infil. Rate (in/hr) = K_{sat} initial x CF_T	**1.25**	

PORT OF PORT TOWNSEND Parametrix

WORKSHEET FOR SMALL-SCALE PILOT INFILTRATION TEST Test Date: June 27, 2016

Test Loc. **Pit 3**

Width (ft)	3.25	Start Pre-Soak	1245
Length (ft)	4	End Pre-Soak	1450
Area (sf)	13	Pre-Soak Elapsed Time	2:05
Pit Depth (in)	16		
Pre-soak Depth (in)	2 to 12		
Test Depth (in)	12		

Date	Time	Elapsed Time (min)	Water Added (gal)	Water Depth (in)	Flow (gpm)	Flow (gph)	Infil. Rate (in/hr)	Notes
06/27/16	14:50	0	0	12	0.0	0.0	-	Start Stabilized Flow Test
	15:05	15	60	12	4.0	240.0	29.62	Continuous flow using water truck
	15:20	30	60	12	4.0	240.0	29.62	
	15:25	35	20	12	4.0	240.0	29.62	
	15:35	45	40	12	4.0	240.0	29.62	
	15:50	60	60	12	4.0	240.0	29.62	End Stabilized Flow Test
	15:54	64	0	8.5	NA	NA	52.50	
	16:02	70	0	6	NA	NA	25.00	
	16:08	76	0	3	NA	NA	30.00	
	16:14	82	0	0	NA	NA	30.00	End Drawdown Test

Ave. Stabilized Flow Infiltration Rate (in/hr)	29.62	K_{sat} initial
Correction Factors:		2014 SMMWW Vol. III Table 3.3.1
Site Var. and No. Locs. Tested Correction Factor (CF_v) =	0.67	Small # tests, uniform soils
Test Method Correction Factor (CF_t) =	0.5	
Degree of Influent Control to Prevent Siltation and Bio Buildup Correction Factor (CF_m) =	0.9	
Total Correction Factor (CF_T) = CF_v x CF_t x CF_m =	0.3015	
Design Infil. Rate (in/hr) = K_{sat} initial x CF_T	**8.93**	

Appendix E

WWHM12 and MES Flood Output

WWHM2012
PROJECT REPORT

Project Name: P of PT Flows
Site Name:
Site Address:
City :
Report Date: 10/6/2016
Gage : Port Angeles
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 0.80
Version Date: 2016/02/25
Version : 4.2.12

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
C, Forest, Flat	19.6
Pervious Total	19.6

Impervious Land Use	acre
Impervious Total	0
Basin Total	19.6

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
Pervious Total	0

Impervious Land Use	acre
PARKING FLAT	19.6
Impervious Total	19.6
Basin Total	19.6

Element Flows To:
Surface Interflow Groundwater

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:19.6
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:0
Total Impervious Area:19.6

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.117625
5 year	0.288667
10 year	0.438213
25 year	0.658753
50 year	0.840341
100 year	1.03266

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	5.462604
5 year	7.401896
10 year	8.734471
25 year	10.474715
50 year	11.812897
100 year	13.187386

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

Year	Predeveloped	Mitigated
1949	0.040	7.255
1950	0.193	4.949
1951	0.140	10.180
1952	0.025	3.457
1953	0.042	8.291
1954	0.399	7.181
1955	0.370	5.728
1956	0.130	5.012
1957	0.227	4.819
1958	0.035	5.729
1959	0.223	7.122
1960	0.334	6.214
1961	0.413	5.052
1962	0.025	4.339
1963	0.083	5.514
1964	0.097	10.043
1965	0.047	3.643
1966	0.043	4.247
1967	0.397	5.401
1968	0.073	5.304
1969	0.025	4.713
1970	0.020	7.070
1971	0.313	11.780
1972	0.456	6.205
1973	0.060	5.155
1974	0.049	2.901
1975	0.080	7.505
1976	0.098	6.479
1977	0.017	4.260
1978	0.012	4.268
1979	0.012	8.906
1980	0.212	4.484
1981	0.168	8.363
1982	0.315	7.636
1983	0.294	6.088
1984	0.055	4.196
1985	0.293	9.754
1986	0.685	5.281
1987	0.256	12.357
1988	0.092	5.018
1989	0.085	5.309
1990	0.164	6.084
1991	0.326	6.085
1992	0.375	5.519
1993	0.021	3.371
1994	0.004	3.010
1995	0.035	2.927
1996	0.179	3.280
1997	0.195	4.327
1998	0.019	4.754
1999	0.718	6.068
2000	0.204	8.080
2001	0.040	3.110
2002	0.268	5.255

