MEMORANDUM

Project No. 190293B-2.4

February 21, 2024

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Re: **Addendum to Source Control Review Memorandum**
South Park Marina, Seattle, Washington

1 Update Objectives and Summary of Findings

In September 2022, in accordance with Agreed Order No. DE 16185 for the South Park Marina site (Site), Aspect Consulting (Aspect) completed a Source Control Review Memorandum (SCR Memorandum; Aspect, 2022a). This memorandum was completed in part to provide the Washington State Department of Ecology (Ecology) with information necessary to make a determination regarding "source control sufficiency," as defined in the Lower Duwamish Waterway (LDW) Source Control Strategy (Ecology, 2016), for the Site.

The LDW Source Control Strategy identifies source control sufficiency as achieving the near-term goal to "…address existing, ongoing sources of contaminants to the LDW so that in-waterway sediment cleanup can begin without the risk of sediment recontamination above remedial action levels (RALs), as defined in EPA's Record of Decision (ROD; EPA, 2014)." The SCR Memorandum concluded that the Site does not present a risk of recontaminating LDW surface sediments[1] above LDW ROD RALs in the near-term time frame, and therefore an interim action is not required at the Site to achieve source control sufficiency as defined in the LDW Source Control Strategy.

Based on information presented in the SCR Memorandum, Ecology's Lower Duwamish Waterway Source Control Sufficiency Evaluation Report for the LDW Upper Reach (Source Control Sufficiency Evaluation Report; Ecology, 2023a) concluded the following for the Site:

> *"Ecology's source control sufficiency evaluation found that contamination at this Site presents a low risk of recontaminating sediments with the COCs[2] identified in corresponding sediments above the RAL. Sources of LDW COCs present at this Site are sufficiently controlled."*

In addition to concluding the Site does not pose a near-term recontamination risk, the SCR Memorandum presented data limitations encountered while conducting the source control review, a plan to collect supplemental data during Phase 2 of the Site Remedial Investigation (RI), and a commitment to incorporate the supplemental data in an update to the SCR Memorandum focused on potential discharges of polychlorinated biphenyls (PCBs) from the Site's southern stormwater catchment area (which includes the Site's Southwest Property Area and the Former A&B Barrel Pond area [Pond Area], described below). Ecology's Source Control Sufficiency Evaluation Report (Ecology, 2023a) reiterated the latter commitment:

> *"Ecology expects that the PLPs will reevaluate all pathways under phase II of the RI. This evaluation will focus on potential PCB discharges from the southern catchment area. Once the RI Phase II data are obtained and analyzed, the PLPs will coordinate with Ecology about whether the update should be provided as an addendum to the Source Control Memo (Aspect, 2022) or as a component of the Site RI. Ecology has not determined whether additional interim actions will be needed to control sources of contamination to the sediments."*

Based on review of the RI Phase 2 data relative to source control goals, Ecology and South Park Marina's Potentially Liable Party (PLP) Group[3] agreed to document the source control review update in this Addendum to the SCR Memorandum. This Addendum presents the supplemental data collected since issuance of the SCR Memorandum and evaluates the new data with respect to each of the three pathways by which Site contaminants may recontaminate marina basin sediment within the LDW Upper Reach.

[1] Surface sediments represent the upper 10 centimeters (0-10 cm) of sediment.
[2] Contaminants of concern for LDW sediments as identified in the LDW ROD (EPA, 2014).
[3] The PLP Group is comprised of South Park Marina Limited Partnership, the Port of Seattle (Port), and the City of Seattle (City).

1.1 Summary of Findings

Supplemental data was collected for LDW surface sediments immediately offshore of the Site's southern stormwater catchment area in 2022 to support remedial design for the LDW Upper Reach. Additional groundwater, stormwater, catch basin (CB) solids, and surface soil samples were collected during Phases 2 and 3 of the Site RI. Collectively, this additional data strengthens the SCR Memorandum's conclusion that the Site does not present a risk of recontaminating LDW surface sediments in the near-term time frame. Therefore, it is our opinion that an interim action is not required to achieve source control sufficiency prior to beginning active remediation of sediments in the LDW Upper Reach.

The rest of this Addendum presents and evaluates, in the context of source control, the supplemental LDW sediment data and upland data collected during Site RI Phases 2 and 3 and formulates conclusions regarding near-term source control at the Site based on this new data. In addition, Appendix A to this Addendum presents updates to South Park Marina's stormwater management, under the National Pollution Discharge Elimination System (NPDES) Boatyard General Permit, which have occurred since issuance of the SCR Memorandum in September 2022.

2 Supplemental Upland and In-Water Sediment Data Collected

This section describes the supplemental upland and in-water sediment data that were considered in this source control review update for the Site. As described in the SCR Memorandum (Aspect, 2022a), the area of LDW sediments immediately offshore of the upland SPM Property is referred to as the "marina basin." The data previously presented and evaluated in the SCR Memorandum are not repeated in this update.

2.1 Review of Prior and Supplemental Marina Basin Sediment Data

After preparation of the SCR Memorandum, additional sediment data were collected by the Lower Duwamish Waterway Group (LDWG) to further characterize a portion of the marina basin where PCB concentrations in samples previously exceeded the RAL. This section summarizes the previous exceedances and describes the supplemental sediment data collected by LDWG.

As described in the SCR Memorandum, a total PCB concentration (22 milligrams per kilogram [mg/kg]-OC[4]) exceeding the 12 mg/kg-OC RAL was detected in one sample of intertidal surface sediment collected in the southwest corner of the marina basin as part of LDWG's 2021 Phase II Pre-Design Investigation (PDI) for the Upper Reach[5] (sample LDW21-SS559 on Figure 1). Near that sample location, two 2011 surface sediment samples, LDW-SS2214-A and LDW-SS2214-D[6], contained total PCB concentrations lower than the LDW ROD RAL, which is normalized for sediment total organic carbon (TOC), but exceeding the marine-benthic lowest apparent effects threshold (LAET) presented in Ecology's LDW Preliminary Cleanup Level (PCUL) Workbook (Ecology, 2023b). Those three samples were located adjacent to the Site stormwater Unnamed Outfall No. 1 and 80 to 90 feet north (downstream) of the City of Seattle's 17th Avenue South

[4] Milligram per kilogram (mg/kg) normalized for sediment organic carbon (OC) content.
[5] Windward Environmental and Anchor QEA (2022a).
[6] The samples SS2214-A and SS2214-D contained TOC of 2.70 and 3.56 percent, respectively. The latter exceeds Ecology's recommended 3.5 percent TOC upper limit for OC normalization of organic contaminant concentrations.

storm drain outfall (Figure 1). In addition, a 2011 surface sediment sample, LDW-SS2214-U[7], collected approximately 60 feet southeast of LDW21-SS559, contained concentrations of total PCBs and 4-methylphenol exceeding respective RALs. The SCR Memorandum concluded that the sediment represented by sample LDW-SS2214-U had been removed by dredging during the subsequent Terminal 117 (T-117) Phase 1 cleanup action (2013-2015)[8], and that sample's data were therefore excluded from the Site source control analysis (Aspect, 2022a).

LDWG's 30 percent Basis of Design Report for the Upper Reach (Anchor QEA and Windward, 2022) defined RAL Exceedance Area 13 (Area 13; red dashed line on Figure 1) as the area encompassing those four sample locations plus the adjacent area of sediment that was remediated to the extent practical using vacuum extraction (vactor) during the T-117 Phase 1 cleanup action. That report states:

> *"The RAL exceedance boundary in Area 13 was developed using data that are likely not representative of current conditions, based on a more detailed review of the as-built data from the adjacent EAA at T-117. The T-117 as-built survey indicates that sediments in the location of the existing data were dredged. Additional data will be collected during Phase III PDI to characterize the current condition in this location and to adjust the Area 13 RAL exceedance boundary as appropriate."*

In early December 2022, as part of the LDW Upper Reach Phase III PDI, surface sediment samples (0 to 10 cm) were collected from two subtidal locations (LDW22-SS771 and LDW22-SS772) and two intertidal locations (LDW22-SS773 and LDW22-SS774; Figure 1) within Area 13 for analysis of PCB Aroclors and 4-methylphenol. Subsurface (0 to 60 cm) sediment samples were also collected at the two subtidal locations for analysis of PCB Aroclors, in accordance with the Quality Assurance Project Plan (QAPP) Addendum for the Phase III PDI (Windward Environmental and Anchor QEA, 2022b). Only the surface sediment data are evaluated for the Site source control review process, in accordance with the LDW Source Control Strategy.

2.2 Supplemental Site RI Data

The SCR Memorandum (Aspect, 2022a) identified the following data gaps to be filled by additional sampling conducted for Phase 2 of the Site RI:

- Limited shoreline groundwater data for some analytes because of limited groundwater volume in the Fill Unit[9] along the shoreline at low tide stages.
- The only sample data for Alluvial Unit groundwater were from 2007-2008, and they had elevated analytical reporting limits for polycyclic aromatic hydrocarbons (PAHs) and PCBs.
- Limited dioxin/furan data for all media.

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[7] Sample contained 2.69 percent TOC.
[8] Figure 1 depicts the extents of sediment removal, by both dredging and vactor methods, in this area during the T-117 Phase 1 cleanup action.
[9] The SCR Memorandum provides a brief overview of Site hydrogeologic conditions, including the Fill Unit and Alluvial Unit hydrostratigraphic units.

In accordance with the Site's AO, the RI is intended to provide sufficient information to (1) select a cleanup action for the Site in accordance with the Model Toxics Control Act (MTCA), and (2) complete the source control review for the Site in accordance with the LDW Source Control Strategy. The RI Work Plan Addendum (Aspect, 2022b) documented the data gathered in Phase 1 of the RI, described the current Conceptual Site Model, identified remaining data gaps with respect to the AO requirements, and described data collection activities intended to fill those data gaps during Phase 2 of the RI.

Consistent with the data evaluated in the SCR Memorandum, RI Phase 2 data collection relevant to this Site source control update included sampling of surface soils across the Site, installation of new wells, groundwater sampling from new and existing monitoring wells positioned along the Site shoreline, and sampling of stormwater and CB solids from the Site stormwater drain system. The specific RI Phase 2 data collection activities were as follows:

- Sampling of surface soils from 21 drilled borings (MW-04D, -05D, -06D, -09D, -11D, -13D, -16, -17, -18D, -19D, -20, and -22, and SB-35 through SB-43), and four shallow hand-augered borings (HA-03, -04, -05, and -07).
- Installation of four new shoreline monitoring wells completed in the Alluvial Unit (MW-06D, -08D, -09D, and -11D), addressing a specific data gap identified in the SCR Memorandum.
- One round of dry-season groundwater sampling (October 2022) from the four new Alluvial Unit shoreline monitoring wells (MW-06D, -08D, -09D, and -11D) and the six existing Fill Unit shoreline monitoring wells (MW-06, -07, -08, -09, -10, and -11), addressing a specific data gap identified in the SCR Memorandum.
- One round of stormwater sampling from catch basins CB-02 and CB-06 and the StormwateRx™ pretreatment vault (SWRX-Pre), and one round of CB solids sampling at CB-02, CB-05, and SWRX-Pre. One sample of effluent from the Site's StormwateRx™ treatment system (SWRX-Post) was also collected.
- Dioxins/furans analyses were conducted for selected samples of groundwater and surface soil to address a specific data gap identified in the SCR Memorandum.

Of these RI Phase 2 explorations, Fill Unit wells MW-16 and MW-17, Alluvial Unit wells MW-04D, -05D, -06D, -16D, -and -18D, and soil borings SB-35, -36, -37, -38, -39, -42 and -43 were completed within the Site's southern stormwater catchment area – the focus area for this Addendum as defined by Ecology (Ecology, 2023a). A subset of these explorations (wells MW-04D, -05D, -06D, -16, and -16D and soil borings SB-42 and -43) were completed in the Pond Area. The boundaries of the southern stormwater catchment area and Pond Area are shown on Figure 2.

Following receipt and review of the Phase 2 data, a third phase of RI data collection (Phase 3) was designed and completed in accordance with the Proposed Phase 3 Groundwater Sampling Memorandum (Aspect, 2023). Phase 3 data collection relevant to this Site source control update included sampling the six shoreline Fill Unit wells (MW-06, -07, -08, -09, -10, and -11) and one shoreline Alluvial Unit well (MW-09D). Figure 2 shows locations of all Site explorations with data used in the Site source control review (historical plus RI Phase 1) and highlights the RI Phase 2 and 3 sample locations with data evaluated for this Addendum.

Not all data collected during RI Phases 2 and 3 are relevant to this source control review and therefore some of the supplemental RI data are not discussed in this Addendum. This includes additional RI data collected to characterize contaminant nature and extent in subsurface soils; in groundwater inland from the shoreline; and in soil gas and indoor air to assess vapor intrusion potential. Data collected to characterize chemicals that are not LDW COCs are also not discussed in this Addendum. All Site data will be presented and evaluated in the Site RI Report.

2.2.1 Additional Analyses during RI Phase 2 Investigations

During Aspect's Phase 2 soil sampling effort, South Park Marina's consultant, TIG Environmental (TIG), collected additional soil samples from selected borings. TIG submitted samples of surface soil from seven locations (MW-04D, -11D, and -18D and SB-37, -39, -40, and -42) for analysis of PCB congeners, and from 15 locations (MW-04D, -06D, -11D, -13D, -18D, -19D, -20, and -22, SB-36, -37, -39, -40, and -42, and HA-05 and -07) for analysis of dioxins/furans, to support South Park Marina's efforts for source identification. The samples were submitted for analysis to Enthalpy Analytical Laboratory (formerly known as Vista Analytical) in El Dorado Hills, California, for these two analyses. The laboratory results were submitted to Environmental Data Services for data quality validation. The validated data from TIG's supplemental soil samples will be incorporated into the Site RI dataset and are incorporated into this Addendum. TIG transmitted the data report for their samples (TIG, 2023) to Ecology in July 2023.

3 Evaluation of Supplemental Data with Respect to Site Source Control

The supplemental data described above were evaluated to determine whether there is new evidence that changes the SCR Memorandum's (Aspect, 2022a) conclusion that the Site does not pose a near-term recontamination risk to marina basin sediments. Consistent with the SCR Memorandum's approach, Step 1 evaluates the LDW sediment data collected during PDI Phase III as a primary line of evidence regarding whether discharges from the Site are contaminating marina basin sediments to concentrations greater than the LDW ROD RALs. Then, as a secondary line of evidence, Step 2 evaluates the upland data collected during RI Phases 2 and 3 with respect to sediment recontamination due to discharge of upland Site contaminants to sediments via the following three transport pathways defined in the AO:

1. "Soil leaching to groundwater discharging to the LDW through sediment.
2. Contaminated soils entering the storm drain system and discharging to the LDW.
3. Erosion of contaminated soil and transport to the LDW via overland flow or bank sloughing."

These pathway names were simplified in some portions of the SCR Memorandum as 1) groundwater discharge 2) stormwater drain discharge, and 3) discharge of eroded soil via overland flow or bank sloughing.

The supplemental data collected for marina basin sediment and for Site groundwater, stormwater, CB solids, and soil were evaluated relative to the same source-control screening levels applied in the SCR Memorandum and are described in Sections 4 through 7. The data for their respective media is presented in Tables 1, 2, 3, 4, and 5.

4 LDW Phase III Surface Sediment Data

This section describes the supplemental sediment data collected by the LDWG in the marina basin, the applicable screening levels, and the comparison of the data against those screening levels for Step 1 of this source control update.

4.1 Sediment Quality Dataset

The sediment data evaluated for this update includes four surface sediment samples collected in Sediment Management Area 13 during LDWG's PDI Phase III sediment sampling in December 2022, as described in Section 2.1. Table 1 presents the PDI Phase III sediment data evaluated in this Addendum.

4.2 Source-Control Screening Levels for Sediment

The source-control screening levels are LDW ROD RALs for surface (0-10 cm) sediment, site-wide. For sediment samples with TOC content in the range of 0.5 to 3.5 percent, the OC-normalized PCB concentrations are screened against the LDW ROD's OC-normalized RAL; for sediment samples with TOC content outside that range, dry-weight PCB concentrations are screened against the LAET as presented in Ecology's LDW PCUL Workbook (Ecology, 2023b).

4.3 Sediment Concentrations Relative to Screening Levels

The total PCB and 4-methylphenol concentrations in the 2022 surface sediment samples are below LDW ROD RALs (Table 1). Based on the supplemental data, LDWG's 90 percent Basis of Design Report (Anchor QEA and Windward Environmental, 2023b) decreased the lateral extent of Area 13 to encompass only samples LDW-SS559 and LDW-SS214-D. LDWG's revised boundary for Area 13 is depicted as a solid red line on Figure 1 and the other data figures in this Addendum. The selected remedy for Area 13 is enhanced natural recovery (Anchor QEA and Windward Environmental, 2023b).

4.4 Primary Line of Evidence Regarding Site Source Control

The 2022 supplemental sediment data did not exceed screening levels (LDW RALs and LAET) and thus provides additional evidence that discharges of PCBs and 4-methylphenol from the Site are not driving concentrations above screening levels in marina basin surface sediments.

5 Upland Pathway 1: Groundwater Discharge

In the AO, Pathway 1 is identified as "soil leaching to groundwater discharging to the LDW through sediment." Consistent with the approach applied in the SCR Memorandum (Aspect, 2022a), the empirical groundwater data collected at the Site are the most reliable means to characterize Pathway 1 because (1) marina operations have remained generally consistent for many years, and (2) operations at the A&B Barrel Co., a primary historical source of Site contamination adjacent to Area 13, concluded more than 60 years ago. Therefore, sufficient time has passed for migration of contaminants of concern (COCs) from Site soil into groundwater to justify using groundwater data to empirically evaluate the soil-to-groundwater pathway in accordance with MTCA (WAC 173-340-747(9)(b)).

The assessment of Pathway 1 also relies upon groundwater data collected from monitoring wells along the Site shoreline because of the near-term time frame of the source control review and because data from shoreline wells are a conservative representation of groundwater concentrations that could reach and potentially recontaminate the sediment bioactive zone (upper 10 cm).

Data collected from the newly installed wells in the Fill and Alluvial Units during the RI Phase 2 tidal study corroborated the SCR Memorandum's interpretation that the sheet pile wall installed along the Site's southeast corner (Figure 3) redirects the majority of the Fill Unit and Alluvial Unit groundwater flow in the Pond Area northward to the north edge of the sheet pile wall, where it then discharges eastward to the LDW. Although some groundwater in the Fill and Alluvial Units is expected to flow through seams between the individual steel sheets comprising the wall and through weep holes drilled through the wall, most of the groundwater flows around the north edge of the sheet pile wall. Therefore, groundwater quality data from shoreline wells MW-06 and MW-06D in the Fill Unit and Alluvial Unit respectively, located near the wall's north edge (Figure 2), are considered the best measure of the predominant groundwater discharge pathways from the Pond Area to marina basin sediments. Based on the Alluvial Unit's greater saturated thickness and higher average permeability relative to the Fill Unit, it is likely that the Alluvial Unit supplies the majority of the groundwater discharging from the Site to the LDW. Additional detail regarding groundwater flow conditions will be included in the Site RI Report.

The following sections describe the groundwater data collected since issuance of the SCR Memorandum (Section 5.1), the groundwater screening levels applied for the source control review (Section 5.2), the evaluation of new groundwater data relative to source-control screening levels (Section 5.3), and the conclusion regarding Pathway 1 (groundwater discharge to sediments) as a potential recontamination source based on the supplemental data (Section 5.4).

5.1 Groundwater Dataset for Shoreline Wells

Following the installation of additional monitoring wells in RI Phase 2, groundwater samples were collected from monitoring wells throughout the Site. For the purposes of the Pathway 1 evaluation, only data from shoreline monitoring wells are discussed in this Addendum, consistent with the approach applied for the SCR Memorandum.

5.1.1 RI Phase 2 Collection

In accordance with the RI Work Plan Addendum (Aspect, 2022b), RI Phase 2 included the installation of five new Fill Unit monitoring wells and twelve new Alluvial Unit monitoring wells. None of the new Fill Unit wells were located at the shoreline. Four of the new Alluvial Unit wells were installed at the following locations along the shoreline, from south to north (Figure 2):

- MW-06D adjacent to existing Fill Unit well MW-06 at the north end of the sheet pile wall and downgradient of the Pond Area that borders Area 13.
- MW-08D between existing Fill Unit well MW-08 and boring SB-27, the area of greatest soil impacts along the shoreline.
- MW-09D adjacent to Fill Unit well MW-09 and near the north-south midpoint of the Site shoreline.
- MW-11D adjacent to Fill Unit well MW-11 near the northern boundary of the Site.

During RI Phase 2, groundwater samples from six Fill Unit wells (MW-06, -07, -08, -09, -10, and -11) and four Alluvial Unit wells (MW-06D, -08D, -09D, and -11D) located along the shoreline were collected in October 2022, representative of the dry season. The groundwater samples from these monitoring wells were analyzed for the following LDW COCs:

- PCB Aroclors
- Total and dissolved metals
- Low-level PAHs
- Selected semivolatile organic compounds (SVOCs) other than PAHs
- Dioxin/furans (analyzed in MW-06 sample only[10])

5.1.2 RI Phase 3 Data Collection

RI Phase 3 groundwater sampling was conducted in March 2023 due to a desire to further refine understanding of Site groundwater quality, as described in the Proposed Phase 3 Groundwater Sampling Memorandum (Aspect, 2023). The seven Phase 3 groundwater sample locations pertinent to the source control review included Fill Unit shoreline wells MW-06, MW-07, MW-08, MW-09, MW-10[11], and MW-11, and Alluvial Unit shoreline well MW-09D. Groundwater samples were analyzed for the following LDW COCs:

- Dioxin/furan from three Fill Unit wells (MW-06, MW-08, and MW-11)
- Total and dissolved metals from Fill Unit wells MW-06 through MW-11and Alluvial Unit well MW-09D
- Total and dissolved metals analyses with reductive precipitation preconcentration (EPA Method 1640) to reduce potential salinity interferences that potentially create analytical high bias in detected trace metal concentrations[12] (wells MW-06, MW-07, MW-08, MW-09, MW-09D, and MW-11)
- PCB Aroclors from MW-06, MW-07, MW-08, and MW-11

Table 2 presents the RI Phases 2 and 3 groundwater data evaluated in this Addendum.

5.2 Source-Control Screening Levels for Groundwater

The source-control screening levels for groundwater are groundwater screening levels based on sediment protection (GW-3) from Ecology's LDW PCUL Workbook (Ecology, 2023b).

5.3 Groundwater Concentrations Relative to Screening Levels

The following sections compare the groundwater data collected during RI Phases 2 and 3 (October 2022 and March 2023, respectively) relative to source-control screening levels. As explained above, the assessment of Pathway 1 relies upon groundwater data collected from the shoreline monitoring

[10] The Phase 2 dioxin/furan data were subsequently rejected due to analytical data quality concerns.
[11] MW-10 was sampled both at low tide and high tide to assess the effect of tidal stage on metals results.
[12] Additional information regarding the preconcentration method is available in these documents: https://www.epa.gov/sites/default/files/2015-10/documents/method_1640_1997.pdf; and https://nemc.us/docs/2016/presentations/pdf/Tue-Metals%20and%20Metal%20Speciation%20Analyses%20in%20Environmental%20Samples-14.1-Ugrai.pdf

wells, which includes the four new Alluvial Unit shoreline wells that were not available during preparation of the SCR Memorandum.

5.3.1 Fill Unit Groundwater

During the Phase 2 and 3 groundwater sampling events, the only constituents exceeding source control screening levels in Fill Unit shoreline wells were copper and chromium (MW-06, MW-10, and/or MW-11; Table 2). Copper and chromium exceedances were inconsistent for total and dissolved metals analyses across the two sampling events, as outlined below. The highest detected concentrations have been used to evaluate source control sufficiency as a conservative measure; additional analysis of the groundwater metals data will be provided in the RI. No PCBs were detected in Phase 2 or Phase 3 groundwater samples from shoreline wells in the Fill Unit (MW-06 through MW-11) (Table 2).

Chromium Exceedances by Well

- Well MW-06. A marginal exceedance of total chromium (exceedance factor[13] of 1.04) was detected in the Phase 2 (dry season) sample, but its dissolved chromium concentration was lower than the screening level. No total or dissolved chromium exceedances were detected in the Phase 3 (wet season) sample. In addition, the chromium concentrations detected in the Phase 1 (March 2021) sample from this well were lower than the screening level (Aspect, 2022a).
- Well MW-10. The Phase 2 sample contained a total chromium exceedance (exceedance factor of 2.7), but the dissolved chromium concentration was lower than the screening level. The Phase 3 sample collected during falling tide had a high total chromium concentration of 5,760 micrograms per liter (µg/L) (exceedance factor of 180). However, that sample also had the highest turbidity measured for any groundwater sample collected during RI Phases 2 and 3 (67 nephelometric turbidity units [NTU]) and the sample's dissolved chromium concentration was only 15.7 µg/L (0.87 µg/L in the filtered sample aliquot run with reductive precipitation preconcentration), which is less than the screening level. The sample collected from MW-10 the next day during high tide had no exceedances for total or dissolved chromium. The Phase 1 groundwater sample from this well was not analyzed for metals due to low sample volume (Aspect, 2022a).
- Well MW-11. Chromium concentrations detected in the Phase 1 and Phase 2 samples were below the screening level. The Phase 3 sample contained a total chromium concentration that exceeded the screening level (exceedance factor of 2.8). The Phase 3 sample was also analyzed using reductive precipitation pretreatment, and that result also exceeded the screening level (exceedance factor of 3.0); however, the dissolved chromium concentration without the pretreatment was less than the screening level. The Phase 3 sample had moderately elevated turbidity (22 NTU; Table 2).

Copper Exceedances by Well

- Well MW-06. Total and dissolved copper concentrations exceeded the screening level in the Phase 2 sample. The exceedance factors for both were low (less than 1.3), and total and

[13] Ratio of detected concentration to screening level.

dissolved copper did not exceed the screening level in the Phase 3 sample. In addition, no copper exceedances were detected in the Phase 1 sample from this well (Aspect, 2022a).

- Well MW-10. The dissolved copper concentration in the Phase 2 sample exceeded the screening level (exceedance factor of 2.5); the total copper concentration in the sample was less than the screening level. The total copper concentration in the Phase 3 sample collected during falling tide exceeded the screening level (exceedance factor of 1.3), but the dissolved copper concentration did not exceed the screening level. The sample collected the next day during high tide did not exceed the screening level for either total or dissolved copper.

5.3.2 Alluvial Unit Groundwater

No exceedances of screening levels were detected in Phase 2 and 3 groundwater samples collected from the four Alluvial Unit shoreline wells (MW-06D, MW-08D, MW-09D, and MW-11D; Table 2).

5.4 Conclusion Regarding Pathway 1, Groundwater Discharge to LDW Sediments

The Phase 2 and 3 groundwater data strengthen the SCR Memorandum's conclusion that discharge of Site groundwater (Pathway 1) does not pose a threat for near-term recontamination of LDW sediments above ROD RALs within the marina basin. There is a high level of confidence in this conclusion for the following reasons:

1. Chromium and copper are the only chemicals to exceed source-control screening levels in shoreline groundwater (Fill Unit and Alluvial Unit); however, these COCs did not exceed sediment screening levels (ROD RALs) and are not projected to exceed the RALs in the near-term.

2. Groundwater COC concentrations in upland shoreline wells do not account for natural attenuation processes occurring along the groundwater flow path from these wells to the sediment bioactive zone where the screening levels apply.

3. Ecology's GW-3 screening levels applied for source control are calculated using the most stringent LDW ROD Cleanup Levels as the sediment concentrations to protect, rather than the less-stringent LDW ROD RALs used for evaluating sediment recontamination in this source control review. This provides a measure of conservatism to the groundwater screening level comparison.

6 Upland Pathway 2: Stormwater Drain System Discharge

In the AO, Pathway 2 is "contaminated soils entering the storm drain system and discharging to the LDW." The SCR Memorandum (Aspect, 2022a) describes the South Park Marina stormwater infrastructure (conveyance, treatment, outfalls) and its NPDES Boatyard General Permit WAG030045, and therefore that information is not repeated here. South Park Marina's monitoring of and improvements to the stormwater system completed since the SCR Memorandum, in accordance with the NPDES permit requirements, are summarized in Appendix A.

The following sections describe the stormwater and CB solids data collected since issuance of the SCR Memorandum (Section 6.1); the screening levels for those media applied for the source control review (Section 6.2); the evaluation of the supplemental data relative to screening levels (Section 6.3); and the conclusion regarding recontamination Pathway 2 (discharge of solids from the storm drain system to sediments) based on the supplemental data (Section 6.4).

6.1 Phase 2 Stormwater and Catch Basin Solids Datasets

The RI Work Plan Addendum (Aspect, 2022b) identified data gaps related to collection of untreated stormwater and/or CB solids samples from catch basins CB-02 and CB-06 in the central catchment area, and the StormwateRx™ pretreatment vault (SWRX-Pre) in the southern catchment area. Additionally, a sample of treated effluent (whole-water) from the Site StormwateRx™ treatment system (SWRX-Post) was to be collected. Phase 2 catch basin solids and stormwater samples were collected in October 2022 and November 2022, respectively. Table 3 presents the RI Phase 2 stormwater data evaluated in this Addendum.

During the Phase 2 sampling event, an insufficient quantity of solids was present in CB-02 to allow collection of a sample. After consultation with Ecology, a CB solids sample was instead collected from CB-05, which is located downstream from CB-02 in the central catchment stormwater conveyance system. Therefore, the CB solids dataset for this source control update includes samples collected from the CB-05, CB-06, and SWRX-Pre locations (Figure 5), each of which was analyzed for the full suite of LDW COCs excluding dioxins/furans. Table 4 presents the RI Phase 2 catch basin solids data evaluated in this Addendum.

6.2 Source-Control Screening Levels for Stormwater and Catch Basin Solids

The source-control screening levels for the stormwater (whole-water) data are groundwater PCULs based on sediment protection (GW-3). The LDW ROD includes RALs based on dry-weight concentrations for some COCs, and RALs based on OC-normalized concentrations for other COCs. The source-control screening levels for CB solids are as follows:

- LDW ROD RALs for those COCs with dry-weight LDW ROD RALs
- LAET for PCBs
- Dry-weight values equal to two times Sediment Cleanup Objective ("2xSCO") for those remaining COCs with OC-normalized LDW ROD RALs, as obtained from Ecology (2023b).

6.3 Stormwater and Catch Basin Solids Concentrations Relative to Screening Levels

6.3.1 Stormwater (Whole-Water)

Consistent with the stormwater (whole-water) dataset evaluated in the SCR Memorandum (Aspect, 2022a), which included historical samples plus RI Phase 1 samples, one or more of the Phase 2 samples of untreated stormwater from the CB-02, CB-06, SWRX-Pre locations had detected concentrations of total copper, indeno(1,2,3cd)pyrene, and bis(2-ethylhexyl)phthalate (BEHP) exceeding the screening levels (Table 3). All but one of the maximum detected concentrations of these compounds were less in the Phase 2 samples than those in the prior dataset, as follows:

- Total copper: 127 µg/L in Phase 2 samples vs 970 µg/L in prior dataset
- Indeno(1,2,3-cd)pyrene: 0.039 µg/L in Phase 2 samples vs 0.019 µg/L in prior dataset

- BEHP: 11 µg/L in Phase 2 samples vs 59 µg/L in prior dataset

Two compounds, pentachlorophenol and total cPAH (TEQ)[14], exceeded screening levels in one or more Phase 2 stormwater samples but not in the prior dataset, as follows:

- The one pentachlorophenol exceedance was detected in the CB-06 sample, but the detected concentration (0.89 µg/L) only marginally exceeded the 0.88 µg/L screening level.
- The total cPAH (TEQ) exceedances were detected in the CB-06 and SWRX-Pre samples at concentrations up to 0.066 µg/L, relative to the 0.032 µg/L screening level (maximum exceedance factor of 2.1).

Cadmium and zinc exceeded screening levels in the prior dataset but not in the Phase 2 samples for untreated stormwater (Table 3).

Total copper exceeded the screening level in the sample of treated effluent from the StormwateRx™ system with a concentration of 17.7 µg/L (exceedance factor of 1.3). However, that concentration is well below the most-stringent benchmark in the Site's NPDES permit (50 µg/L). No other constituents exceeded screening levels in the StornwaterRx™ effluent sample.

No exceedances for total PCBs were detected in the Phase 2 stormwater samples from the central or southern catchment areas (Figure 4; Table 3).

6.3.2 Catch Basin Solids

Consistent with the CB solids dataset evaluated in the SCR Memorandum, which included historical samples plus RI Phase 1 samples, two or more of the Phase 2 CB solids samples from the CB-05, CB-06, and SWRX-Pre locations had detected concentrations of copper and total PCBs exceeding screening levels (Table 4). The maximum detected concentrations for copper and total PCBs were less in the Phase 2 samples than in the dataset evaluated previously in the SCR Memorandum:

- Copper: 2,300 mg/kg in Phase 2 samples vs 14,000 mg/kg in prior dataset
- Total PCBs: 0.24 mg/kg in Phase 2 samples vs 4.11 mg/kg in prior dataset

The following constituents exceeded screening levels in the CB solids dataset evaluated previously in the SCR Memorandum but not in the Phase 2 CB solids samples: arsenic, cadmium, lead, mercury, zinc, eleven PAHs, and eight SVOCs (Table 4).

6.4 Conclusion Regarding Stormwater Drain System Discharge (Pathway 2)

The sediment recontamination model analysis presented in Section 5 of the SCR Memorandum (Aspect, 2022a) indicated that, despite a wide range of constituents exceeding source-control screening levels in Site stormwater and CB solids samples, none posed a risk of recontamination to the marina basin sediments via discharge from the Site storm drain system (Pathway 2). The Phase 2 stormwater and CB solids dataset has fewer constituents that exceed screening levels and generally lower maximum concentrations for constituents that do exceed relative to the prior dataset evaluated in the model. Notably, the Phase 2 stormwater and CB solids sample concentrations were

[14] TEQ = Total toxic equivalent concentration of benzo(a)pyrene calculated in accordance with MTCA (WAC 173-340-708(8)(e).

less than respective maximum concentrations that were incorporated in the SCRM sediment recontamination model analysis (arsenic, copper, total PCBs, 2-methylnaphthalene, and dimethyl phthalate were the chemicals modeled). For reference, the far-right columns on Tables 3 and 4 present the maximum concentrations for those chemicals from the prior dataset used in the SCRM modeling.

Therefore, it was decided, in agreement with Ecology, that further modeling efforts were not needed to demonstrate the absence of risk for sediment recontamination.

The Phase 2 stormwater and CB solids data strengthen the SCR Memorandum's conclusion that discharge of solids from the Site storm drain system (Pathway 2) does not pose a threat for recontamination of LDW sediments within the marina basin.

7 Upland Pathway 3: Discharge of Eroded Soil via Overland Flow or Bank Sloughing

In the AO, Pathway 3 is "erosion of contaminated soil and transport to the LDW via overland flow or bank sloughing." As discussed in the SCR Memorandum (Aspect, 2022a) and confirmed during the RI Phase 2 field activities, there are no riverbank soils exposed for erosion along the Site shoreline because of the marina's ecology block wall and riprap armoring. Therefore, Pathway 3 encompasses erosion and overland flow of surface soils across the Site.

The following sections describe the upland surface soil data collected since issuance of the SCR Memorandum (Section 7.1), the soil screening levels applied for the source control review (Section 7.2), the evaluation of the supplemental data relative to screening levels (Section 7.3), and the conclusion regarding recontamination Pathway 3 based on the supplemental data and evaluation of site conditions (Section 7.4).

7.1 Phase 2 Surface Soil Dataset

In accordance with the RI Work Plan Addendum (Aspect, 2022b), Phase 2 surface soil samples were collected from 25 locations distributed across Site in September 2023, including a relatively higher density of sampling in the Southwest Property Area, where the 2021 fire occurred[15], and in the Pond Area, adjacent to LDW RAL Exceedance Area 13 (Figure 6). Most of the surface soil samples were analyzed for a broad range of analytes, including the LDW COCs; however, the analyses conducted varied for some samples based on data gaps identified from the Phase 1 investigation that were specific to the Site investigation areas described in the RI Work Plan Addendum. Table 5 presents the RI Phase 2 surface soil data evaluated in this Addendum.

7.2 Source-Control Screening Levels for Surface Soil

The source-control screening levels for surface soil are as follows:

- LDW ROD RALs for those COCs with dry-weight LDW ROD RALs
- LAET for PCBs

[15] The 2021 fire is described in Section 1.1 of the SCR Memorandum (Aspect, 2022a).

- 2xSCO dry-weight values for those remaining COCs with OC-normalized LDW ROD RALs, as obtained from Ecology (2023b).

7.3 Surface Soil Concentrations Relative to Screening Levels

The Phase 2 surface soil samples contained exceedances of source-control screening levels for a range of metals (cadmium, copper, lead, mercury, and zinc), total PCBs, total dioxin/furan (TEQ), eight individual PAHs, two summed PAHs (total high molecular weight PAHs and total cPAHs [TEQ]), BEHP, dimethyl phthalate, and pentachlorophenol (Table 5).

Of the constituents that exceeded screening levels in Phase 2 samples, cadmium, zinc, the eight PAHs, BEHP, and pentachlorophenol had detected concentrations in the prior surface soil samples evaluated in the SCR Memorandum (Aspect, 2022a) lower than screening levels. The frequency and magnitude of exceedance for those constituents were low in the Phase 2 surface samples, as noted below.

- The cadmium and zinc exceedances occurred together at two boring locations: MW-16, a paved location on the upgradient edge of the Pond Area; and SB-38, a paved location in the Southwest Property Area. The maximum exceedance factors for cadmium and zinc in the two samples were low (1.8 and 2.2, respectively).
- The only PAH exceedances were detected at boring MW-17, which is a paved location adjacent to Dallas Avenue (Figure 6). The maximum exceedance factors for the PAHs in the sample ranged from 1.1 to 6.3.
- The only BEHP exceedance was detected at boring SB-39, a paved location in the Southwest Property Area (exceedance factor of 1.9).
- The only pentachlorophenol exceedance was detected at boring MW-16 (exceedance factor of 4.0).

For all but one of the constituents that exceeded screening levels in both the Phase 2 and prior surface soil samples, the maximum detected concentrations were comparable or less in the Phase 2 samples relative to the prior dataset, as follows:

- Copper: 1,200 mg/kg in Phase 2 samples vs 2,470 mg/kg in prior dataset
- Mercury: 11.0 mg/kg in Phase 2 samples vs 11.5 mg/kg in prior dataset
- Total PCBs[16]: 57.4 mg/kg in Phase 2 samples vs 76.5 mg/kg in prior dataset
- Total dioxin/furan (TEQ): 2,940 nanograms per kilogram [ng/kg] in Phase 2 samples vs 2,546 ng/kg in prior dataset
- Dimethyl phthalate: 0.76 mg/kg in Phase 2 samples vs 0.54 mg/kg in prior dataset

Lead was the only constituent with a maximum concentration detected in the Phase 2 samples higher than that detected in the prior dataset (4,640 mg/kg vs 1,490 mg/kg; Table 5).

As depicted on Figure 6, each of the Phase 2 surface soil samples with PCB exceedances were located within the southern stormwater catchment area. Each of the Phase 2 surface soil samples

[16] Higher of Total Aroclors and Total congeners for samples analyzed.

with total dioxin/furan (TEQ) exceedances also had total PCB exceedances. Each of the five samples with total dioxin/furan (TEQ) concentrations exceeding a 46 ng/kg Seattle urban background concentration[17] are located in the Southwest Property and Pond Areas (179 to 2,940 ng/kg [exceedance factors of 7 to 118] at borings SB-37, SB-38, SB-39, SB-42, and MW-04D; Table 5).

7.4 Conclusion Regarding Soil Erosion via Overland Flow/Bank Sloughing Discharge (Pathway 3)

As observed in the surface soil dataset evaluated in the SCR Memorandum (Aspect, 2022a), the Phase 2 samples contain a range of constituents exceeding the source control screening levels with the greatest number of exceeding constituents, and the highest concentrations of them, occurring within the Site's southern stormwater catchment area. COC concentrations in the Phase 2 surface soil samples are generally at or below those previously evaluated in the SCR Memorandum. While Site surface soils exceed the source control screening levels, engineering controls remain in place in the form of an existing ecology block wall and riprap armoring along the Site's entire shoreline to prevent the erosion and transport of surface soils to the LDW. The block wall's effectiveness in preventing overland flow was verified during the Phase 2 field activities, in which no overland flow to the LDW was observed during a heavy rain event. South Park Marina has no plans to remove or otherwise reconfigure the block wall in the near-term.

The Phase 2 surface soil data and block wall observations corroborate the SCR Memorandum's conclusion that, because of the engineering controls, overland flow of upland soils and riverbank sloughing (Pathway 3) do not pose a threat for recontamination of LDW sediments within the marina basin.

8 Conclusions

As agreed to by Ecology and South Park Marina's PLP Group, this Addendum presents the supplemental data collected for marina basin sediments and for Site groundwater, stormwater, CB solids, and surface soil since issuance of the September 2022 SCR Memorandum, and evaluates this additional data with respect to each of the three pathways by which Site contaminants may re-contaminate marina basin sediment.

The supplemental data strengthen the SCR Memorandum's conclusion that the Site does not present a risk of recontaminating LDW surface sediments above LDW ROD RALs for the near-term time frame. Therefore, it is our opinion that an interim action is not required to control Site sources of contamination to the marina basin sediments.

[17] 90^{th} percentile concentration based on 120 samples of residential soils collected throughout Seattle (Ecology, 2011).