2003	0.195	3.813
2004	0.309	5.317
2005	0.121	6.766
2006	0.353	4.850
2007	0.341	11.004
2008	0.059	4.429
2009	0.083	3.639

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

Rank	Predeveloped	Mitigated
1	0.7181	12.3574
2	0.6848	11.7800
3	0.4563	11.0037
4	0.4126	10.1798
5	0.3992	10.0429
6	0.3968	9.7535
7	0.3746	8.9056
8	0.3704	8.3625
9	0.3534	8.2911
10	0.3406	8.0802
11	0.3344	7.6359
12	0.3265	7.5053
13	0.3146	7.2545
14	0.3126	7.1812
15	0.3086	7.1223
16	0.2938	7.0699
17	0.2930	6.7659
18	0.2678	6.4791
19	0.2557	6.2144
20	0.2265	6.2049
21	0.2228	6.0880
22	0.2117	6.0851
23	0.2044	6.0845
24	0.1955	6.0682
25	0.1946	5.7293
26	0.1929	5.7282
27	0.1792	5.5190
28	0.1675	5.5140
29	0.1637	5.4008
30	0.1403	5.3166
31	0.1300	5.3085
32	0.1212	5.3043
33	0.0981	5.2814
34	0.0975	5.2553
35	0.0921	5.1551
36	0.0849	5.0524
37	0.0832	5.0181
38	0.0827	5.0124
39	0.0799	4.9492
40	0.0729	4.8498
41	0.0604	4.8186
42	0.0594	4.7536
43	0.0547	4.7132
44	0.0487	4.4837
45	0.0474	4.4291

46	0.0427	4.3387
47	0.0425	4.3270
48	0.0403	4.2678
49	0.0401	4.2603
50	0.0355	4.2474
51	0.0351	4.1961
52	0.0254	3.8125
53	0.0253	3.6426
54	0.0246	3.6395
55	0.0213	3.4569
56	0.0200	3.3709
57	0.0192	3.2804
58	0.0173	3.1101
59	0.0123	3.0105
60	0.0122	2.9266
61	0.0040	2.9008

Stream Protection Duration
POC #1

Facility FAILED duration standard for 1+ flows.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0588	25217	151347	600	Fail
0.0667	21774	143989	661	Fail
0.0746	18925	137573	726	Fail
0.0825	16613	131691	792	Fail
0.0904	14707	126515	860	Fail
0.0983	13015	121745	935	Fail
0.1062	11503	117510	1021	Fail
0.1141	10247	113468	1107	Fail
0.1220	9210	110216	1196	Fail
0.1299	8158	106773	1308	Fail
0.1378	7195	103500	1438	Fail
0.1456	6367	100463	1577	Fail
0.1535	5659	97554	1723	Fail
0.1614	5020	94817	1888	Fail
0.1693	4517	92229	2041	Fail
0.1772	4075	89726	2201	Fail
0.1851	3683	87395	2372	Fail
0.1930	3317	85170	2567	Fail
0.2009	3024	83309	2754	Fail
0.2088	2753	81192	2949	Fail
0.2167	2505	79224	3162	Fail
0.2246	2312	77321	3344	Fail
0.2325	2126	75502	3551	Fail
0.2404	1967	73834	3753	Fail
0.2483	1776	72102	4059	Fail
0.2562	1604	70476	4393	Fail
0.2641	1456	68893	4731	Fail
0.2720	1361	67546	4962	Fail
0.2799	1245	66134	5311	Fail
0.2877	1137	64787	5698	Fail
0.2956	1027	63503	6183	Fail
0.3035	923	62156	6734	Fail
0.3114	850	60937	7169	Fail

0.3193	762	59739	7839	Fail
0.3272	683	58584	8577	Fail
0.3351	632	57386	9080	Fail
0.3430	582	56381	9687	Fail
0.3509	547	55483	10143	Fail
0.3588	509	54434	10694	Fail
0.3667	475	53451	11252	Fail
0.3746	432	52445	12140	Fail
0.3825	401	51568	12859	Fail
0.3904	372	50670	13620	Fail
0.3983	338	49793	14731	Fail
0.4062	319	48873	15320	Fail
0.4141	303	47996	15840	Fail
0.4219	290	47269	16299	Fail
0.4298	271	46435	17134	Fail
0.4377	253	45622	18032	Fail
0.4456	242	44810	18516	Fail
0.4535	232	44040	18982	Fail
0.4614	223	43248	19393	Fail
0.4693	217	42478	19575	Fail
0.4772	211	41730	19777	Fail
0.4851	205	41024	20011	Fail
0.4930	200	40403	20201	Fail
0.5009	185	39740	21481	Fail
0.5088	170	39077	22986	Fail
0.5167	160	38393	23995	Fail
0.5246	155	37773	24369	Fail
0.5325	147	37174	25288	Fail
0.5404	141	36553	25924	Fail
0.5483	135	35955	26633	Fail
0.5561	130	35377	27213	Fail
0.5640	123	34778	28274	Fail
0.5719	118	34308	29074	Fail
0.5798	113	33773	29887	Fail
0.5877	109	33217	30474	Fail
0.5956	102	32618	31978	Fail
0.6035	97	32126	33119	Fail
0.6114	92	31634	34384	Fail
0.6193	87	31099	35745	Fail
0.6272	80	30672	38340	Fail
0.6351	76	30222	39765	Fail
0.6430	69	29816	43211	Fail
0.6509	62	29324	47296	Fail
0.6588	56	28853	51523	Fail
0.6667	41	28426	69331	Fail
0.6746	23	27998	121730	Fail
0.6825	17	27592	162305	Fail
0.6904	10	27185	271850	Fail
0.6982	7	26779	382557	Fail
0.7061	5	26394	527880	Fail
0.7140	2	26009	1300450	Fail
0.7219	0	25688	n/a	Fail
0.7298	0	25346	n/a	Fail
0.7377	0	24961	n/a	Fail
0.7456	0	24576	n/a	Fail
0.7535	0	24212	n/a	Fail
0.7614	0	23849	n/a	Fail

0.7693	0	23485	n/a	Fail
0.7772	0	23121	n/a	Fail
0.7851	0	22800	n/a	Fail
0.7930	0	22522	n/a	Fail
0.8009	0	22180	n/a	Fail
0.8088	0	21817	n/a	Fail
0.8167	0	21496	n/a	Fail
0.8246	0	21188	n/a	Fail
0.8324	0	20880	n/a	Fail
0.8403	0	20567	n/a	Fail

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 1.8058 **acre-feet**
On-line facility target flow: 2.5767 **cfs.**
Adjusted for 15 min: 2.5767 **cfs.**
Off-line facility target flow: 1.4044 **cfs.**
Adjusted for 15 min: 1.4044 **cfs.**

LID Report

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

Perlnd and Implnd Changes

No changes have been made.

BIORETENTION/INFILTRATION BASIN SIZING OUTPUT SUMMARY USING MGS FLOOD

Massmann Infiltration	29.62	(in/hr, hydraulic conductivity of Pit 3)
Depth to Water Table	3	
Max Pond Elevation	19	
Side Slopes (Z:1)	0	
Live Storage Elevation	17	
Layer Thickness	1.5	
Riser Structure	Circular Overflow Riser	
Crest El.	18.5	
Diameter	24	
Common L	0	
Basin Size (acres)	19.6	
Pond Bottom Length	1020	
Pond Bottom Width	20	
Volume	30600	@Riser Crest Elevation
	42840	@Maximum Pond Elevation
Facility Size	20400	
Percent of Total Area	**2.39%**	
Percent Passing	91.00%	
Discharge Rate (WQ)	2.255	
10-year Flow Rate	3.530	
25-year Flow Rate	4.442	
50-year Flow Rate	4.709	
100-year Flow Rate	5.129	