9 References

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Limitations

Work for this project was performed for Seattle City Light, the Port of Seattle, and South Park Marina Limited Partnership (PLP Client Group), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

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Attachments:

Table 1 – 2022 LDWG Design Phase III Surface Sediment Analytical Data within Marina Basin Screened for Source Control Review

Table 2 – Remedial Investigation Phase 2 and Phase 3 Groundwater Analytical Data Screened for Source Control Review

Table 3 – Remedial Investigation Phase 2 Stormwater Analytical Data Screened for Source Control Review

Table 4 – Remedial Investigation Phase 2 Catch Basin Solids Analytical Data Screened for Source Control Review

Table 5 – Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review

Figure 1 – New Surface Sediment Data Screened for Source Control Review

Figure 2 – Upland Investigation Locations Used for Source Control Review

Figure 3 – Total PCB Analytical Results in Groundwater - Remedial Investigation Phases 2 and 3

Figure 4 – Total PCB Analytical Results in Stormwater - Remedial Investigation Phase 2

Figure 5 – Total PCB Analytical Results in Catch Basin Solids - Remedial Investigation Phase 2

Figure 6 – Total PCB Analytical Results in Surface Soil - Remedial Investigation Phase 2

Appendix A – NPDES Stormwater Management for South Park Marina (Prepared by TIG)

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TABLES

Table 1. 2022 LDWG Design Phase III Surface Sediment Analytical Data within Marina Basin Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

			Investigation:	2022 - LDW Pre-Design Investigation Phase 3			
			Location:	LDW22-SS771	LDW22-SS772	LDW22-SS773	LDW22-SS774
			Date:	12/06/2022	12/06/2022	12/02/2022	12/02/2022
			Depth:	0 - 10 cm	0 - 10 cm	0 - 10 cm	0 - 10 cm
Analyte	**Unit**	**LDW ROD RALs (0-10 cm, Sitewide)**	**LAET**				
Polychlorinated Biphenyls (PCBs), organic carbon-normalized							
Aroclor 1016	mg/kg-OC	--	--	0.15 U	0.14 U	0.17 U	0.08 U
Aroclor 1221	mg/kg-OC	--	--	0.15 U	0.14 U	0.17 U	0.08 U
Aroclor 1232	mg/kg-OC	--	--	0.15 U	0.14 U	0.17 U	0.08 U
Aroclor 1242	mg/kg-OC	--	--	0.15 U	0.14 U	0.17 U	0.08 U
Aroclor 1248	mg/kg-OC	--	--	**0.524**	**0.429**	0.17 U	0.08 U
Aroclor 1254	mg/kg-OC	--	--	**0.745**	**0.613**	**1.74**	0.08 U
Aroclor 1260	mg/kg-OC	--	--	**0.749**	**0.589**	**5.29**	0.08 U
Total PCB Aroclors (ND=0)	mg/kg-OC	12	--	**2.02**	**1.63**	**7.01**	0.08 U
Polychlorinated Biphenyls (PCBs), dry weight							
Aroclor 1016	mg/kg	--	--	0.004 U	0.004 U	0.004 U	0.004 U
Aroclor 1221	mg/kg	--	--	0.004 U	0.004 U	0.004 U	0.004 U
Aroclor 1232	mg/kg	--	--	0.004 U	0.004 U	0.004 U	0.004 U
Aroclor 1242	mg/kg	--	--	0.004 U	0.004 U	0.004 U	0.004 U
Aroclor 1248	mg/kg	--	--	**0.0144**	**0.0121**	0.004 U	0.004 U
Aroclor 1254	mg/kg	--	--	**0.0205**	**0.0173**	**0.0420**	0.004 U
Aroclor 1260	mg/kg	--	--	**0.0206**	**0.0166**	**0.128**	0.004 U
Total PCB Aroclors (ND=0)	mg/kg	--	0.13	**0.055**	**0.046**	**0.170**	0.004 U
Semivolatile Organic Compounds							
4-Methylphenol	mg/kg	1.34	--	**0.0075 J**	0.0200 U	0.0200 U	0.0199 U
Phenol	mg/kg	0.84	--	--	**0.012 J**	--	--
Conventionals							
Total Organic Carbon	%	--	--	**2.75**	**2.82**	**2.42**	**0.05**

Notes

Screening levels: For sediment samples with total organic carbon (TOC) content in the range of 0.5 to 3.5%, the OC-normalized PCB data are screened against the LDW ROD's OC-normalized RALs for surface (0-10 cm) sediment, site-wide. For sediment samples with TOC content outside that range, dry-weight PCB data are screened against the Lowest Apparent Effects Threshold (LAET).

The screening levels presented are applied for source control review only and are not used for compliance purposes.

Bold = detected

Light Gray Shaded = This dry-weight concentration is not evaluated because the sediment sample's TOC content is within the 0.5-3.5% range.

Dark Gray Shaded = This OC-normalized concentration is not evaluated because the sediment sample's TOC content is outside of the 0.5-3.5% range.

Total PCB Aroclors (ND = 0) are the sum of Aroclors available, with non-detects = 0, unless all Aroclors were not detected, in which case the Total PCB Aroclors concentration is shown as non-detect at the maximum reporting limit for any individual Aroclor.

-- = No applicable screening level or analysis not performed.

J = Result value estimated.

U = Analyte not detected at or above the reporting limit shown.

mg/kg = milligrams per kilogram - dry weight

mg/kg-OC = milligrams per kilogram - organic carbon-normalized (dry weight divided by the fraction of total organic carbon)

% = per cent

cm = centimeters

Table 2. Remedial Investigation Phase 2 and Phase 3 Groundwater Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

			Site Investigation Area:	**Shoreline**												
			Hydrogeologic Unit:	**Fill Unit**												
			Location:	MW-06		MW-07		MW-08		MW-09		MW-10			MW-11	
			Date:	10/26/2022	03/23/2023	10/27/2022	03/23/2023	10/31/2022	03/22/2023	10/31/2022	03/22/2023	10/31/2022	03/22/2023	03/24/2023	10/27/2022	03/23/2023
Analyte	**Fraction**	**Unit**	**Screening Level**													
Metals																
Arsenic	D	ug/L	220	**14.2**	**5.8**	**15.6**	**7.37**	**20.6**	**13.2**	**14.7**	**3.42**	**22.4**	**5.85**	**6.11**	**17.6**	**7.03**
Arsenic	DRP	ug/L	220	--	0.5 U	--	0.5 U	--	0.5 U	--	0.5 U	--	0.5 U	0.5 U	--	0.5 U
Arsenic	T	ug/L	220	**14.8**	0.5 U	**14.5**	0.5 U	--	0.5 U	--	**4.16**	--	**7.43**	0.5 U	**16.7**	0.5 U
Cadmium	D	ug/L	1.2	1 U	0.2 UJ	1 U	0.2 UJ	0.2 U	0.2 UJ	0.2 U	0.2 U	1 U	0.2 U	0.2 UJ	1 U	0.2 UJ
Cadmium	DRP	ug/L	1.2	--	**0.173**	--	**0.045**	--	**0.075**	--	0.02 U	--	0.02 U	**0.023**	--	**0.03**
Cadmium	T	ug/L	1.2	1 U	**0.17**	1 U	**0.047**	1 U	**0.09**	1 U	0.02 U	1 U	0.02 U	**0.025**	1 U	**0.036**
Chromium	D	ug/L	32	**16.4**	**1.21**	**9.68**	**1.61**	**5.9**	**1.82**	**3.25**	**1.01**	**28.6**	**15.7**	**1**	**6.33**	**8.89**
Chromium	DRP	ug/L	32	--	**0.57**	--	**0.31**	--	**1.13**	--	**0.39**	--	**0.87**	0.2 U	--	**94.6**
Chromium	T	ug/L	32	**33.5**	**1.6**	**11.4**	**1.69**	**7.07**	**1.9**	**3.76 J**	**1.6**	**91.5**	**5760**	0.2 U	**28.8**	**88**
Copper	D	ug/L	14	**16.3**	**3.44**	**11**	**4.22**	**5.23**	**4.41**	**6.11**	**1.4**	**35.5**	**4.36**	**2.42**	**8.57**	**3.73**
Copper	DRP	ug/L	14	--	**2.95**	--	**2.11**	--	**1.14**	--	**1.26**	--	**0.99**	0.1 U	--	**3.62**
Copper	T	ug/L	14	**17.6**	**3.78**	**11.3**	**4.22**	**13.1**	**7.45**	**11.1**	**2.41**	**12.3**	**18.8**	0.1 U	**8.99**	**5.36**
Lead	D	ug/L	19	1 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	1 U	0.2 U	0.2 U	1 U	0.2 U
Lead	DRP	ug/L	19	--	0.05 U	--	0.05 U	--	0.05 U	--	0.05 U	--	0.05 U	0.05 U	--	**0.33**
Lead	T	ug/L	19	1 U	0.05 U	1 U	**0.052**	1 U	0.05 U	1 U	0.05 U	1 U	**3.98**	0.05 U	1 U	**0.716**
Mercury	D	ug/L	2	**0.0018**	--	**0.00088**	--	**0.0018**	--	**0.00084**	--	**0.001**	--	--	**0.00083**	--
Mercury	T	ug/L	2	**0.00084**	--	0.0008 U	--	**0.002 J**	--	**0.0012 J**	--	**0.0012 J**	--	--	0.0008 U	--
Zinc	D	ug/L	770	**72.3**	**16.3**	**24.8**	**8.1**	**10.6**	**5.12**	**8.65**	**0.795**	**8.77**	**1.89**	**2.89**	**12.6**	**4.13**
Zinc	DRP	ug/L	770	--	**18.1**	--	**5.2**	--	**3.05**	--	**1.01**	--	0.5 U	**0.7**	--	**3.13**
Zinc	T	ug/L	770	**73.6**	**17.6**	**22.7**	**6.32**	**10.5**	**5.76**	**10.4**	**1.16**	**9.13**	**10.7**	**2.12**	**12.1**	**3.71**
Polychlorinated biphenyls (PCBs)																
Total PCB Aroclors (ND=0)	T	ug/L	0.086	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U	0.0035 U	--	0.0035 U	--	--	0.0035 U	0.0035 U
Dioxins/Furans																
Total Dioxin/Furan TEQ (ND = 0)	T	ug/L	4.2E-07	--	**7.0E-08 J**	--	--	--	**1.8E-09**	--	--	--	--	--	--	**3.2E-09 J**
Polycyclic aromatic hydrocarbons (PAHs)																
2-Methylnaphthalene	T	ug/L	14	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	--	0.1 U	--
Acenaphthene	T	ug/L	5.3	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Anthracene	T	ug/L	2.1	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Benzo(g,h,i)perylene	T	ug/L	NA	0.02 U	--	0.02 U	--	0.02 U	--	0.02 U	--	0.02 U	--	--	0.02 U	--
Dibenzofuran	T	ug/L	3.1	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	--	0.1 U	--
Fluoranthene	T	ug/L	1.8	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Fluorene	T	ug/L	3.7	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Naphthalene	T	ug/L	90	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	1 U	0.1 U	--	--	0.1 U	--
Phenanthrene	T	ug/L	NA	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Pyrene	T	ug/L	2.0	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Benzo(a)anthracene	T	ug/L	0.19	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Benzo(a)pyrene	T	ug/L	0.087	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Chrysene	T	ug/L	0.40	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Dibenzo(a,h)anthracene	T	ug/L	0.0068	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Indeno(1,2,3-cd)pyrene	T	ug/L	0.016	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--

Table 2. Remedial Investigation Phase 2 and Phase 3 Groundwater Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

			Site Investigation Area:	Shoreline												
			Hydrogeologic Unit:	Fill Unit												
			Location:	MW-06		MW-07		MW-08		MW-09		MW-10			MW-11	
			Date:	10/26/2022	03/23/2023	10/27/2022	03/23/2023	10/31/2022	03/22/2023	10/31/2022	03/22/2023	10/31/2022	03/22/2023	03/24/2023	10/27/2022	03/23/2023
Analyte	**Fraction**	**Unit**	**Screening Level**													
Total Benzofluoranthenes (ND = 1/2 RDL)	T	ug/L	NA	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Total HPAHs[4] (ND = 1/2 RDL)	T	ug/L	NA	0.02 U	--	0.02 U	--	0.02 U	--	0.02 U	--	0.02 U	--	--	0.02 U	--
Total LPAHs[5] (ND = 1/2 RDL)	T	ug/L	NA	1 U	--	0.1 U	--	1 U	--	1 U	--	0.1 U	--	--	0.1 U	--
Total cPAHs[6] TEQ (ND = 1/2 RDL)	T	ug/L	0.032	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	0.01 U	--	--	0.01 U	--
Other semivolatile organic compounds (SVOCs)																
3- & 4-Methylphenol	T	ug/L	110	2 U	--	2 U	--	2 U	--	2 U	--	2 U	--	--	2 U	--
Benzoic acid	T	ug/L	590	5 U	--	5 U	--	5 U	--	5 U	--	5 U	--	--	5 U	--
Benzyl alcohol	T	ug/L	56	1 U	--	1 U	--	1 U	--	1 U	--	1 U	--	--	1 U	--
Benzyl butyl phthalate	T	ug/L	0.24	1 U	--	1 U	--	1 U	--	1 U	--	1 U	--	--	1 U	--
Bis(2-ethylhexyl) phthalate	T	ug/L	0.62	1.6 U	--	1.6 U	--	1.6 U	--	1.6 U	--	1.6 U	--	--	1.6 U	--
Dimethyl phthalate	T	ug/L	59	1 U	--	1 U	--	1 U	--	1 U	--	1 U	--	--	1 U	--
Hexachlorobenzene	T	ug/L	0.014	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	--	0.1 U	--
N-Nitrosodiphenylamine	T	ug/L	0.55	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	--	--	0.1 U	--
Pentachlorophenol	T	ug/L	0.88	0.5 U	--	0.5 U	--	0.5 U	--	0.5 U	--	0.5 U	--	--	0.5 U	--
Phenol	T	ug/L	100	1 U	--	1 U	--	1 U	--	1 U	--	1 U	--	--	1 U	--
1,2,4-Trichlorobenzene	T	ug/L	0.96	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	1 U	0.1 U	--	--	0.1 U	--
1,2-Dichlorobenzene	T	ug/L	4.5	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	1 U	0.1 U	--	--	0.1 U	--
1,4-Dichlorobenzene	T	ug/L	8.9	0.1 U	--	0.1 U	--	0.1 U	--	0.1 U	1 U	0.1 U	--	--	0.1 U	--
Conventionals																
Total Suspended Solids	T	mg/L	NA	5 U	5 U	5 UJ	5 U	5 U	5 U	5 U	**15**	**46**	**8**	**7.6**	5 UJ	**5.6**
Field Parameters																
Temperature	--	deg C	NA	**9.32**	**8.45**	**17.08**	**7.14**	**11.5**	**7.8**	--	**7.72**	--	**12.15**	**6.63**	**15**	**7.85**
Specific Conductance	--	uS/cm	NA	**6673**	**5354**	**12069**	**4349.6**	**11007**	**9618.8**	--	**2809.5**	**16756**	**3518.3**	**6188.2**	**12909**	**5576.9**
Dissolved Oxygen	--	mg/L	NA	**5.77**	**10.47**	**7.4**	**11.61**	**9.27**	**11.69**	--	**11.58**	**9.22**	**10.54**	**12**	**6.4**	**10.74**
pH	--	pH units	NA	**5.9**	**6.38**	**6.32**	**6.67**	**7.44**	**7.46**	--	**7.08**	**6.85**	**7.05**	**7.2**	**6.34**	**6.77**
Oxidation Reduction Potential	--	mV	NA	**192.4**	**223.3**	**63.8**	**193.9**	**63.9**	**191.7**	--	**204.8**	**111.6**	**224.2**	**219.9**	**144.5**	**223**
Turbidity	--	NTU	NA	**6.91**	**1.43**	**6.39**	**2.67**	**1.91**	**1.45**	**28**	**5.79**	**3.58**	**66.7**	**3.83**	**7.84**	**21.7**

Table 2. Remedial Investigation Phase 2 and Phase 3 Groundwater Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

			Site Investigation Area:	Shoreline				
			Hydrogeologic Unit:	Alluvial Unit				
			Location:	MW-06D	MW-08D	MW-09D		MW-11D
			Date:	10/31/2022	10/25/2022	10/24/2022	03/22/2023	10/25/2022
Analyte	Fraction	Unit	Screening Level					
Metals								
Arsenic	D	ug/L	220	**2.03**	**4.74**	**3.46**	**1.46**	**3.51**
Arsenic	DRP	ug/L	220	--	--	--	0.5 U	--
Arsenic	T	ug/L	220	**2.23**	**3.47**	**3.48**	**1.8**	3.57
Cadmium	D	ug/L	1.2	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Cadmium	DRP	ug/L	1.2	--	--	--	0.02 U	--
Cadmium	T	ug/L	1.2	0.2 U	0.2 U	0.2 U	0.02 U	0.2 U
Chromium	D	ug/L	32	**0.909**	**0.936**	**1.08**	0.5 U	**1.5**
Chromium	DRP	ug/L	32	--	--	--	0.2 U	--
Chromium	T	ug/L	32	**0.873**	**1.58**	**0.826**	0.2 U	**2.05**
Copper	D	ug/L	14	**3.38**	**2.39**	**4.52**	**1.81**	**3.13**
Copper	DRP	ug/L	14	--	--	--	**1.94**	--
Copper	T	ug/L	14	**3.76**	**3.32**	**4.89**	**2.24**	3.32
Lead	D	ug/L	19	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Lead	DRP	ug/L	19	--	--	--	0.05 U	--
Lead	T	ug/L	19	0.2 U	0.2 U	0.2 U	0.05 U	0.2 U
Mercury	D	ug/L	2	**0.0013**	**0.0011**	**0.0019**	--	**0.0012**
Mercury	T	ug/L	2	**0.0016 J**	**0.0015**	**0.0023**	--	**0.0013**
Zinc	D	ug/L	770	**2.11**	**2.16**	**1.43**	0.68 U	**1.53**
Zinc	DRP	ug/L	770	--	--	--	0.5 U	--
Zinc	T	ug/L	770	**2.22**	**1.1**	**1.04**	0.5 U	1.15
Polychlorinated biphenyls (PCBs)								
Total PCB Aroclors (ND=0)	T	ug/L	0.086	0.0035 U	0.0035 U	0.0035 U	--	0.0035 U
Dioxins/Furans								
Total Dioxin/Furan TEQ (ND = 0)	T	ug/L	4.2E-07	--	--	--	--	--
Polycyclic aromatic hydrocarbons (PAHs)								
2-Methylnaphthalene	T	ug/L	14	0.1 U	0.1 U	0.1 U	--	0.1 U
Acenaphthene	T	ug/L	5.3	0.01 U	0.01 U	0.01 U	--	0.01 U
Anthracene	T	ug/L	2.1	0.01 U	0.01 U	0.01 U	--	0.01 U
Benzo(g,h,i)perylene	T	ug/L	NA	0.02 U	0.02 U	0.02 U	--	0.02 U
Dibenzofuran	T	ug/L	3.1	0.1 U	0.1 U	0.1 U	--	0.1 U
Fluoranthene	T	ug/L	1.8	0.01 U	0.01 U	0.01 U	--	0.01 U
Fluorene	T	ug/L	3.7	0.01 U	0.01 U	0.01 U	--	0.01 U
Naphthalene	T	ug/L	90	0.1 U	0.1 U	0.1 U	10 U	0.1 U
Phenanthrene	T	ug/L	NA	0.01 U	0.01 U	0.01 U	--	0.01 U
Pyrene	T	ug/L	2.0	0.01 U	0.01 U	0.01 U	--	0.01 U
Benzo(a)anthracene	T	ug/L	0.19	0.01 U	0.01 U	0.01 U	--	0.01 U
Benzo(a)pyrene	T	ug/L	0.087	0.01 U	0.01 U	0.01 U	--	0.01 U
Chrysene	T	ug/L	0.40	0.01 U	0.01 U	0.01 U	--	0.01 U
Dibenzo(a,h)anthracene	T	ug/L	0.0068	0.01 U	0.01 U	0.01 U	--	0.01 U
Indeno(1,2,3-cd)pyrene	T	ug/L	0.016	0.01 U	0.01 U	0.01 U	--	0.01 U

Table 2. Remedial Investigation Phase 2 and Phase 3 Groundwater Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

			Site Investigation Area:	**Shoreline**				
			Hydrogeologic Unit:	**Alluvial Unit**				
			Location:	MW-06D	MW-08D	MW-09D		MW-11D
			Date:	10/31/2022	10/25/2022	10/24/2022	03/22/2023	10/25/2022
Analyte	**Fraction**	**Unit**	**Screening Level**					
Total Benzofluoranthenes (ND = 1/2 RDL)	T	ug/L	NA	0.01 U	0.01 U	0.01 U	--	0.01 U
Total HPAHs[(4)] (ND = 1/2 RDL)	T	ug/L	NA	0.02 U	0.02 U	0.02 U	--	0.02 U
Total LPAHs[(5)] (ND = 1/2 RDL)	T	ug/L	NA	1 U	1 U	0.1 U	--	1 U
Total cPAHs[(6] TEQ (ND = 1/2 RDL)	T	ug/L	0.032	0.01 U	0.01 U	0.01 U	--	0.01 U
Other semivolatile organic compounds (SVOCs)								
3- & 4-Methylphenol	T	ug/L	110	2 U	2 U	2 U	--	2 U
Benzoic acid	T	ug/L	590	5 U	5 U	5 U	--	5 U
Benzyl alcohol	T	ug/L	56	1 U	1 U	1 U	--	1 U
Benzyl butyl phthalate	T	ug/L	0.24	1 U	1 U	1 U	--	1 U
Bis(2-ethylhexyl) phthalate	T	ug/L	0.62	1.6 U	1.6 U	1.6 U	--	1.6 U
Dimethyl phthalate	T	ug/L	59	1 U	1 U	1 U	--	1 U
Hexachlorobenzene	T	ug/L	0.014	0.1 U	0.1 U	0.1 U	--	0.1 U
N-Nitrosodiphenylamine	T	ug/L	0.55	0.1 U	0.1 U	0.1 U	--	0.1 U
Pentachlorophenol	T	ug/L	0.88	0.5 U	0.5 U	0.5 U	--	0.5 U
Phenol	T	ug/L	100	1 U	1 U	1 U	--	1 U
1,2,4-Trichlorobenzene	T	ug/L	0.96	0.1 U	0.1 U	0.1 U	10 U	0.1 U
1,2-Dichlorobenzene	T	ug/L	4.5	0.1 U	0.1 U	0.1 U	10 U	0.1 U
1,4-Dichlorobenzene	T	ug/L	8.9	0.1 U	0.1 U	0.1 U	10 U	0.1 U
Conventionals								
Total Suspended Solids	T	mg/L	NA	**7.6**	5 U	5 U	5 U	5 U
Field Parameters								
Temperature	--	deg C	NA	**13.7**	**15.25**	**14.8**	**12.6**	--
Specific Conductance	--	uS/cm	NA	**934**	**3144**	**2480**	**901.94**	**2384.1**
Dissolved Oxygen	--	mg/L	NA	**0.97**	**5.46**	**0.75**	**3.88**	**0.1**
pH	--	pH units	NA	**6.42**	**7.45**	**6.46**	**6.34**	**7**
Oxidation Reduction Potential	--	mV	NA	**36.2**	**147.6**	**129.9**	**175.2**	**-35.1**
Turbidity	--	NTU	NA	**23.8**	**0.82**	**0.08**	**1.88**	**15.32**

Table 2. Remedial Investigation Phase 2 and Phase 3 Groundwater Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

Notes

Screening levels are groundwater concentrations protective of sediment (GW-3) sourced from the LDW Preliminary Cleanup Level (PCUL) Workbook (Ecology, 2023b).

The screening levels presented are applied for source control review only and are not used for compliance purposes.

Bold = detected

Gray Shaded = Nondetect result has a reporting limit that exceeds the screening level.

Blue Shaded = Reported concentration exceeds the screening level.

Screening level shading is hierarchical: If only non-detect values exceed the screening level, the screening level is shaded grey; if detected results (and potentially non-detected results) exceed the screening level, the screening level is shaded blue.

Total PCB Aroclors concentrations are the sum of Aroclors with non-detects = 0 (ND=0), unless all Aroclors were not detected, in which case the Total PCB Aroclors concentration is shown as non-detect at the maximum reporting limit for any individual Aroclor.

3- and 4-Methylphenol were reported together during RI Phase 2; the results are screened against the screening level for 4-methylphenol.

NA = No applicable screening level in the LDW PCUL Workbook.

-- = Analysis not performed.

TEQ = total toxicity equivalence.

ND = 0 indicates the summation is calculated using 0 for non-detected components.

ND = 1/2 RDL indicates summation is calculated using 1/2 the analytical reporting limit for non-detected components.

HPAHs (high molecular weight polycyclic aromatic hydrocarbons): fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

LPAHs (low molecular weight polycyclic aromatic hydrocarbons): naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

cPAHs (carcinogenic polycyclic aromatic hydrocarbons): benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

J = Result value estimated

U = Analyte not detected at or above the reporting limit shown

UJ = Analyte was not detected at or above the reported limit, and the value shown is an estimate

D = Dissolved fraction (filtered) sample result

DRP = Dissolved fraction (filtered), prepared using reductive precipitation, sample result

T = Total fraction (unfiltered) sample result

ug/L = micrograms per liter

mg/L = milligrams per liter

deg C = degrees Celsius

uS/cm = microsiemens per centimeter

mV = millivolts

NTU = nephelometric turbidity units

Table 3. Remedial Investigation Phase 2 Stormwater Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

			Stormwater Catchment Area:	Central Area To SPM Outfall		Southern Area to UOF-1 Outfall		For Reference: Maximum Prior Stormwater Sample Concentrations Included in Sediment Recontamination Model Analysis (Aspect, 2022a)
			Location:	CB-02	CB-06	StormwaterRx Pre-Treatment Vault (Untreated Influent)	StormwaterRx System Discharge (Treated Effluent)	
			Date:	11/22/2022	11/22/2022	11/22/2022	11/22/2022	
Analyte	**Fraction**	**Unit**	**Groundwater PCUL Protective of Sediment (GW-3)**					
Metals								
Arsenic	D	ug/L	220	**1.08**	**0.913**	**1.6**	0.5 U	**15.7**
Arsenic	T	ug/L	220	**1.97**	**1.99**	**2.13**	0.5 U	**19**
Cadmium	D	ug/L	1.2	0.2 U	0.2 U	**0.221**	0.2 U	
Cadmium	T	ug/L	1.2	**0.286**	**0.303**	**0.265**	0.2 U	
Chromium	D	ug/L	32	1 U	**3.19 J**	**0.691 J**	1 U	
Chromium	T	ug/L	32	**3.13 J**	**2.7 J**	**1.21 J**	**1.3 J**	
Copper	D	ug/L	14	**38.7**	**13.1**	**80.1**	**10.8**	**320**
Copper	T	ug/L	14	**80.7**	**41.5**	**127**	**17.7**	**970**
Lead	D	ug/L	19	**0.261**	0.2 U	**0.778**	**0.412**	
Lead	T	ug/L	19	**8.34**	**4.3**	**5.38**	**1.8**	
Mercury	D	ug/L	2	0.0008 U	0.0008 U	0.0008 U	0.0008 U	
Mercury	T	ug/L	2	**0.0046**	**0.0046**	**0.0088**	**0.0026**	
Zinc	D	ug/L	770	**314**	**39.1**	**139**	**10.9**	**1800**
Zinc	T	ug/L	770	**324**	**79**	**150**	**11.3**	**1800**
Polychlorinated biphenyls (PCBs)								
Total PCB Aroclors (ND=0)	T	ug/L	0.086	**0.015 J**	**0.0046 J**	**0.017 J**	0.05 U	**0.048**
Polycyclic aromatic hydrocarbons (PAHs)								
2-Methylnaphthalene	T	ug/L	14	0.1 U	0.1 U	0.1 U	0.1 U	**0.822**
Acenaphthene	T	ug/L	5.3	0.01 U	0.01 U	**0.015**	0.01 U	
Anthracene	T	ug/L	2.1	0.01 U	0.01 U	0.01 U	0.01 U	
Benzo(g,h,i)perylene	T	ug/L	NA	0.02 U	**0.041**	**0.038**	0.02 U	
Dibenzofuran	T	ug/L	3.1	0.1 U	0.1 U	0.1 U	0.1 U	
Fluoranthene	T	ug/L	1.8	**0.15**	**0.14**	**0.1**	0.01 U	
Fluorene	T	ug/L	3.7	0.01 U	**0.019**	**0.011**	0.01 U	
Naphthalene	T	ug/L	90	0.1 U	0.1 U	0.1 U	0.1 U	
Phenanthrene	T	ug/L	NA	**0.05**	**0.089**	**0.06**	0.01 U	
Pyrene	T	ug/L	2.0	**0.13**	**0.18**	**0.099**	0.01 U	
Benzo(a)anthracene	T	ug/L	0.19	**0.026**	**0.024**	**0.029**	0.01 U	
Benzo(a)pyrene	T	ug/L	0.087	**0.019**	**0.046**	**0.04**	0.01 U	
Chrysene	T	ug/L	0.40	**0.077**	**0.091**	**0.062**	0.01 U	
Dibenzo(a,h)anthracene	T	ug/L	0.0068	0.01 U	0.01 U	0.01 U	0.01 U	
Indeno(1,2,3-cd)pyrene	T	ug/L	0.016	**0.014**	**0.031**	**0.039**	0.01 U	
Total Benzofluoranthenes (ND = 1/2 RDL)	T	ug/L	NA	**0.081**	**0.128**	**0.0102**	0.01 U	
Total HPAHs(3) (ND = 1/2 RDL)	T	ug/L	NA	**0.512**	**0.686**	**0.514**	0.02 U	
Total LPAHs(4) (ND = 1/2 RDL)	T	ug/L	NA	**0.12**	**0.194**	**0.146**	0.1 U	
Total cPAHs(5) TEQ (ND = 1/2 RDL)	T	ug/L	0.032	**0.03**	**0.066**	**0.058**	0.01 U	
Other semivolatile organic compounds (SVOCs)								
2,4-Dimethylphenol	T	ug/L	2.9	R	R	R	R	
3- & 4-Methylphenol	T	ug/L	110	2 U	2 U	2 U	2 U	
Benzoic acid	T	ug/L	590	5 U	5 U	5 U	5 U	
Benzyl alcohol	T	ug/L	56	1 U	1 U	**1.3**	1 U	
Benzyl butyl phthalate	T	ug/L	0.24	1 U	1 U	1 U	1 U	
Bis(2-ethylhexyl) phthalate	T	ug/L	0.62	**11**	**7.5**	**4**	1.6 U	
Dimethyl phthalate	T	ug/L	59	1 U	1 U	1 U	1 U	**17**
Hexachlorobenzene	T	ug/L	0.014	0.1 U	0.1 U	0.1 U	0.1 U	
N-Nitrosodiphenylamine	T	ug/L	0.55	0.1 U	0.1 U	0.1 U	0.1 U	
Pentachlorophenol	T	ug/L	0.88	0.5 U	**0.89**	**0.82**	0.5 U	
Phenol	T	ug/L	100	1 U	1 U	1 U	1 U	
1,2,4-Trichlorobenzene	T	ug/L	0.96	0.1 U	0.1 U	0.1 U	0.1 U	
1,2-Dichlorobenzene	T	ug/L	4.5	0.1 U	0.1 U	0.1 U	0.1 U	
1,4-Dichlorobenzene	T	ug/L	8.9	0.1 U	0.1 U	0.1 U	0.1 U	
Conventionals								
Total Suspended Solids	T	mg/L	NA	**23**	**20**	5 U	5 U	

Table 3. Remedial Investigation Phase 2 Stormwater Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

Notes

Screening levels are groundwater concentrations protective of sediment (GW-3) sourced from the LDW Preliminary Cleanup Level (PCUL) Workbook (Ecology, 2023b).
The screening levels presented are applied for source control review only and are not used for compliance purposes.
Bold = detected
Gray Shaded = Nondetect result has a reporting limit that exceeds the screening level.
Blue Shaded = Reported concentration exceeds the screening level.
Screening level shading is hierarchical: If only non-detect values exceed the screening level, the screening level is shaded grey; if detected results (and potentially non-detected results) exceed the screening level, the screening level is shaded blue.
Total PCB Aroclors concentrations are the sum of Aroclors with non-detects = 0 (ND=0), unless all Aroclors were not detected, in which case the Total PCB Aroclors concentration is shown as non-detect at the maximum reporting limit for any individual Aroclor.
3- and 4-Methylphenol were reported together during RI Phase 2; the results are screened against the screening level for 4-methylphenol.
NA = No applicable screening level in the LDW PCUL Workbook.
-- = Analysis not performed.
TEQ = total toxicity equivalence.
ND = 0 indicates the summation is calculated using 0 for non-detected components.
ND = 1/2 RDL indicates summation is calculated using 1/2 the analytical reporting limit for non-detected components.
HPAHs (high molecular weight polycyclic aromatic hydrocarbons): fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
LPAHs (low molecular weight polycyclic aromatic hydrocarbons): naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.
cPAHs (carcinogenic polycyclic aromatic hydrocarbons): benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.
J = Result value estimated
U = Analyte not detected at or above the reporting limit shown
R = Analytical result rejected.
D = Dissolved fraction (filtered) sample result
T = Total fraction (unfiltered) sample result
ug/L = micrograms per liter
mg/L = milligrams per liter

Table 4. Remedial Investigation Phase 2 Catch Basin Solids Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

		Stormwater Catchment Area:	Central Area To SPM Outfall		Southern Area to UOF-1 Outfall	For Reference: Maximum Prior CB Solids Sample Concentrations Included in Sediment Recontamination Model Analysis (Aspect, 2022a)
		Location:	CB-05	CB-06	StormwaterRx Pre-Treatment Vault (Untreated Influent)	
		Date:	10/07/2022	10/07/2022	10/07/2022	
Analyte	Unit	Screening Levels				
Metals						
Arsenic	mg/kg	57	**49.4**	**5.36**	**13.4**	**69**
Cadmium	mg/kg	10.2	**2.11**	**0.942**	**1.42**	
Chromium	mg/kg	520	**83.5**	**16.9**	**94.6**	
Copper	mg/kg	780	**1310**	**750**	**2300**	**14000**
Lead	mg/kg	900	**273**	**141**	**111**	
Mercury	mg/kg	0.82	**0.18**	**0.11**	**0.17**	
Zinc	mg/kg	820	**642**	**224**	**452**	**7330**
Polychlorinated biphenyls (PCBs)						
Total PCB Aroclors (ND=0)	mg/kg	0.13	**0.24**	**0.17**	**0.24**	**4.11**
Polycyclic aromatic hydrocarbons (PAHs)						
2-Methylnaphthalene	mg/kg	1.34	0.05 U	0.04 U	0.04 U	**4.7**
Acenaphthene	mg/kg	1.0	0.05 U	0.04 U	0.04 U	
Anthracene	mg/kg	1.92	0.05 U	0.04 U	0.04 U	
Benzo(g,h,i)perylene	mg/kg	1.34	**0.073**	**0.14**	**0.14**	
Dibenzofuran	mg/kg	1.08	0.25 U	0.2 U	0.2 U	
Fluoranthene	mg/kg	3.4	**0.18**	**0.55**	**0.58**	
Fluorene	mg/kg	1.08	0.05 U	0.04 U	0.04 U	
Naphthalene	mg/kg	4.2	0.05 U	0.04 U	0.04 U	
Phenanthrene	mg/kg	3.0	**0.1**	**0.16**	**0.17**	
Pyrene	mg/kg	5.2	**0.16**	**0.46**	**0.49**	
Benzo(a)anthracene	mg/kg	2.6	0.05 U	**0.16**	**0.16**	
Benzo(a)pyrene	mg/kg	3.2	**0.05**	**0.23**	**0.24**	
Chrysene	mg/kg	2.8	**0.18**	**0.35**	**0.36**	
Dibenzo(a,h)anthracene	mg/kg	0.46	0.05 U	0.04 U	0.04 U	
Indeno(1,2,3-cd)pyrene	mg/kg	1.2	0.05 U	**0.16**	**0.16**	
Total Benzofluoranthenes (ND = 1/2 RDL	mg/kg	6.4	--	--	--	
Total HPAHs(3) (ND = 1/2 RDL)	mg/kg	24	**0.718**	**2.07**	**2.15**	
Total LPAHs(4) (ND = 1/2 RDL)	mg/kg	10.4	**0.2**	**0.24**	**0.25**	
Total cPAHs(5) TEQ (ND = 1/2 RDL)	mg/kg	5.5	**0.06**	**0.27**	**0.28**	
Other semivolatile organic compounds (SVOCs)						
2,4-Dimethylphenol	mg/kg	0.058	2.5 U	2 U	2 U	
3- & 4-Methylphenol	mg/kg	1.3	5 U	4 U	4 U	
Benzoic acid	mg/kg	1.3	12 U	10 U	10 U	
Benzyl alcohol	mg/kg	0.114	2.5 U	2 U	2 U	
Benzyl butyl phthalate	mg/kg	0.126	2.5 U	2 U	2 U	
Bis(2-ethylhexyl) phthalate	mg/kg	2.6	4 U	3.2 U	3.2 U	
Dimethyl phthalate	mg/kg	0.142	2.5 U	2 U	2 U	**70**
Hexachlorobenzene	mg/kg	0.014	0.25 U	0.2 U	0.2 U	
N-Nitrosodiphenylamine	mg/kg	0.056	0.25 U	0.2 U	0.2 U	
Pentachlorophenol	mg/kg	0.72	1.2 U	1 U	1 U	
Phenol	mg/kg	0.84	2.5 U	2 U	2 U	
1,2,4-Trichlorobenzene	mg/kg	0.062	0.25 U	0.2 U	0.2 U	
1,2-Dichlorobenzene	mg/kg	0.07	0.25 U	0.2 U	0.2 U	
1,4-Dichlorobenzene	mg/kg	0.22	0.25 U	0.2 U	0.2 U	

Table 4. Remedial Investigation Phase 2 Catch Basin Solids Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

Notes:

Screening levels are LDW ROD RALs for those COCs with dry-weight LDW ROD RALs, LAET for PCBs, and 2xSCO values for the other COCs with OC-normalized LDW ROD RALs, all sourced from Ecology (2023b).
The screening levels presented are applied for source control review only and are not used for compliance purposes.

Bold = detected.

Blue Shaded = Reported concentration exceeds the screening level.

Gray Shaded = Nondetect result has a reporting limit that exceeds a screening level.

Screening level shading is hierarchical: If only non-detect values exceed the screening level, the screening level is shaded grey; if detected results (and potentially non-detected results) exceed the screening level, the screening level is shaded blue.

Total PCB Aroclors concentrations are the sum of Aroclors with non-detects = 0 (ND=0), unless all Aroclors were not detected, in which case the Total PCB Aroclors concentration is shown as non-detect at the maximum reporting limit for any individual Aroclor.

3- and 4-Methylphenol were reported together during RI Phase 2; the results are screened against the screening level for 4-methylphenol.

-- = Analysis not performed.

ND = 1/2 RDL indicates summation is calculated using 1/2 the analytical reporting limit for non-detected components.

HPAHs (high molecular weight polycyclic aromatic hydrocarbons): fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

LPAHs (low molecular weight polycyclic aromatic hydrocarbons): naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

cPAHs (carcinogenic polycyclic aromatic hydrocarbons): benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

TEQ = total toxicity equivalence.

U = Analyte not detected at or above the reporting limit shown

mg/kg = milligrams per kilogram - dry weight

Table 5. Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

		Site Investigation Area:	Shoreline				Former A&B Barrel Pond Area				Former Service Station Area		
		Surface Cover:	Unpaved				Unpaved			Paved	Paved		
		Location:	MW-06D	MW-09D	MW-11D	SB-41	MW-04D	MW-05D	SB-42	MW-16	MW-13D	MW-20	MW-22
		Date:	09/21/2022	09/14/2022	09/15/2022	09/13/2022	09/22/2022	09/21/2022	09/22/2022	09/23/2022	09/23/2022	09/14/2022	09/14/2022
		Depth (ft bgs):	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0.5 - 1.5 ft	0 - 2 ft
Analyte	**Unit**	**Screening Levels**											
Metals													
Arsenic	mg/kg	57	**11.3**	--	**3.36**	**4.28**	**3.61**	**1.33**	**7.92**	**4.82**	--	**3.42**	--
Cadmium	mg/kg	10.2	**1.21**	--	0.2 U	**0.484**	**1.25**	**1.01**	**1.23**	**10.6**	--	0.2 U	--
Chromium	mg/kg	520	**22.5**	--	**7.37**	**23.1**	**28.4**	**33.9**	**36.4**	**162**	--	**7.5**	--
Copper	mg/kg	780	**221**	--	**16.2**	**74.3**	**29.9**	**25.4**	**1200**	**95.6**	--	**12**	--
Lead	mg/kg	900	**150**	--	**315**	**65.5**	**187 J**	**223**	**276**	**1260**	--	**11.3**	--
Mercury	mg/kg	0.82	**0.15 J**	--	0.025 U	**0.049**	**3.9**	**0.73 J**	**9.5**	**11**	--	**0.031**	--
Zinc	mg/kg	820	**191**	--	**31.6**	**77.4**	**90.6 J**	**104**	**242**	**936**	--	**30.2**	--
Polychlorinated biphenyls (PCBs)													
Total PCB Aroclors (ND=0)	mg/kg	0.13	**1.5**	--	**0.041**	**0.145**	**4.4**	**22**	**50**	**36**	--	0.004 U	--
Total PCB Congeners (ND=0)	mg/kg	0.13	--	--	**0.12**	--	**6.05 J**	--	**57.4**	--	--	--	--
Dioxins/Furans													
Total Dioxin/Furan TEQ (ND = 0)	ng/kg	25	**19.4 J**	--	**1.18 J**	**15.3 J**	**2940 J**	--	**888 J**	--	**12.7 J**	**0.333 J**	**0.082 J**
Polycyclic aromatic hydrocarbons (PAHs)													
2-Methylnaphthalene	mg/kg	1.34	0.005 U	--	0.005 U	0.01 U	0.02 U	0.1 U	0.01 U	**0.1**	--	0.0025 U	--
Acenaphthene	mg/kg	1	0.005 U	--	0.005 U	0.01 U	0.02 U	0.1 U	0.01 U	0.05 U	--	**0.0028**	--
Anthracene	mg/kg	1.92	0.005 U	--	0.005 U	0.01 U	0.02 U	0.1 U	0.01 U	0.05 U	--	**0.014**	--
Benzo(g,h,i)perylene	mg/kg	1.34	**0.012 J**	--	**0.011**	**0.033 J**	**0.052 J**	0.1 J	**0.14**	**0.06**	--	**0.097**	--
Dibenzofuran	mg/kg	1.08	0.025 U	--	0.025 U	0.05 U	0.1 U	0.5 U	0.05 U	0.25 U	--	--	--
Fluoranthene	mg/kg	3.4	**0.036**	--	**0.041**	**0.032**	**0.023**	0.1 U	**0.059**	**0.054**	--	**0.18**	--
Fluorene	mg/kg	1.08	0.005 U	--	0.005 U	0.01 U	0.02 U	0.1 U	0.01 U	0.05 U	--	0.0025 U	--
Naphthalene	mg/kg	4.2	**0.0085**	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	**0.13 J**	--	0.0025 U	--
Phenanthrene	mg/kg	3	**0.018**	--	**0.028**	**0.014**	0.02 U	0.1 U	**0.04**	**0.1**	--	**0.069**	--
Pyrene	mg/kg	5.2	**0.038**	--	**0.066**	**0.055**	**0.03**	0.1 U	**0.067**	**0.12**	--	**0.27**	--
Benzo(a)anthracene	mg/kg	2.6	**0.018**	--	**0.023**	**0.018**	0.02 U	0.1 U	**0.03**	0.05 U	--	**0.11**	--
Benzo(a)pyrene	mg/kg	3.2	**0.024 J**	--	**0.025**	**0.035 J**	**0.017 J**	0.1 J	**0.076**	**0.04 J**	--	**0.22**	--
Chrysene	mg/kg	2.8	**0.03**	--	**0.038**	**0.032**	0.02 U	0.1 U	**0.066**	**0.088**	--	**0.14**	--
Dibenzo(a,h)anthracene	mg/kg	0.46	0.005 J	--	0.005 U	0.01 J	0.02 J	0.1 J	**0.03**	0.05 U	--	**0.017**	--
Indeno(1,2,3-cd)pyrene	mg/kg	1.2	**0.015 J**	--	**0.01**	**0.031 J**	**0.029 J**	0.1 J	**0.18**	**0.05**	--	**0.092**	--
Total Benzofluoranthenes (ND = 1/2 RDL)	mg/kg	6.4	**0.065 J**	--	**0.043**	**0.077 J**	**0.038 J**	0.1 J	**0.14**	**0.10**	--	**0.37**	--
Total HPAHs[4] (ND = 1/2 RDL)	mg/kg	24	**0.241 J**	--	**0.26**	**0.318 J**	**0.219 J**	0.1 U	**0.789**	**0.568 J**	--	**1.49**	--
Total LPAHs[5] (ND = 1/2 RDL)	mg/kg	10.4	**0.0365**	--	**0.0405**	**0.0365**	0.02 U	0.1 U	**0.065**	**0.203**	--	**0.0908**	--
Total cPAHs[6] TEQ (ND = 1/2 RDL)	mg/kg	5.5	**0.034 J**	--	**0.033**	**0.048 J**	**0.026 J**	0.1 UJ	**0.115**	**0.06 J**	--	**0.28**	--

Table 5. Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review
Project No. 190293, South Park Marina, Seattle, Washington

		Site Investigation Area:	Shoreline				Former A&B Barrel Pond Area				Former Service Station Area		
		Surface Cover:	Unpaved				Unpaved			Paved	Paved		
		Location:	MW-06D	MW-09D	MW-11D	SB-41	MW-04D	MW-05D	SB-42	MW-16	MW-13D	MW-20	MW-22
		Date:	09/21/2022	09/14/2022	09/15/2022	09/13/2022	09/22/2022	09/21/2022	09/22/2022	09/23/2022	09/23/2022	09/14/2022	09/14/2022
		Depth (ft bgs):	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0.5 - 1.5 ft	0 - 2 ft
Analyte	**Unit**	**Screening Levels**											
Other Semivolatile Organic Compounds (SVOCs)													
2,4-Dimethylphenol	mg/kg	0.058	0.25 U	--	0.25 U	0.5 U	1 U	5 U	0.5 U	2.5 U	--	--	--
3- & 4-Methylphenol	mg/kg	1.3	0.5 U	--	0.5 U	1 U	2 U	10 U	1 U	5 U	--	--	--
Benzoic acid	mg/kg	1.3	1.2 U	--	1.2 U	2.5 U	5 U	25 U	2.5 U	12 U	--	--	--
Benzyl alcohol	mg/kg	0.114	0.25 U	--	0.25 U	0.5 U	1 U	5 U	0.5 U	2.5 U	--	--	--
Benzyl butyl phthalate	mg/kg	0.126	0.25 U	--	0.25 U	0.5 U	1 U	5 U	0.5 U	2.5 U	--	--	--
Bis(2-ethylhexyl) phthalate	mg/kg	2.6	0.4 U	--	0.4 U	0.8 U	1.6 U	8 U	0.8 U	4 U	--	--	--
Dimethyl phthalate	mg/kg	0.142	0.25 U	--	0.25 U	0.5 U	1 U	5 U	**0.76**	2.5 U	--	--	--
Hexachlorobenzene	mg/kg	0.014	0.025 U	--	0.025 U	0.05 U	0.1 U	0.5 U	0.05 U	0.25 U	--	--	--
N-Nitrosodiphenylamine	mg/kg	0.056	0.025 U	--	0.025 UJ	0.05 U	0.1 U	0.5 U	0.05 U	0.25 U	--	--	--
Pentachlorophenol	mg/kg	0.72	0.12 U	--	0.12 U	0.25 U	0.5 U	2.5 U	**0.39**	**2.9**	--	--	--
Phenol	mg/kg	0.84	0.25 U	--	0.25 U	0.5 U	1 U	5 U	0.5 U	2.5 UJ	--	--	--
1,2,4-Trichlorobenzene	mg/kg	0.062	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 UJ	--	0.01 U	--
1,2-Dichlorobenzene	mg/kg	0.07	0.025 U	0.05 U	0.025 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 UJ	--	0.05 U	--
1,4-Dichlorobenzene	mg/kg	0.22	0.025 U	0.05 U	0.025 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 UJ	--	0.05 U	--

Table 5. Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

		Site Investigation Area:	Boat Maintenance Area						Historical Boat Manf. Area
		Surface Cover:	Unpaved				Paved		Paved
		Location:	HA-03	HA-04	HA-07	MW-19D	HA-05	MW-17	SB-40
		Date:	09/20/2022	09/20/2022	09/20/2022	09/14/2022	09/20/2022	09/14/2022	09/26/2022
		Depth (ft bgs):	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft
Analyte	**Unit**	**Screening Levels**							
Metals									
Arsenic	mg/kg	57	**6.61**	**2.17**	--	**3.21**	--	**12.7**	**11.8**
Cadmium	mg/kg	10.2	**0.634**	**0.207**	--	**0.335**	--	**1.25**	**0.798**
Chromium	mg/kg	520	**9.31**	**7.87**	--	**6.53**	--	**22.8**	**13.1**
Copper	mg/kg	780	**182**	**22**	--	**12.7**	--	**102**	**41.5**
Lead	mg/kg	900	**73.3**	**27.5**	--	**20.9**	--	**384**	**208**
Mercury	mg/kg	0.82	**0.1**	**0.068**	--	**0.038**	--	**0.16**	**0.11**
Zinc	mg/kg	820	**76**	**42.6**	--	**66.6**	--	**287**	**93.2**
Polychlorinated biphenyls (PCBs)									
Total PCB Aroclors (ND=0)	mg/kg	0.13	--	--	--	0.004 U	--	**4.8**	**1.3**
Total PCB Congeners (ND=0)	mg/kg	0.13	--	--	--	--	--	--	**1.57 J**
Dioxins/Furans									
Total Dioxin/Furan TEQ (ND = 0)	ng/kg	25	--	--	**1.36**	**1.47 J**	**4.82**	**1.11**	**30 J**
Polycyclic aromatic hydrocarbons (PAHs)									
2-Methylnaphthalene	mg/kg	1.34	--	--	--	**0.0063**	--	0.05 U	0.01 U
Acenaphthene	mg/kg	1	--	--	--	**0.0032**	--	**0.057**	0.01 U
Anthracene	mg/kg	1.92	--	--	--	**0.0095**	--	**0.11**	0.01 U
Benzo(g,h,i)perylene	mg/kg	1.34	--	--	--	**0.062**	--	**8.5**	**0.028**
Dibenzofuran	mg/kg	1.08	--	--	--	0.012 U	--	0.25 U	0.05 U
Fluoranthene	mg/kg	3.4	--	--	--	**0.19**	--	**4.3**	**0.038**
Fluorene	mg/kg	1.08	--	--	--	**0.011**	--	0.05 U	0.01 U
Naphthalene	mg/kg	4.2	--	--	--	**0.029**	--	**0.054**	0.005 U
Phenanthrene	mg/kg	3	--	--	--	**0.14**	--	**0.66**	**0.018**
Pyrene	mg/kg	5.2	--	--	--	**0.21**	--	**5.5**	**0.049**
Benzo(a)anthracene	mg/kg	2.6	--	--	--	**0.059**	--	**8.7**	**0.019**
Benzo(a)pyrene	mg/kg	3.2	--	--	--	**0.14**	--	**22**	**0.029**
Chrysene	mg/kg	2.8	--	--	--	**0.098**	--	**11**	**0.033**
Dibenzo(a,h)anthracene	mg/kg	0.46	--	--	--	**0.0071**	--	**2.2**	0.01 U
Indeno(1,2,3-cd)pyrene	mg/kg	1.2	--	--	--	**0.06**	--	**11**	**0.026**
Total Benzofluoranthenes (ND = 1/2 RDL)	mg/kg	6.4	--	--	--	**0.22**	--	**38**	**0.058**
Total HPAHs(4) (ND = 1/2 RDL)	mg/kg	24	--	--	--	**1.04**	--	**111**	**0.285**
Total LPAHs(5) (ND = 1/2 RDL)	mg/kg	10.4	--	--	--	**0.211**	--	**0.88**	**0.043**
Total cPAHs(6) TEQ (ND = 1/2 RDL)	mg/kg	5.5	--	--	--	**0.18**	--	**28**	**0.041**

Table 5. Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

		Site Investigation Area:	Boat Maintenance Area						Historical Boat Manf. Area
		Surface Cover:	Unpaved				Paved		Paved
		Location:	HA-03	HA-04	HA-07	MW-19D	HA-05	MW-17	SB-40
		Date:	09/20/2022	09/20/2022	09/20/2022	09/14/2022	09/20/2022	09/14/2022	09/26/2022
		Depth (ft bgs):	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft
Analyte	**Unit**	**Screening Levels**							
Other Semivolatile Organic Compounds (SVOCs)									
2,4-Dimethylphenol	mg/kg	0.058	--	--	--	0.12 U	--	2.5 U	0.5 U
3- & 4-Methylphenol	mg/kg	1.3	--	--	--	0.25 U	--	5 U	1 U
Benzoic acid	mg/kg	1.3	--	--	--	0.62 U	--	12 U	2.5 U
Benzyl alcohol	mg/kg	0.114	--	--	--	0.12 U	--	2.5 U	0.5 U
Benzyl butyl phthalate	mg/kg	0.126	--	--	--	0.12 U	--	2.5 U	0.5 U
Bis(2-ethylhexyl) phthalate	mg/kg	2.6	--	--	--	0.2 U	--	4 U	0.8 U
Dimethyl phthalate	mg/kg	0.142	--	--	--	0.12 U	--	2.5 U	0.5 U
Hexachlorobenzene	mg/kg	0.014	--	--	--	0.012 U	--	0.25 U	0.05 U
N-Nitrosodiphenylamine	mg/kg	0.056	--	--	--	0.012 UJ	--	0.25 UJ	0.05 UJ
Pentachlorophenol	mg/kg	0.72	--	--	--	0.062 U	--	1.2 U	0.25 U
Phenol	mg/kg	0.84	--	--	--	0.12 U	--	2.5 U	0.5 U
1,2,4-Trichlorobenzene	mg/kg	0.062	--	--	--	0.01 U	--	0.01 U	0.01 U
1,2-Dichlorobenzene	mg/kg	0.07	--	--	--	0.012 U	--	0.05 U	0.05 U
1,4-Dichlorobenzene	mg/kg	0.22	--	--	--	0.012 U	--	0.05 U	0.05 U

Table 5. Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

		Site Investigation Area:	Southwest Property Area						
		Surface Cover:	Paved					Unpaved	
		Location:	SB-35	SB-37		SB-38	SB-39	SB-36	MW-18D
		Date:	09/12/2022	09/13/2022	09/13/2022	09/12/2022	09/13/2022	09/12/2022	09/12/2022
		Depth (ft bgs):	0 - 1 ft	0 - 1 ft	0 - 2 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft
Analyte	**Unit**	**Screening Levels**							
Metals									
Arsenic	mg/kg	57	**2.72**	**3.37**	--	**7.35**	**3.01**	**4.27**	**4.13**
Cadmium	mg/kg	10.2	**1.83**	**0.787**	--	**18**	**1.2**	**5.69**	0.2 U
Chromium	mg/kg	520	**43.6**	**246**	--	**385**	**64.5**	**87.6**	**10.8**
Copper	mg/kg	780	**85.7**	**16.8**	--	**266**	**32.4**	**40.7**	**21.3**
Lead	mg/kg	900	**502**	**916**	--	**4640**	**642**	**749**	**5.82**
Mercury	mg/kg	0.82	**1.2**	**0.18**	--	**1.8**	**0.28**	**4.3**	**0.08**
Zinc	mg/kg	820	**209**	**175**	--	**1770**	**276**	**459**	**23.2**
Polychlorinated biphenyls (PCBs)									
Total PCB Aroclors (ND=0)	mg/kg	0.13	--	**6.8**	--	**3.5**	**24**	--	0.004 U
Total PCB Congeners (ND=0)	mg/kg	0.13	--	--	**0.973 J**	--	**21.7**	--	**0.000728 J**
Dioxins/Furans									
Total Dioxin/Furan TEQ (ND = 0)	ng/kg	25	--	--	--	**599**	**1750 J**	--	--
Polycyclic aromatic hydrocarbons (PAHs)									
2-Methylnaphthalene	mg/kg	1.34	0.1 U	**0.012**	--	0.2 U	0.02 U	**0.066**	0.0005 U
Acenaphthene	mg/kg	1	0.1 U	0.01 U	--	0.2 U	0.02 U	0.01 U	0.0005 U
Anthracene	mg/kg	1.92	0.1 U	**0.011**	--	0.2 U	0.02 U	0.01 U	0.0005 U
Benzo(g,h,i)perylene	mg/kg	1.34	0.1 U	**0.12 J**	--	**0.21**	**0.059 J**	**0.046 J**	**0.0012**
Dibenzofuran	mg/kg	1.08	0.5 U	0.05 U	--	1 U	0.1 U	0.05 U	0.0025 U
Fluoranthene	mg/kg	3.4	0.1 U	**0.036**	--	0.2 U	**0.057**	**0.067**	**0.0022**
Fluorene	mg/kg	1.08	0.1 U	0.01 U	--	0.2 U	0.02 U	**0.054**	0.0005 U
Naphthalene	mg/kg	4.2	0.005 U	**0.022**	--	0.005 U	0.005 U	**0.21**	0.0005 U
Phenanthrene	mg/kg	3	0.1 U	**0.024**	--	0.2 U	**0.027**	**0.083**	**0.00093**
Pyrene	mg/kg	5.2	0.1 U	**0.11**	--	0.2 U	**0.07**	**0.11**	**0.0033**
Benzo(a)anthracene	mg/kg	2.6	0.1 U	**0.037**	--	0.2 U	**0.03**	**0.033**	**0.0015**
Benzo(a)pyrene	mg/kg	3.2	**0.12**	**0.081 J**	--	**0.21**	**0.084 J**	**0.047 J**	**0.0027**
Chrysene	mg/kg	2.8	**0.17**	**0.13**	--	**0.28**	**0.056**	**0.059**	**0.0018**
Dibenzo(a,h)anthracene	mg/kg	0.46	0.1 U	**0.02 J**	--	0.2 U	0.02 J	0.01 J	0.0005 U
Indeno(1,2,3-cd)pyrene	mg/kg	1.2	0.1 U	**0.097 J**	--	**0.2**	**0.06 J**	**0.039 J**	**0.0013**
Total Benzofluoranthenes (ND = 1/2 RDL)	mg/kg	6.4	**0.23**	**0.19**	--	**0.45**	**0.25 J**	**0.10**	**0.0038**
Total HPAHs[4] (ND = 1/2 RDL)	mg/kg	24	**0.82**	**0.816 J**	--	**1.75**	**0.672 J**	**0.506 J**	**0.0181**
Total LPAHs[5] (ND = 1/2 RDL)	mg/kg	10.4	0.1 U	**0.072**	--	0.2 U	**0.0695**	**0.362**	**0.00443**
Total cPAHs[6] TEQ (ND = 1/2 RDL)	mg/kg	5.5	**0.16**	**0.116 J**	--	**0.30**	**0.119 J**	**0.065 J**	**0.0034**

Table 5. Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

		Site Investigation Area:	Southwest Property Area						
		Surface Cover:	Paved					Unpaved	
		Location:	SB-35	SB-37		SB-38	SB-39	SB-36	MW-18D
		Date:	09/12/2022	09/13/2022	09/13/2022	09/12/2022	09/13/2022	09/12/2022	09/12/2022
		Depth (ft bgs):	0 - 1 ft	0 - 1 ft	0 - 2 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft	0 - 1 ft
Analyte	**Unit**	**Screening Levels**							
Other Semivolatile Organic Compounds (SVOCs)									
2,4-Dimethylphenol	mg/kg	0.058	5 U	0.5 U	--	10 U	1 U	0.5 U	0.025 U
3- & 4-Methylphenol	mg/kg	1.3	10 U	1 U	--	20 U	2 U	1 U	0.05 U
Benzoic acid	mg/kg	1.3	25 U	2.5 U	--	50 U	5 U	2.5 U	0.12 U
Benzyl alcohol	mg/kg	0.114	5 U	0.5 U	--	10 U	1 U	0.5 U	0.025 U
Benzyl butyl phthalate	mg/kg	0.126	5 U	0.5 U	--	10 U	1 U	0.5 U	0.025 U
Bis(2-ethylhexyl) phthalate	mg/kg	2.6	8 U	0.8 U	--	16 U	**5**	0.8 U	0.04 U
Dimethyl phthalate	mg/kg	0.142	5 U	0.5 U	--	10 U	1 U	0.5 U	0.025 U
Hexachlorobenzene	mg/kg	0.014	0.5 U	0.05 U	--	1 U	0.1 U	0.05 U	0.0025 U
N-Nitrosodiphenylamine	mg/kg	0.056	0.5 U	0.05 U	--	1 U	0.1 U	0.05 U	0.0025 U
Pentachlorophenol	mg/kg	0.72	2.5 U	**0.27**	--	5 U	0.5 U	**0.56**	0.012 U
Phenol	mg/kg	0.84	5 U	0.5 U	--	10 U	1 U	0.5 U	0.025 U
1,2,4-Trichlorobenzene	mg/kg	0.062	0.01 U	0.01 U	--	0.01 U	0.01 U	0.01 U	0.0025 U
1,2-Dichlorobenzene	mg/kg	0.07	0.05 U	0.05 U	--	0.05 U	0.05 U	0.05 U	0.0025 U
1,4-Dichlorobenzene	mg/kg	0.22	0.05 U	0.05 U	--	0.05 U	0.05 U	0.05 U	0.0025 U

Table 5. Remedial Investigation Phase 2 Surface Soil Analytical Data Screened for Source Control Review

Project No. 190293, South Park Marina, Seattle, Washington

Notes

Screening levels are LDW ROD RALs for those COCs with dry-weight LDW ROD RALs, LAET for PCBs, and 2xSCO values for the other COCs with OC-normalized LDW ROD RALs, all sourced from Ecology (2023b).

The screening levels presented are applied for source control review only and are not used for compliance purposes

Surface soil samples are those collected starting at ground surface to a maximum depth of 1 foot, where ground surface is the top of soil below any paving, pavement gravel base course, or gravel surfacing.

Bold = detected.

Blue Shaded = Reported concentration exceeds the screening level.

Gray Shaded = Nondetect result has a reporting limit that exceeds a screening level.

Screening level shading is hierarchical: If only non-detect values exceed the screening level, the screening level is shaded grey; if detected results (and potentially non-detected results) exceed the screening level, the screening level is shaded blue.

Total PCB Aroclors concentrations are the sum of Aroclors with non-detects = 0 (ND=0), unless all Aroclors were not detected, in which case the Total PCB Aroclors concentration is shown as non-detect at the maximum reporting limit for any individual Aroclor.

3- and 4-Methylphenol were reported together during RI Phase 2; the results are screened against the screening level for 4-methylphenol.

-- = Analysis not performed.

ND = 0 indicates the summation is calculated using 0 for non-detected components.

ND = 1/2 RDL indicates summation is calculated using 1/2 the analytical reporting limit for non-detected components.

HPAHs (high molecular weight polycyclic aromatic hydrocarbons): fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

LPAHs (low molecular weight polycyclic aromatic hydrocarbons): naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

cPAHs (carcinogenic polycyclic aromatic hydrocarbons): benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

TEQ = total toxicity equivalence.

J = Result value estimated

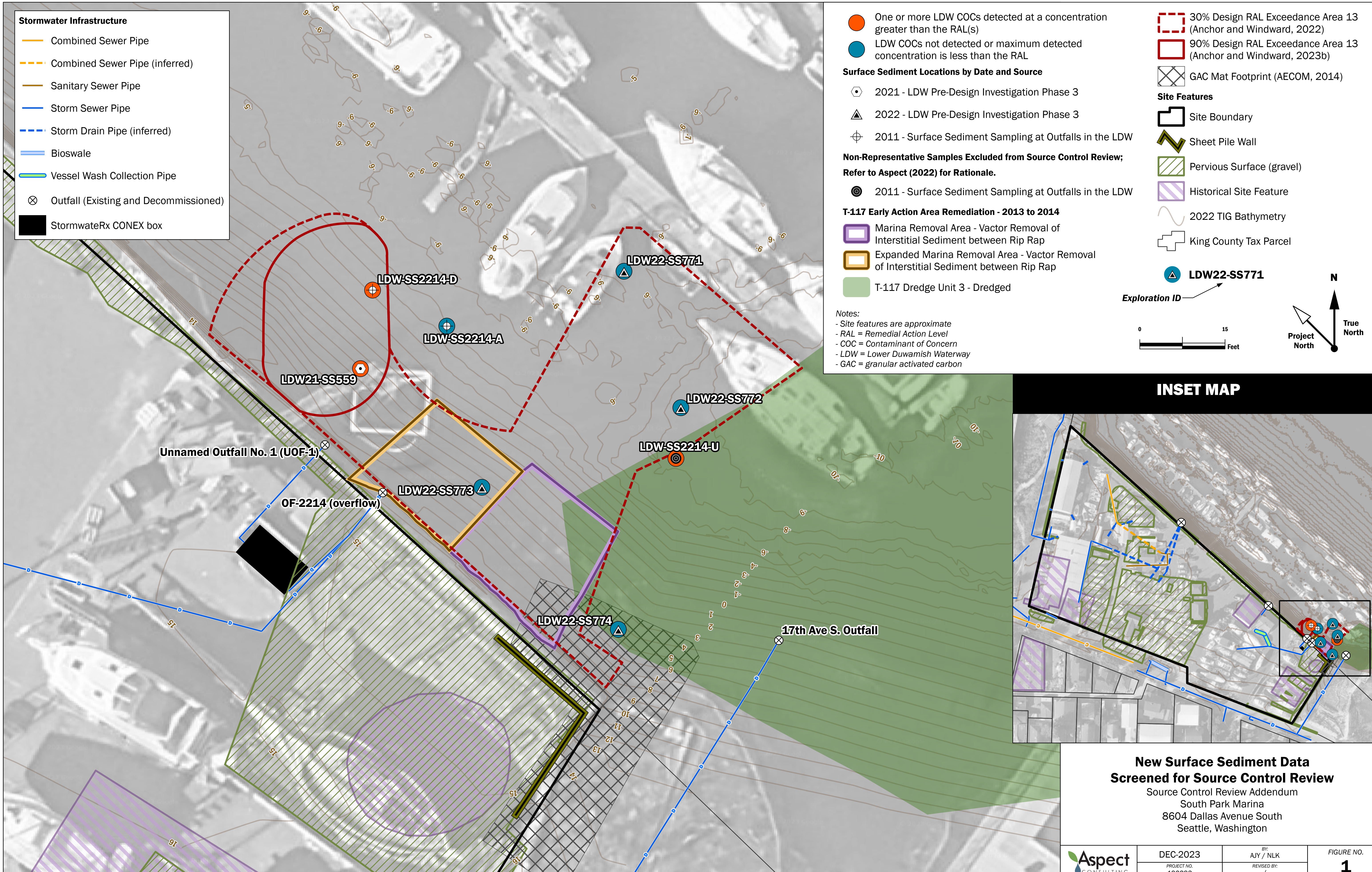
U = Analyte not detected at or above the reporting limit shown

UJ = Analyte was not detected at or above the reported limit, and the value shown is an estimate

mg/kg = milligrams per kilogram - dry weight

ft bgs = feet below ground surface

FIGURES

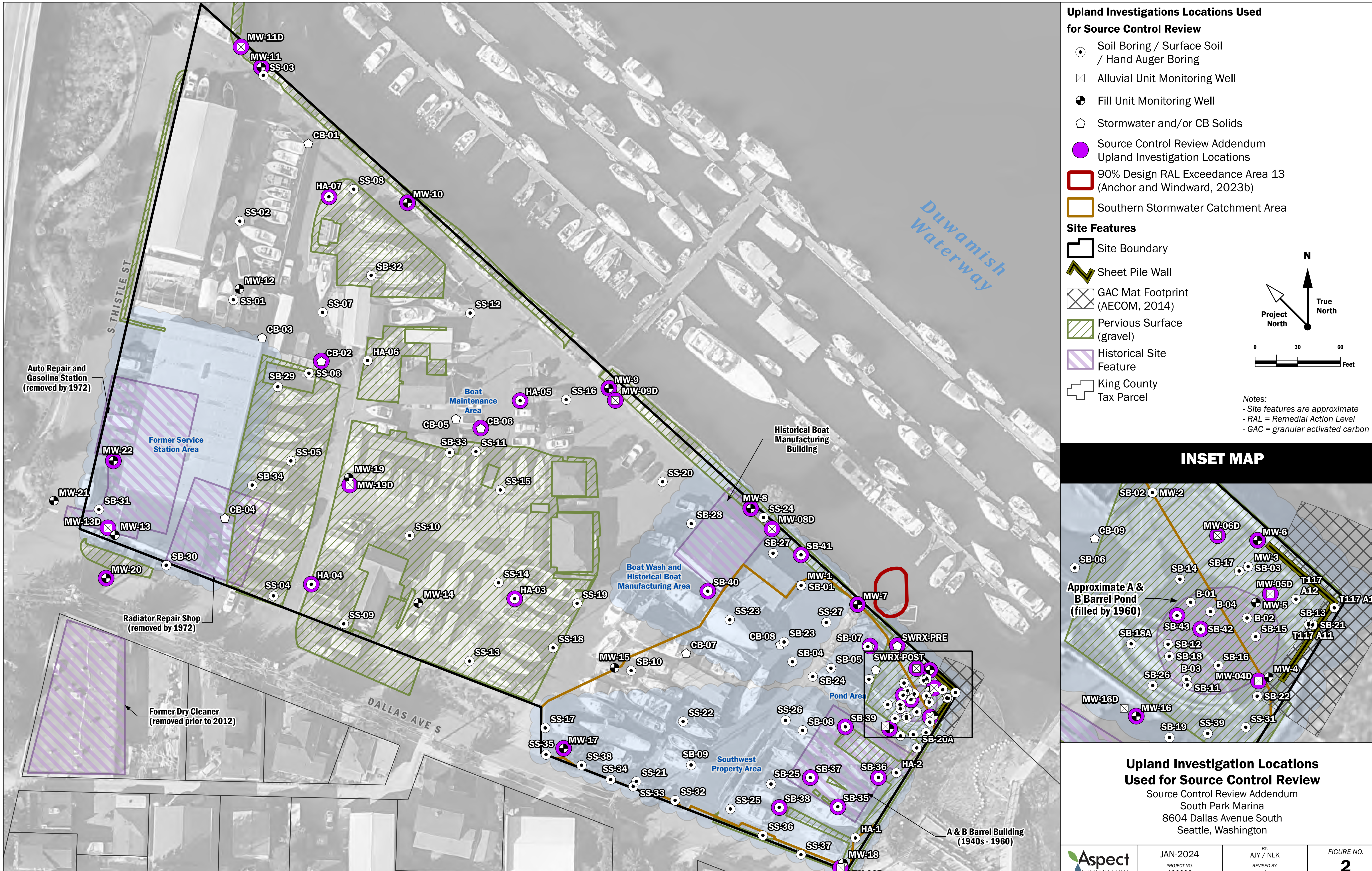


New Surface Sediment Data Screened for Source Control Review

Source Control Review Addendum
South Park Marina
8604 Dallas Avenue South
Seattle, Washington

Aspect CONSULTING	DEC-2023	BY: AJY / NLK	FIGURE NO.
	PROJECT NO. 190293	REVISED BY: - - - / - - -	1

Data source credits: None || Basemap Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA



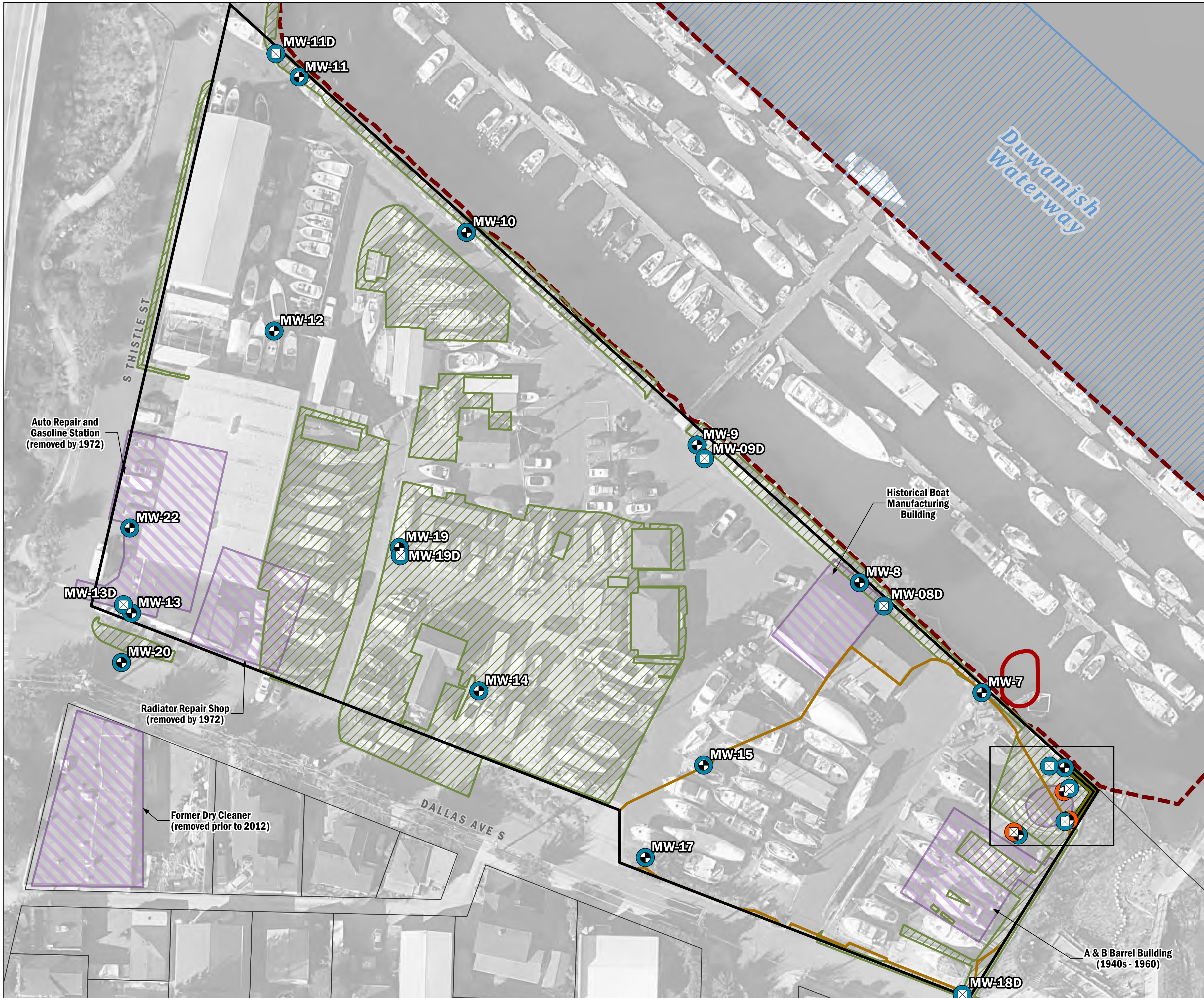
Upland Investigation Locations Used for Source Control Review

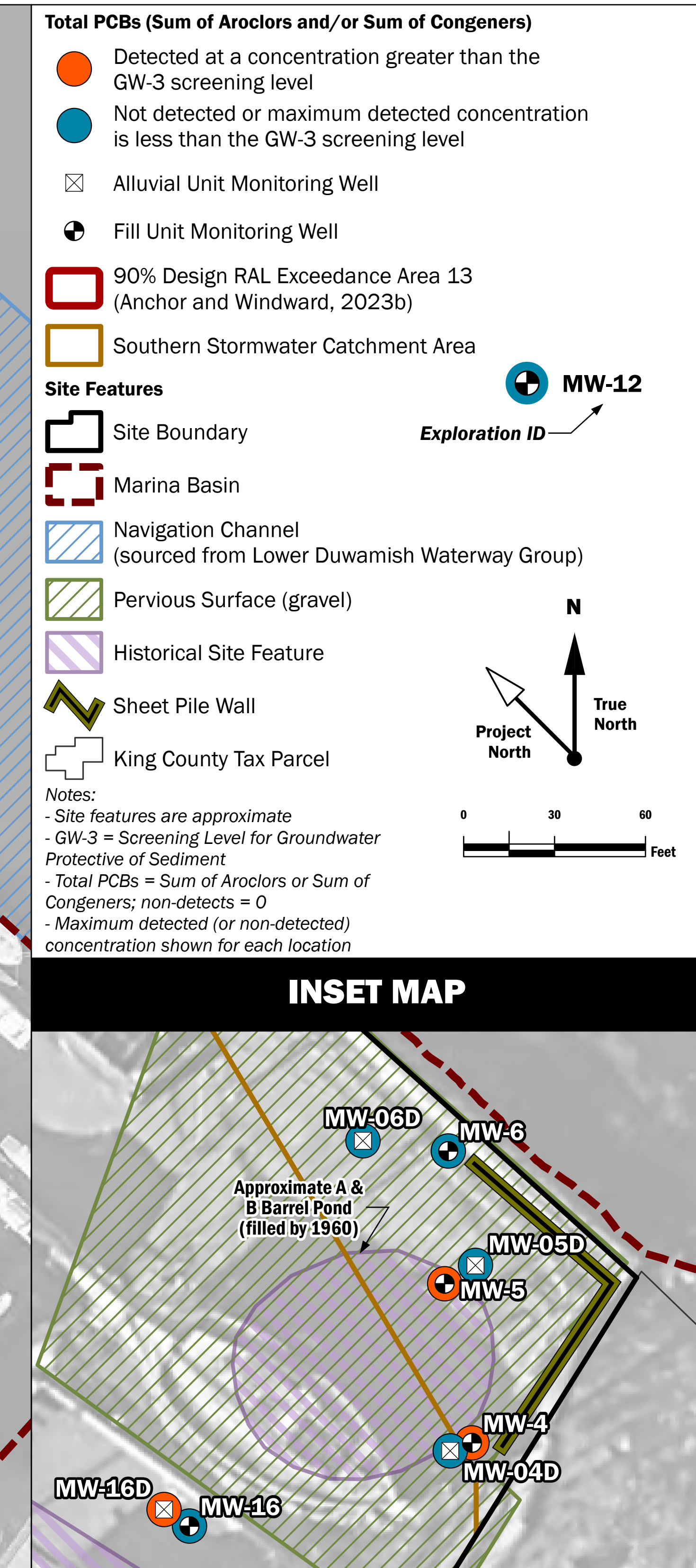
Source Control Review Addendum
South Park Marina
8604 Dallas Avenue South
Seattle, Washington

Aspect CONSULTING

JAN-2024	BY: AJY / NLK	FIGURE NO.
PROJECT NO. 190293	REVISED BY: - - - / - - -	2

Data source credits: None || Basemap Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA

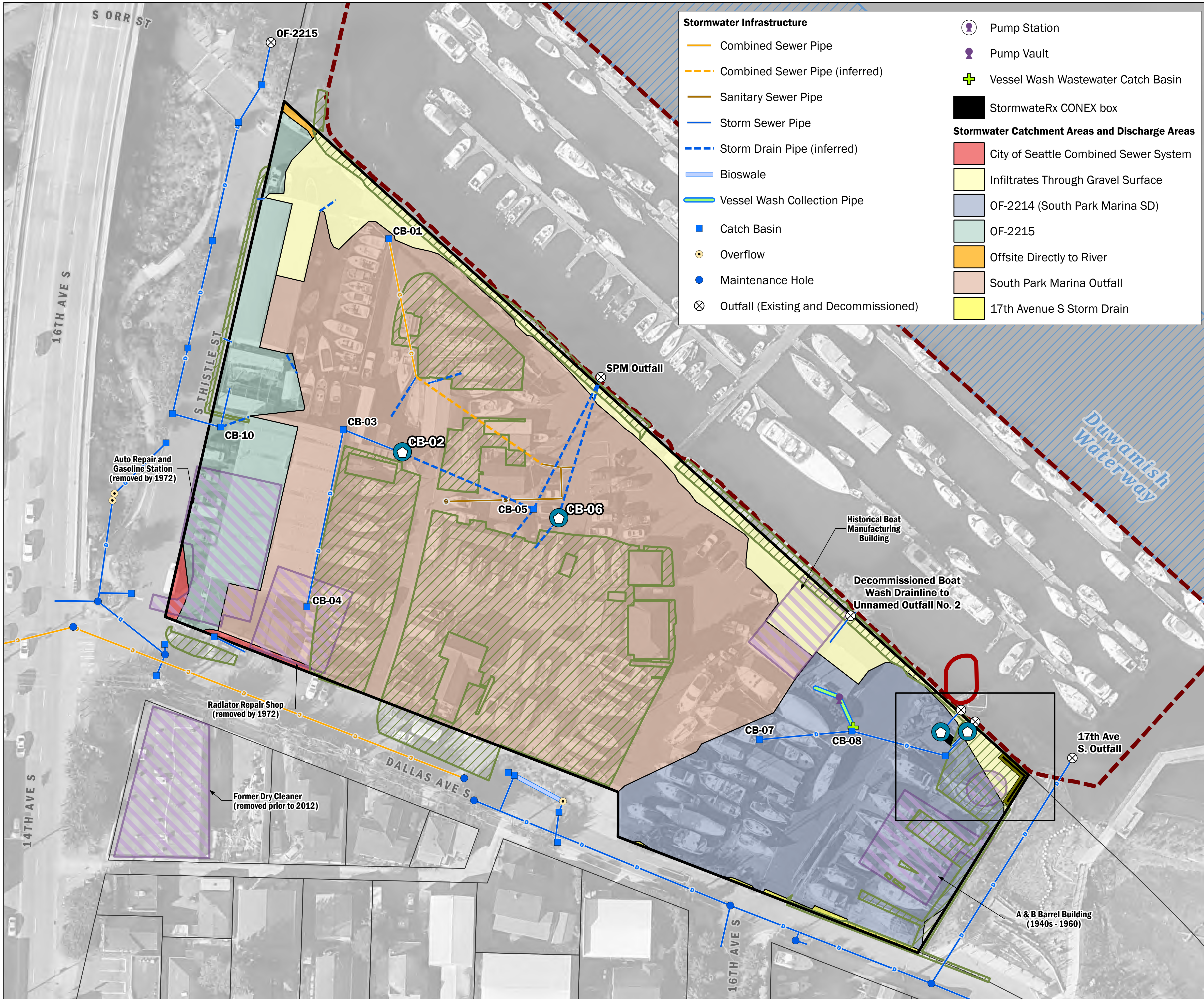




Total PCB Analytical Results in Groundwater - Remedial Investigation Phases 2 and 3

Source Control Review Addendum
South Park Marina
8604 Dallas Avenue South
Seattle, Washington

Aspect Consulting	JAN-2024	BY: AJY / NLK	FIGURE NO.
	PROJECT NO. 190293	REVISED BY: --- / ---	3



Total PCBs (Sum of Aroclors and/or Sum of Congeners)

- Detected at a concentration greater than the GW-3 screening level
- Not detected or maximum detected concentration is less than the GW-3 screening level
- Stormwater Sample Locations
- 90% Design RAL Exceedance Area 13 (Anchor and Windward, 2023b)

Site Features

- Site Boundary
- Marina Basin
- Pervious Surface (gravel)
- Historical Site Feature
- Navigation Channel (sourced from Lower Duwamish Waterway Group)
- Sheet Pile Wall
- King County Tax Parcel

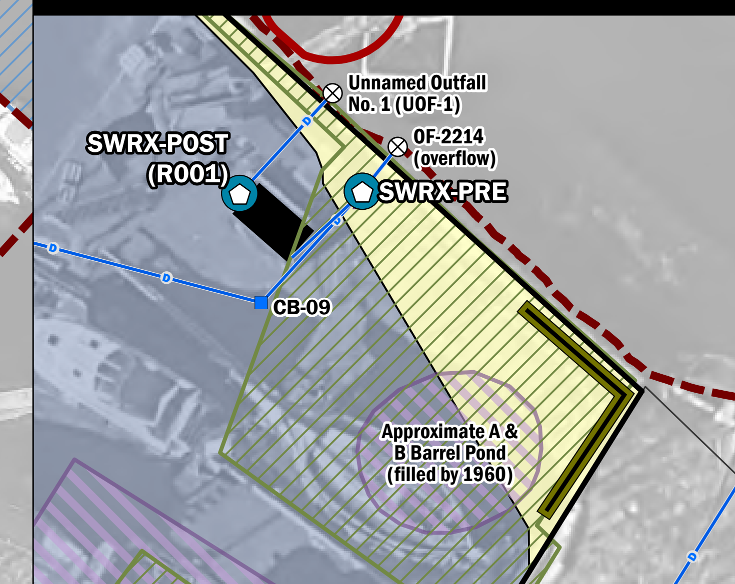
CB-06 — *Exploration ID*

Notes:
- Site features are approximate
- GW-3 = Screening Level for Groundwater Protective of Sediment
- Total PCBs = Sum of Aroclors or Sum of Congeners; non-detects = 0
- On-Property stormwater infrastructure and catchment areas adapted from TIG, 2019
- Locations R001, CB-02, and CB-06 are used as Monitoring Points under the National Pollution Discharge Elimination System Boatyard General Permit for South Park Marina.