Massmann Infiltration	29.62	(in/hr, hydraulic conductivity of Pit 3)
Depth to Water Table	5	
Max Pond Elevation	19	
Side Slopes (Z:1)	0	
Live Storage Elevation	17	
Layer Thickness	1.5	
Riser Structure	Circular Overflow Riser	
Crest El.	18.5	
Diameter	24	
Common L	0	
Basin Size (acres)	19.6	
Pond Bottom Length	380	
Pond Bottom Width	50	
Volume	28500	@Riser Crest Elevation
	39900	@Maximum Pond Elevation
Facility Size	19000	
Percent of Total Area	**2.23%**	
Percent Passing	91.43%	
Discharge Rate (WQ)	2.226	
10-year Flow Rate	3.529	
25-year Flow Rate	4.453	
50-year Flow Rate	4.711	
100-year Flow Rate	5.124	

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.40
Program License Number: 200510005
Project Simulation Performed on: 10/10/2016 1:37 PM
Report Generation Date: 10/10/2016 1:38 PM

Input File Name: Port of Port Townsend, Site.fld
Project Name: Port of Port Townsend
Analysis Title:
Comments: Using Port Angeles Station Data
Project Location Coordinates Scaled to 2.22 25-yr, 24-hr

PRECIPITATION INPUT

Computational Time Step (Minutes): 60

Precipitation Station Data Selected
Climatic Region Number: 0

Full Period of Record Available used for Routing
Precipitation Station : 456624 Port Angeles 10/01/1948-10/01/2005
Evaporation Station : 456803 Puyallup
At Site 25-Year, 24-Hour Precipitation (inches): 2.22
Gage 25-Year, 24-Hour Precipitation (inches) : 2.90
Precipitation Scale Factor : 0.800
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

		Predeveloped	Post Developed
Total Subbasin Area (acres)	19.600	19.570	
Area of Links that Include Precip/Evap (acres)	0.000	0.000	
Total (acres)	19.600	19.570	

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

Till Grass	0.980
Impervious	18.620
Subbasin Total	19.600

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
Till Grass	0.950
Impervious	18.620
Subbasin Total	19.570

********** LINK DATA **********

----------SCENARIO: PREDEVELOPED
Number of Links: 0

********** LINK DATA **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: New Structure Lnk1
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	17.00
Riser Crest Elevation (ft)	:	18.50
Max Pond Elevation (ft)	:	19.00
Storage Depth (ft)	:	1.50
Pond Bottom Length (ft)	:	1020.0
Pond Bottom Width (ft)	:	20.0
Pond Side Slopes (ft/ft)	:	L1= 0.00 L2= 0.00 W1= 0.00 W2= 0.00
Bottom Area (sq-ft)	:	20400.
Area at Riser Crest El (sq-ft)	:	20,400.
(acres)	:	0.468
Volume at Riser Crest (cu-ft)	:	30,600.
(ac-ft)	:	0.702
Area at Max Elevation (sq-ft)	:	20400.
(acres)	:	0.468
Vol at Max Elevation (cu-ft)	:	42,840.
(ac-ft)	:	0.983

Massmann Infiltration Option Used

Hydraulic Conductivity (in/hr)	:	29.62
Depth to Water Table (ft)	:	3.00

Bio-Fouling Potential : Low
Maintenance : Average or Better

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 24.00
Common Length (ft) : 0.000
Riser Crest Elevation : 18.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 0

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

********** Link: New Structure Lnk1 ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	18.196
1.11-Year	18.558
1.25-Year	18.625
2.00-Year	18.725
3.33-Year	18.752
5-Year	18.781
10-Year	18.806
25-Year	18.860
50-Year	18.876
100-Year	18.900

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Model Element	Total Predeveloped Recharge During Simulation Recharge Amount (ac-ft)
Subbasin: Subbasin 1	13.414
Total:	13.414

Total Post Developed Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: Subbasin 1		13.004
Link:	New Structure Lnk1	1038.149
Total:		1051.153

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 57)
Predeveloped: 0.235 ac-ft/year, Post Developed: 18.441 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 0

----------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 77932. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 116897. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 55.29

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 1140.79
Inflow Volume Including PPT-Evap (ac-ft): 1140.79
Total Runoff Infiltrated (ac-ft): 1038.15, 91.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 100.28
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 91.00%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	3.677	2-Year	2.255
5-Year	4.742	5-Year	3.115
10-Year	5.552	10-Year	3.530

25-Year	5.926	25-Year	4.442
50-Year	6.317	50-Year	4.709
100-Year	6.739	100-Year	5.129
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than 0%):	-78.8%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than 0%):	-78.1%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-80.1%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	-91.4%	PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	-78.1%	PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.40
Program License Number: 200510005
Project Simulation Performed on: 09/06/2016 9:11 AM
Report Generation Date: 09/06/2016 9:11 AM