N — True North — Project North

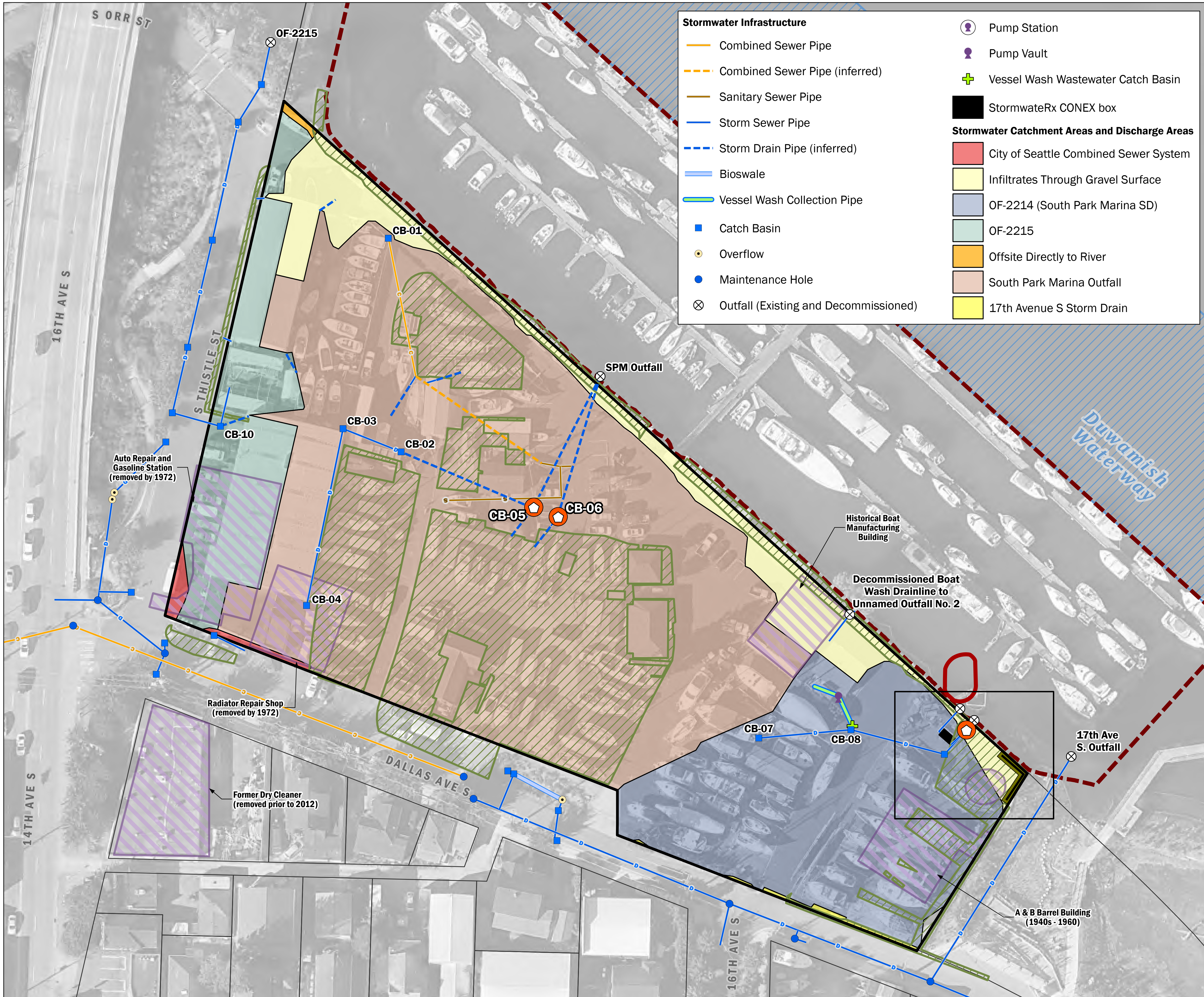
0 35 70 Feet

INSET MAP



Total PCB Analytical Results in Stormwater - Remedial Investigation Phase 2
Source Control Review Addendum
South Park Marina
8604 Dallas Avenue South
Seattle, Washington

Aspect Consulting	DEC-2023	BY: AJY / NLK	FIGURE NO.
	PROJECT NO. 190293	REVISED BY: - - - / - - -	4



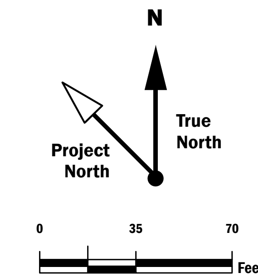
Total PCBs (Sum of Aroclors and/or Sum of Congeners)

- Detected at a concentration greater than RAL
- Not detected or maximum detected concentration is less than the RAL
- CB Solids Sampling Locations
- 90% Design RAL Exceedance Area 13 (Anchor and Windward, 2023b)

Site Features

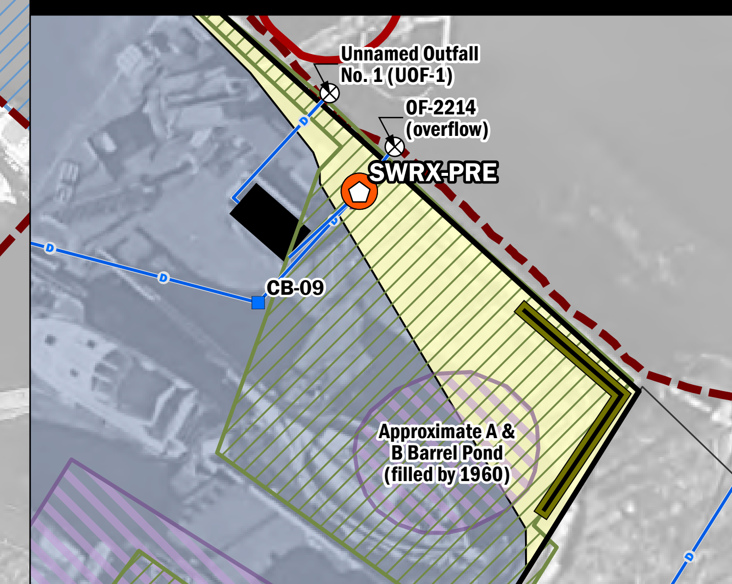
- Site Boundary
- Marina Basin
- Pervious Surface (gravel)
- Historical Site Feature
- Navigation Channel (sourced from Lower Duwamish Waterway Group)
- Sheet Pile Wall
- King County Tax Parcel

CB-06
Exploration ID



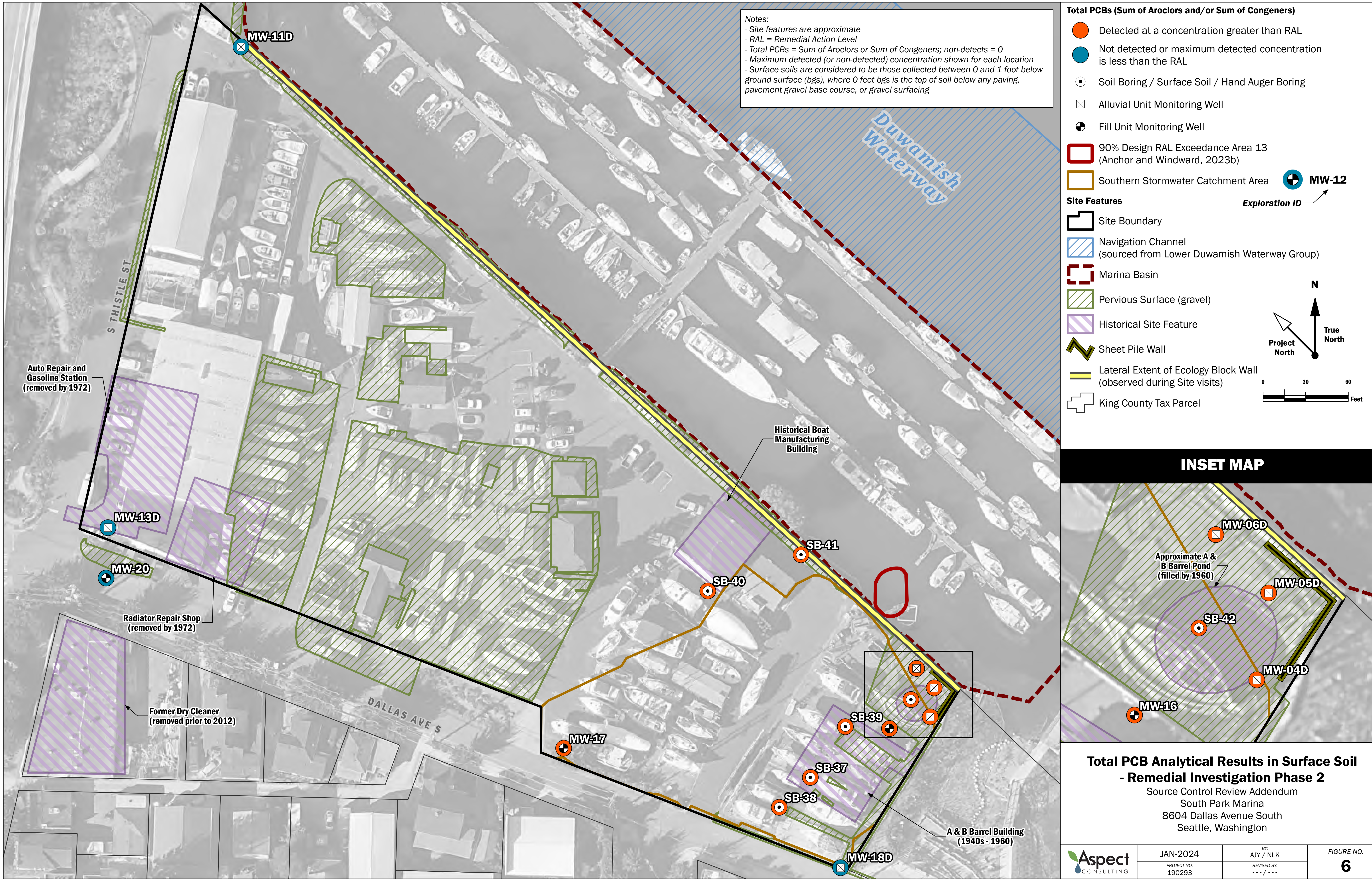
Notes:
- Site features are approximate
- RAL = Remedial Action Level
- Total PCBs = Sum of Aroclors or Sum of Congeners; non-detects = 0
- On-Property stormwater infrastructure and catchment areas adapted from TIG, 2019

INSET MAP



Total PCB Analytical Results in Catch Basin Solids - Remedial Investigation Phase 2
Source Control Review Addendum
South Park Marina
8604 Dallas Avenue South
Seattle, Washington

Aspect CONSULTING	DEC-2023	BY: AJY / NLK	FIGURE NO.
	PROJECT NO. 190293	REVISED BY: - - - / - - -	5



Total PCB Analytical Results in Surface Soil - Remedial Investigation Phase 2

Source Control Review Addendum
South Park Marina
8604 Dallas Avenue South
Seattle, Washington

Aspect CONSULTING

JAN-2024	BY: AJY / NLK	FIGURE NO.	6
PROJECT NO. 190293	REVISED BY: --- / ---		

APPENDIX A

NPDES Stormwater Management for South Park Marina

(Prepared by TIG)

Appendix A

NPDES Stormwater Management for South Park Marina

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NPDES Stormwater Management
for South Park Marina

Addendum to Source Control Review Memorandum

This appendix briefly summarizes relevant updates to the South Park Marina (SPM) facility stormwater infrastructure and stormwater management under the National Pollution Discharge Elimination System (NPDES) Boatyard General Permit (BYGP) since Aspect's issuance of the Source Control Review (SCR) Memorandum in September 2022.The SCR Memorandum contained a detailed summary of the information presented below; however, this appendix aims to present updates since September 2022.

A.1 Stormwater Catchment Areas and Infrastructure

Figure 4 illustrates the SPM Property stormwater drainage system infrastructure and catchment areas determined based on methods detailed in the RI Work Plan (Aspect, 2021). SPM Property's stormwater system is divided into four main catchment areas and three smaller areas, as described in the SCR Memorandum (Aspect, 2022).

Since the SCR Memorandum, there has been one StormwateRx bypass event at Unnamed Outfall No. 1 (UOF-1) to the LDW. This event occurred in January 2023. TIG collected water samples of both the untreated (CB-02 and CB-06) and treated (R001) water. Results are summarized in the January 2023 electronic discharge monitoring report (DMR) and concentrations for all analytes were below permit benchmarks (Table A-1).

A.2 SPM Boatyard General Permit (NPDES)

The SPM facility discharges stormwater under a BYGP (Permit No. WAG030045), which is both a NPDES Permit and State Waste Discharge General Permit. The BYGP sets forth the requirements for stormwater runoff monitoring, boat washwater monitoring, discharge limits, reporting, and best management practices (BMPs). The current version of BYGP was issued on July 20, 2022; it became effective September 1, 2022, and expires on August 31, 2027.

A.2.1 Boatyard Best Management Practices

The facility's BYGP stipulates a number of BMPs for meeting Washington State water quality standards. Tenants of the marina are provided a copy of Puget Soundkeeper Alliance's *Best Management Practices (BMPs) for Boaters and Marinas* pamphlet, which is based on BMPs set forth by Ecology and EPA. In accordance with SPM's October 2022 stormwater pollution prevention plan (SWPPP), the mandatory BMPs implemented at the facility are posted on signs around the facility. BMPs are summarized in the SCR Memorandum (Aspect, 2022).

A.2.2 NPDES-Related Inspections and Investigations

NPDES-related inspections and investigations that have occurred at SPM between 2015 and 2022 are summarized in Appendix A of the SCR Memorandum (Aspect, 2022). Following Ecology's most recent stormwater compliance inspection of the SPM Property on February 25, 2022, the Ecology site inspector concluded that SPM needed to complete the following:

- Update the site map and SWPPP to include two new sampling points at CB-02 and either CB-05 or CB-06.
- Begin sampling stormwater in CB-02 and either CB-05 or CB-06 to characterize stormwater reaching the South Park Marina outfall.
- Correct secondary containment issues identified in the gated storage area south of Dallas Avenue South from the south end of the SPM Property.
- Conduct a Level 2 response for copper and a Level 3 response for zinc based on catch basin stormwater results collected in April and May 2021.
- Submit catch basin sampling results collected in April and May 2021.

Following the inspection, SPM has been conducting a Level Three Response for zinc and copper, and sampling and reporting stormwater analytical results for samples taken from CB-02 and CB-06.

On May 20, 2022, a Level Three Response for copper and zinc was officially initiated in the untreated portion of the SPM Property (catch basins CB-02 and CB-06) during the April 2022 DMR submission. Per Ecology's request, SPM submitted the April and May 2021 catch basin results with the electronic DMR for the April 2022 monitoring event on May 20, 2022, triggering the Level Three Response. According to the 2016-2022 Boatyard General Permit Sections S7(a)(2) and S7(a)(3), the Level Three Response includes the preparation of an Engineering Report that summarizes stormwater treatment alternatives and recommendation of a preferred treatment method. TIG submitted the Level Three Engineering Report to Ecology on August 19, 2022, and Ecology approved the final report on February 7, 2023 (provided as Attachment A-1).

As of the date of this addendum, TIG is managing the implementation of the selected stormwater treatment alternative at the SPM property. The new infrastructure will include a second above-ground filtration system and catchment area infrastructure upgrades, which will consist of the removal and replacement of catch basins CB-02, CB-05, and CB-06; decommissioning of existing lines running between each of the basins and replacement with functional lines; and replacement of the SPM Outfall (Attachment A-1, Figure 5). TIG has since selected a stormwater vendor to install the new treatment system at SPM and is working with a civil engineer, geotechnical engineer, electrical engineer, archeological monitoring consultant, and construction contractor to provide civil and stormwater design services in support of TIG's Level Three Response.

A.2.3 SPM Stormwater Monitoring under the Boatyard General Permit

In SPM's permit coverage letter dated July 27, 2022, Ecology establishes Monitoring Points R001, CB-02, and CB-06 as representative of stormwater discharges across the SPM Property. Monitoring Point R001 is located on the StormwateRx™ system's outlet valve and represents treated stormwater from CB-07 through CB-09 (Figure 4). Monitoring Points CB-02 and CB-06 both drain to the SPM Outfall and represent untreated stormwater in the central portion of the SPM Property.

Under Section S2(D)(2) of the BYGP, the permittee must collect at least one stormwater discharge sample in each wet-season month (October, November, January, March, April, and May) for analysis of total copper and total zinc, pH, total suspended solids, turbidity, total petroleum hydrocarbons – diesel fraction, and visual observation of oil sheen. The BYGP establishes maximum daily benchmarks for the six parameters for which the Site's stormwater discharges must be tested. Table A-1 provides SPM's monitoring data compared against both the maximum daily benchmarks.

If a benchmark value is exceeded, one or more responses from South Park Marina may be required for continued compliance, as identified under Section S7(A) of the permit. The permit requires: a Level One Response after one or two benchmark exceedances during a calendar year, a Level Two Response after three benchmark exceedances during a calendar year, and a Level Three Response after four benchmark exceedances during a calendar year.

A.3 References for Appendix A

Aspect, 2022. Source Control Review Memorandum, Prepared for Washington State Department of Ecology on behalf of City of Seattle, Seattle City Light, The Port of Seattle, South Park Marina Limited Partnership, September 2022.

TIG Environmental (TIG), 2022. Level Three Response Engineering Report for Zinc and Copper, Prepared for Washington State Department of Ecology, January 2023.

Table A-1: Treated Stormwater Data Comparison to Boatyard Permit Benchmarks, 2017–2023

Addendum to Source Control Review Memorandum

Sample Date[1]	Sample LocationError! Bookmark not defined.	Total Copper	Total Zinc	TSS	pH	Turbidity	Visible Oil Sheen	TPH Diesel Fraction
	Units	µg/L	µg/L	mg/L	SU	NTU	Yes/No	mg/L
	Daily Max Benchmark	36	90	30[2]	6–9	25	No	10
2022–2023 Season								
10/25/22	R001	1500	770	140	7.3	84	No	1.5
	CB-02	110	1400	27	7.0	23	No	0.47
	CB-06	81	150	26	7.0	35	No	0.43
11/4/22	R001	6.9	11	ND	6.1	1.4	No	ND
	CB-02	45	1400	9	7.4	14	No	0.22
	CB-06	17	79	7	6.7	4.3	No	0.41
11/22/22	R001	14	12	ND	--	2.3	No	--
	CB-02	--	--	--	--	--	No	--
	CB-06	--	--	--	--	--	No	--
1/12/23	R001	7.1	46	ND	6.7	0.41	No	ND
	R001 overflow	25	65	ND	6.9	1.1	No	ND
	CB-02	63	590	8	6.5	6.4	No	0.16
	CB-06	37	96	19	6.7	44	No	0.20
3/2/23	R001	11	20	ND	6.2	1.7	No	ND
	CB-02	44	280	7	6.6	3.6	No	0.16
	CB-06	40	160	7	7.0	21	No	0.30
4/7/23	R001	ND	17.7	ND	7.86	0.71	No	ND
	CB-02	63.3	416	ND	7.85	3.1	No	0.063
	CB-06	27.2	86.1	ND	7.88	9.2	No	0.068
9/20/23	R001	10.3	20.2	ND	6.86	1.3	No	ND
	CB-02	87.8	547	11	6.80	5.5	No	0.36
	CB-06	82.2	133	6.3	6.85	9.1	No	1.1
2021–2022 Season								
10/28/21	R001[3]	8.7	7.7	ND	6.77	--	--	--
11/9/21	R001	4.7	17	ND	6.70	--	--	--

Table A-1: Treated Stormwater Data Comparison to Boatyard Permit Benchmarks, 2017–2023

Addendum to Source Control Review Memorandum

Sample Date[1]	Sample LocationError! Bookmark not defined.	Total Copper	Total Zinc	TSS	pH	Turbidity	Visible Oil Sheen	TPH Diesel Fraction
	Units	µg/L	µg/L	mg/L	SU	NTU	Yes/No	mg/L
	Daily Max Benchmark	36	90	30[2]	6–9	25	No	10
1/10/22	R001	7.6	12	ND	6.5	--	--	--
4/19/22[4]	R001	4.9	22	ND	6.9	--	--	--
	CB-02[5]	60	850	ND	6.4	--	--	--
	CB-06[5]	53	100	ND	6.5	--	--	--
5/5/22	R001	6.9	23	ND	7.1	--	--	--
	CB-02	110	170	ND	6.1	--	--	--
	CB-06	75	110	18	6.8	--	--	--
	Seasonal Average Benchmark[6]	50	85	--	--	--	--	--
	2017-2018	11	115	--	--	--	--	--
	2018-2019	43	20	--	--	--	--	--
	2019-2020	19	26	--	--	--	--	--
	2020-2021	40	49	--	--	--	--	--
	2021-2022	6.6	16	--	--	--	--	--
	2022-2023[7]	42.5	361.1	--	--	--	--	--

Notes

[1] For samples with field duplicate results, the higher concentration reported from the parent sample or duplicate sample is used in this analysis, consistent with South Park Marina's NPDES Discharge Monitoring Reports.

[2] The TSS value listed is a limit and not a benchmark. A limit exceedance does not trigger a specific response, but it is instead defined as an automatic violation of the permit conditions. A benchmark exceedance, by contrast, triggers a response and is not automatically a permit violation. This limit is on a 3-year compliance schedule, effective July 1, 2025, whereas all other benchmarks listed became effective on September 1, 2022.

[3] R001 sample location represents the treated effluent from the StormwateRx system.

[4] Beginning in April 2022, catch basins CB-06 and CB-02 were included in SPM's stormwater monitoring program as requested by Ecology following the February 2022 compliance inspection.

[5] CB-02 and CB-06 represent the untreated portion of SPM.

[6] The seasonal benchmarks presented herein are reflective of the 2017–2021 permit cycle only. The seasonal average calculation is no longer a permit requirement for the 2022–2027 permit cycle.

[7] The seasonal average calculations for the 2022–2023 stormwater season include all three sample locations.

Acronyms and Abbreviations

mg/L: milligrams per liter
µg/L: micrograms per liter
--: not applicable
ND: non-detect result
NTU: nephelometric turbidity units
SU: standard units
TIG: TIG Environmental
TPH: total petroleum hydrocarbons
TSS: total suspended solids

Attachment A-1

January 2023 Level Three Response Engineering Report for Zinc and Copper for South Park Marina

TIG environmental®
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a verdantas company

January 2023

Level Three Response Engineering Report for Zinc and Copper

South Park Marina

A facility covered by:

Washington Department of Ecology

Boatyard General Permit # WAG030045

Level Three Response Engineering Report for Zinc and Copper

January 2023

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Level Three Response Engineering Report and Level Two Response Source Control Evaluation

South Park Marina

1. Introduction

TIG Environmental (TIG)[1] prepared this Engineering Report as part of the Level Three Response for South Park Marina (SPM) (the site) in accordance with the conditions of the Boatyard General Permit (Boatyard Permit) issued by the Washington State Department of Ecology (Ecology). South Park Marina is located at 8604 Dallas Avenue South in Seattle, Washington. Figure 1 shows a vicinity map and Figures 2 and 3 show an overview of the site depicting the site's drainage system and catchment areas.

The current Boatyard 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. This Boatyard Permit technically expired on August 31, 2021; however, since South Park Marina submitted its notice of intent to renew (NOI), it remained effectively covered under the permit issued August 8, 2016 until the effective date of the new permit, September 1, 2022.[2] Throughout this report, the 2016–2022 version of the permit will be referred to as the current Boatyard Permit or the Boatyard Permit, and the recently updated and reissued version of the permit, effective September 1, 2022, will be referred to as the new Boatyard Permit or new permit.

The Boatyard Permit requires that one water quality sample be collected during a qualifying storm event during the months of October, November, January, April, and May[3] from locations affected by boatyard related activity (Ecology 2016). The Boatyard Permit also establishes benchmark concentrations for water discharged from each covered facility for two parameters: zinc and copper.[4] A Level Three response action was triggered at one particular area within the Boatyard following six exceedances of the zinc and copper benchmarks since August 8, 2016, the effective date of the current permit.

This Level Three Response Engineering Report has been prepared in accordance with the Boatyard Permit and to meet the applicable requirements of Washington Administrative Code (WAC) 173-240 and Ecology Publication No. 05-10-014, *State Requirements for Submission of Engineering Reports and Plans for Industrial Wastewater Treatment Facilities* (Ecology n.d.). In addition, although this facility is covered under the Boatyard Permit and not the Industrial Stormwater General Permit, the relevant portions of the February 2013 Ecology document, *Guidelines for the Preparation of Industrial Stormwater General Permit Engineering Reports* (Ecology 2013), were considered.

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[1] TIG Environmental is a member of The Intelligence Group, LLC.

[2] The initial expiration date of the 2016 permit was August 2021, but delays to the reissuance process extended the 2016 permit into August 2022.

[3] The new permit will include the month of March, effective September 1, 2022 (Ecology 2022).

[4] The new permit establishes benchmark concentrations for the following additional parameters: turbidity, pH, oil sheen, and petroleum hydrocarbons (diesel fraction), effective September 1, 2022 (Ecology 2022). The new permit also establishes total suspended solids (TSS) limits, effective September 1, 2025.

1.1 Summary of Findings and Recommendations

This Engineering Report contains TIG's evaluation of six treatment alternatives for efficacy, feasibility, and practicality in reducing zinc and copper concentrations in site stormwater. The proposed alternatives involve either (1) routing stormwater to the existing treatment system or (2) adding a new filtration system in the untreated portion of the site. To select a preferred alternative, TIG developed a ranking framework that assigns a value for each of the following metrics: technical effectiveness, initial cost, operations and maintenance (O&M) costs, and system ease of use. As a result of this evaluation, TIG recommends adding a new filtration system in the untreated portion of the site and narrowed down the preferred treatment system to be the Aquip System Model 110SBE manufactured by StormwateRx based on technical feasibility, upfront cost, O&M cost, and ease of use. In addition to implementing a new treatment system, TIG recommends sitewide infrastructure upgrades prior to installation of a new above-ground filtration system to ensure maximum effectiveness.

1.2 Regulatory Background

South Park Marina first established coverage under the Boatyard Permit in 2016. At the time that permit coverage was established, the StormwateRx treatment system was already in place and actively treating runoff in the CA-02 catchment area. Since 2016, Ecology conducted only two stormwater compliance inspections, in March 2021 and February 2022. Following the March 2021 inspection, Ecology directed South Park Marina to address several deficiencies with the site including the need to improve general site housekeeping and secondary containment protocols, sample the South Park Marina outfall (SPM outfall) associated with CA-01, move the sample port on the existing treatment system, and update the site's Stormwater Pollution Prevention Plan (SWPPP). TIG concluded that it was impossible to take a sample directly from the SPM outfall; therefore, as an alternative, TIG sampled the catch basins draining to the SPM outfall in April and May 2021. Once TIG addressed the deficiencies indicated in the March 2021 inspection, Ecology conducted another inspection in February 2022. Following the second inspection, Ecology instructed South Park Marina to continue sampling the catch basins draining to the SPM outfall as part of monthly stormwater monitoring to characterize representative stormwater pollutant loading and flow. Sampling these catch basins will need to continue until the sample results prove to be continually below benchmark requirements.

The main change resulting from both of the inspections was the requirement that monitoring occur at the CA-01 catchment area (draining to the SPM outfall). The requirement to monitor and report copper and zinc concentrations in discharges in this area had not been brought to South Park Marina's attention prior to the two inspections in 2021 and 2022. Up until the February 2022 Ecology inspection, South Park Marina maintained compliance under the Boatyard Permit when TIG collected stormwater samples solely from the existing treatment system in the CA-02 catchment area.

Stormwater samples collected in April and May 2021 in catch basins CB-02, CB-05, and CB-06 (located in CA-01) were initially collected for informational and planning purposes; however, following further discussion with Ecology, TIG was required to submit these sample results to Ecology's Discharge Monitoring Report (DMR) database. The copper and zinc benchmark exceedances observed in the samples from CA-01 triggered the Level 2 and Level 3 responses addressed by this report.

2. Site Background and Existing Conditions

South Park Marina Limited Partnership is an independently owned small business that supports a Seattle family and employs several full and part-time staff members. It remains as one of the last do-it-yourself boatyards in the City of Seattle. The site operates under standard industrial code 3732 (boat building and repairing). However, boats are not built at the site and repair work is generally limited to bottom painting, hull side finishing, routine engine maintenance, and other general maintenance. Activities conducted at the site include:

- Vessel moorage
- Haul-out services
- Upland storage
- Pressure washing[5]
- Routine engine maintenance (e.g., engine fluid changeouts, belt changeouts, and other similar tasks; major repairs and rebuilds are not conducted at the site)
- Other general maintenance (e.g., painting and sanding)

Stormwater from the site either infiltrates at the site or discharges to the Duwamish River through four outfalls. In 2017, catchment areas for the site were delineated using topographical and boundary survey data. A description of these catchment areas is summarized in the table below and are shown on Figure 3.

The following sections describe the general characteristics of each catchment area within South Park Marina, including operations conducted within catchment areas CA-01 and CA-02 and identify existing stormwater treatment in each area. The information presented herein is to the best of TIG's knowledge and TIG acknowledges uncertainties in the drainage network that leads to these outfalls. These uncertainties will need to be resolved prior to implementation of a new treatment system in the catchment area of interest.

2.1 Site Catchment Areas

South Park Marina is divided into four catchment areas (CAs), as described below. The catchment area of focus for this document is catchment area CA-01, as it was the focus of the March 2021 and February 2022

[5] Pressure washing is conducted only by site personnel within the designated boat wash area. Washwater is collected and treated in a closed-loop system and is not discharged with stormwater.

Ecology inspections and is the monitoring location where concentrations of copper and zinc in stormwater exceeded benchmarks and triggered the requirement to produce a Level 3 response. The remaining three catchment areas are summarized here briefly for completeness.

2.1.1 CA-01 Catchment Area

Catchment area CA-01 has the following characteristics:

- Size: Approximately 2.25 acres; occupies 60 percent of the total site area (Figure 3).
- Surface: Consists of pervious and impervious areas. The pervious areas are mostly compacted by cars and boats and infiltration may be reduced; therefore, sheet flow is possible in those areas. Although TIG has observed the site during a wide variety of precipitation events, this sheet flow has not been observed.
- Stormwater discharge location: The SPM outfall via catch basins CB-02, CB-05, and CB-06.
- Operations: South Park Marina staff and tenants conduct general boat maintenance and boat repair activities as well as conduct vehicle parking and boat transport.
- Existing treatment/best management practices (BMPs): Minimal stormwater treatment exists;[6] however, operational controls and BMPs are in place to reduce initial contaminant concentrations. The operational controls and BMPs implemented in CA-01 include regular inspection and catch basin cleanout, vacuum sander restrictions, good housekeeping, and zinc waste material management. Stormwater benchmark exceedances of copper and zinc measured in CA-01 in 2021 and 2022 triggered a Level 3 response.

Throughout conversations with Ecology and during inspections, the main catchment area of interest for applying stormwater treatment is CA-01 draining to the SPM outfall, because boat maintenance occurs within this catchment area, and it currently has limited stormwater treatment.

2.1.2 CA-02 Catchment Area

Catchment area CA-02 has the following characteristics:

- Size: Approximately 0.80 acres; occupies 22 percent of the total site area (Figure 3).
- Surface: Consists of mostly impervious areas.
- Stormwater discharge location: CA-02 drains to Unnamed Outfall No. 1 and Outfall OF-2214 via catch basins CB-07, CB-08, and CB-09.
- Operations: Regular activities that occur in this catchment area include vessel storage, routine engine maintenance, and other general exterior boat maintenance and repair activities.

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[6] Drop-in catch basin filter inserts manufactured by AbTech industries are installed in the catch basins throughout the property. Refer to Figure 2 for locations. Appendix B provides a copy of the AbTech Ultra-Urban® Filter Operation and Maintenance Manual, dated December 2020.

- Existing treatment/BMPs: An existing stormwater treatment system[7] designed to treat suspended solids and metals is located on the eastern portion of CA-02.

2.1.3 CA-03 Catchment Area

Catchment area CA-03 has the following characteristics:

- Size: Approximately 0.33 acres; occupies 9 percent of the total site area (Figure 3).
- Surface: Consists of impervious areas.
- Stormwater discharge location: This area receives untreated runoff that drains from the galvanized metal roof at Rick's Master Marine Shop, in addition to stormwater from the South Park Tire Factory Shop. CA-03, near the Tire Factory, drains to CB-10 and is transported to the river via outfall OF-2215.
- Operations: Maintenance activities and tire storage occurs in upland portions of the site.
- Existing treatment/BMPs: Not applicable.

2.1.4 CA-04 Catchment Area

Catchment area CA-04 has the following characteristics:

- Size: Approximately 0.31 acres; occupies 8 percent of the total site area (Figure 3).
- Surface: Consists of some pervious and some impervious areas.
- Stormwater discharge location: Stormwater runoff from this this area is infiltrated directly into the Lower Duwamish Waterway (LDW) and does not lead to any outfall.
- Operations: This catchment area is primarily composed of gravel along the LDW shoreline and no operations take place in this area.
- Existing treatment/BMPs: Not applicable.

2.2 Potential Site Sources of Copper and Zinc

2.2.1 Potential Sources of Zinc in Catchment Area CA-01

Zinc concentrations exceeded the maximum daily benchmark four times in CA-02 and ten times in CA-01. Potential sources of zinc at the site include boat bottom paint and particles generated during boat bottom maintenance and repair; a metal roof at the Rick's Master Marine building; wear of vehicle and boat travel lift tires; and outdoor tire storage at the Tire Factory Shop. Maintenance activities and tire storage areas commonly occurred in CA-01 until prohibited in October 2021 (refer to Section 2.4 for more details about

[7] The Aquip model 50 SBE treatment system manufactured by StormwateRx currently exists at the site. Refer to Figure 3 for location and Figure 4 for the system process diagram and connection to site drainage infrastructure. Appendix C provides additional information from the manufacturer on the design and operation of the system.

this source control best management practice) and are current operations in CA-02. Because zinc concentrations exceeded the maximum daily benchmark in both CA-01 and CA-02, TIG researched zinc sources in both catchment areas.

Catch basin CB-01, now decommissioned, located nearest to Rick's Master Marine Shop drained zinc-containing runoff (likely from metal roofing and siding) at Rick's Master Marine from approximately 1990 until the basin was decommissioned in 2018. In the present day, rainwater from the roof drains to CB-02 and is ultimately transported to the river via CA-01. Contamination from outdoor tire storage at the Tire Factory Shop is another potential source of zinc.

2.2.2 Potential Sources of Copper in Catchment Area CA-01

Copper concentrations exceeded the maximum daily benchmark once in CA-02 and five times in CA-01. Potential sources of copper at the site include vessel surface preparation, bottom paint removal, sanding, copper-based bottom painting, and engine maintenance and repairs. These activities were performed in CA-01 until prohibited in October 2021. Currently, these industrial operations only occur in the designated area encompassing CA-02.

CB-02, CB-05, and CB-06 are located within CA-01 and transports rainwater to the LDW. Copper-contaminated runoff from historical exterior maintenance and vessel surface preparation would have entered these catch basins from the start of operations as a marina in 1970 until October 2021 when these practices were no longer permitted. Although boat exterior maintenance occurred on tarped areas, any discharges to the catch basins and LDW were untreated from 1970 until November 2021 when South Park Marina installed drop-in catch basin filter inserts to all catch basins throughout the property. The likely sources of copper would be attributed to poor housekeeping during vessel surface preparation, bottom paint removal, and copper-based bottom painting.

2.3 Boatyard Stormwater Sampling Results

Zinc benchmarks have been exceeded 14 times since August 8, 2016, the effective date of the current permit. Concentrations of zinc were above the maximum daily benchmark value of 90 micrograms per liter (µg/L)[8] in two StormwateRx samples in January 2018, one StormwateRx sample in April 2018, one StormwateRx sample in April 2021, one catch basin sample in April 2021, three catch basin samples in May 2021, two catch basin samples in April 2022, and four catch basin samples in May 2022. The seasonal average zinc concentration for the 2018 to 2019 sampling period, collected in April, was above the seasonal average benchmark of 85 µg/L. The seasonal average zinc concentration for the 2021 to 2022 sampling period, collected in May, was above the seasonal average benchmark of 85 µg/L.

Copper benchmarks have been exceeded six times since the effective date of the permit. Concentrations of copper were above the maximum daily benchmark value of 147 µg/L[9] in one StormwateRx sample in May

[8] (Ecology 2016)

[9] (Ecology 2016)

2019, two catch basin samples in April 2021, one catch basin sample in May 2021, and two catch basin samples in May 2022. The seasonal average copper concentration for the 2021-2022 sampling period, collected in May, was above the seasonal average benchmark of 50 µg/L.

Although total suspended solids (TSS) are not required to be analyzed under the existing permit, TIG analyzed TSS for informational purposes in preparation for the permit renewal and to better evaluate the treatment methods for dissolved contaminants. TSS benchmarks have only been exceeded once since the effective date of the current permit. The TSS concentration was above the maximum daily benchmark value of 30 milligrams per liter (mg/L) in one catch basin sample in April 2021. The following table provides a summary of stormwater sampling results for zinc, copper, and TSS under the current permit. Refer to the next page for the table legend and table notes.

Table 1: Stormwater Sampling Results

Catchment Area	Sample Collection Point	Sample Collection Date	Zinc Analytical Result (µg/L)	Copper Analytical Result (µg/L)	TSS (mg/L)[1]
CA-02	StormwateRx (Post-treatment)	1/5/2018	**300**	7.0	--
	StormwateRx (Post-treatment)	1/23/2018	**120**	6.6	--
	StormwateRx (Post-treatment)	4/10/2018	**115**[2]	7.3	--
	StormwateRx (Post-treatment)	5/14/2019	36	**150**	--
	StormwateRx (Post-treatment)	4/24/2021	**98**	130	ND
CA-01	CB-02	4/24/2021	**1900**	**180**	**130**
	CB-05	4/24/2021	89	**300**	8.0
	CB-02	5/27/2021	**860**	67	4.0
	CB-05	5/27/2021	**130**	110	8.0
	CB-06	5/27/2021	**330**	**300**	20
	CB-02	4/19/2022	**850**	60	ND
	CB-06	4/19/2022	**100**	53	ND
	CB-02	5/5/2022	**170**	**85**[3]	ND

Catchment Area	Sample Collection Point	Sample Collection Date	Zinc Analytical Result (µg/L)	Copper Analytical Result (µg/L)	TSS (mg/L)[1]
	CB-06	5/5/2022	**110**	75	18
	CB-02	5/5/2022	**510**[4]	110	ND
	CB-06	5/5/2022	**105**[5]	**64**[6]	18
Maximum Daily Benchmark (µg/L)[7]			**90**	**147**[8]	N/A[9]
2018 Seasonal Average Benchmark (µg/L)			**85**	**50**	N/A

Bold Result is above the maximum daily benchmark

-- This parameter was not analyzed

N/A The 2018 seasonal average benchmark does not apply

ND Non-detect result

These results triggered a Level Three Response

Notes

[1] This analyte is not required under the existing permit and was analyzed here for informational purposes and to prepare for the permit renewal.

[2] The April 2018 zinc result was 28 µg/L, but the calculated seasonal average for all 2017–2018 monitoring events was 115 µg/L, to be compared with the seasonal average benchmark of 85 µg/L.

[3] The May 2022 copper result from CB-02 was 110 µg/L, but the calculated seasonal average for all 2021–2022 monitoring events was 85 µg/L, to be compared with the seasonal average benchmark of 50 µg/L.

[4] The May 2022 zinc result from CB-02 was 170 µg/L, but the calculated seasonal average for all 2021–2022 monitoring events was 510 µg/L, to be compared with the seasonal average benchmark of 50 µg/L.

[5] The May 2022 zinc result from CB-06 was 110 µg/L, but the calculated seasonal average for all 2021–2022 monitoring events was 105 µg/L, to be compared with the seasonal average benchmark of 50 µg/L.

[6] The May 2022 copper result from CB-06 was 75 µg/L, but the calculated seasonal average for all 2021–2022 monitoring events was 64 µg/L, to be compared with the seasonal average benchmark of 50 µg/L.

[7] (Ecology 2016).

[8] The new permit establishes a copper benchmark of 36 µg/L (Ecology 2022).

[9] This benchmark is not currently in effect. The new permit, however, establishes a TSS limit of 30 mg/L.

3. Proposed Stormwater Treatment Improvement Alternatives

Based on the stormwater data, qualitative evaluation of operations, existing BMPs, and lack of stormwater treatment for the runoff to the SPM outfall, source control and treatment improvements should be focused on CA-01. This section evaluates requirements, restrictions, and considerations for treatment of stormwater runoff from CA-01.

Methods and alternatives that were considered for stormwater treatment improvements are based on site evaluation consistent with Volume V of the Stormwater Management Manual for Western Washington (SWMMWW) (Ecology 2014; Ecology 2019). This volume outlines BMPs to address the treatment of runoff and describes the process for selecting applicable permanent runoff treatment facilities.

3.1 Regulatory Considerations for Selection of the Treatment Method

Using the methodology presented in Ecology's 2019 SWMMWW, TIG evaluated site and regulatory conditions for preliminary design of a treatment alternative appropriate to reduce copper and zinc concentrations to below benchmark values.

3.1.1 Receiving Waters

In the Boatyard Permit, Ecology establishes benchmarks for site contaminants in stormwater discharging to waters of the State of Washington. These benchmarks include seasonal average and maximum daily benchmarks for copper and zinc. In addition, the SWMMWW describes further stormwater treatment controls for waterways where there is a concern for phosphorus or other contaminants affecting designated aquatic uses (Ecology 2019).

Enhanced treatment facilities are necessary for industrial, commercial, multi-family residential, and certain roadway development projects that discharge to fresh waters designated for use by aquatic life. Federally listed waterways that have been designated as not supporting beneficial uses due to phosphorus and waterways in Washington State listed as needing non-point source assessment due to nutrients require a phosphorous control treatment facility (Ecology 2019). Stormwater from the site discharges to the Duwamish River, which Ecology describes "from the mouth, south of a line from the NW corner of berth 3, terminal No. 37 to the Black River" as "Rearing/Migration" fresh-water aquatic use.

Based on review of the receiving waters, stormwater discharges from the site will not require phosphorus control. Although the Duwamish River includes listed aquatic uses, the site is not considered a development project and therefore does not require enhanced treatment. Treatment facilities at the site will be constructed to address Boatyard Permit benchmarks for copper and zinc.

3.1.2 Site Characteristics

The site occupies a total of 3.7 acres along the LDW in South Seattle. Since the site is a recreational marina and do-it-yourself boatyard, as much of the available surface area as possible is used for boat parking and for tenant and marina staff to conduct boat maintenance and repair. Because of the importance of maintaining as much facility space as possible for revenue generating operations, TIG considered the size of alternatives when determining the preferred alternative.

Site operations and site-specific features guide the selection of the stormwater treatment method. SWMMWW requires specific treatment methods for facilities that generate high amounts of oil due to "high-use" (Ecology 2019). Sites considered "high-use" include sites with average daily traffic greater than 100 vehicles per 1,000 square feet (sq ft) of building area; petroleum storage and transfer exceeding 1,500 gallons per year; parking, storage, or maintenance of more than 25 vehicles over 10 tons; some roadways; and a list of other specified land uses (Ecology 2019). Because the site does not fall under the definition of “high-use” included in the SWMMWW, the site will not require an oil control facility.

Ecology also indicates sites should potentially consider infiltration for pollutant removal. Infiltration facilities must include soil that is chemically and physically suitable for pollutant removal and, the soil must meet site suitability criteria (SSC) for groundwater protection, depth to bedrock, water table, or impermeable layer, and setback criteria. Unstable slopes (SSC-7) can preclude the use of infiltration. The majority of the site (68 percent or 2.5 acres) is paved and/or occupied by site operations. Unpaved areas could potentially be used for an infiltration facility; such areas are located along the site’s boundary slope with the Duwamish River (Ecology 2019).

In addition to site characteristics described by Ecology, site-specific considerations for treatment selection such as wheel loading on the site’s pavement were considered. Any underground infrastructure constructed must withstand loading from site equipment.

Based on requirements for the receiving waters and the site-specific characteristics, TIG developed design criteria for screening of treatment methods to determine which methods can be considered for the site.

3.1.3 Design Criteria

As specified in SWMMWW Volume V, the selected treatment alternative will be designed to accommodate the volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a 6-month, 24-hour storm) (Ecology 2019). In addition to the single event evaluation, TIG reviewed the Western Washington Hydrology Model to determine runoff amount (Appendix I). The volume of runoff calculated below is representative of catchment area CA-01 only, as this is the catchment area that is proposed for treatment in this report.

This value was not amended to reflect local precipitation statistics. Therefore, the 6-month, 24-hour precipitation amount is assumed to be 72 percent of 2-year 24-hour amount described in SWMMWW Volume III, Section 2.3.1. The single event storm evaluation is summarized in the table below.

Table 2: Single Event Evaluation

Sea-Tac 6-month Storm Depth (inches)[1]	1.32
Outfall Basin Area (sq ft)	97,900
Design Storm Volume (gallons per day [gpd])	80,552
Design Storm Volume (liters per day [lpd])	304,922
Representative zinc concentration[2] (µg/L)	512
Treatment System Zinc Loading[3] (grams per day [g/day])	197

Representative copper concentration (µg/L)[4]	136
Treatment system copper loading (grams per day [g/day])	43

Notes

[1] Volume I Appendix 1-B (Ecology 2014; Ecology 2019).

[2] Representative zinc concentration for the design storm was calculated by obtaining the average zinc concentrations for all catch basin samples collected in CA-01.

[3] Treatment system zinc loading for the design storm was calculated by multiplying the representative zinc concentration by the design storm volume.

[4] Representative copper concentration for the design storm was calculated by obtaining the average zinc concentrations for all catch basin samples collected in CA-01.

Based on the estimated zinc concentration and anticipated treatment system loading, TIG estimates that an approximate reduction percentage of at least 85 percent would be required to consistently achieve benchmark requirements. Based on the estimated copper concentration and anticipated treatment system loading, on average no reduction is necessary; however, based on the single highest event, the system would need to achieve a 50 percent reduction in copper concentrations to achieve benchmarks.

3.2 Screening of Stormwater Management / Treatment Approaches

The following table identifies treatment methods and their applications as presented by Ecology in their Stormwater Management Manual (Ecology 2014, 735–737; Ecology 2019). The methods were screened by TIG for their applicability at the South Park Marina facility based on site-specific conditions and considerations.

Table 3: Evaluation of Treatment Methods

Treatment Method	Use	Considered For Site?	Reasoning
Wetpools	Sedimentation	N	The primary pollutants for treatment are dissolved.
Biofiltration	Sedimentation; pollutant removal	N	Presence of subsurface contamination in site soils makes this treatment methodology infeasible.
Oil/Water Separation	Floating oil removal	N	Site is not a “high-use” area.
Pretreatment	Pre-sedimentation for infiltration facilities	N	Precluded because infiltration is not considered for the site.

Treatment Method	Use	Considered For Site?	Reasoning
Infiltration	Filtration or adsorption using native materials; must have compatible soils (silty and sandy loams) for treatment; coarser soils used for flow control only	N	Contaminated soils at site could present a hazard to groundwater.
Bioretention	Filtration or adsorption using imported soils	N	Space limitations at the site do not allow sufficient pervious surface area for this technology.
Filtration and adsorption	Media removal of TSS and soluble metals	Y	Consistent with demonstrated effectiveness for other portions of the site.
Emerging technologies	Technologies subject to conditions specified in Technology Assessment Protocol - Ecology (TAPE) program	N	Project does not include listed development described by Ecology.
Online systems	Excess flows pass through facility with lessor or no removal efficiency (in contrast, offline systems bypass excess flows around them)	N	Existing treatment system uses bypass. New facility is expected to operate similarly.

Upon evaluation of the treatment methodologies detailed in the above table, TIG determined that filtration is the most feasible treatment technology. The following sections describe the proposed alternatives, each of which uses filtration technology.

3.3 Stormwater Treatment Systems Evaluation and Proposed Alternatives

This section presents the five alternatives considered for treatment of runoff in catch basin CB-01. Consistent with the determination made in Section 3.2, each of the proposed alternatives uses filtration and adsorption technology.

3.3.1 Alternatives 1a and 1b: Routing of CA-01 Drainage to Existing Treatment Facility

Alternative 1 includes the construction of a conveyance system to route runoff from CA-01 to an existing treatment facility treating stormwater in catchment area CA-02. Operations conducted in CA-01 are substantially similar to those conducted in the CA-02, and the existing treatment in CA-02 effectively reduces contaminant concentrations to below benchmark values; therefore, the existing treatment system media is appropriate to treat the runoff from CA-01.

According to product documentation provided by the manufacturer, StormwateRx, the existing system is sized to treat approximately 25 to 75 gallons per minute (gpm) or an area of approximately 0.5 to 1 acre. Adding stormwater runoff from CA-01 requires new stormwater conveyance infrastructure and either the replacement of the existing treatment system with a larger model to accommodate the addition runoff, the addition of a supplemental model in existing location, or the addition of pretreatment storage to allow the existing system to treat the larger volume of stormwater over an extended period of time. The combined area to be treated is 3.05 acres. Required treatment facility upgrades necessary for this alternative would be specified by the manufacturer.

Costs for Alternative 1a, using the existing system which would require installing tankage for temporary storage of the additional runoff from CA-01 ranges from approximately $59K to $84K (Appendix D). Costs for Alternative 1b, upgrading the existing treatment system to a larger model, to accommodate the runoff from both CA-01 and CA-02, as well as addition of storage for contingency purposes range from $114K to $140K. These costs do not consider the additional expense required to update the conveyance infrastructure to convey all of the site stormwater to the existing treatment system. It is anticipated that the conveyance infrastructure updates to achieve the necessary drainage pattern would be approximately double what is currently presented in Section 3.5. Due to this logistical complexity and cost consideration, as well as the increased disruption to the operational areas of the site, TIG does not consider this alternative to be realistic or practical for implementation at the site, and therefore will no longer evaluate it throughout this report or its appendices.

3.3.2 Alternative 2: New Treatment System at CA-01

Each of the below alternatives (Alternative 2a through 2d) includes modifications to the stormwater conveyance system across catchment area CA-01 (Section 3.4) to route runoff to a new above-ground treatment facility upgradient of the SPM outfall. This treatment facility would consist of an above-ground multi-media filtration system specified and sized by the manufacturer to treat copper and zinc in stormwater in the SPM outfall basin. Additional details including design criteria, technical specifications, and flow diagrams are provided for each alternative in Appendix D.

Alternative 2a: StormwateRx Aquip System

For this alternative, TIG chose to evaluate placement of a second, StormwateRx Aquip system on the site to treat runoff from CA-01. TIG recommend installation of the Model 110SBE size StormwateRx Aquip system based on the information provided by the manufacturer’s design engineer as well as the information presented in Appendix D and Appendix E. This system would occupy approximately 11 ft by 19.5 ft of surface area and contain a single treatment chamber with layers of inert media to filter out copper and zinc to below benchmark values.

The estimated total initial cost of this alternative is $433K and the annualized operation and maintenance costs are $25K. TIG anticipates that this alternative will be effective in treating stormwater runoff to below permit benchmarks because the site currently uses an Aquip System with steel basic enhanced (SBE) media to treat stormwater runoff from CA-02, the existing system effectively reduces contaminant concentrations to below benchmarks, and the characteristics of the runoff in CA-01 and CA-02 are expected to be substantially similar. Therefore, installing a second StormwateRx unit in CA-01 is a technically feasible and appropriate alternative.

Alternative 2b: Clear Creek Systems Pressurized Filtration System

For this alternative, TIG chose to evaluate placement of Clear Creek Systems active, pressurized filtration system that can either be completely above ground or contain some above and some below ground elements. This system contains a series of five steps designed to reduce dissolved metals concentrations: gravity settling, mechanical filtration, adsorptive media, ion exchange, and discharge.

The estimated total initial cost of this alternative is $567K with annual O&M costs estimated around $10K based on the information presented in Appendix D and Appendix F. TIG anticipates that this alternative will be effective in treating stormwater runoff to below permit benchmarks because Clear Creek Systems has used a similar configuration and media design at other boatyards with similar operations and contaminant concentrations in Washington State and has observed successful reduction of contaminants to below benchmark values in these example locations.

Alternative 2c: Clear Water Services Gravity Filtration System

For Alternative 2c, TIG evaluated an above-ground treatment system provided by Clear Water Systems, designed to reduce concentrations of metals, including zinc and copper, to below benchmark levels. This above-ground treatment technology incorporates both sand filtration and active media filtration.

The estimated total initial cost of this alternative is $576K with annual O&M costs estimated around $9,300 based on the information presented in Appendix D and Appendix G. TIG anticipates that this alternative will be effective in treating stormwater runoff to below permit benchmarks because Clear Water Services has used a similar configuration and system design at other boatyards with similar operations in Washington State and has observed successful reduction of contaminants to below benchmarks in these example locations.

Alternative 2d: Enpurion Coupled Pressurized Filtration System

Alternative 2d is a multi-step treatment system proposed by Enpurion. This system would include two levels of pretreatment of runoff, downspout filtration and catch basin filtration, prior to a series of above-ground active treatment chambers.

The estimated total initial cost of this alternative is $377K with annual O&M costs estimated around $29K based on the information presented in Appendix D and Appendix H. TIG anticipates that this alternative will be effective in treating stormwater runoff to below permit benchmarks because Enpurion has demonstrated successful reduction of contaminants to below benchmark limits in other facilities that have this technology implemented and where extensive bench trials have taken place.

3.4 Comparison of Treatment Alternatives

To evaluate each of the proposed alternatives, TIG developed a ranking framework that assigns a value for each of the following metrics: technical effectiveness, initial cost, O&M costs, and system ease of use. The definitions of the four values are listed in Appendix D. Following assignment of these values, TIG summed the individual metric values for each alternative, and the alternative with the highest overall score was selected as the preferred alternative.

Table 4: Ranked Comparison of Treatment Alternatives

	Alternative 2a[1]	Alternative 2b	Alternative 2c	Alternative 2d
Technical Feasibility	4	4	4	4
Initial Cost	3	2	1	4
O&M Costs	2	3	4	1
Ease of Use	4	3	2	1
Total	**13**	**12**	**11**	**10**

Notes

[1] As is described at the end of Section 3.3.1, Alternative 1 was ruled out prior to the rankings due to the cost and logistical infeasibility of routing all of the site drainage to catchment area CA-02.

Following assignment of the values in the above table, TIG determined that Alternative 2a is the preferred alternative for implementation at the South Park Marina site.[10]

3.5 Stormwater Infrastructure Upgrades Required for All Alternatives

Prior to installation of a new above-ground filtration system, site and catchment area infrastructure upgrades are required to ensure maximum effectiveness. The proposed infrastructure updates include removal and replacement of catch basins CB-02, CB-05, and CB-06; decommissioning of existing lines running between each of the basins and replacement with functional lines; and replacement of the SPM outfall (Figure 5).

During installation, the outlet sample port will be moved from its standard location to a new location that includes possible overflows. TIG will determine the new sample port location based on discussion with Ecology and the manufacturer so that both the outlet and overflow of the treatment system can be sampled. TIG will obtain Ecology approval before installation.

[10] Following review of this *Level Three Response Engineering Report for Zinc and Copper*, Ecology recommended that the facility have a second pump available at the site for repairs. This recommendation will be implemented during design and installation of the system.

Catchment-area wide infrastructure updates include replacement of basin CB-02, and consolidation of CB-05 and CB-06 into one, larger basin. South Park Marina will also decommission the existing stormwater lines running between these basins and replace with new pipes. Finally, South Park Marina will replace the line running between the new combined catch basin proposed for location where CB-05 and CB-06 currently reside and the SPM outfall and will replace the outfall itself. Each of these updates is necessary to ensure the conveyance system is fully functional and that any treatment system incorporated with the conveyance system will function as effectively and efficiently as possible.

Below is a table of approximate costs for each of the work items to be completed as part of the infrastructure updates.

Table 5: Cost Breakdown of Sitewide Infrastructure Upgrades

Task	Assumptions	Approximate Cost
Decommission existing stormwater lines	Grout, 6" diameter pipe, approx. 75 yards of controlled density fill (CDF). Includes a line pump for a day, time to create access points, and eco pans for cleaning at task completion.	$25K
Replace catch basin CB-2, remove catch basins CB-05 and CB-06 and replace with a single, new basin (larger) with a pump to move water into treatment system	Includes labor over multiple days for removal of existing basins, purchase of approx. 5' diameter basin, trucking, purchase, placement, and compaction backfill and existing pan disposal.	$18K
Replace stormwater lines between CB-02 and new catch basins in locations CB-05 and CB-06	Includes Schedule 80 pipe, equipment, labor, excavation, trucking and disposal of non-hazardous waste, installation of pipes, fittings, and placement and compaction of backfill.	$27K
Replace stormwater line between CB-05 and CB-06 and Duwamish River	Includes equipment, labor, excavation, trucking and disposal of non-hazardous waste, pipes, and fittings. Assumes tying into existing pipe prior to shoreline.	$25K
Install a 10’ x 20’ cement foundation	Assuming adequacy for each stormwater system alternative.	$20K
Replace the SPM outfall	Can be done under a "maintenance upgrade" later.	TBD
	Total	$135K

3.6 Schedule and Expectation of Benchmark Achievement

As required by Section S7A of the Boatyard Permit, implementation of the preferred option will occur within 12 months of the time Ecology accepts the Engineering Report. The following items will be completed within that timeframe:

- Selection of an alternative to be implemented and procurement of all contractors and vendors
- Acquisition of all required permits
- Construction of all site conveyance system and infrastructure updates
- Construction and/or installation of the above-ground stormwater filtration system

Contingent actions following completion of the above stormwater treatment steps will be to implement additional media layers, or pretreatment options (catch basin or downspout filters). Those contingent treatment BMPs would be implemented in a sequential manner, as necessary, within 90 days of receiving the analytical results from sampling.

The schedule for monitoring will follow regular monitoring as required by the site's Boatyard Permit. Inc and copper benchmarks are expected to be met immediately following successful implementation of the selected alternative.

4. Use of this Report

The Level 3 Engineering Design Report has been prepared for the exclusive use of South Park Marina and applicable regulatory agencies for specific application to stormwater system improvements at the site. No other party is entitled to rely on this information, conclusions, and recommendations included in this document without the express written consent of TIG Environmental. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by TIG Environmental, shall be at the user's sole risk. TIG Environmental warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, neither express nor implied.

5. References

Ecology (Washington State Department of Ecology). 2013. Guidelines for the Preparation of Industrial Stormwater General Permit Engineering Reports.

Ecology (Washington State Department of Ecology). 2014. 2012 Stormwater Management Manual for Western Washington, as Amended in December 2014.

Ecology (Washington State Department of Ecology). 2016. Boatyard General Permit.

Ecology (Washington State Department of Ecology). 2019. Stormwater Management Manual for Western Washington.

Ecology (Washington State Department of Ecology). 2022. Boatyard General Permit.

Ecology (Washington State Department of Ecology). n.d. State Requirements for Submission of Engineering Reports and Plans for Industrial Wastewater Treatment Facilities.

Figures

TIG environmental®
INVESTIGATIONS ▾ FORENSICS ▾ REMEDIATION

Figure 1

South Park Marina Site Location Map

South Park Marina

Level Three Response Engineering Report

TIG environmental

Data Location: Syracuse Created By: mkohberger Modified By: kives
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Legend:

- Catch basin/inlet
- Outfall
- Manhole
- Roof drain
- Roof drain associated with metal roof
- Sewer pipe, unknown drainage destination
- Pump station
- Flush tank
- Pump vault
- Sanitary sewer vault
- Catch basin insert
- Storm sewer pipe
- Unknown link - stormwater system
- Vessel wash collection pipe
- Combined sewer pipe
- Sanitary sewer pipe
- Structure
- StormwateRx™ CONEX box
- Washwater treatment CONEX box
- Duwamish River (approximate)
- South Park Marina site boundary
- Upland parcel

Notes:

1. Sewer network data for the riverfront parcel provided by the City of Seattle (City of Seattle 2013) and modified by TIG based on findings from the March 2017 topographic survey, the September 2017 catch basin camera scoping survey, and the February 2018 dye tracer investigation. Sewer network data for the upland parcel provided by the City of Seattle (City of Seattle 2020) and verified during a site walk conducted on April 15, 2021.
2. Parcel boundaries provided by King County (King County 2013).
3. Aerial imagery provided by ESRI online services (ESRI 2020).

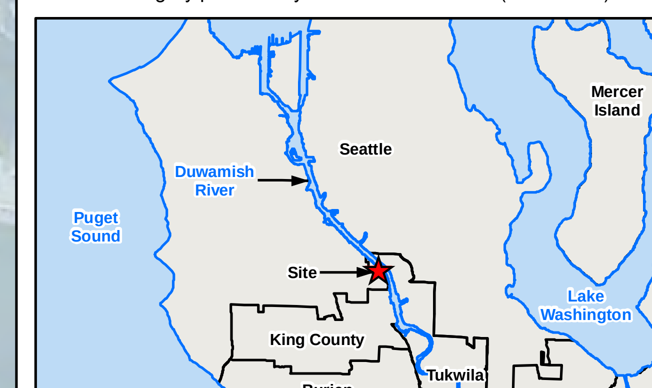

Figure 2

Drainage from South Park Marina Uplands Parcel

South Park Marina

Level Three Response Engineering Report

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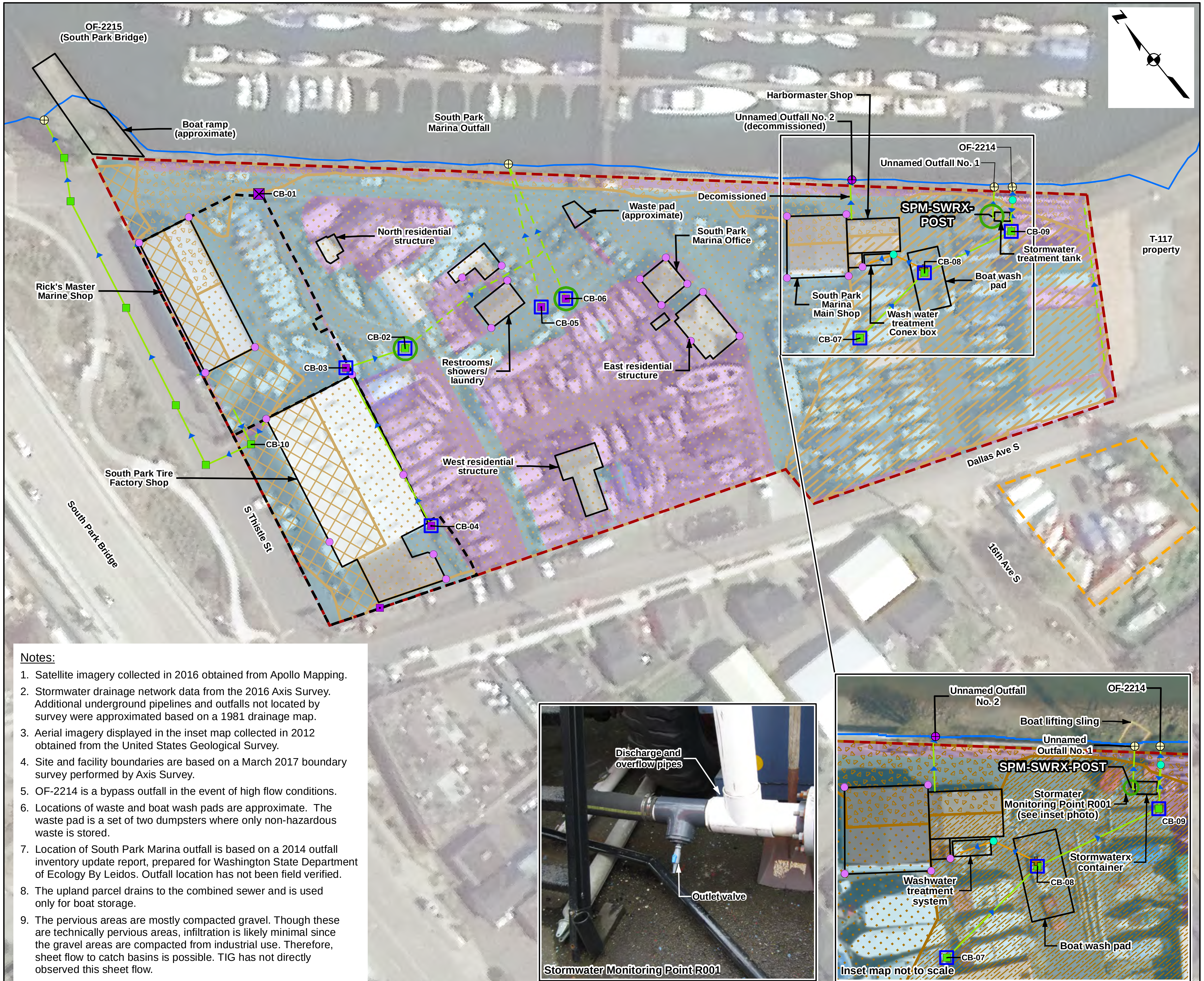

Notes:

1. Satellite imagery collected in 2016 obtained from Apollo Mapping.
2. Stormwater drainage network data from the 2016 Axis Survey. Additional underground pipelines and outfalls not located by survey were approximated based on a 1981 drainage map.
3. Aerial imagery displayed in the inset map collected in 2012 obtained from the United States Geological Survey.
4. Site and facility boundaries are based on a March 2017 boundary survey performed by Axis Survey.
5. OF-2214 is a bypass outfall in the event of high flow conditions.
6. Locations of waste and boat wash pads are approximate. The waste pad is a set of two dumpsters where only non-hazardous waste is stored.
7. Location of South Park Marina outfall is based on a 2014 outfall inventory update report, prepared for Washington State Department of Ecology By Leidos. Outfall location has not been field verified.
8. The upland parcel drains to the combined sewer and is used only for boat storage.
9. The pervious areas are mostly compacted gravel. Though these are technically pervious areas, infiltration is likely minimal since the gravel areas are compacted from industrial use. Therefore, sheet flow to catch basins is possible. TIG has not directly observed this sheet flow.

Legend:

- Sampling location
- Outfall
- Catch basin/inlet
- Roof drain
- Pump vault
- Vessel washwater catch basin (approximate)
- Yard drain
- Catch basin insert
- Storm sewer pipe
- Unknown link - stormwater system
- Vessel wash collection pipe
- Decommissioned outfall
- Decommissioned catch basin
- Tenant lease boundary
- Structure/area
- Pervious area
- Impervious area
- Shoreline (approximate)
- Site boundary
- Upland parcel

Site catchment areas:

- Infiltrates through gravel surface (CA-04)
- Unnamed Outfall No. 1/OF-2214 (CA-02)
- OF-2215 (CA-03)
- South Park Marina Outfall (CA-01)

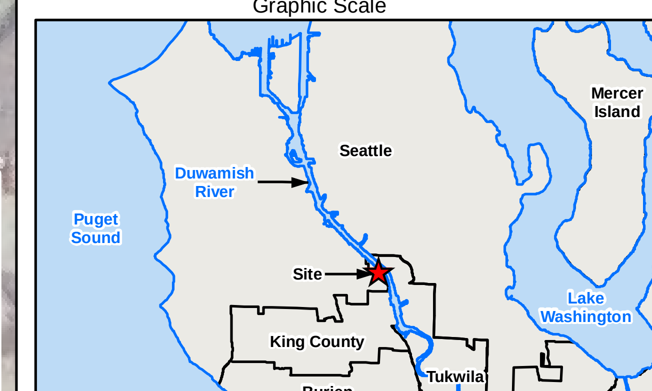

Figure 3

South Park Marina Catchment Area Overview

South Park Marina

Level Three Response Engineering Report

TIG environmental

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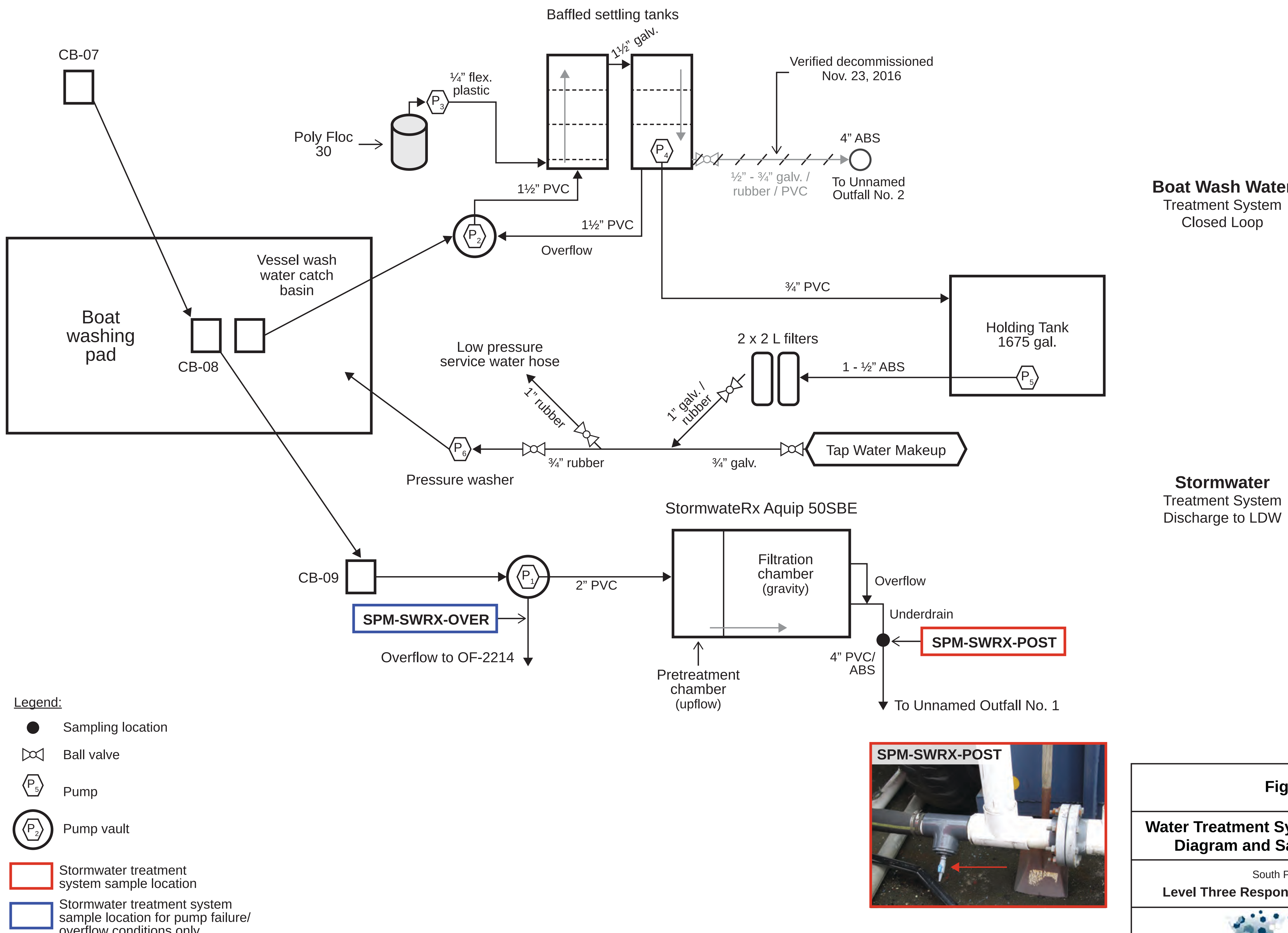

Figure 4

Water Treatment Systems Process Flow Diagram and Sampling Location

South Park Marina

Level Three Response Engineering Report

TIG environmental

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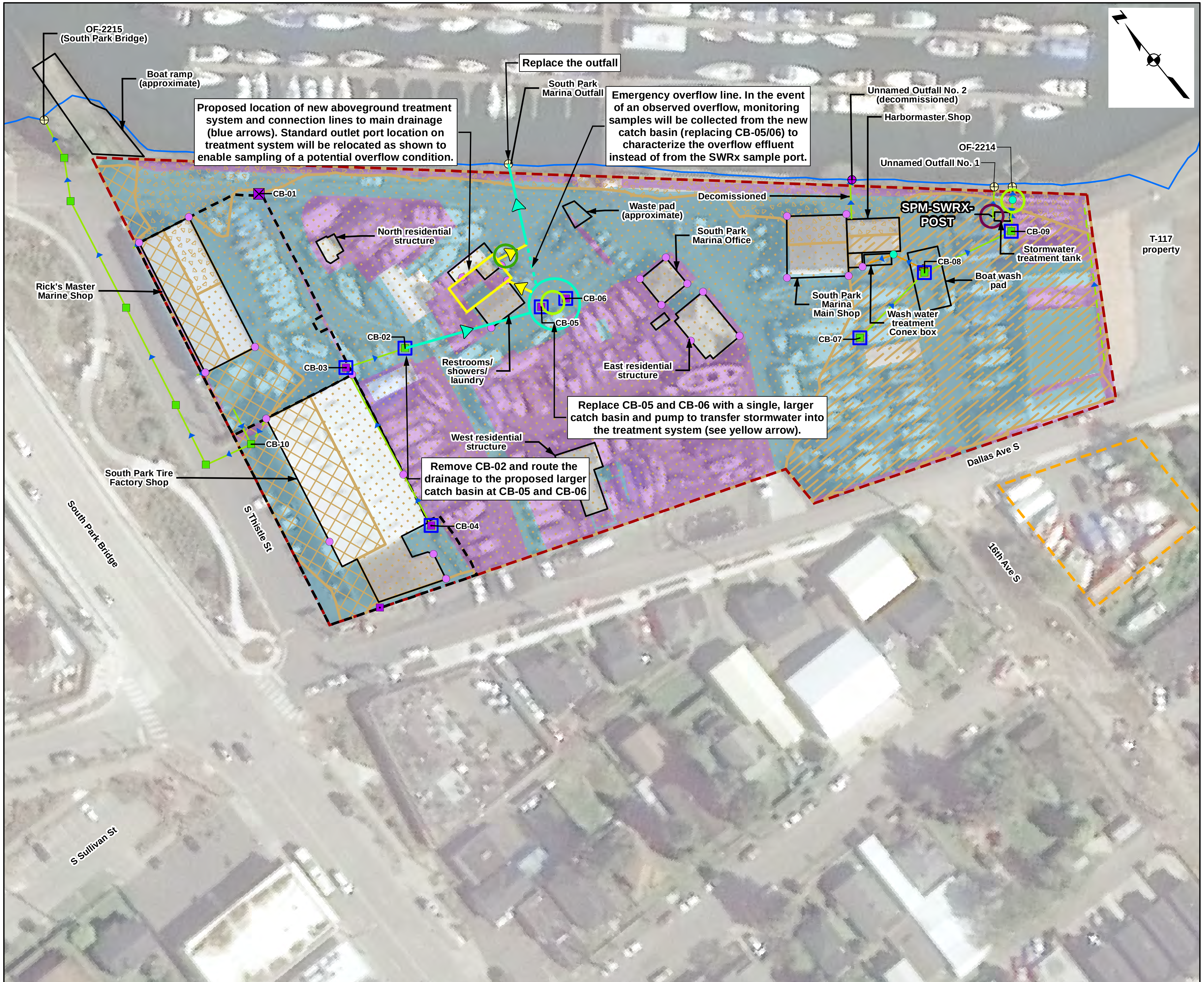

Legend:

- Existing sample location
- Proposed sample location
- Overflow sample location
- Outfall
- Catch basin/inlet
- Roof drain
- Pump vault
- Vessel washwater catch basin (approximate)
- Yard drain
- Catch basin insert
- Storm sewer pipe
- Unknown link - stormwater system
- Vessel wash collection pipe
- Proposed drainage network
- Decommissioned outfall
- Decommissioned catch basin
- Tenant lease boundary
- Structure/area
- Pervious area
- Impervious area
- Shoreline (approximate)
- Site boundary
- Upland parcel

Site catchment areas:

- Infiltrates through gravel surface (CA-04)
- Unnamed Outfall No. 1/OF-2214 (CA-02)
- OF-2215 (CA-03)
- South Park Marina Outfall (CA-01)

Notes:

1. Satellite imagery collected in 2016 obtained from Apollo Mapping.
2. Stormwater drainage network data from the 2016 Axis Survey. Additional underground pipelines and outfalls not located by survey were approximated based on a 1981 drainage map.
3. Site and facility boundaries are based on a March 2017 boundary survey performed by Axis Survey.
4. OF-2214 is a bypass outfall in the event of high flow conditions.
5. Locations of waste and boat wash pads are approximate. The waste pad is a set of two dumpsters where only non-hazardous waste is stored.
6. Location of South Park Marina outfall is based on a 2014 outfall inventory update report, prepared for Washington State Department of Ecology By Leidos. Outfall location has not been field verified.
7. The upland parcel drains to the combined sewer and is used only for boat storage.

0 70 140 Feet

Graphic Scale

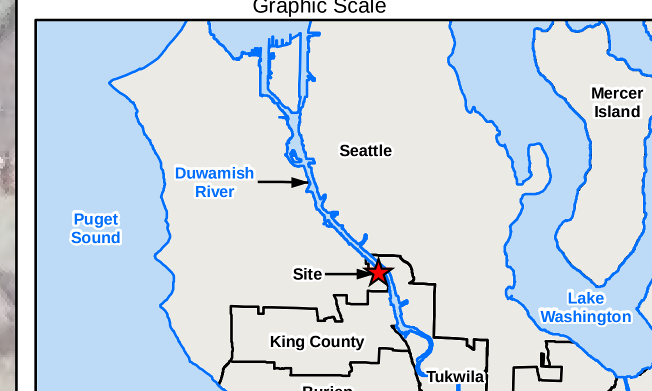

Figure 5

Proposed Site Infrastructure Updates

South Park Marina

Level Three Response Engineering Report

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Appendix A

Acronyms and Abbreviations

Appendix A: Acronyms and Abbreviations

Level Three Response Engineering Report for Zinc and Copper

BMP	best management practice
CA	catchment area
CDF	controlled density fill
DMR	discharge monitoring report
Ecology/~~ECY~~	Washington State Department of Ecology
GAC	granular activated carbon
gpd	gallons per day
gpm	gallons per minute
g/day	grams per day
LDW	Lower Duwamish Waterway
lpd	liters per day
µg/L	micrograms per liter
mg/L	milligrams per liter
NaOH	sodium hydroxide
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
SBE	steel basic enhanced
SPM	South Park Marina
SPM Outfall	South Park Marina Outfall
SSC	site suitability criteria
sq ft	square feet
SWMMWW	Stormwater Management Manual for Western Washington
SWPPP	Stormwater Pollution Prevention Plan
TAPE	Technology Assessment Protocol - Ecology
TIG	TIG Environmental
TSS	total suspended solids
WAC	Washington Administrative Code
WWHM	Western Washington Hydrology Model

Appendix B

Operation, Inspection, and Maintenance Guide for AbTech Ultra-Urban® Filter

Operation, Inspection, and Maintenance Guide
Rev A
December 2020

Table of Contents

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2.0 Operation 2
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6.0 Inspection Data Sheet 6
7.0 Maintenance Report 7
8.0 Warranty 8

1.0 Description

The Ultra-Urban® Filter (UUF) Chester series is a passive, flow-through, stainless-steel, stormwater filtration, and optional purification system designed as an insert sleeve for catch basins. There are two types of models: the UUF “Drop-In” (UUF DI) and the UUF “Curb Opening” (UUF CO). This Guide is specific for the UUF Chester CO models.

The UUF Chester CO filters are comprised of all stainless-steel parts. Figure 1 is a rendered image showing the key components: flow diverter (if applicable), mounting bracket, filter enclosure, and media (if applicable). As an insert sleeve that is positioned in catch basins lower than street level, it is a gravity operated filter that does not require mechanical parts or power. The unit utilizes a filter screen with orifices of less than 5mm in size to reduce trash, debris, and sediment. In addition to TSS reduction, inclusion of AbTech’s Smart Sponge® media to the filter enclosure can reduce both particulate and dissolved contaminants.

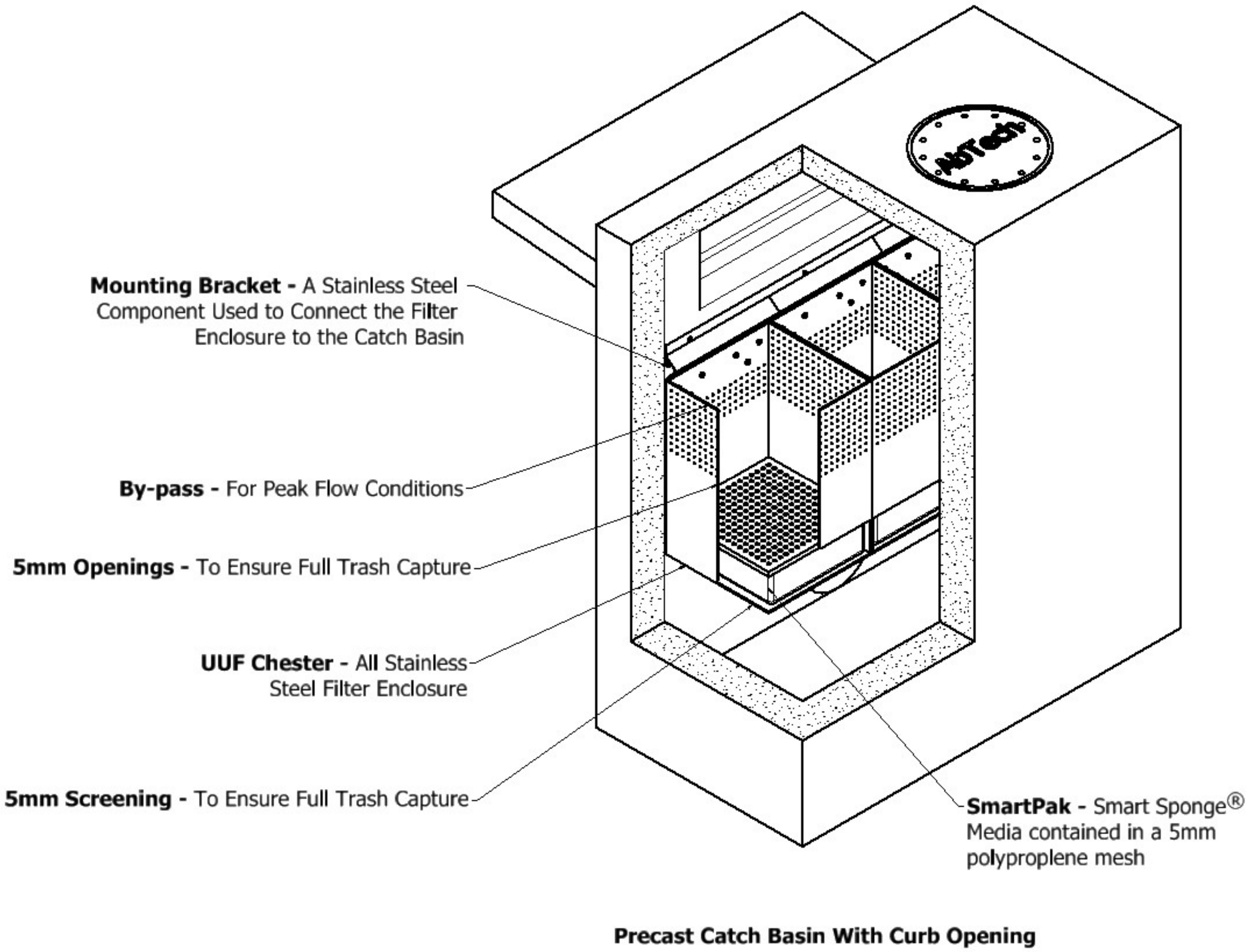


Figure 1: Ultra-Urban® Chester Curb-Opening

2.0 Operation

The UUF Chester CO is positioned beneath the curb opening of catch basin structures used to intercept stormwater runoff from roadways. Untreated stormwater will enter from the curb opening and fall via gravity into the top of the filter insert sleeve(s) positioned beneath the curb opening. Depending on the curb opening size, a flow diverter may be used to ensure that flow entering the curb opening does not short-circuit the filters. This untreated stormwater continues into the face of the filter screen at the bottom of the unit and, subsequently, will be filtered to less than 5mm in particle size. If media is added at the bottom of the filter enclosure, the media and wrap used to restrain the media will provide additional filtration.

Media may be installed as a Smart Pak® at the bottom of the filter enclosure to ensure 100% of water flow is treated. The filtered and purified water will flow out of the unit to be discharged or re-used. The UUF Chester CO is designed with a bypass feature to allow flows exceeding the maximum filtration rate to leave the filter enclosure. Screened bypass initiates when the water levels in the filter enclosure rise above the solid portion of the sides. Full bypass occurs when the water levels rise above the top of the filter insert. A UUF Chester CO is installed in a typical curb opening catch basin and its operation is illustrated in Figure 2.