Input File Name: Port of Port Townsend, Site.fld
Project Name: Port of Port Townsend
Analysis Title:
Comments: Using Port Angeles Station Data
Project Location Coordinates Scaled to 2.22 25-yr, 24-hr

PRECIPITATION INPUT

Computational Time Step (Minutes): 60

Precipitation Station Data Selected
Climatic Region Number: 0

Full Period of Record Available used for Routing
Precipitation Station : 456624 Port Angeles 10/01/1948-10/01/2005
Evaporation Station : 456803 Puyallup
At Site 25-Year, 24-Hour Precipitation (inches): 2.22
Gage 25-Year, 24-Hour Precipitation (inches) : 2.90
Precipitation Scale Factor : 0.800
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : USGS Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** WATERSHED DEFINITION **********

Predevelopment/Post Development Tributary Area Summary

		Predeveloped	Post Developed
Total Subbasin Area (acres)	19.600	19.570	
Area of Links that Include Precip/Evap (acres)	0.000	0.000	
Total (acres)	19.600	19.570	

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------
-------Area (Acres) --------

Till Grass	0.980
Impervious	18.620
Subbasin Total	19.600

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
Till Grass	0.950
Impervious	18.620
Subbasin Total	19.570

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 0

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: New Structure Lnk1
Link Type: Structure
Downstream Link: None

Prismatic Pond Option Used

Pond Floor Elevation (ft)	:	17.00			
Riser Crest Elevation (ft)	:	18.50			
Max Pond Elevation (ft)	:	19.00			
Storage Depth (ft)	:	1.50			
Pond Bottom Length (ft)	:	380.0			
Pond Bottom Width (ft)	:	50.0			
Pond Side Slopes (ft/ft)	:	L1= 0.00	L2= 0.00	W1= 0.00	W2= 0.00
Bottom Area (sq-ft)	:	19000.			
Area at Riser Crest El (sq-ft)	:	19,000.			
(acres)	:	0.436			
Volume at Riser Crest (cu-ft)	:	28,500.			
(ac-ft)	:	0.654			
Area at Max Elevation (sq-ft)	:	19000.			
(acres)	:	0.436			
Vol at Max Elevation (cu-ft)	:	39,900.			
(ac-ft)	:	0.916			

Massmann Infiltration Option Used

Hydraulic Conductivity (in/hr)	:	29.62
Depth to Water Table (ft)	:	5.00

Bio-Fouling Potential : Low
Maintenance : Average or Better

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 24.00
Common Length (ft) : 0.000
Riser Crest Elevation : 18.50 ft

Hydraulic Structure Geometry

Number of Devices: 0

************************FLOOD FREQUENCY AND DURATION STATISTICS********************

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 0

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

********** Link: New Structure Lnk1 ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	18.223
1.11-Year	18.555
1.25-Year	18.606
2.00-Year	18.723
3.33-Year	18.750
5-Year	18.779
10-Year	18.806
25-Year	18.861
50-Year	18.876
100-Year	18.899

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	13.414
Total:	13.414

Total Post Developed Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	13.004
Link: New Structure Lnk1	1042.998
Total:	1056.002

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 57)
Predeveloped: 0.235 ac-ft/year, Post Developed: 18.526 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 0

----------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: New Structure Lnk1 **********

Basic Wet Pond Volume (91% Exceedance): 77932. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 116897. cu-ft

Time to Infiltrate 91% Treatment Volume, (Hours): 49.81

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 1140.79
Inflow Volume Including PPT-Evap (ac-ft): 1140.79
Total Runoff Infiltrated (ac-ft): 1043.00, 91.43%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 94.59
Secondary Outflow To Downstream System (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered)/Total Volume: 91.43%

*************Compliance Point Results ***************

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: New Structure Lnk1

***** Point of Compliance Flow Frequency Data *****
Recurrence Interval Computed Using Gringorten Plotting Position

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	3.677	2-Year	2.226
5-Year	4.742	5-Year	3.092
10-Year	5.552	10-Year	3.529

25-Year	5.926	25-Year	4.453
50-Year	6.317	50-Year	4.711
100-Year	6.739	100-Year	5.124
200-Year	**	200-Year	**