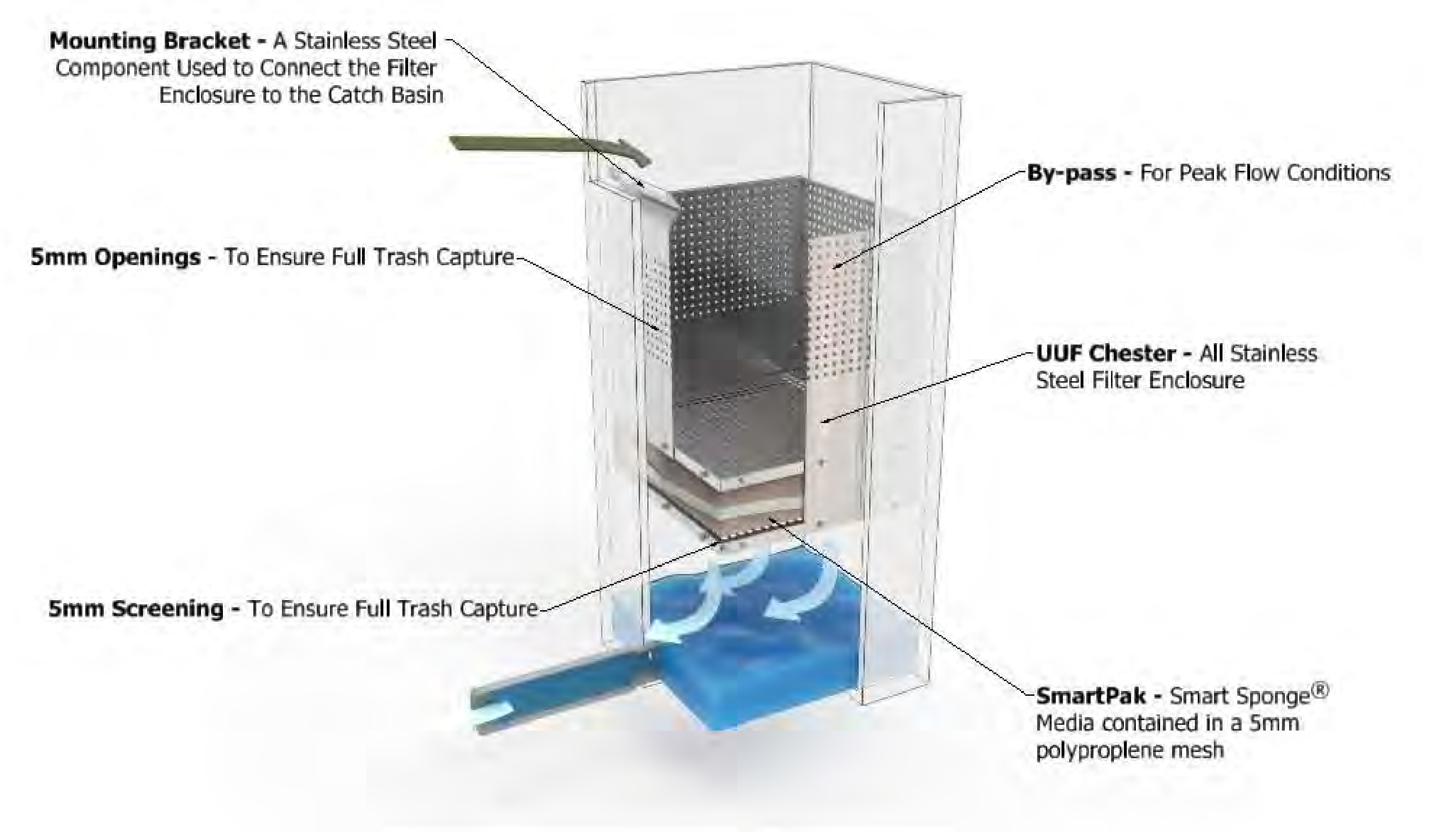


Figure 2: UUF Chester Flow Curb-Opening

3.0 Inspection

3.1 General

Catch basin inspection, maintenance and historic documentation is an integral part of any comprehensive stormwater management plan. A thorough inspection program is necessary to ensure the treatment filter is operating as designed and to provide the necessary pollutant removal. Actively reviewing and updating inspection and monitoring plans will minimize unnecessary maintenance and provide insight to the status of the receiving water bodies. The frequency in which catch basins are cleaned should be based on site-specific factors such as: weather, rainfall events, and expected debris accumulation. It is important to closely monitor and document the first year of operation after initial installation to develop a long-term maintenance plan for the filter that is consistent with actual pollutants loadings.

3.2 Inspection Frequency and Timing

In general, all treatment systems need to be inspected on a routine and recurring basis. The frequency and timing of the inspections will vary based on the configuration of the filter, its location within the drainage system, and the geographic region. During the first year of operation, after initial installation, the UUF Chester should be inspected more frequently to create a baseline of understanding for operation of the filter. Subsequent years of operation can have the inspection frequency adjusted based on working experience provided no irregular events occur during the year.

- First-Year Inspection – Quarterly inspections in the first year are recommended. The first inspection should occur on, or near, the start of the heaviest rainfall season with the last inspection occurring on or around the end of the season. If the location of installation has no definitive rainy season, inspections should be spaced evenly throughout the year. Maintenance visits may coincide with inspection visits.

- Second-Year and Subsequent Year Inspections – Semi-annual inspections are recommended. The first inspection should occur on, or near, the start of the heaviest rainfall season with the last inspection occurring on or around the end of the season. If the location of installation has no definitive rainy season, inspections should be spaced evenly throughout the year. If during the first-year inspection the Filter and/or location is determined have high pollutant loadings or irregular loadings of sediment, trash, and debris, additional inspections may be necessary. Maintenance visits may coincide with inspection visits.

3.3 Inspection Safety and Equipment Considerations

Safety is the most important consideration before inspecting and removing pollutants from the UUF Chester CO. Always employ proper traffic management and handling procedures for all inspections/maintenance where vehicles and pedestrians have access. Disposing of waste liquids and solids may be regulated and should be understood before removing waste products from the treatment system. Urban stormwater drainage structures are often installed along roadside curbs or in parking lots with limited space.

Consider plans for:

- Personal Protective Equipment (PPE) – reflective vests, glasses, steel-toed shoes, gloves
- Allowing personnel space to remove and temporarily store surface grates
- Maneuvering and parking maintenance vehicles
- Equipment for directing traffic and pedestrians - safety cones or barriers and use of appropriate signage
- Equipment for removing the manway/grate (i.e., crowbar, manhole hook, jib crane)
- Tools to loosen consolidated sediment and debris covering the manway/grate
- Storing and disposal of pollutants
- Inspection Data Sheet

In the event of accidental or chemical spill, contact emergency services and follow standard hazmat procedures.

3.4 Inspection Procedures

The UUF Chester CO is typically inspected without entry into the catch basin. The inspection should begin by preparing and installing all safety measures followed by inspection and then documentation. Specific procedures for the inspection are detailed below:

1. Wear all PPE and prepare documentation equipment.

2. Install all work zone safety equipment and conduct a brief safety meeting. Work zone safety equipment should protect the inspector(s) from vehicular traffic and should also isolate and protect pedestrians and vehicles from the work zone.

3. Remove the manhole cover utilizing the manhole puller/remover and safely set aside out of the way of the inspection operations and pedestrians or vehicles.

4. Inspect the grate and catch basin lip. The areas outside of the curb opening should be free from debris, obstructions, and standing water. The presence of any of these conditions outside of the catch basin are potential indicators for a maintenance event. If any of these maintenance indicators are encountered, they should be documented and, depending on severity, should be rectified through recommended maintenance.

Maintenance may occur simultaneously with inspection provided the maintenance indicators have already been documented.

5. Inspect the inside of the catch basin. A flashlight may be needed depending on outside lighting. The interior of the catch basin and pipe outlet(s) should be free from debris, obstructions, and standing water. The presence of any of these conditions in the interior of the catch basin are potential indicators for a maintenance event. If any of these maintenance indicators are encountered, they should be documented and depending on the severity, should be rectified through recommended maintenance. Maintenance may occur simultaneously with inspection provided the maintenance indicators have already been documented.

6. Inspect the mounting bracket and filter enclosure for physical or structural damage. The mounting bracket should be firmly mounted to the catch basin sidewall and there should be no loose or missing hardware. The filter should be supported by the mounting bracket. Bent, broken, or otherwise damaged structural components should be documented and recommended for replacement as needed.

7. Inspect the filter screen for pollutants. Pollutants such as trash and debris, and sediment are expected to be captured inside of the treatment system. The presence of such pollutants are indicators the filter is operating as intended. Conversely, the lack or low quantity of such pollutants present in the filter may be an indicator that the filter is not functioning as intended. The quantities of pollutants should be documented and compared with the maximum capacities for the filter. Maintenance to be scheduled as needed.

8. Inspect the media (if included). When equipped with media, the UUF Chester CO should be inspected to determine the condition of the media wrapping. Smart Sponge® media material darkens in color as it collects pollutants, but with the media wrapping in a Smart Pak, it may be difficult to observe. Observe if a black or oily film has accumulated on top of the media wrapping. If so, its useful life has ended, and replacement is necessary. Alternatively, replacement of the filter media may be necessary after fine sediment has accumulated in the media pack. After dry cleaning the Smart Pak, the media will need to be changed when the increase in weight of a dry Smart Pak equals two times its initial product weight except for sediment, trash, and debris. The condition of the media should be documented, and recommended for maintenance, as needed.

9. Inspect the flow divertor (if installed) for physical damage. The flow diverter should be firmly mounted to the sidewall of the curb opening to direct water into the filter enclosure without short-circuiting the filter(s).

10. Finalize the Inspection Data Sheet. Photograph the conditions of interior and exterior of the catch basin and filter unit. Document the inspection event utilizing the Inspection Data Sheet included with this manual or similar. The presence of standing water or mosquitos should be highlighted per vector control procedures. The local vector control

agency should be notified if mosquitos are present in the catch basin or filter unit.

11. Replace the manhole cover and remove all work zone safety equipment.

4.0 Maintenance and Media Replacement

4.1 General

Catch basin inspection and maintenance is an integral part of any comprehensive stormwater management plan. A thorough maintenance plan is necessary to ensure the treatment filter is operating as designed and is providing the intended pollutant removal. A maintenance plan should be structured based on the type of treatment filter, location, and function of the treatment filter. The frequency in which catch basins are cleaned should be based on site-specific factors such as: weather, rainfall events, and expected debris accumulation. It is important to closely inspect and document the first year of operation after initial installation to develop a long-term maintenance plan for the filter that is consistent with the effluent requirements of the installation.

4.2 Maintenance Frequency and Timing

The UUF Chester CO requires recurring maintenance that is scheduled based on observations made during routine inspections. The frequency and timing of the maintenance visits can be variable based on the configuration of the filter, location of the filter within the drainage system, and the geographic region of installation. During the first year of operation, after initial installation, the UUF Chester should be inspected more frequently to create a baseline of understanding for operation of the filter and servicing needs. Subsequent years of operation can have reduced inspection/maintenance provided no irregular events occur during the year.

- First and Subsequent Year Maintenance – Refer to Section 3.2: Inspection Frequency and Timing. Quarterly inspection visits in the first year are recommended and depending on inspection findings will determine if maintenance is required. A maintenance event will be scheduled following inspections or should occur on or near the start of the heaviest rainfall season with the last inspection occurring on or around the end of the that season. If the location of installation has no definitive rainy season, maintenance visits should be spaced evenly throughout the year. Maintenance visits may coincide with inspection visits.

- Second-Year and Subsequent Year Maintenance – Semi-annual maintenance visits are recommended. The first maintenance visit should occur on or near the start of the heaviest rainfall season with the last visit occurring on or around the end of the that season. If the location of installation has no definitive rainy season, maintenance should be spaced evenly throughout the year to align with inspection visits. If during the first-year inspection/maintenance visit the filter and/or location is determined have high pollutant loadings or irregular loadings of sediment, trash, and debris, additional maintenance visits may be necessary. Maintenance visits may coincide with inspection visits.

4.3 Maintenance Safety and Planning Considerations

Safety is the most important consideration before maintaining and removing pollutants from the UUF Chester CO unit. Always employ proper traffic management and handling procedures for all inspections/maintenance where vehicles and pedestrians have access. Disposing of waste liquids and solids may be regulated and should be understood before removing waste products from the treatment system. Urban stormwater drainage structures are often installed along roadside curbs or in parking lots with limited space.

Consider plans for:

- Personal Protective Equipment (PPE) – reflective vests, glasses, steel-toed shoes, gloves
- Allowing personnel space to remove and temporarily store surface grates
- Maneuvering and parking maintenance vehicles
- Equipment for directing traffic and pedestrians - safety cones or barriers and use of appropriate signage
- Equipment for removing the manway/grate (i.e., crowbar, manhole hook, jib crane)
- Tools to loosen consolidated sediment and debris covering the manway/grate
- Tools for removal of Smart Pak® media
- Storing and disposal of pollutants
- Maintenance Report

In the event of accidental or chemical spill, contact emergency services and follow standard hazmat procedures.

4.4 Maintenance Procedures

The UUF Chester CO is typically maintained without entry into the catch basin and requires very little time. Maintenance should begin by preparing and installing all safety measures followed by the maintenance and documentation. Specific procedures for the maintenance are detailed below:

1. Wear all PPE and prepare documentation equipment.

2. Install all work zone safety equipment and conduct a brief safety meeting. Work zone safety equipment should protect the inspector(s) from vehicular traffic and should also isolate and protect pedestrians and vehicles from the work zone.

3. Remove the manhole grate utilizing the manhole puller/remover and safely set aside out of the way from maintenance operations and pedestrians or vehicles.

4. If during inspection it is determined the accumulated trash, debris, and sediment requires removal, an industrial vacuum should be utilized to remove the material. Using a reduced diameter suction hose, vacuum the trash, debris, and sediment from the catch basin filter. The suction hose may be inserted into the filter through curb opening as illustrated in Figure 3a or through the manway opening as illustrated in Figure 3b. A pressure washing wand may be utilized to assist this process by freeing clogged material from the enclosure screen or media fabric. The suction hose should remain inside the filter while the filter is being washed down. It is also possible to remove sediment by hand by removing the filter enclosure from the catch basin.

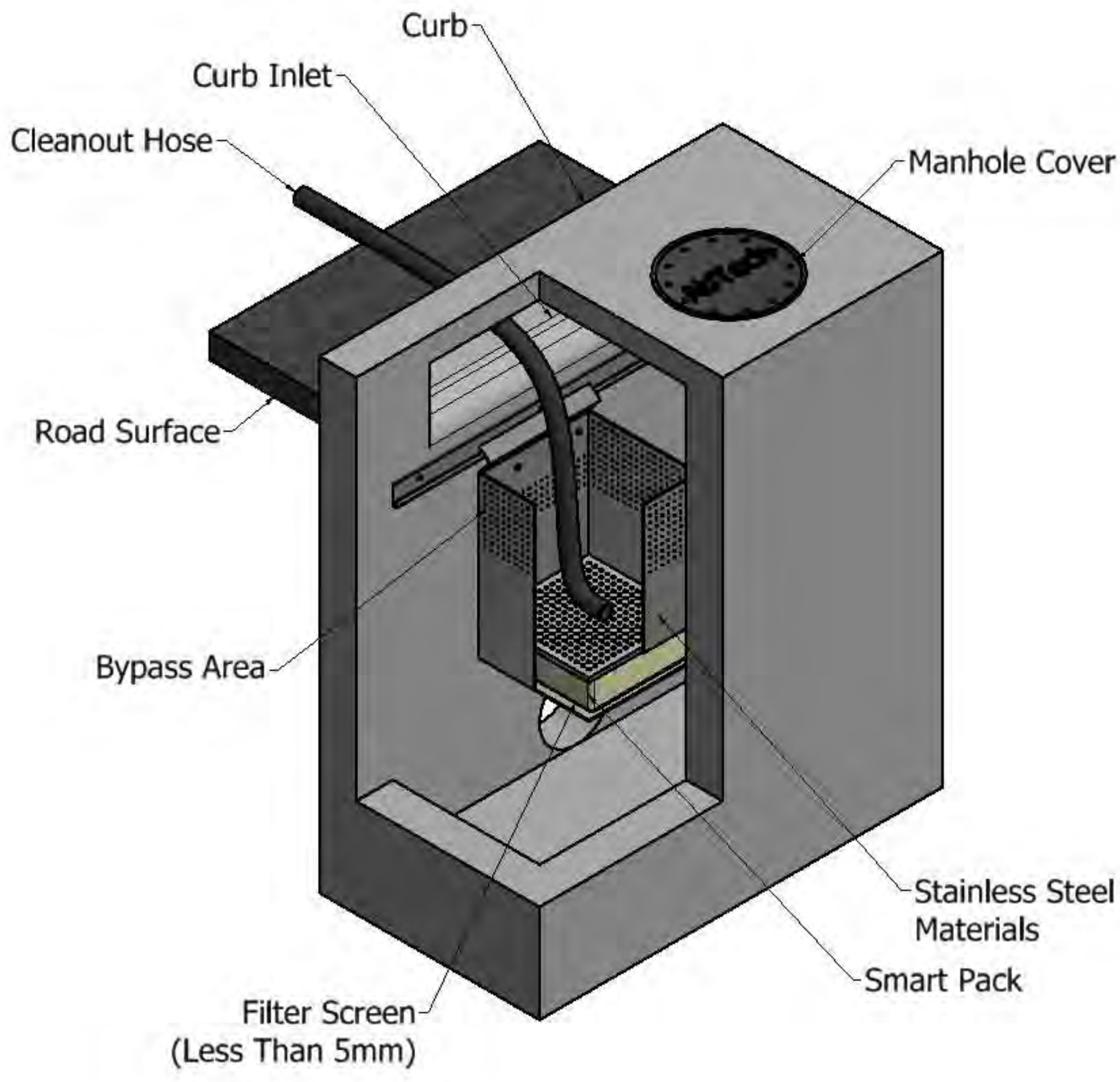


Figure 3a: Maintenance Hose Through the Curb Opening

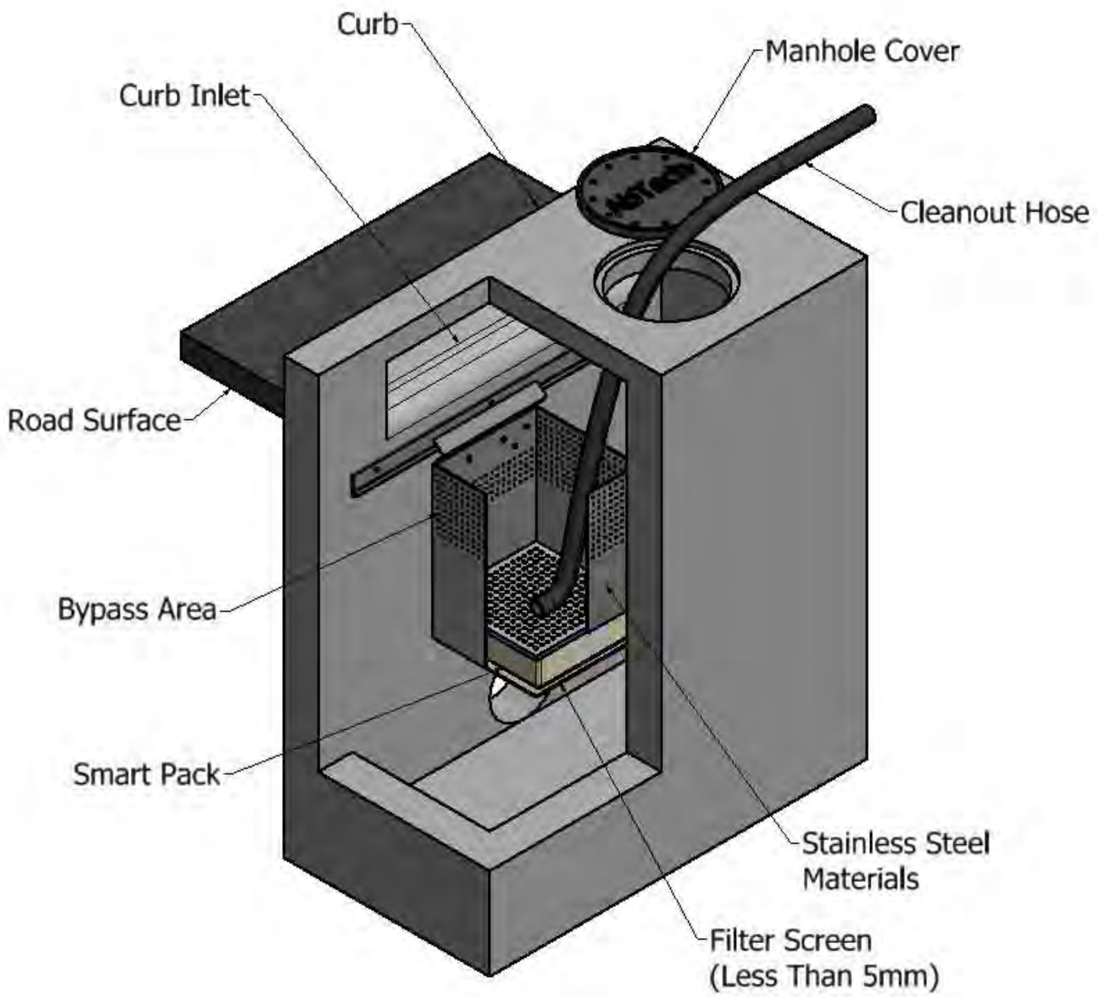


Figure 3b: Maintenance Hose Through the Manway Opening

5. If during inspection it is determined the media requires replacement, the following replacement procedures should be implemented.
   - Replacement media should be pre-ordered in advance of the maintenance visit.
   - After removal of sediment, remove the Smart Pak® from the filter enclosure. The Smart Pak may be removed by hand or using a media removal tool. Additional cleaning may be needed under the Smart Pak where sediment may have accumulated on the filter screen.
   - Once cleaned, place a new Smart Pak into the bottom of the filter enclosure. Ensure the Smart Pak fit tightly and is placed flat into the filter enclosure.
6. Removed trash, debris, and sediment should be disposed of following local, state, and federal guidelines. Media should likewise be disposed of following local, state, and

federal guidelines. Material disposal is discussed in section 5.0.

7. Finalize the Maintenance Report. Photograph the conditions of interior and exterior of the catch basin and filter unit. Document the maintenance event using the Maintenance Report included with this manual or similar. The presence of standing water or mosquitos should be highlighted per vector control procedures. The local vector control agency should be notified if mosquitos are present in the catch basin or filter unit.

8. Replace the manhole cover and remove all work zone safety equipment.

4.5 Related Maintenance Activities

UUF Chester CO's are often just one of many treatment practices in a comprehensive stormwater drainage treatment system. To maximize the performance of the filter, it is imperative that all upstream infrastructure and treatment practices also be properly maintained. The inspection, maintenance, and repair of upstream facilities should be carried out as part of a comprehensive stormwater management plan. In addition to considering upstream facilities, it is also important to correct any problems identified in the runoff area. Runoff area concerns may include erosion problems, infrastructure damage or failure, and discharges or releases of inappropriate materials.

5.0 Material Disposal

The accumulated sediment found in stormwater treatment and conveyance systems must be handled and disposed of in accordance with regulatory protocols. It is possible for sediments to contain measurable concentrations of heavy metals and organic chemicals (such as pesticides and petroleum products). Areas with the greatest potential for high pollutant loading include industrial areas and heavily traveled roads. Sediments and water must be disposed of in accordance with all applicable waste disposal regulations. When scheduling maintenance, consideration must be made for the disposal of solid and liquid wastes. This typically requires coordination with a local landfill for solid waste disposal. For liquid waste disposal several options are available including a municipal vacuum truck decant facility, local wastewater treatment plant or on-site treatment and discharge.

Collected, retired Smart Sponge® filtration media used in standard stormwater applications is classified as a non-hazardous substance. Also, Smart Sponge filtration media saturated with hydrocarbons, both in the lab and field settings, have been tested according to the EPA's Toxicity Characteristic Leaching Procedure (TCLP). These tests have indicated that Smart Sponge® filtration media is a non-leaching product. For the reasons noted, many cost effective and environmentally friendly disposal options are available as follows:

- Subtitle D Landfills
- Waste-to-Energy Facilities
- Thermal Conversion Process Facilities
- Cement Kilns

6.0 Inspection Data Sheet

Date______________________________ **Personnel**____________________________

Location___________________________ **System Size**____________________________

No.	Inspection Item	
1	Is settled trash, debris, and/or sediment on the surrounding area? Is the curb opening occluded?	☐ Yes ☐ No
2	Is standing water surrounding the curb opening of the catch basin?	☐ Yes ☐ No
3	Check the flow diverter for structural integrity. Are there any abnormalities?	☐ Yes ☐ No
4	Check the mounting bracket for any physical damage. Is there any damage?	☐ Yes ☐ No
5	Check the filter enclosure for structural integrity. Is there any damage to the enclosure?	☐ Yes ☐ No
6	Is there any damage to the filter screen?	☐ Yes ☐ No
7	Is there trash and debris, and sediment accumulated in the filter? If so, document the qty. If yes, then must be removed as part of the maintenance plan.	☐ Yes ☐ No

8	**Is there a black or oily sheen on top of the Smart Pak®? (if included). If yes, then media must be replaced as part of maintenance plan.**	☐ Yes ☐ No
9	**Is there standing water inside the catch basin?**	☐ Yes ☐ No
10	**Do you observe any mosquitos? If yes, contact vector control as per local guidelines.**	☐ Yes ☐ No

7.0 Maintenance Report

No.	Maintenance Activity	Date
1	Set up appropriate safety equipment and put on safety gear.	
2	Collect and remove trash, debris, etc. surrounding the catch basin and on the grate.	
3	Remove the trash, debris, and sediment from the filter using a vacuum hose, or by hand	
4	Repair or replace damaged or deteriorated structural components such as flow diverter, mounting bracket, or enclosure.	
5	Remove obstructions from filter screen	
6	Remove the spent media and replace with new media.	
7	Conduct O+M procedures as needed for any instrumentation, valves, and other devices. Repair or replace as needed.	
8	Notify agency or owner representative.	

8.0 Warranty

AbTech Industries, Inc. (AbTech) warrants to buyer that the Ultra-Urban Filter Chester Stainless Steel Infrastructure Sleeve (the "Infrastructure Sleeve") shall materially conform to the description in AbTech's product documentation as of sale date and shall be free from defects in material and workmanship for twenty (20) years from the date of purchase. This warranty is non-transferable and is conditioned on: (a) the Infrastructure Sleeve being properly installed by a documented authorized service provider of AbTech,(b) buyer's delivery to AbTech of annual certifications evidencing that buyer has inspected and maintained the Infrastructure Sleeve at least annually from the time of installation, (c) no unauthorized repairs or alterations having been made to the Infrastructure Sleeve, (d) buyer not being in default on any contractual obligation for the Infrastructure Sleeve, (e) buyer registering the Infrastructure Sleeve with AbTech within thirty (30) days of delivery, and (f) any warranty claim being provided to AbTech in writing within thirty (30) days of buyer's identification of the suspected defect. This warranty specifically excludes coverage of any damage caused by circumstances beyond the control of the party affected, including without limitation acts of God, fire, vandalism, natural disaster, chemical action, abrasive material, misuse, explosion, war, action or demand of governmental authority, injunction or labor strikes, or improper or unauthorized installation or repairs.

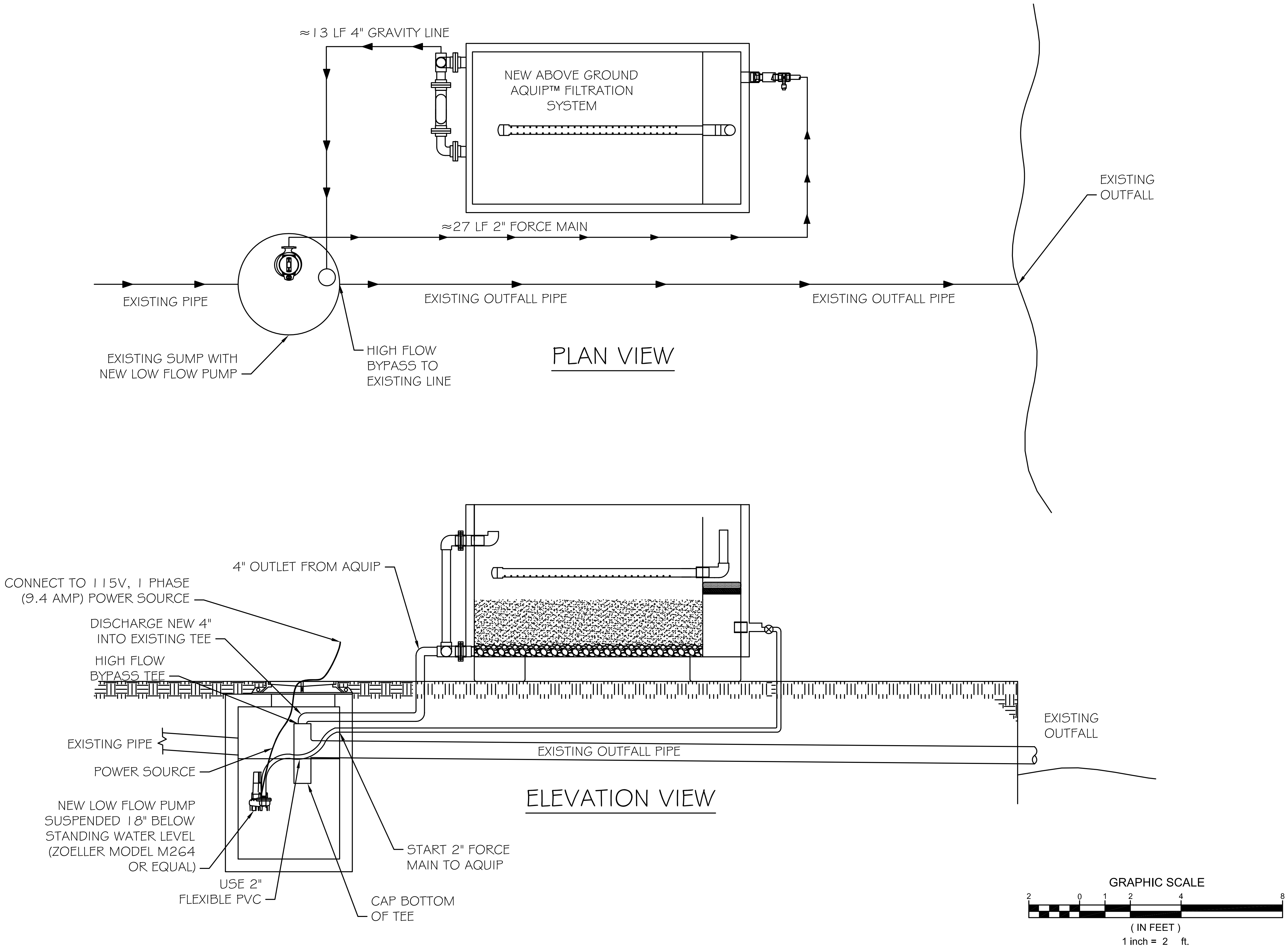
This warranty does not apply to (i) any consumable or wearable parts used in conjunction with the Infrastructure Sleeve, or other parts which are designed to diminish or wear over time; or (ii) damage caused by use with a third-party component or product that is not provided by AbTech. The warranties set forth herein are AbTech's sole and exclusive warranties and are in lieu of all other warranties, remedies and conditions, whether oral, written statutory, express or implied. AbTech disclaims all statutory and implied warranties, including without limitation, warranties of merchantability, fitness for a particular purpose and non-infringement.

If AbTech responds to a claim from buyer under this warranty, and it is later determined that the claim is not, in fact, covered by this warranty, buyer shall pay AbTech its then customary charges for any repair or replacement made by AbTech. IN NO EVENT WILL ABTECH BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES, SUCH AS, BY WAY OF EXAMPLE AND NOT LIMITATION, LOSS OF REVENUES, BUSINESS OPPORTUNITIES OR GOODWILL, ARISING OUT OF OR IN CONNECTION WITH THE INFRASTRUCTURE SLEEVE, HOWSOEVER CAUSED, WHETHER OR NOT BUYER HAS BEEN ADVISED, KNEW OR SHOULD HAVE KNOWN OF THE POSSIBILITY OF SUCH DAMAGES.

Appendix C

StormwateRx Manual and Specifications

TIG environmental®
INVESTIGATIONS • FORENSICS • REMEDIATION



stormwateRx™
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AQUIP FILTRATION SYSTEM
ABOVE-GROUND WITH PUMP SCHEMATIC
PLAN & ELEVATION VIEW

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SHEET
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1 OF 1

Stormwater Filtration System Operation & Maintenance Manual

stormwateRx®
Reclaiming the world's water.®
122 Southeast 27th Avenue
Portland, OR 97214
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Important!

Do not neglect upstream source control and stormwater management once Aquip is installed. This may result in the premature fouling of the Aquip filtration and pollutant reduction capacity, shortening bed life.

Do not flush spills or otherwise use Aquip to capture pollutants from stormwater drain line jetting or pavement washing.

Lifting Aquip once the media has been installed may result in damage to the tank. All the media except the underdrain gravel should be removed before attempting to move Aquip.

Regular maintenance of the media surface will ensure optimal performance results as well as increase the lifespan of the media bed. The removed media needs replacement after removing more than 2”. Media replacement should not be done in the place of seasonal maintenance.

Do not pressure-wash or rinse the inside of the Aquip prior to removing the filtration media.

Stormwater sampling should be done with care. Use new sampling bottles and avoid contaminating samples with dirt from the Aquip sample port or your hands.

Freezing conditions can cause damage to the external plumbing on Aquip. Please refer to this manual to take the necessary precautions.

1 Introduction and System Description

Aquip is a passive adsorptive depth filtration technology designed specifically for reduction of stormwater pollutants such as suspended solids, turbidity, heavy metals, nutrients and organics from industrial sites. Aquip is a patented system that uses a pre-treatment chamber followed by a series of inert and adsorptive (depending on the configuration) filtration media to effectively trap pollutants in a pre-configured package. The Aquip structure is typically concrete (C), steel (S) or pre-cast concrete blocks for high flow applications (HF). Pollutant removal within the pre-treatment chamber occurs by gravity settling; pollutant removal within the filtration chamber occurs through a combination of chemical complexing, co-precipitation, adsorption, absorption, micro-sedimentation, filtration and biological degradation.

Figure 1: Aquip Stormwater Filtration System

1.1 Aquip Features

(1) **Inlet:** Polluted stormwater flows into the Aquip via the inlet pipe which controls and monitors the flow into the system.

a. **Inline Flow Meter:** An electromagnetic flow meter displays the operating flow rate and the total volume of water treated by the Aquip. The volume of water treated should be recorded at regular intervals to help in planning maintenance intervals.
b. **Flow Control Valve:** The valve used to calibrate the proper flow rate into the Aquip.
c. **Inlet Check Valve:** This check valve keeps the standing water level in the pretreatment chamber at the correct level.
d. **Inlet Sample Port:** Allows for the convenient sampling of the inlet stormwater.

(2) **Pretreatment:** This chamber is customized to improve the quality of the stormwater prior to treatment in the filtration chamber. The pretreatment chamber can be configured for settling coarse solids, skimming free floating oil, conditioning the stormwater for dissolved metals removal, or optimizing organics removal, or any combination thereof.

The **conditioning** option is the most common configuration. Aquip uses a passive pretreatment process which accelerates the output of alkalinity, an important constituent in natural waters. This pretreatment works synchronously with several of the adsorptive filtration media layers within the filtration chamber. The pretreated water helps positively charged metallic ions find negatively charged alkalinity compounds. Some of these positive and negative ions form insoluble complexes that are removed in the filtration chamber. Within the Aquip filtration treatment chamber some of the metals are removed as precipitates by micro-sedimentation. Because of the low alkalinity common to most stormwater, particularly those from facilities where most of the surface is paved, there is not lingering effect of the pretreatment process.

Other options are the basic solid settling configuration or the oil water separator design. All configurations come standard with a precautionary **oil skimmer** that helps to trap and absorb free oil inside of the pretreatment chamber.

(3) **Inlet Distributor:** Water from the pretreatment chamber flows into the inlet distributor and is dispersed along the full length of the filter media bed optimizing the contact area of stormwater with filtration media. The **energy dissipation fabric** lies beneath the distributor to prevent scouring of the media bed.

(4) **Filtration Treatment:** Layers of inert and adsorptive media make up the **media bed** which filters out stormwater pollutants such as metals, particulates, oil, organics and nutrients. Once filtered through the media bed, clean stormwater flows into the **underdrain** located along the bottom of the media bed.

(5) **Outlet Manifold:**

a. **Outlet Sample Port:** Allows for the convenient sampling of treated stormwater.
b. **Adjustable Head Control:** Clean stormwater leaving the filter bed passes through the adjustable head control. This device can be adjusted in the field and assures optimal water-filter media contact under a range of operating conditions.

(6) **Emergency Overflow:** The upturned elbow provides a means of bypass for stormwater if the media bed is no longer draining at a rate that keeps pace with the influent design flow rate. A passive **overflow indicator** on the outside of the Aquip tank visually indicates when an emergency overflow has occurred. After each overflow event, this feature needs to be reset by releasing the water stored inside the overflow indicator by turning the petcock valve at the bottom of the device.

(7) **Outlet:** Clean stormwater is discharged from Aquip through the outlet pipe to an existing conveyance line or to an infiltration gallery or other means of disposal or reuse.

(8) **Sample Port:** Effluent stormwater samples are collected from the sample tap installed on the outlet manifold.

The “Installed Aquip Project Specifications” sheet at the beginning of this manual will provide the details of the system installed at your site. Refer to this document for details on your site-specific Aquip system. A description of the Aquip model numbers are provided in Table 1 below.

Table 1: Aquip Model Descriptions

System Size	Tank Material	Pretreatment Media	Filtration Chamber Media
10	P: Plastic	B: Conditioning	E: Enhanced Metals
25	S: Steel	O: Oil Coalescing	I: Inert
50	C: Concrete	X: Settling (no media)	Z: Special
80	U: User Supplied		G: Enhanced Organics
110	H: High Flow		
160	G: Green - Infiltrating		
210			
300			
400			
800			
Example: Model 210SBE			

1.2 Typical Installation Configuration

In most applications, the Aquip system is installed as a retrofit and installation is above ground. In this case, stormwater needs to be pumped from a below-ground vault or catch basin to the Aquip. In some cases stormwater is first pumped to an above-ground storage tank and stormwater is drained by gravity through Aquip. A configuration with a storage tank is referred to as “Storage Discharge” (Figure 2). Configurations without a storage tank are called “Direct Discharge” (Figure 3).

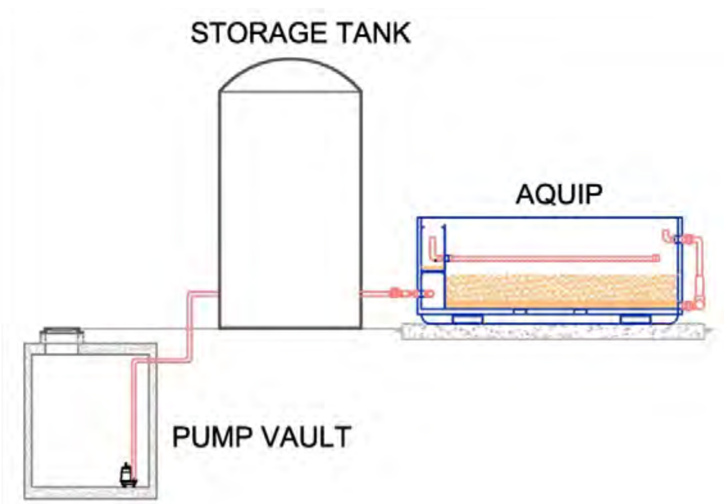

Figure 2. Storage Discharge configuration

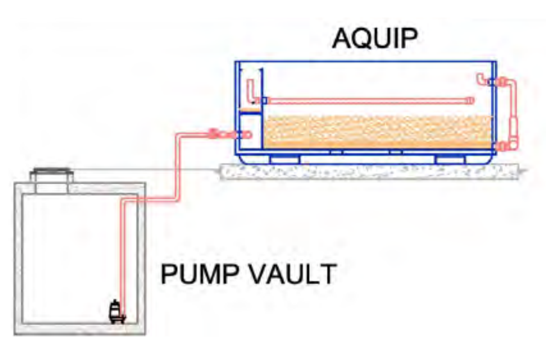

Figure 3. Direct Discharge configuration

2 Aquip Operations

Regular inspection and maintenance is required for the proper operation of the Aquip. Site conditions vary such that the maintenance requirements cannot be prescribed without regular inspections. Inspections determine the type and frequency of maintenance required and regular maintenance keeps the Aquip operating at optimal conditions to improve the performance and media longevity.

2.1 Wet Start-Up Procedures

The Aquip is typically installed during dry weather when there is not sufficient stormwater available to complete the final steps to put the Aquip online. StormwateRx LLC personnel will leave the Inlet Flow Control Valve set to half open until the flow rate to the system can be calibrated. During the first storm event it is imperative that the owner calibrate the flow rate through the system to that designated in the Installed Aquip Project Specification sheet at the front of this manual.

Step 1. **Fill Above Ground Storage Tanks:** For Storage Discharge configurations only. For Direct Discharge, proceed to Step 2. Close the outlet valve from the storage tank (or the Inlet Flow Control Valve to Aquip) and fill the above ground storage tank(s) until the water level is near the top of the tank(s).

Step 2. **Flow Calibration**: Adjust the Inlet Flow Control Valve until the Inline Flow Meter indicates the design/nameplate flow rate as noted on the flow meter (Figure 4). The design flow rate is listed in the Installed Aquip Project Specification sheet at the front of this manual.

Step 3. **Inlet Distributor Adjustment**: Adjust the height of the Inlet Distributor until each arc of water is roughly uniform across the entire length of the Aquip filtration chamber (Figure 4). This is done by tightening or loosening the plastic washers on the threaded rod suspending the Inlet Distributor.

Step 4. **System Operation:** Monitor system throughout the first storm event to confirm stormwater is passing through Aquip. Inspect outfall point of stormwater conveyance line to confirm there is free discharge. Note that the Aquip filter performance improves (outlet water clarity should improve) after the first or second storm event. This occurs because the stormwater particulates that are captured by the Aquip filtration bed in early storm events actually assist the particle filtration process, thereby producing better water clarity with time. This process is known as "bed seasoning."

Step 5. **After Storm Inspection:** Inspect Aquip after the storm event. Normally, owners observe an accumulation of fine solids over the top of the filtration chamber. If the thickness is greater than 1/4-inch, additional upstream source control may be beneficial to reduce sediment loading to the system (see Section 7).

Figure 4. Inlet piping with flow meter (right); Uniform flow out the inlet distributor (left)

2.2 Inspections

During the first rainy season, inspections should be conducted weekly or every two to three storms to establish site-specific inspection and maintenance intervals. Regular inspections will verify that the system is in good operating condition and should be recorded as part of the monthly inspection program and the facility Stormwater Pollution Prevention (or Control) Plan (SWPPP or SWPCP). Inspections are also recommended after every major storm event. An Inspection Report is included at the end of this manual to assist with record keeping.

AN INSPECTION DURING A RAIN EVENT IS THE BEST METHOD OF ASSESSING HOW WELL THE AQUIP SYSTEM IS OPERATING

Flow meter

- Verify that the flow rate to Aquip matches the design flow rate. Operating Aquip at a rate other than the designated design flow rate will affect the system performance and may not be allowable under the stormwater permitting rules. Adjust the flow rate as necessary. Opening the flow control valve such that the flow rate is increased will decrease system performance. The flow rate should only be adjusted when the storage tank(s) are full for the Storage Discharge system configuration.

Pretreatment Chamber

For Aquip SBE- with pretreatment media

- Inspect the amount and distribution of the pretreatment media. There should be at least 3 inches of pretreatment media evenly distributed across the media grates.
- Inspect for the accumulation of solids and debris on top of the pretreatment media. Before removing accumulated debris, drain down the pretreatment chamber through the inlet sample port.
- Inspect for solidification of the pretreatment media. If present, clumps of media should be broken up with a shovel.

For Aquip SOI or SOE- with oil coalescing packs

- Inspect the water surface for heavy oil sheen. If a heavy sheen is present, remove the accumulated oil from the surface.
- Inspect the side walls of the Pretreatment Chamber for heavy oil and debris accumulation. If heavy oil and debris are present, follow the maintenance steps described in the Section 3.3.

Inlet Distributor

- Inspect the perforations for the accumulation of debris. The accumulation of any debris should be removed by hand.
- During a storm event, verify that the flow of water out of the perforations is uniform the entire length of pipe. For Storage Discharge configurations, the Inlet Distributor should only be adjusted when the storage tank(s) are full.

Media Bed

- During a storm event, observe the water level above the media bed relative to the Inlet Distributor. Note that the water level may increase during the first 15 minutes of operation.
- Inspect the accumulation of solids on the surface of the media (Figure 5). Observe the appearance of the solids and its distribution across the media surface. If more solids than sand are visible on top of the media, refer to Routine Surface Maintenance Section 3.1.1.
- Check for a hardened or brittle media surface in the absence of solids accumulation. If the media surface is hardened, break up the media surface to help restore hydraulic capacity.
- Verify that the Energy Dissipation Fabric is clean and laying flat beneath the Inlet Distributor. The Energy Dissipation Fabric may be re-anchored by pushing small amounts of filter sand over the fabric at various intervals.

Outlet Sample Port

- Collect the effluent from the Aquip to observe changes in water clarity. The clarity of the water is best observed using a clear glass/plastic container. As mentioned earlier, water clarity should improve after the first few storms.

Figure 5. Accumulation of solids on the media bed surface

2.3 Optimal Operating Conditions

The Aquip should be maintained regularly for optimal performance and media longevity. Observe the water level within the Filtration Chamber to determine optimal operation. Both of the following conditions need to be met for the Aquip to be operating at optimal conditions:

- Water has been draining through the Inlet Distributor continuously for 15 minutes or more.
- The water level within the filter is above the surface of the media and below the Inlet Distributor (Figure 6)

However, for LIGHT RAIN or INTERMITTENT RAIN conditions, neither of the two conditions may be established.

Should the water level within the Filtration Chamber reach the Inlet Distributor, maintenance should be performed to re-establish the proper flow through Aquip (see Section 3).

Figure 6. Best operating water level in filtration chamber for optimal pollutant removal conditions

2.4 Freezing Weather

The external piping components are empty or nearly so between storm events with the exception of sample ports. If a hard freeze occurs as water is draining down from Aquip, external plumbing on the Aquip can freeze and temporarily impair its operation. The steps below should be followed to minimize damage to external plumbing and get the Aquip back on-line as quickly as possible.

The influent plumbing leading to the Aquip may be susceptible to damage during freezing conditions if a weep hole has not been installed at the pump discharge. For systems installed in freezing climates, StormwateRx LLC recommends heat tracing all above-ground connecting piping to and from Aquip.

The media bed will likely become icy during freezing conditions which will temporarily impair the flow and treatment capability of Aquip. It is important to allow the media bed to fully thaw before conducting stormwater quality sampling. Following are some additional operating tips for freezing conditions.

<u>For Aquip systems with Storage Discharge</u>

1. Insulate or heat-trace the force main lines for this condition.
2. Close the shut-off valve between the above ground storage tank and the Aquip.
3. If no shut off valve has been installed, open the plug between the pretreatment chamber and the filtration chamber to drain down water from the storage tank through Aquip.
4. Once the storage tank has fully drained down, open the inlet sample port located on the inlet pipe to the Aquip. This will drain down the pretreatment chamber.

5. Open the outlet sample port to drain any water that still may remain in the filtration chamber.

Warning: For systems without a shut-off valve between the detention tank and Aquip, the storage tank will drain down through the inlet sample port spilling onto the ground. Owners may favor heat tracing the plumbing instead of emptying the storage tanks for freeze protection.

For Aquip systems with Direct Discharge

1. StormwateRx recommends insulating or heat-tracing all above-ground piping to the Aquip system.
2. Turn off pump.
3. Open the inlet sample port located on the inlet pipe to the Aquip to drain down the pretreatment chamber.
4. Open the outlet sample port to drain any water that still may remain in the filtration chamber.

2.5 Sampling Protocol and Methodology

Water quality samples should be taken only when the system has been maintained and is operating effectively (see Section 2.3). The inlet and outlet sample ports on Aquip provide a convenient and reliable method of taking samples.

AFTER INSTALLING NEW FILTRATION MEDIA, OPERATE THE AQUIP FOR TWO HOURS BEFORE COLLECTING AN EFFLUENT SAMPLE

Use caution when collecting water quality samples to prevent contamination of the sample bottles. A small amount of dirt goes a long way to contaminating a stormwater sample. Make sure the sample port and your hands or gloves are clean BEFORE collecting your compliance sample. The following precautions should be taken immediately before sampling:

1. Using a CLEAN cloth, wipe off any visible dirt from the sample port valve spigot.
2. Open sample valve and allow water to flush through the port for a minimum of 10 seconds.
3. Use the proper unused sample bottle – do not reuse sample bottles.
4. Do not touch the sample bottle to the sample port.
5. Do not put fingers inside or around the sample port or the mouth of the sample bottle.
6. For sample bottles with liquid preservative inside, do not allow the bottle to overflow.
7. Cap the sample bottle as quickly as possible. Store on ice. Ice helps reduce the amount of metals that move from particulate to dissolved phase and reduces the rate of growth of biological organisms within the sample bottles.

StormwateRx recommends sampling the inlet to the Aquip each time that the outlet is sampled. Without the inlet sample data, StormwateRx LLC cannot diagnose or provide recommendations on tuning system performance. The inlet should be sampled approximately 15 minutes before sampling the outlet to get the most representative inlet/outlet sample pair.

3 Maintenance Guidelines

The Aquip, like all filtration systems, requires periodic maintenance to restore the system to its original effectiveness. The type and frequency of maintenance required for the Aquip varies significantly from site to site due to differences in facility operations, upstream stormwater management, and rainfall frequency. Routine inspections conducted on the Aquip will help to determine how frequently to maintain your Aquip stormwater filter (see Section 2.2).

LOADING TO AND MAINTENANCE OF AQUIP CAN BE REDUCED BY IMPROVING UPSTREAM SOURCE CONTROL BMPS.

3.1 Filter Media Maintenance

Maintaining the filter media is the most important step for achieving the optimal results from your Aquip filtration system. The media can be maintained either by cleaning and leveling the surface or replacing specific layers of media. The type of maintenance required is based upon the flow rate through the Aquip and/or the type of pollutants entering the system. Media maintenance is done to provide uniform flow downward through the media, preventing preferential flow and utilizing the entire surface area of the media bed. By providing uniform flow, treatment is maximized.

The layers of media have been configured in a specific arrangement to provide treatment for the identified pollutants in your stormwater. Refer to Figure 7 for media layer nomenclature.

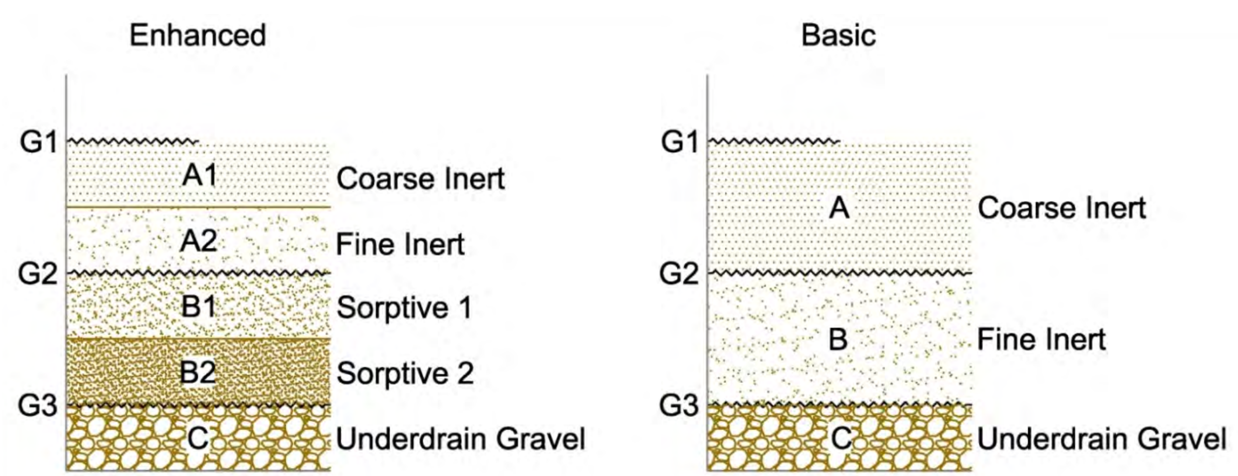

Figure 7. Enhanced and basic media bed configurations

3.1.1 Maintenance Type I – Routine Surface Maintenance

Refer to Figure 7 (page 13) to identify the media and fabric layers described in this section.

Maintenance Description

A Routine Surface Maintenance consists of cleaning the entire media surface by shoveling off and removing the top ¼ - ½ inches of media. The media below the Energy Dissipation Fabric should also be clean at this time. The surface of the media should then be leveled using the filter shovel provided.

The Inlet Distributor and Energy Dissipation Fabric should also be inspected and cleaned if necessary at the time of Routine Surface Maintenance (see Section 2.2).

The removed media should be replaced after 2" of the top inert layer is removed as a result of routine surface maintenances. Replenish the removed media with new media if less than 7" of inert media remains on top of the media bed.

SURFACE MAINTENANCE AND MEDIA REPLENTISHMENT DO NOT SERVE AS A REPLACEMENT TO SEASONAL MAINTENANCE BUT DO EXTEND SYSTEM RUN-TIMES

Maintenance Timing/Frequency

A Routine Surface Maintenance should be conducted when the water level within Aquip begins to stack up. Optimal operating conditions for Aquip occur when the following conditions exist:

1. The Aquip has been operating for more than more than 15 minutes.
2. The water level within the Filtration Chamber reaches a point within 3 inches of the lowest point on the Inlet Distributor (Figure 6).

A Routine Surface Maintenance may need to be done as frequently as every 3 – 4 weeks depending on the amount of loading on the Aquip.

Maintenance Steps

The steps in conducting a Routine Surface Maintenance are:

1. Remove and set aside the Energy Dissipation Fabric (Fabric Layer G1, see Figure 7).
2. Clean the Energy Dissipation Fabric if necessary.
3. Clean the entire surface of the media by shoveling off the accumulated solids and the top ¼ - ½ inches of media (approximate). The newly exposed media should look cleaner than the removed media. Remove more depth if necessary.
4. Dispose of the removed media and accumulated debris.
5. Level the surface of the media.

6. Measure the depth of the remaining inert media layer by inserting a shovel directly down into the media until it reaches the lower-lying fabric layer. This will indicate the depth of the inert media layer.
7. Replenish the removed media with new media if less than 7” of the inert layer remains (more than 2” of the inert layer has been removed over the course of several surface maintenances).
8. Re-install the Energy Dissipation Fabric beneath the Inlet Distributor using scoops of sand to hold down the edges.

ROUTINE SURFACE MAINTENANCE HELPS TO AVOID MORE COSTLY FULL MAINTENANCES AND IMPROVES TREATMENT PERFORMANCE

Figure 8. Surface cleaning during a Routine Surface Maintenance

3.1.2 Maintenance Type II – Seasonal Maintenance

Refer to Figure 7 (page 13) to identify the media and fabric layers described in this section.

<u>Maintenance Description</u>
During a Seasonal Maintenance, the inert media on top (Media Layer A) is replaced to restore the proper flow rate through the Aquip. Typically, dirt and debris are trapped within the top layer of media which eventually causes the media to plug.

<u>Maintenance Timing/Frequency</u>
Media replacement is necessary when the proper flow rate through the Aquip cannot be established by a Routine Surface Maintenance or lowering the Adjustable Head Control (see Section 3.2). Seasonal Maintenance is recommended when stormwater sampling shows consistent pollutant reductions and solids loading in the lower-lying media (Media Layer B) is not appreciable.

Maintenance Steps

StormwateRx can provide a quotation for Seasonal Maintenance which includes the new media, filter fabric, and optional technical supervision at the time of the maintenance. The steps to conduct a Seasonal Maintenance are:

1. Set up safety equipment if the system is near vehicle and pedestrian traffic.
2. Sparingly pressure-wash or hand-wipe the side walls of the Aquip prior to removing any media. Cleaning the inside walls of the Aquip will allow the operator to observe the system’s most recent operating water level based upon the scum line left behind inside of the Aquip. No detergent or hot water should be used when cleaning the insides of the Aquip.
3. Remove and dispose of the Energy Dissipation Fabric (Fabric Layer G1, see Figure 7).
4. Excavate the spent filter media (Media Layer A) down to the first layer of geotextile fabric (Fabric Layer G2). A shovel or vactor truck may be used to remove the filter media. See Section 5 for media disposal.
5. Remove Fabric Layer G2 and inspect the underlying filter media (Media Layer B).
6. Break up the the top three to six inches of media to regenerate Media Layer B. Level and smooth the filter media.
7. Re-install Fabric Layer G2 on the top of Media Layer B.
8. Install the new inert filter media (Media Layer A). Media should be added in uniform, level layers using the level indicators on the side walls of the Aquip as a guide. Each media layer should be leveled before adding the next media layer.
9. Install the new Energy Dissipation Fabric (Fabric Layer G1) on top Media Layer A using scoops of sand to hold down the edges.

When conducting a Seasonal Maintenance, the pretreatment chamber should also be maintained (see Section 3.3).

NO DETERGENT OR HOT WATER SHOULD BE USED WHEN CLEANING THE INSIDES OF THE AQUIP

Figure 9. Vactor service removing the top layers of sand during a Seasonal Maintenance

3.1.3 Maintenance Type III – Full Maintenance

Refer to Figure 7 (page 13) to identify the media and fabric layers described in this section.

Maintenance Description

A Full Maintenance replaces all of the filtration media (Media Layers A and B) not including the underdrain gravel (Media Layer C). The filtering capacity of the media can be exhausted due to a combination of heavy loading, inadequate maintenance of the Aquip, and extended Aquip run-times.

Maintenance Timing/Frequency

Full Maintenance is recommended when a decline in treatment is observed in the water quality sampling and Routine Surface Maintenance is no longer capable of restoring the proper flow. Significant loading in the lower-lying media layers (Media Layer B) will often accompany a decline in treatment.

Maintenance Steps

StormwateRx can provide a quotation for a Full Maintenance which includes the new media, filter fabric, and optional technical supervision at the time of the maintenance. The steps to conduct a Full Maintenance are:

1. Set up safety equipment if the system is near vehicle and pedestrian traffic.
2. Sparingly pressure-wash or hand-wipe the side walls of the Aquip prior to removing any media as shown in Figure 10. Do not use any detergents. Cleaning the inside walls of the Aquip will allow the operator to observe the system's most recent operating water level based upon the scum line left behind inside of the Aquip. No detergent or hot water should be used when cleaning the insides of the Aquip.

Figure 10. Pressure wash the sidewalls of Aquip before removing filter media during a full maintenance.

3. Remove and dispose of the Energy Dissipation Fabric (Fabric Layer G1, see Figure 7). Use a vacuum truck or shovel to remove all spent media (Media Layers A and B). Stop at the geotextile fabric above the underdrain gravel (Fabric Layer G3). The underdrain gravel (Media Layer C) should ***not*** be removed.

DO NOT PRESSURE WASH OR RINSE THE SIDE WALLS OF THE AQUIP ONCE THE FILTRATION MEDIA HAS BEEN REMOVED.

4. Remove the PVC plugs located at each of the ends of the underdrain. Also remove the Adjustable Head Control located on the outlet end of the Aquip by loosening the flanges located on both sides of this PVC loop (see Figure 1).
5. Pressure-wash the insides of the underdrain to flush its insides.
6. Reinstall all of the PVC plugs on the underdrain and the Adjustable Head Control.
7. Install new geotextile fabric (Fabric Layer G3) on top of Media Layer C.
8. Install the new media layers and filter fabric layers as shown in Figure 7. Media should be added in uniform, level layers using the level indicators on the side walls of the Aquip as a guide. Each media layer should be leveled before adding the next media layer.
9. Install a new Energy Dissipation Layer (Fabric Layer G1) on top layer of the media using scoops of sand to hold down the edges.

When conducting a Full Maintenance, the pretreatment chamber should also be maintained (see Section 3.3).

3.2 Adjustable Head Control

The flow rate through the Aquip may be increased using the Adjustable Head Control. This should be done only when the proper flow rate cannot be established with Routine Surface Maintenance. By lowering the Adjustable Head Control, the back pressure within the media bed is reduced allowing the water to flow more freely through the system. The steps to lowering the Adjustable Head Control are:

1. Loosen all of the bolts on the two flanges located on both sides of the Adjustable Head Control. Some bolts may need to be loosened further after the flange assembles change their positioning.
2. Rotate the Adjustable Head Control downward away from the Aquip so that it is positioned parallel to level ground.
3. Evenly tighten the bolts on both flanges. Do not over tighten the bolts. The rubber gasket between the flange assembles will create a seal with even pressure around the flange.

3.3 Pretreatment Chamber Maintenance

The pretreatment chamber should be maintained when performing a Seasonal or Full Maintenance. Inspections of the pretreatment chamber should be performed as part of your routine inspections. The maintenance procedure for each type of pretreatment configuration is described below.

For Aquip SBE- with loose pretreatment media

1. Remove and dispose of the solids that have accumulated on the surface of the pretreatment media.
2. Shovel the loose media to one side of the pretreatment chamber.
3. If the walls of the pretreatment chamber are coated in mud or debris, hose down the walls.
4. Lift up and remove the grate exposed by shoveling aside the media.
5. Suspend a pump off of the floor of the pretreatment chamber and pump down the water beneath the pretreatment media grates.
6. Shovel or vactor out the accumulated solids on the floor of the pretreatment chamber.
7. Replace grates and level the pretreatment media across the surface of the grates.

Figure 11. Pretreatment chamber (with pretreatment media) in need of maintenance (left); pretreatment media after maintenance (right)

For Aquip SOI or SOE- with oil coalescing packs

1. Remove the accumulation of any heavy oil sheen on the water's surface using an oil adsorbent pad(s) or vactor service.
2. Drain down the pretreatment chamber using the inlet sample port.
3. Remove the coalescing packs from pretreatment chamber.
4. Remove the plastic media blocks from stainless steel frame.
5. Clean the plastic media blocks and stainless steel frame using a low pressure hose.
6. Collect and dispose the removed oil and debris.
7. Reassemble coalescing packs and reinstall in pretreatment chamber.

For Aquip SXI - with pretreatment settling

1. Drain down the pretreatment chamber using the inlet sample port.
2. If necessary, hose down the walls of the pretreatment chamber.
3. Suspend a pump off of the floor of the pretreatment chamber and pump down the water beneath the pretreatment media grates.
4. Shovel or vactor out the accumulated solids on the floor of the pretreatment chamber.

3.4 Oil Skimmer Maintenance

The oil sorbent pad on the oil skimmer should be routinely checked. The sorptive media within the pad will expand when reacting with oil causing the pad to swell in size. The oil sorbent pad should be replaced once the pad has swollen to its maximum size.

Figure 12. Pretreatment chamber oil skimmer sorbent pad.

3.5 Flow Meter Maintenance

The inside of the flow meter should be cleaned at a minimum of once a year to remove accumulating oil and dirt. Any accumulation on the surfaces of the electrodes will impede the proper operation of the flow meter. Remove the flow meter from the influent line on the Aquip and clean the small metal surfaces (electrodes) and all other surfaces inside of the flow meter using a soft cloth and a 50/50 solution of denatured alcohol and water.

The user manual for the installed flow meter is attached at the end of this O&M manual.

Table 2. Replacement batteries for Aquip flow meters

Type of Flow Meter	Batteries Required
Seametrics 2” Flow Meter	6 AA batteries
Seametrics 3” Flow Meter	Battery pack of 2 Lithium XL-205F batteries
Seametrics 4” Flow Meter	Battery pack of 2 Lithium XL-205F batteries

4 Troubleshooting

The table below provides a quick reference to address specific issues confronted with the operation of the Aquip. Sections 2 and 3 should be reviewed to reduce the onset of these issues.

Table 3. Aquip Troubleshooting

Symptom	Probable Cause	Recommended Action
Water is spilling over the baffle wall between the Pretreatment Chamber and the Filtration Chamber.	The flow rate into the system is not correct. The Inlet Distributor needs to be cleaned of accumulated debris.	Adjust the flow control valve (see Section 2.2). Remove the accumulated solids within the Inlet Distributor (see Section 2.2).
There is an uneven distribution of water across the media surface or from the Inlet Distributor.	The media surface is not level. Water is channeling unevenly across the media surface. The Inlet Distributor is not properly adjusted. More water is flowing out of one end of the Inlet Distributor more than the other.	Clean the media surface by removing accumulated debris and then level the top of the media to reduce uneven channeling. When the system is operating at the design flow rate, adjust the height of the Inlet Distributor so that the flow out of the pipe is even on both ends (see Section 2.1).
The water level within the Aquip is significantly higher than the inlet distributor (up to the emergency overflow) during Aquip operation.	The flow rate into the system is not correct. Too much solids have accumulated on the media surface. This can be observed as a thin brittle crust or as heavy solids accumulation. Solids have migrated deep within the media bed.	Adjust the flow control valve (see Section 2.2). In either of these cases, use a square point shovel to remove the top 1/4” of sand (approximate, see Section 3.1.1). The Adjustable Head Control should be lowered (see Section 3.3). A Seasonal or Full Maintenance may also be necessary (see Section 3.1.2).

Symptom	Probable Cause	Recommended Action
The Aquip is not draining water through the media bed.	Solids accumulation on the media surface is preventing flow through the media.	From the outside edge of the tank, use a shovel to disturb the media surface in several locations. Conduct a Routine Surface Maintenance once the water drains down completely (see Section 3.1.1). A Seasonal Maintenance may be necessary (see Section 3.1.2).
The pretreatment media racks within the Pretreatment Chamber have been moved out of place.	Heavy oil and/or solids accumulation has accumulated on the bottom side of the pretreatment media racks allowing the water to push them out of place.	Conduct Pretreatment Chamber Maintenance (see Section 3.4). Clean both sides of the racks by spraying them down with water.
The metals removal efficiency from the Aquip is beginning to decrease.	Loading on the media surface is preventing uniform flow downward through the media. The sorptive media within the media bed is beginning to reach its capacity.	For a brittle or hardened media surface, break up and remove the hardened media to regain the hydraulic capacity. For heavy solids loading (i.e. more solids than sand visible on top), remove the top1/4" of inert media (approximate, see Section 3.1.1). A Full Maintenance will be necessary (see Section 3.1.3).

5 Material Disposal

Water and sediment removed from the Aquip filter must be disposed of in accordance with all applicable waste disposal regulations. The removed accumulated sediment in the Aquip can typically be sent to the local landfill. Follow local regulations for standard guidelines for solid waste disposal.

6 Maintenance Support

If you have any questions about maintenance procedures, contact StormwateRx LLC at (800) 680-3543.

7 Best Management Practice Requirements

Achieving the benchmarks consistently requires rigorous implementation of best management practices (BMPs) including source control, structural and treatment BMPs. Treatment BMPs (i.e. the Aquip filtration system) are not designed to operate in the absence of other BMPs. Employing source control practices on a regular basis is essential in extending the life of the Aquip system as heavy pollutant loading can result in a shorter maintenance cycle than expected. The Aquip system is not designed as an all-in-one treatment device for all types and quantities of stormwater pollution.

Your Stormwater Pollution Prevention (or Control) Plan (SWPPP or SWPCP) should address the BMPs appropriate for your facility. During normal business operation, make sure that all best management practices are deployed and maintained. When engaging in operations that are atypical of standard business practices, please utilize source control measures to prevent heavy pollutant loading into the Aquip. The following are a few examples of typically employed practices.

- **Sweeping:** Sweep site on a regular basis, such as daily, weekly or bi-monthly, especially in areas of heavy industrial activities.
- **Covering activities:** When practical, cover significant materials or industrial operations that are outdoors, to prevent stormwater contact with potential pollutants.
- **Spill control:** When a spill occurs, contain and use onsite spill kits to dispose of material.

DO NOT FLUSH SPILLS OF ANY KIND INTO THE AQUIP FILTRATION SYSTEM

- **Catch basin and stormwater conveyance clean out:** When cleaning out catch basins and jetting stormwater conveyance lines turn off the pump that diverts water to the Aquip system. This water should not enter the Aquip system.

JETTING YOUR STORMWATER LINES INTO THE AQUIP FILTRATION SYSTEM IS NOT ADVISED.

This document is subject to change without notice.

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aquip®

stormwateRx®
Reclaiming the world's water.®

Aquip® Stormwater Filtration System: A Technical Description

 ver017

aquip® Fundamentals

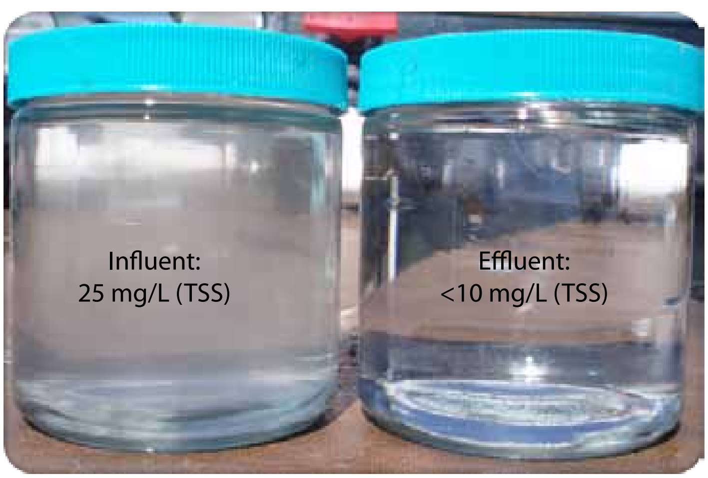
Aquip® (uh-kwip) is a patented, multi-media filtration system for stormwater applications. This robust stormwater treatment Best Management Practice (BMP) produces good stand-alone stormwater quality for a wide range of industries, is easy to retrofit to existing stormwater collection and conveyance infrastructure, and requires no operator attention during rain events.[1]

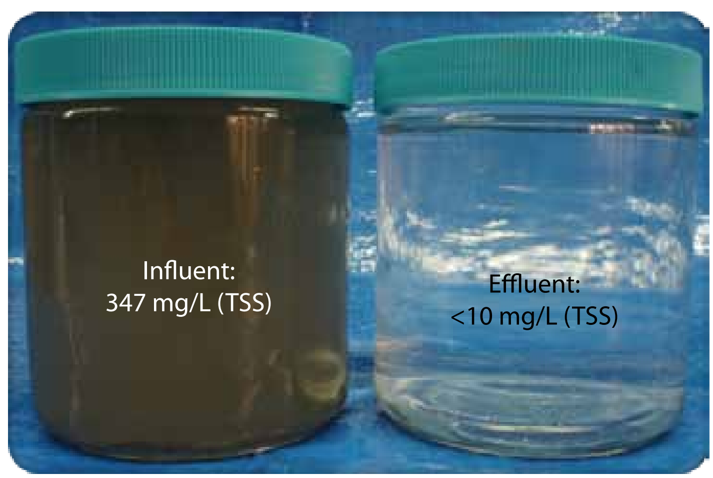
Aquip uses passive adsorptive filtration technology designed specifically for reduction of stormwater pollutants such as suspended solids, turbidity, heavy metals, nutrients, and organics from runoff. The passive system uses no chemicals and has no moving parts so operation is simple and safe. Aquip includes a pre-treatment chamber followed by inert and adsorptive filtration media to effectively trap pollutants in a package that is flexible and reliable. Aquip has received a coveted third party regulatory approval[2] for removal of particulates, dissolved metals and phosphorus from stormwater. Compliance samples are collected from a sample port at the outlet of the filter.

Installation of an Aquip 50 system

View of Aquip inlet distributor

Below are photographs of samples taken before and after the Aquip filtration system. Aquip is an effective filter producing good quality effluent under a range of influent stormwater quality conditions.





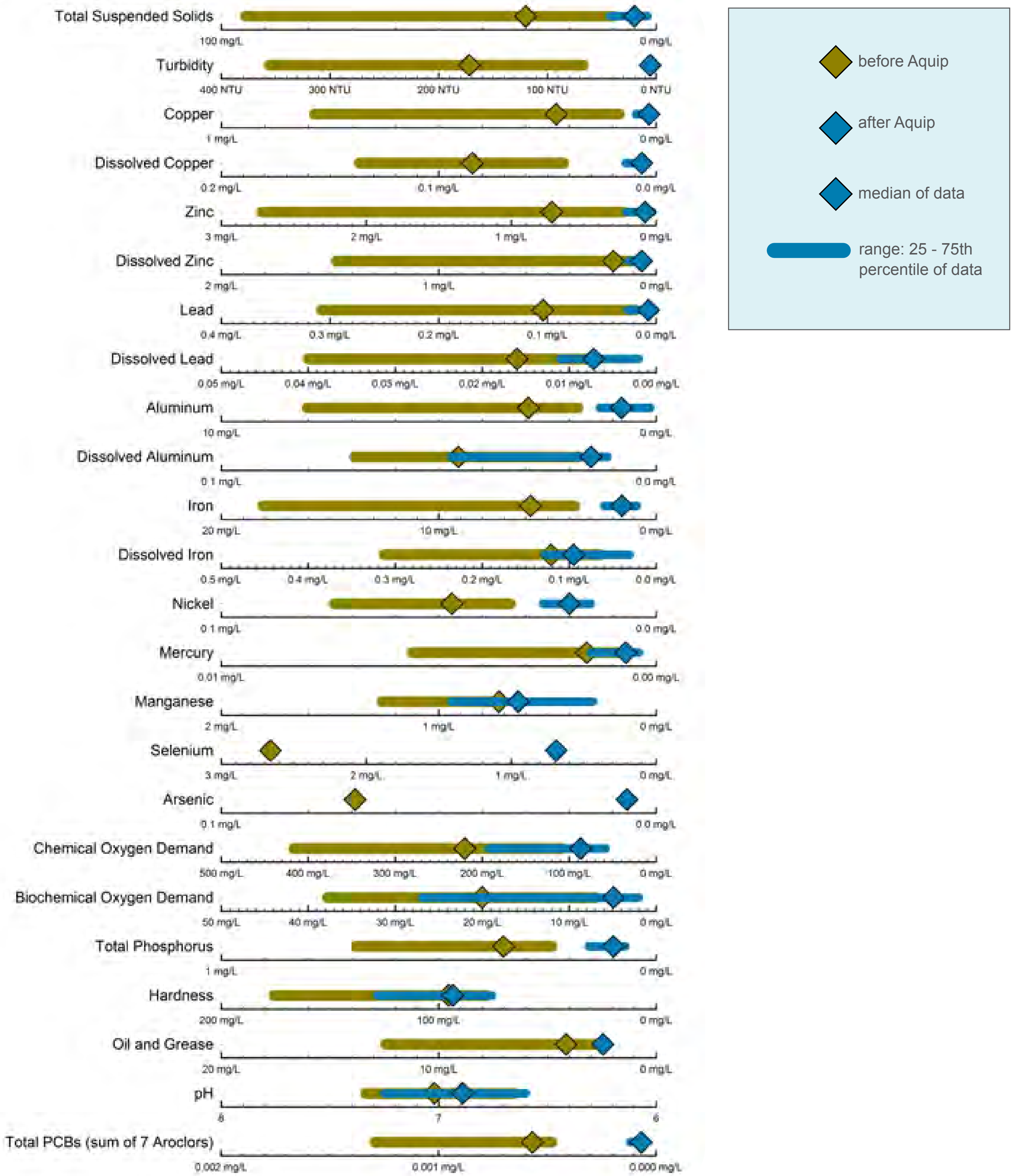
Actual full-scale Aquip influent and effluent samples

1 When properly maintained.

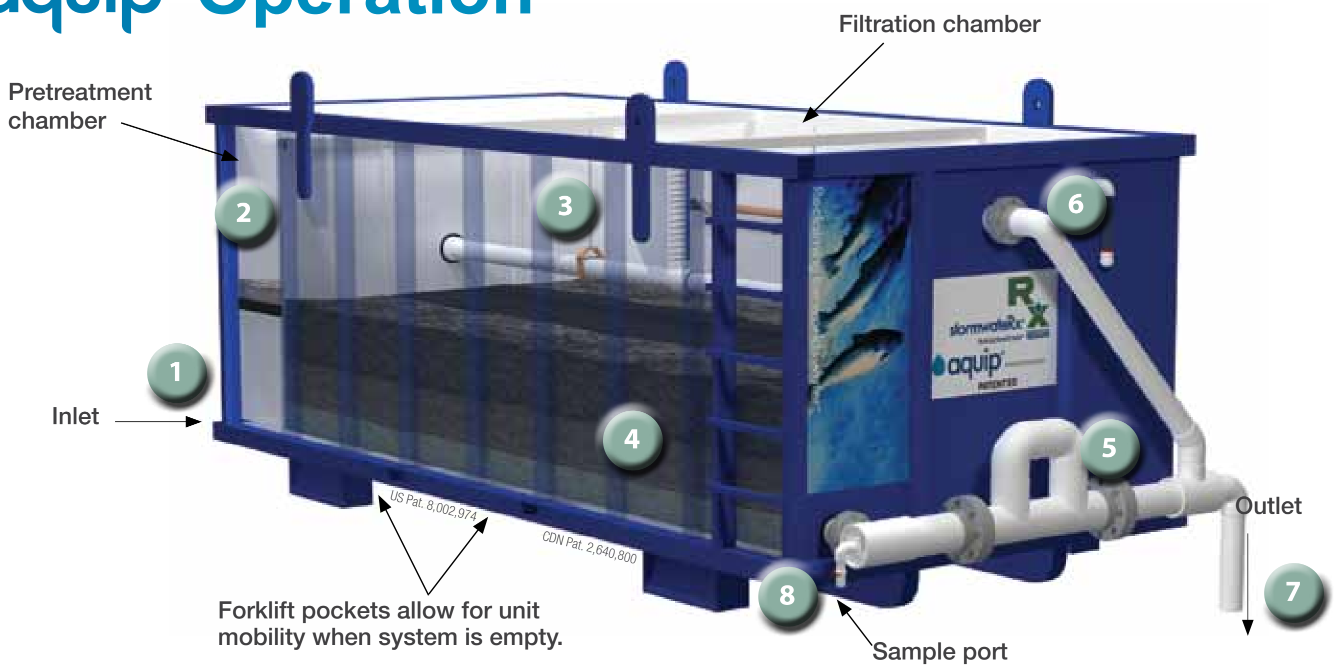
2 The Washington Department of Ecology has conditionally approved (CULD) the Aquip enhanced stormwater filtration system for use for basic, enhanced and phosphorus treatment. The CULD was granted as a part of the Technology Assessment Protocol Ecology (TAPE) process upon review by a Board of External Reviewers consisting of stormwater experts from across the United States. According to Ecology, "...several other states, counties, and cities use TAPE certification to determine whether a technology can be installed within their jurisdiction, including Sacramento CA, Denver CO, St. Louis MO, the State of New Hampshire, Portland OR, the Oregon Department of Transportation, and the State of Rhode Island. Aquip is arguably the first and only industrial stormwater treatment BMP approved for the treatment of solids, metals, and nutrients." The CULD approval means that Aquip can be specified and is approved for use on new and redevelopment projects in Washington as well as retrofits without additional review.

aquip® Performance

Aquip performance has been demonstrated at a wide range of industrial sites including scrap and recycling, galvanizing, metal fabrication, wood treating, automobile salvage, transportation equipment, food processing, power generation, marine and a host of others. Representative performance data from Aquip are presented in the figure below. As the data show, Aquip produces good quality stormwater effluent for the regulated stormwater pollutants as well as for many that are not currently, but may be regulated in the future.



aquip® Operation



1 **Inlet:** Polluted stormwater flows into Aquip via the inlet pipe, then into the pretreatment chamber. In most cases stormwater is pumped to Aquip using a simple float actuated stormwater pump. A totalizing flow meter on the system lets owners track the rate and total amount of stormwater treated to assist with predictive maintenance.

2 **Pretreatment Chamber:** This chamber is customized to naturally balance the water chemistry and improve the quality of the stormwater. The pretreatment chamber can be configured to settle solids, remove oil, or with buffering media for enhanced dissolved metals removal. The buffering process works synchronously with Aquip's adsorptive filtration media, coagulating particulates, adsorbing dissolved metals and creating metal complexes that are more easily removed in the filtration chamber. A mosquito barrier layer is provided to prevent breeding in the pretreatment chamber.

3 **Inlet Distributor:** Water from the pretreatment chamber flows by gravity into the inlet distributor and is dispersed along the full length of the filter media bed, optimizing the contact area of stormwater with filtration media. Energy dissipation fabric lies beneath the distributor to prevent scouring of the media bed.

4 **Filtration Chamber:** Layers of inert and adsorptive media remove stormwater pollutants such as metals, particulates, oil, organics and nutrients. Within the filtration chamber, pollutant removal occurs through a combination of straining, filtration, complexing, adsorption, absorption, micro-sedimentation, and biological degradation, producing excellent water quality. Once passed through the media bed, clean stormwater flows into the underdrain and out of the system, and the pollutants are permanently trapped in the filter bed. The filter bed drains down between storm events. Integrated ladders, filter maintenance tools and an external filter bed drain-down are provided allowing facility personnel to perform routine maintenance without special equipment.

5 **Adjustable Head Control:** Clean stormwater leaving the system passes through the adjustable head controller. This device can be adjusted in the field and assures optimal water/filter media contact under a range of operating conditions.

6 **Emergency Overflow:** This outlet provides a means for stormwater to bypass the filter in case the filter becomes plugged during a rain event. Filter bed plugging is avoided by maintaining the system per StormwateRx recommendations.

7 **Outlet:** Clean stormwater discharges by gravity from the Aquip structure through the outlet.

8 **Outlet Sample Port:** This port provides safe and easy access to system effluent for stormwater compliance sampling.

aquip® Configurations

Aquip is available in a number of configurations. Whether the structure is steel, plastic, concrete, fiberglass, earthen, or owner-supplied, Aquip owners can expect the same high level of performance and reliability. Available upgrades for Aquip include freeze protection, soft or rigid covers, and seismic tie-downs.

Aquip above-grade

Our most popular Aquip configuration, Aquip in a steel configuration for above-ground applications can be moved into place quickly and can be operational in as few as two days.

- Easy to install with a forklift
- Open-top for easy access
- Built-in ladders allow simple maintenance
- Eight sizes available for flow rates up to 600 gpm

Aquip below-grade

This Aquip configuration is designed in a pre-cast concrete vault or panel-vault and is suitable for buried applications.The below ground configuration can be supplied with a solid lid for traffic rated applications or with an open top for easy inspection and maintenance.

- Ideal for large sites such as ports and marine facilities
- Often used for new or redeveloped industrial sites
- Flexible layout to accommodate varying site orientations
- Flow rate virtually unlimited

Aquip portable

Aquip Portable is available in both downspout and wash rack configurations. The downspout configuration uses our advanced media configuration and provides the highest and longest lasting zinc reduction from rooftops in the industry.

- Treats up to ¼ acre, with flow rates up to 15 gpm
- 95-98% zinc reduction for downspout model
- Easy Do-It-Yourself installation
- Used for wash rack applications too!

Aquip green / Aquip user-build

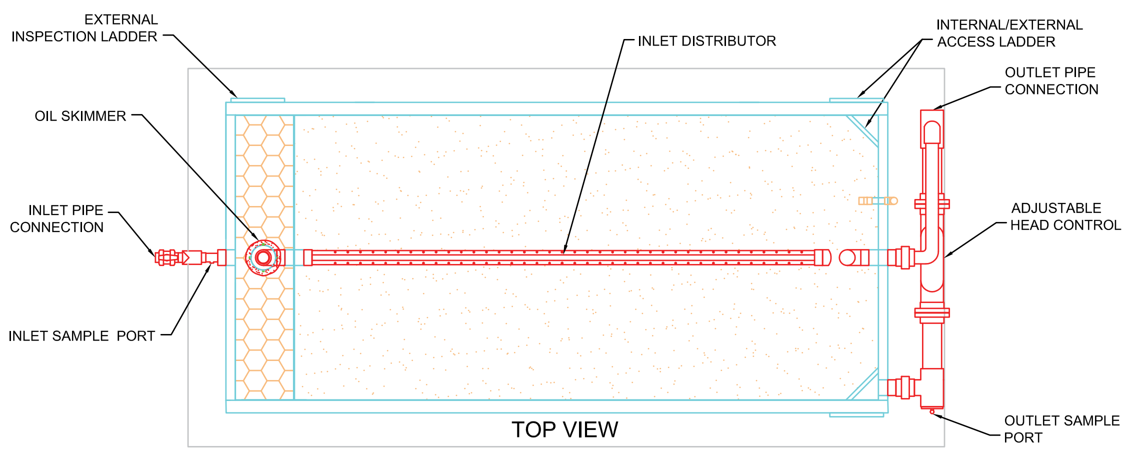
The Aquip filtration system can be supplied in a user-build configuration for applications where the customer desires to supply or build their own Aquip housing. User-supplied Aquip filters have been fabricated from steel, concrete and fiberglass and, in certain cases, StormwateRx can design the filtration technology to fit existing sub-terrain structures or vaults.