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

****** Flow Duration Performance ******

Excursion at Predeveloped 50%Q2 (Must be Less Than 0%):	-79.2%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than 0%):	-78.9%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-78.6%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

****** LID Duration Performance ******

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	-91.8%	PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	-78.7%	PASS

MEETS ALL LID DURATION DESIGN CRITERIA: PASS

Appendix F

Engineer's Opinion of Probable Cost Spreadsheets

PRELIMINARY COST ESTIMATE
BIORETENTION/INFILTRATION BASIN
OPTION 1

PORT OF PORT TOWNSEND

DATE October 13, 2016

PREP. D. DINKUHN
QC B. BALL

			CONSTRUCTION COSTS	ENGINEER'S ESTIMATE	
#	QUANT.	UNIT	DESCRIPTION	UNIT PRICE	TOTAL PRICE
1	1	L.S.	MOBILIZATION (10%)	$98,533	$98,533
2	1	L.S.	PROTECTION AND SUPPORT OF EXISTING UTILITIES	$4,000	$4,000
3	2300	S.Y.	CLEARING AND GRUBBING INCL POPLARS	$5	$11,500
4	1	L.S.	REMOVAL OF STRUCTURE AND OBSTRUCTION	$10,000	$10,000
5	350	C.Y.	ROADWAY EXCAVATION INCL. HAUL	$25	$8,750
6	14273	SF	ULTRA BLOCK WALL	$28	$399,644
7	1330	SY	PVC LINER	$15	$19,950
8	900	L.F.	HDPE STORM SEWER PIPE 6 IN. DIAM.	$40	$36,000
9	1130	L.F.	HDPE STORM SEWER PIPE 4 IN. DIAM.	$35	$39,550
10	1	EACH	LIFT STATION	$200,000	$200,000
11	4	EACH	48 IN OVERFLOW STRUCTURES AND PIPING	$3,500	$14,000
12	2	EACH	NSBB	$17,500	$35,000
13	1	EACH	TIDEFLEX DUCK BILL CHECK VALVE	$20,000	$20,000
14	2600	TON	SAND FILTER SAND	$25	$65,000
15	1150	C.Y.	BIORETENTION SOIL MIX	$50	$57,500
16	2222	S.Y.	BIORETENTION PLANTINGS	$20	$44,440
17	1	L.S.	LANDSCAPING	$6,500	$6,500
18	1	L.S.	EROSION/WATER POLLUTION CONTROL	$2,500	$2,500
19	1	L.S.	TEMPORARY IRRIGATION	$10,000	$10,000
20	1	L.S.	SPCC PLAN	$1,000	$1,000
			SUBTOTAL		**$1,083,900**
			SALES TAX (9%)		**$97,551**
			CONSTRUCTION SUBTOTAL		**$1,181,451**
			CONSTRUCTION CONTINGENCY	**25.00%**	**$295,400**
			TOTAL CONSTRUCTION COSTS		**$1,476,851**
			ENGINEERING DESIGN AND PERMITTING (15%)	**15.00%**	**$221,528**
			CONSTRUCTION MANAGEMENT (10%)	**10.00%**	**$147,685**
			TOTAL PROJECT COSTS		**$1,846,064**

PRELIMINARY COST ESTIMATE
BIORETENTION/INFILTRATION BASIN
OPTION 2

PORT OF PORT TOWNSEND

DATE October 13, 2016

PREP. D. DINKUHN
QC B. BALL

			CONSTRUCTION COSTS	ENGINEER'S ESTIMATE	
#	QUANT.	UNIT	DESCRIPTION	UNIT PRICE	TOTAL PRICE
1	1	L.S.	MOBILIZATION (10%)	$77,399	$77,399
2	1	L.S.	PROTECTION AND SUPPORT OF EXISTING UTILITIES	$4,000	$4,000
3	2000	S.Y.	CLEARING AND GRUBBING	$2	$4,000
4	1	L.S.	REMOVAL OF STRUCTURE AND OBSTRUCTION	$5,000	$5,000
5	1500	C.Y.	ROADWAY EXCAVATION INCL. HAUL	$25	$37,500
6	6850	SF	ULTRA BLOCK WALL	$28	$191,800
7	608	SY	PVC LINER	$15	$9,120
8	830	L.F.	HDPE STORM SEWER PIPE 6 IN. DIAM.	$40	$33,200
9	1055	L.F.	HDPE STORM SEWER PIPE 4 IN. DIAM.	$35	$36,925
10	1	EACH	LIFT STATION	$200,000	$200,000
11	3	EACH	48 IN OVERFLOW STRUCTURES AND PIPING	$3,500	$10,500
12	2	EACH	NSBB	$17,500	$35,000
13	1	EACH	TIDEFLEX DUCK BILL CHECK VALVE	$20,000	$20,000
14	2600	TON	SAND FILTER SAND	$25	$65,000
15	1150	C.Y.	BIORETENTION SOIL MIX	$50	$57,500
16	2222	S.Y.	BIORETENTION PLANTINGS	$20	$44,440
17	1	L.S.	LANDSCAPING	$6,500	$6,500
18	1	L.S.	EROSION/WATER POLLUTION CONTROL	$2,500	$2,500
19	1	L.S.	TEMPORARY IRRIGATION	$10,000	$10,000
20	1	L.S.	SPCC PLAN	$1,000	$1,000
			SUBTOTAL		**$851,400**
			SALES TAX (9%)		**$76,626**
			CONSTRUCTION SUBTOTAL		**$928,026**
			CONTINGENCY	**25.00%**	**$232,000**
			TOTAL CONSTRUCTION COSTS		**$1,160,026**
			ENGINEERING DESIGN AND PERMITTING	**15.00%**	**$174,004**
			CONSTRUCTION MANAGEMENT	**10.00%**	**$116,003**
			TOTAL PROJECT COSTS		**$1,450,033**

PRELIMINARY COST ESTIMATE
BIORETENTION/INFILTRATION BASIN
OPTION 3

PORT OF PORT TOWNSEND

DATE October 13, 2016

PREP. D. DINKUHN
QC B. BALL

			CONSTRUCTION COSTS	ENGINEER'S ESTIMATE	
#	QUANT.	UNIT	DESCRIPTION	UNIT PRICE	TOTAL PRICE
1	1	L.S.	MOBILIZATION (10%)	$63,474	$63,474
2	1	L.S.	PROTECTION AND SUPPORT OF EXISTING UTILITIES	$4,000	$4,000
3	2300	S.Y.	CLEARING AND GRUBBING	$2	$4,600
4	1	L.S.	REMOVAL OF STRUCTURE AND OBSTRUCTION	$5,000	$5,000
5	1490	C.Y.	ROADWAY EXCAVATION INCL. HAUL	$25	$37,250
6	4350	SF	ULTRA BLOCK WALL	$28	$121,800
7	350	SY	PVC LINER	$15	$5,250
8	660	L.F.	HDPE STORM SEWER PIPE 6 IN. DIAM.	$40	$26,400
9	0	L.F.	HDPE STORM SEWER PIPE 4 IN. DIAM.	$35	$0
10	1	EACH	LIFT STATION	$200,000	$200,000
11	1	EACH	48 IN OVERFLOW STRUCTURES AND ASSOCIATED PIPING	$3,500	$3,500
12	1	EACH	NSBB	$20,000	$20,000
13	1	EACH	TIDEFLEX DUCK BILL CHECK VALVE	$20,000	$20,000
14	2600	TON	SAND FILTER SAND	$25	$65,000
15	1150	C.Y.	BIORETENTION SOIL MIX	$50	$57,500
16	2222	S.Y.	BIORETENTION PLANTINGS	$20	$44,440
17	1	L.S.	LANDSCAPING	$6,500	$6,500
18	1	L.S.	EROSION/WATER POLLUTION CONTROL	$2,500	$2,500
19	1	L.S.	TEMPORARY IRRIGATION	$10,000	$10,000
20	1	L.S.	SPCC PLAN	$1,000	$1,000
			SUBTOTAL		**$698,200**
			SALES TAX (9%)		**$62,838**
			CONSTRUCTION SUBTOTAL		**$761,038**
			CONTINGENCY	**25.00%**	**$190,300**
			TOTAL CONSTRUCTION COSTS		**$951,338**
			ENGINEERING DESIGN AND PERMITTING	**18.00%**	**$171,241**
			CONSTRUCTION MANAGEMENT	**10.00%**	**$95,134**
			TOTAL PROJECT COSTS		**$1,217,713**