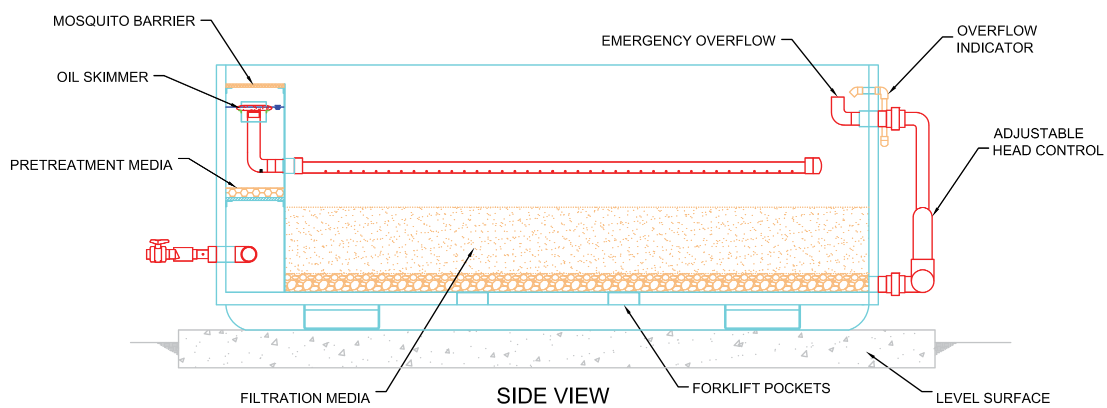
The Aquip green configuration is ideal for jurisdictions where Low Impact Development (LID) or Green Infrastructure designs are encouraged for stormwater volume reduction and where soil properties, groundwater levels and the regulatory framework will allow for stormwater infiltration.

aquip® Sizing

Aquip Model	Treatment Rate (gpm)	Sizing Guideline (acres)*	Footprint (feet)
10	5 – 15	< 0.25	3’ x 9’
25	12 – 40	0.25 – 0.5	5’ x 9’
50	25 – 75	0.5 – 1	7’ x 12’
80	40 – 120	1 – 2	7’ x 16’
110	60 – 170	2 – 3	8’ x 18’
160	80 – 240	3 – 4	8’ x 27’
210	100 – 320	4 – 5	8’ x 32’
300	150 – 450	5 – 8	13’ x 36’
400	200 – 600	6 – 10	13’ x 47’

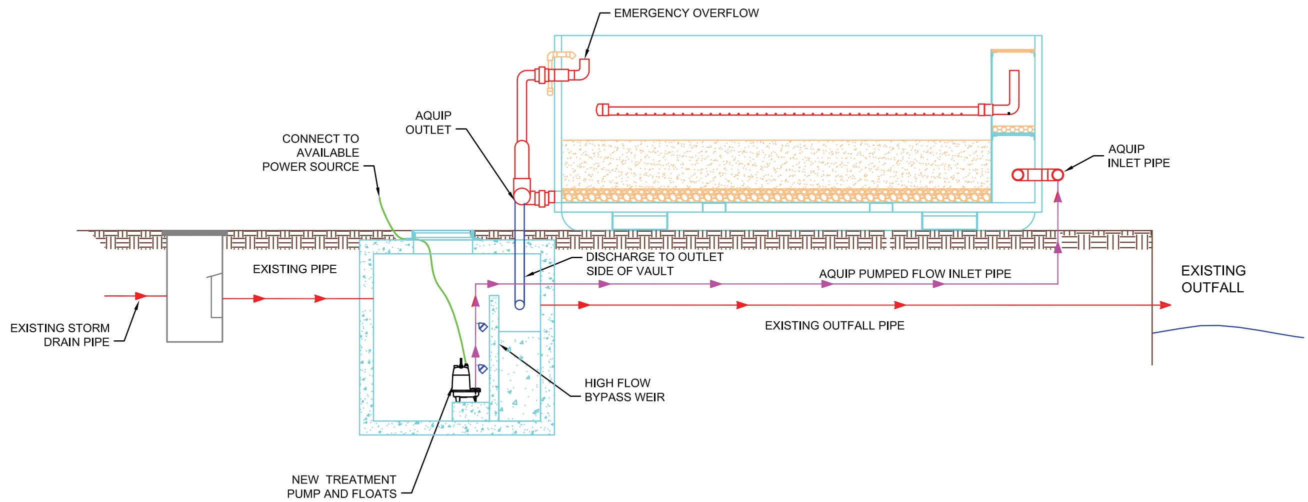
* Varies by region



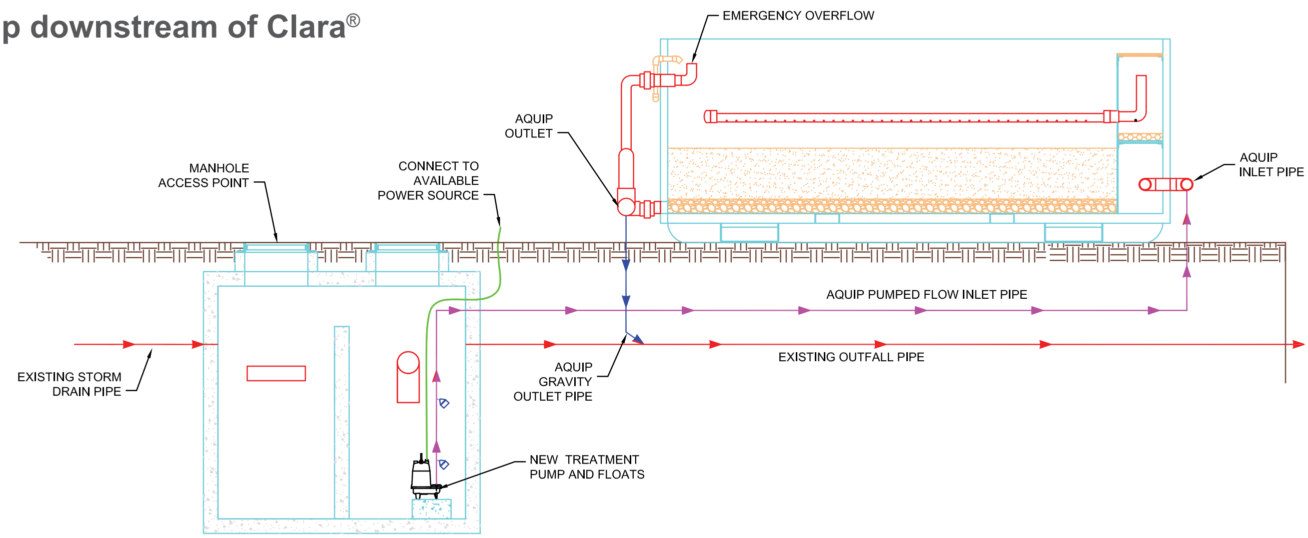


aquip® Treatment Trains

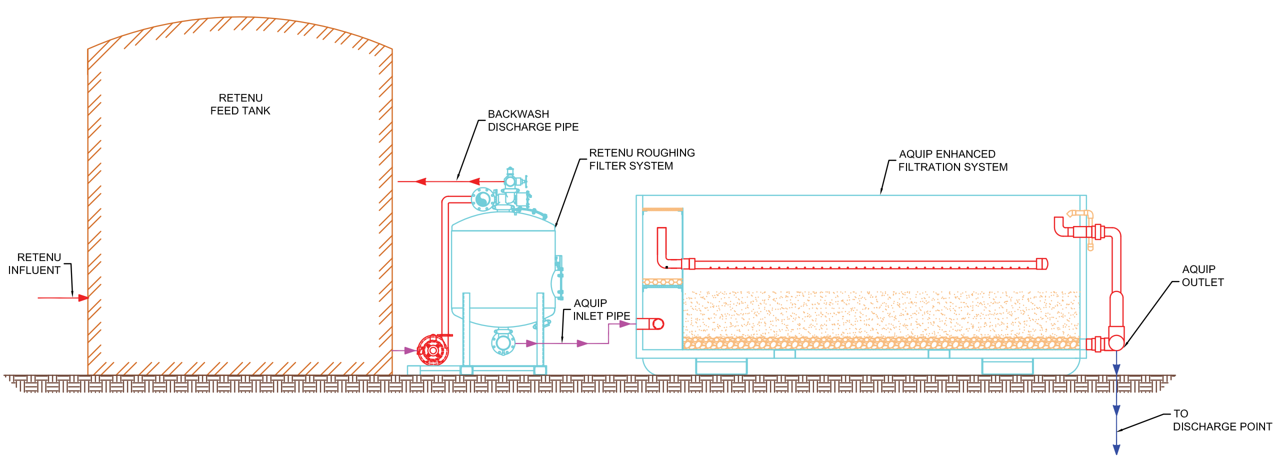
Aquip downstream of bypass pump vault



Aquip downstream of Clara®



Aquip downstream of Retenu®



Testimonials

"As a locally-owned company in a part of the world that is known for its beautiful, clean environment, we are acutely aware that we all share in the responsibility to protect and preserve its health and beauty. At SSC, we take this responsibility seriously and our installation of an environmentally-protective StormwateRx stormwater treatment system is one of the ways we are helping to ensure that our local waterways are clean and healthy for recreation and wildlife for generations to come."
- Paul Razore, President, Sanitary Service Co., Bellingham, Washington

"After years of struggling to stay below permit benchmarks, despite consistent effort and all the right BMPs, we didn't quite believe StormwateRx was going to get us there -- until we saw our first sampling results. The Aquip filter has vastly outperformed our previous filter system and brought us into full compliance."
- Greg Will, Calbag Metals Co., Operations Manager, Portland, Oregon

"Canal Boatyard has always been known as one of the cleanest facilities on the waterfront. We are proud to be at the forefront of the effort to keep runoff pollution to a minimum. The 2009 installation of the StormwateRx system filters runoff water from the entire yard; ensuring contaminants don't make it into the waterway."
- Ivaylo Minkov , Manager, Canal Boatyard, Seattle, Washington

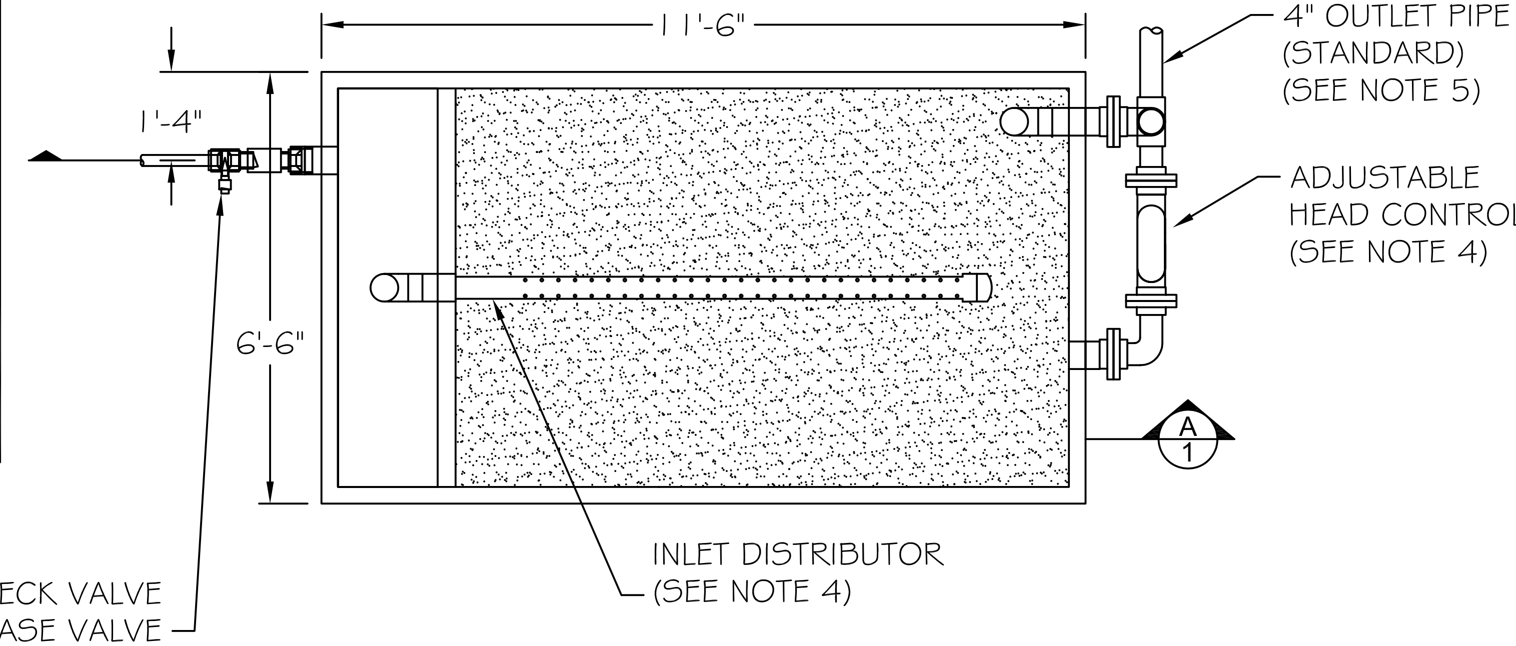
"StormwateRx represents best of class solutions that provide a ROI every manger will appreciate. Given the choice to proactively make a capital investment versus being subject to third party lawsuits I will always choose to invest in the future of our business. This is why we partnered with StormwaterRx."
- Edward Kangeter IV, CEO, CASS, Inc., Oakland, California

"We are always looking for ways to improve the efficiency and sustainability of our operations, and making sure we have the best stormwater treatment equipment is part of that commitment. The StormwateRx treatment train has put Davis Industries at the forefront of environmental technology for the scrap metal recycling industry and we are proud to own one of the most environmentally protective systems on the East Coast."
- Bill Bukevicz, Executive Vice President, Davis Industries, Lorton, Virginia

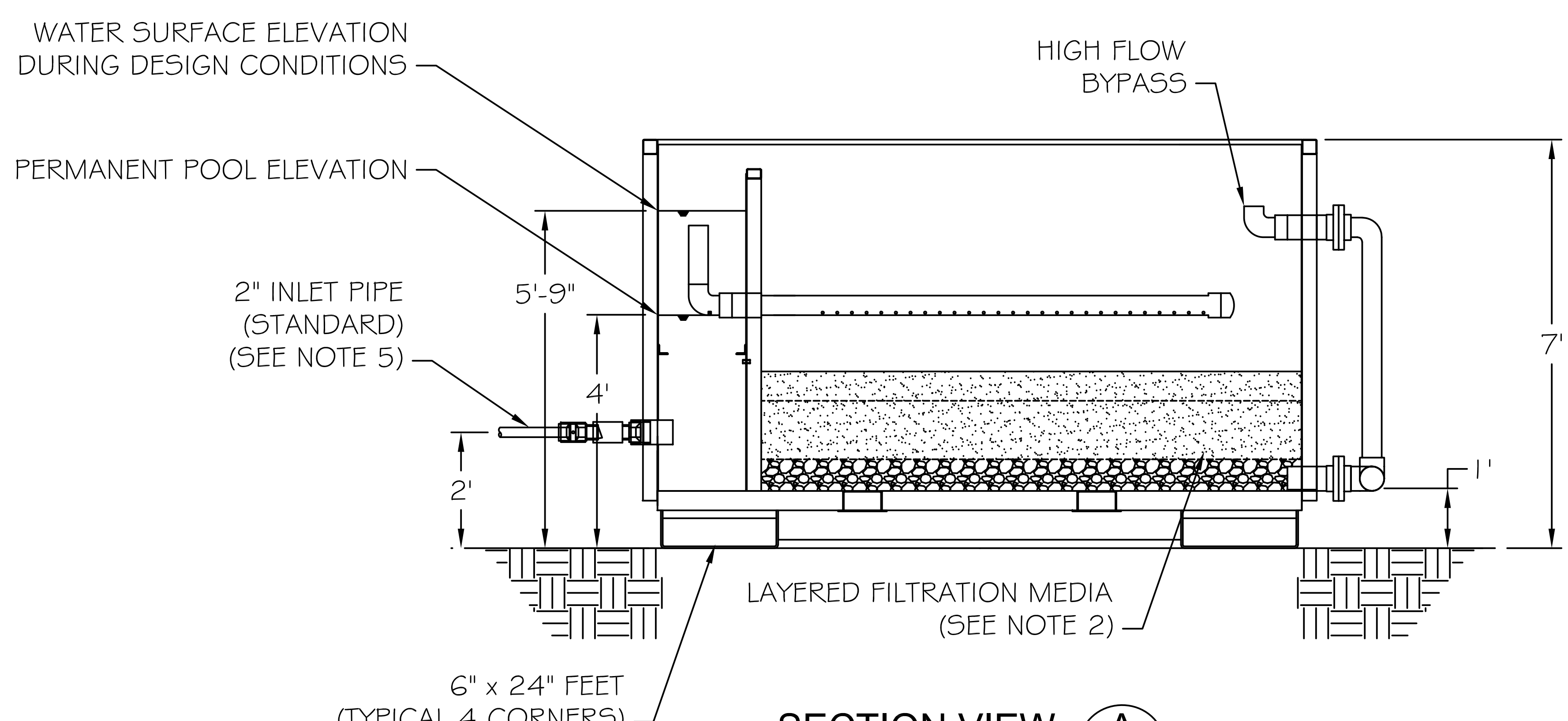
stormwateRx®
Reclaiming the world's water.®

GENERAL NOTES

1. AQUIP FILTRATION SYSTEM BY STORMWATERX LLC - PORTLAND, OREGON - 800.680.3543 (PATENT PENDING).
2. AQUIP LAYERED FILTER MEDIA COMBINATION DEPENDENT ON POLLUTANT REMOVAL REQUIREMENTS. TYPICAL MEDIA DEPTH OF 18 INCHES.
3. AQUIP PRETREATMENT CHAMBER MEDIA DEPENDE ON POLLUTNAT REMOVAL REQUIREMENTS. OPTIONS INCLUDE: NO MEDIA, BUFFERING MEDIA OR COALESCING MEDIA.
4. INTERNAL APPURTENANCES BY STORMWATERX INCLUDE INLET DISTRIBUTOR, UNDERDRAIN SYSTEM AND ADJUSTABLE HEAD FLOW CONTROL.
5. STANDARD DETAIL FOR REFERENCE ONLY. FINAL DIMENSIONS PROVIDED IN SHOP DRAWING.
6. INLET AND OUTLET PIPING CONNECTIONS TO BE SPECIFIED BY STORMWATERX AND PROVIDED BY OTHERS.



TOP VIEW 1/1



SECTION VIEW A/1

aquip™

stormwateRx™
www.stormwaterx.com

AQUIP MODEL 50S
STORMWATER FILTRATION SYSTEM
SOUTH PARK MARINA DETAIL

DATE: 03/03/08 | SCALE: N.T.S. | FILE NAME: AQUIP-50S-DTL | DRAWN: ARG | CHECKED: CPN

REVISIONS | DATE

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Appendix D

Summary of Treatment Vendors and Costs

TIG environmental®
INVESTIGATIONS ▾ FORENSICS ▾ REMEDIATION

1. Introduction

This appendix intends to provide additional technical detail about each of the proposed alternatives beyond the scope of the main report. Please note that all costs reported in this appendix are preliminary feasibility grade costs based on initial evaluations and conversations with vendors. Costs are subject to change based on site-specific conditions identified during detailed design and treatability studies, if deemed necessary.

The costs below are also presented in 2022 dollars, and no effort was made to reconcile or predict potential changes to these costs that may occur between the date of the report and the implementation of the selected alternative.

TIG Environmental (TIG) received information from the following stormwater treatment vendors: StormwateRx, Clear Creek Systems, Clear Water Services, and Enpurion. Each treatment technology offered by these vendors along with a detail cost estimate is summarized below.

2. Alternative 1: Routing Drainage to Existing Treatment System

Alternative 1 includes the construction of a conveyance system to route runoff from CA-01 to an existing treatment facility at the site. A filtration facility (Aquip Model 50SBE) is located on the southern portion of the site to treat suspended solids and metals from catchment area CA-02, draining to Unnamed Outfall No. 1. The existing system is sized to treat approximately 25 to 75 gallons per minute (gpm) or an area of approximately 0.5 to 1 acre.

2.1 Alternative 1a: Retain Existing Aquip 50SBE and Add Storage

TIG considered routing stormwater from CA-01 to the existing system, Aquip 50SBE; however, since the existing system is not correctly sized to treat the volume of runoff present across the entire site, additional storage is required prior to treatment to account for the additional runoff. Additionally, since the subsurface piping currently routes water from CA-01 to the South Park Marina outfall, this alternative would require new stormwater conveyance infrastructure to convey runoff to CA-02. A preliminary cost estimate for Alternative 1a is summarized below:[1]

[1] Assuming the existing, appropriately-sized system treats runoff over a 24-hr accumulation period. Any excess treatment needed beyond this amount will need storage.

2.1.1 Cost Estimate: Purchase, Delivery, and Installation

Cost estimate for keeping the existing treatment system (Aquip 50SBE) and installing a 90,000-gallon tank for temporary storage of the additional runoff from CA-01:

Table D-1 Costs for Existing Aquip Model 50SBE

Component	Quantity	Estimated Unit Cost	Assumptions
90,000-gallon storage tank (e.g., poly tanks)	1	$59K	No secondary containment required, size of the tank would be suitable for the site (cost not including freight or labor costs for installation)
Cost range for media replacement[1]	As needed	$700 to $25K	Likely requires media replacement every 6 months
Order of Magnitude Cost	**$59Kto $84K**		

Note

[1] Standard media replacement guidance in the Aquip Stormwater Filtration System Operation & Maintenance Manual advises partial media replacement every two (2) years and full media replacement every six (6) years. Since this alternative would include effectively doubling the amount of runoff being treated within the system, TIG estimates the media for this alternative would need to be replaced every 6 months.

2.1.2 O&M Considerations and Cost

Currently, the average lifespan of the media in the Aquip 50SBE is two years, and costs about $25K to replace. By routing all of the runoff from CA-01, which is approximately 1.5 times size of CA-02, TIG assumes the effective lifespan of the media would be reduced by approximately 1.5, meaning the media would need to be replaced every six months rather than every year. Therefore, the annual media replacement cost for Alternative 1a would be approximately $50K.

2.2 Alternative 1b: Replace Existing Aquip 50SBE

Consistent with Alternative 2a, Alternative 2b includes routing all of the runoff from catchment area CA-01 to catchment area CA-02. However, instead of ultimately treating the runoff with the existing Aquip 50SBE, TIG proposes replacement of the Aquip 50SBE with the larger Aquip 110SBE which is more appropriately sized to treat the volume of the combined runoff in catchment areas CA-01 and CA-02.

Table D-2: Comparison of Storage Requirements for Existing vs. Larger Treatment System

Aquip Model	Treatment Capacity	Required Storage[1]	Stored Volume Treatment Time
50SBE (existing model)	72,000 gpd	80,500 gal	1.12 days
110SBE	158,400 gpd	10,000 gal[2]	0 (Indicated storage is contingency)

Notes

[1] The required storage volume was calculated by adding the known design storm volume from CA-01 to the assumed design storm volume for CA-02 (Section 3.1.3 of main text). The assumed design storm volume for CA-02 is 72,000 gpd, as this represents the size of the existing treatment system that currently effectively treats the volume of stormwater in CA-02. The required storage volume also assumes the levels of containment at the site do not necessitate secondary containment storage.

[2] No storage is technically needed for this stormwater treatment option, but TIG suggests 10,000 gal storage for potential overflow conditions.

[3] The storage volume of 10,000 gallons listed here is to account for contingencies and potential fluctuations in runoff volume due to different sized storm events.

2.2.1 Cost Estimate: Purchase, Delivery, and Installation

Cost estimate for replacement of the existing Aquip 50SBE treatment system with a larger model (Aquip 110) in CA-02 and installing a 10,000-gallon tank for storage of the additional runoff from CA-01:

Table D-3: Costs for Replacement Aquip Model 110

Component (examples)	Quantity	Estimated Unit Cost	Assumptions
Replacement/New System	1	$94K (includes approx. $5K discount for buyback of existing system)	Cost does not include potential pumps, engineering services, detention, freight, labor.
10,000-gallon storage tank (e.g., poly tanks)	1	$19K	Np secondary containment required, cost does not include freight fees, labor cost, pumps.
Cost range for media replacement	As needed	$1K to $27K	Potential early media replacement needs, labor cost.
Order of Magnitude Cost	**$114K to $140K**		

2.2.2 O&M Considerations and Cost

The existing StormwateRx system (Aquip 50SBE) has a media lifespan of approximately two years, so for the purposes of this evaluation, TIG assumes the same media lifespan for the proposed replacement Aquip 110SBE. Media replacement for the Aquip 50SBE costs approximately $25K, so TIG assumes replacement for the Aquip 110SBE, approximately twice the size, is $50K. Therefore, annualized O&M costs for the proposed Aquip 110SBE are $25K.

2.3 Alternative 1 Evaluation

Both Alternative 1a and 1b are technically feasible and would effectively treat runoff concentrations to below benchmarks. Since the existing treatment system has effectively reduced contaminant concentrations in stormwater from CA-02 to below benchmark levels, and TIG asserts that the stormwater in CA-01 is substantially similar to CA-02 due to the similarity of operations, then it is reasonable to expect similar treatment outcomes.

The site infrastructure work required to re-route runoff from CA-01 to CA-02 would necessitate additional excavation and pipe placement than what is currently proposed to upgrade the infrastructure within CA-01 (Section 4 of this appendix). Due to this logistical complexity and cost consideration, as well as the increased disruption to the operational areas of the site, TIG does not consider either Alternative 1a or 1b alternative to be realistic or practical for implementation at the site, and therefore will no longer evaluate either one in the remainder of this appendix.

3. Alternative 2: Addition of New Filtration System at CA-01

Based on a holistic review of the site's existing infrastructure, required upgrades to the stormwater infrastructure, and additional site consideration presented in the main report text and Section 4 of this appendix, TIG determined the most feasible alternative is installation of a new, above-ground filtration treatment system designed to collect and treat runoff from CA-01. The following set of alternatives presents the different options and associated costs available for above-ground filtration treatment of stormwater in CA-01.

3.1 Alternative 2a: StormwateRx Aquip System in CA-01

Alternative 2a includes modifications to the stormwater conveyance system (Section 4 of this appendix) to route runoff to a new above-ground treatment facility upgradient of the SPM outfall in CA-01. This treatment facility would consist of an above-ground multi-media filtration system specified and sized by the manufacturer to treat copper and zinc in stormwater in the SPM outfall basin. Currently, a StormwateRx Aquip treatment system is present on the site and has been effectively treating runoff from CA-02 since its installation in 2009. Because of the observed effectiveness of the StormwateRx treatment system, as well as the substantially similar nature of operations and contaminant loads across the site, TIG chose to evaluate placement of a second StormwateRx Aquip system on the site to treat runoff from CA-01. The following table summarizes the design criteria for CA-01 compared to the Aquip models offered.

Table D-4: Comparison of StormwateRx Aquip Model Unit Sizes

Design Criteria		Aquip Models Offered	
Treatment Rate from Design Storm (gpm)	Outfall Basin Area (acres)	Aquip Model 80 Treatment Rate (gpm) and Basin Area Sizing (acres)	Aquip Model 110 Treatment Rate (gpm) and Basin Area Sizing (acres)
110[1]	2.25[2]	40-120; 1-2	60-170; 2-3
Quantity needed		2	1

Notes

[1] Or 80,552 gal/day identified in report.

[2] Or 97,900 sq ft identified in report.

The StormwateRx vendor recommends installing the Aquip Model 110SBE designed for a treatment flow rate of 110 gpm with an above-ground system footprint of 8.5' x 21'. Therefore, we will consider the Aquip Model 110 to be appropriate for the site and will not consider the Aquip Model 80 further in this appendix. The system includes a sealed tank structure with forklift pockets, two access ladders, up-flow pretreatment chamber with SBE media and integrated oil skimmer, and down-flow filtration chamber with layered inert and adsorptive biofiltration media for particulates, organics, and dissolved pollutants removal. The system comes with an instantaneous and totalizing flow meter, flow control valve, adjustable head control, emergency overflow indicator, sample ports, and maintenance tool.

This technology works the same way the existing treatment system at the site works, by passively treating stormwater through five layers of adsorptive treatment media separated by geofabric. Refer to the below diagram for basic design and construction elements of this system. The media type recommended by the StormwateRx vendor is the 'SBE' media matrix, which is already being used in the existing treatment system at the site.

According to the StormwateRx vendor, this technology is expected to reduce zinc and copper concentrations in stormwater with an efficiency of 90 to 95 percent, which will facilitate compliance with the permit benchmarks. In conclusion, we believe this alternative to be effective in treating stormwater runoff to below permit benchmarks because we currently use one of these systems at the site with the same media and the characteristics of the runoff in both places are expected to be substantially similar. Therefore, installing a second StormwateRx unit in CA-01 has proven to be a reasonably justified alternative as a proposed remedy for meeting permit benchmarks and limits.

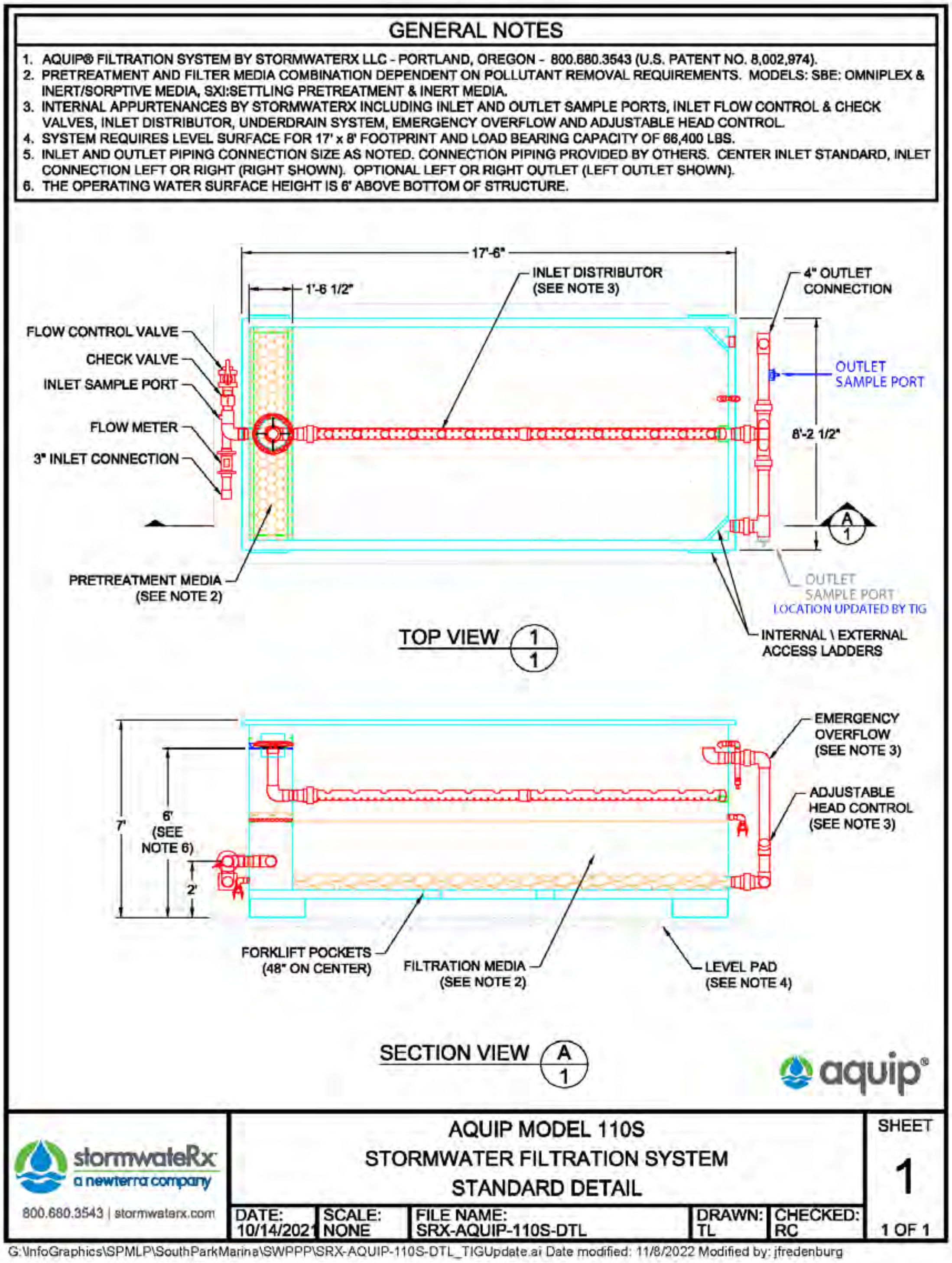

Figure D-1: Flow diagram for Alternative 2a: Installation of a second StormwateRx Aquip Model above-ground treatment system to treat stormwater runoff in catchment area CA-01.

3.1.1 Cost Estimate: Purchase, Delivery and Installation

The preliminary cost estimate for installing a new treatment system (Aquip 110) in CA-01 is presented in the table below.

Table D-5: Aquip Model 110 Cost Estimate for Alternative 2a

Product/Service	Quantity	Description
Aquip Model 110SBE	1	Aquip enhanced stormwater filtration system designed for a treatment flow rate of 110 gpm with an above-ground system footprint of 8.5' x 21'.
Pump System	1	Simplex pump system: 1 HP (230V/1Ph/13A) pump operating at 103 gpm[2] with less than 27 ft total dynamic head, including single float switches (qty. 2) and check valve. A control panel is not included/required.
Startup & Training[1]	1	Includes onsite assembly and installation oversight by a StormwateRx trained technician (2 man-days maximum), Operation and Maintenance Manual and training. Subsequent StormwateRx representative visit charged at $125/hr plus expenses.
Total Cost	**$101K**	

Note

[1] Equipment assembly, installation, and training must be completed during the same visit. Delivery and installation to be scheduled a minimum two weeks in advance.

3.1.2 O&M Considerations and Costs

The existing StormwateRx system (Aquip 50SBE) has a media lifespan of approximately two years, so for the purposes of this evaluation TIG assumes the same media lifespan for the proposed Aquip 110SBE. Media replacement for the Aquip 50SBE costs approximately $25K, so TIG assumes replacement for the Aquip 110SBE, approximately twice the size, is $50K. Therefore, annualized O&M costs for the proposed Aquip 110SBE are $25K.

Since StormwateRx is the manufacturer and maintenance point of contact for the existing stormwater treatment system (Aquip 50SBE), installation of a second treatment system from the same manufacturer achieves efficiency for regular required maintenance and media replacement.

[2] The 103 gpm pump flow rate displayed in this table was calculated by StormwateRx as part of their proposal to provide the described technology for this site. The flow rate was calculated using the Western Washington HydroModel (WWHM). The model run was based on a site-specific 2.5 acre impervious drainage area; the output flow rate used was the "off-line facility target flow." All inputs used to develop this flow rate, as well as the output values, are shown in the output file included at the end of Appendix E.

3.1.3 Estimated Total Alternative Cost

Table D-6: Estimated Total Alternative Cost

Purchase, Delivery, and Installation	CA-01 Infrastructure Upgrades	Indirect Costs	Tax	Total
$101K	$135K	$172K	$26K	$434K

3.2 Alternative 2b: Clear Creek Systems Pressurized Filtration System

Alternative 2b includes modifications to the stormwater conveyance system to route runoff to a new treatment facility upgradient of the SPM outfall. Clear Creek Systems offers an active pressurized filtration system that can include only above-ground technology, or in combination with below-ground components for a smaller footprint. The treatment system is designed to reduce dissolved metals to below benchmark concentrations and involves five general treatment steps: gravity settling, mechanical filtration, adsorptive media, ion exchange, and discharge. This process uses a series of four enclosed pressurized above- or below-ground tanks or vaults, one mixed media filtration system, one pressurized adsorptive media vessel, and one ion exchange vessel before treated water is discharged to receiving waters.

Site stormwater is collected in a lift station and is directed to above grade tank(s) for gravity settling before it is conveyed to the filtration system via a float-controlled filtration pump. The filtration system consists of a deep bed pressurized mixed media filter (anthracite, sand, garnet, and gravel) that provides filtration down to approximately five microns. Effluent from the mixed media filter is routed to a pressurized adsorptive media vessel containing CCS 400 (a proprietary blend of carbon and activated zeolite) for reduction of hydrocarbons and metals. Effluent from the adsorptive media vessel is routed to the ion exchange vessel containing Metlock IX resin (cation exchange resin) for reduction of dissolved metals before treated site stormwater is discharged to receiving waters. Refer to the below diagram for basic design and construction elements of this system. The design of this treatment system assumes a 2.25-acre site that is 90 to 95 percent impervious with an estimated offline treatment flow rate of 100 gpm, is based on bench scale treatability testing results from a nearby site in South Seattle.

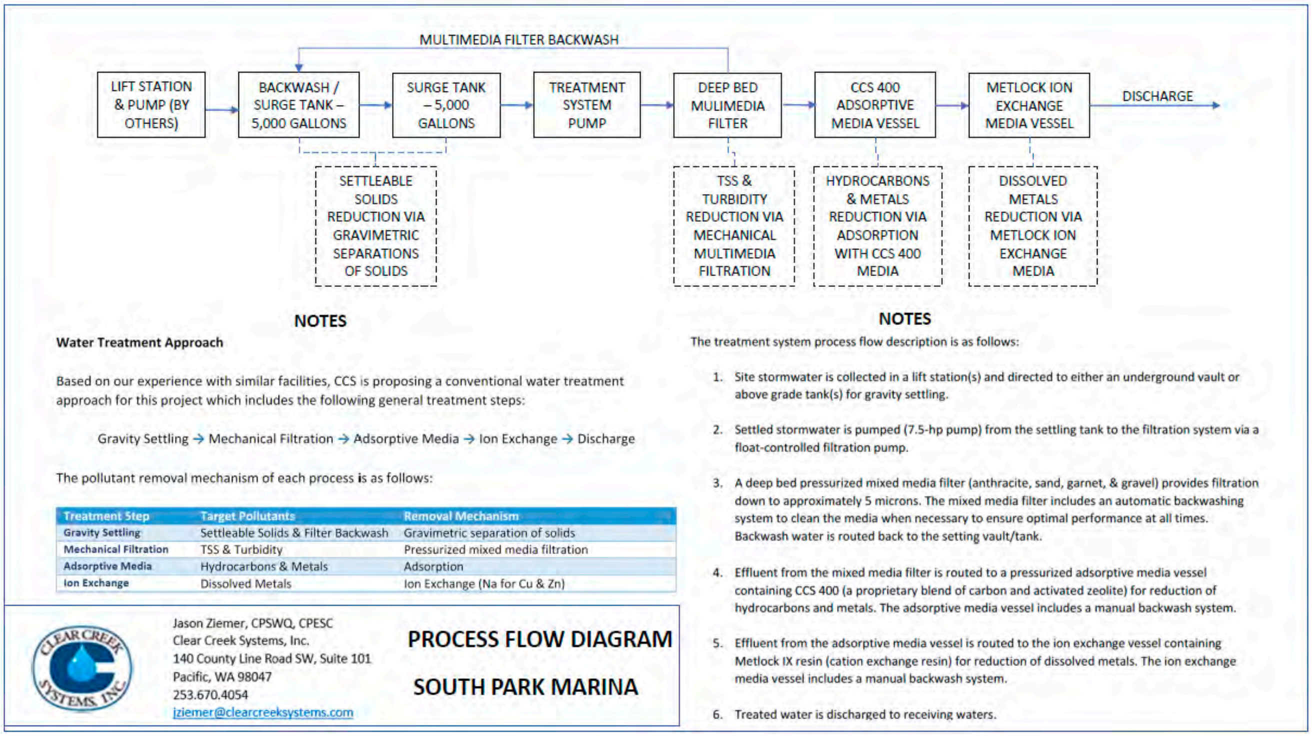

Figure D-2: Flow diagram for Alternative 2b: Installation of a Clear Creek Systems above-ground filtration system to treat stormwater runoff in catchment area CA-01.

The filtration system has an automatic backwashing system to clean the media when necessary and backwash water is routed back to the setting vault/tank. The adsorptive media vessel and ion exchange media vessel includes a manual backwash system. The types of media used in the treatment process includes:

- Mixed media filter of anthracite, sand, garnet, and gravel for filtration of solids
- 3,000 lbs of CCS 400 – a proprietary blend of carbon and activated zeolite for reduction of hydrocarbons and metals
- 50 cubic feet (cf) of Metlock IX resin – cation exchange resin for reduction of dissolved metals

Clear Creek Systems is confident that the proposed treatment equipment will be successful in achieving and maintaining compliance with the site-specific benchmarks as required in the National Pollutant Discharge Elimination System (NPDES) permit issued by the Washington Department of Ecology (Ecology). The results expected from the treatment process are based on the outcomes of previous case studies where this technology is implemented. A project based out of Tacoma, Washington applied a similar type of system. The 2.5-acre site was used for marine vessel manufacturing and failed to meet benchmarks on dissolved metals that were discharged to marine waters (including copper and zinc). Mechanical filtration and ion exchange resin technology treated 100 gallons of stormwater per minute which resulted in 100 percent compliance since the system's delivery date. Another case study with similar outcomes include a shipyard in Charleston, Oregon, where stormwater concentrations of total suspended solids (TSS), copper, zinc, and bacteria decreased to non-detect levels. Bench testing will need to be achieved at SPM to properly assess the exact design required to meet benchmarks.

Since this technology has worked in other places with similar configuration, the proposed treatment is reasonably expected to meet the permit benchmarks and limits. According to the Clear Creek Systems vendor, this technology is expected to reduce zinc and copper concentrations in stormwater by 99 percent, which will facilitate compliance with the permit benchmarks. In conclusion, we believe this alternative to be effective in treating stormwater runoff to below permit benchmarks. Therefore, installing a pressurized filtration system in CA-01 has proven to be a reasonably justified alternative as a proposed remedy for meeting permit benchmarks and limits.

3.2.1 Cost Estimate: Purchase, Delivery and Installation

Table D-7: Clear Creek Systems Cost Estimate for Alternative 2b

Product/Service	Quantity	Description
Settling Tanks	2	5,000-gallon capacity tank for stormwater storage
Filtration Pump	1	7.5 HP with electric panel
Media filter	1	Auto backwashing deep bed mixed media 12.56 sq ft of filtration surface area
Media vessels, plumbing, pressure gauges, flow meters	2	72 cubic ft media vessels, three (3) flow meters, Metlock ion exchange vessels
Delivery and Installation	1	Delivery and installation of the treatment system included
Total Cost	**$220K[1,2]**	

Notes

[1] The total cost assumes above-ground treatment tanks and not below grade vaults. The cost estimate may increase if below grade vaults are preferred.

[2] Leasing options are available for this system.

3.2.2 O&M Considerations and Cost

According to Clear Creek Systems, the lifespan of the media for the proposed treatment system is five years. Costs for media replacement were not provided by the manufacturer, so TIG has assumed media replacement costs are $50K. Clear Creek Systems provided TIG with estimated monthly O&M Costs of $475 which includes technician labor and annual O&M Costs of $760. The total for monthly and annual O&M Costs, including media replacement every five years, are $6K. With the addition of some contingency, annualized O&M costs for this alternative are approximately $10K.

3.2.3 Estimated Total Alternative Cost

Table D-8: Estimated Total Alternative Cost

Purchase, Delivery, and Installation	CA-01 Infrastructure Upgrades	Indirect Costs	Tax	Total
$220K	$135K	$172K	$40K	$567K

3.3 Alternative 2c: Clear Water Services Gravity Filtration System

Alternative 2c includes modifications to the stormwater conveyance system to route runoff to a new treatment facility upgradient of the SPM outfall. Clear Water Services provides an above-ground active stormwater treatment system designed to reduce concentrations of metals, including zinc and copper, to below benchmark levels. This above-ground treatment technology incorporates a standalone pH monitor, a sodium hydroxide (NaOH) chemical injector, one 5,000-gallon upright poly storage tank, one four-pod sand filtration system, two 2,000-lb filtration media vessels, one pump each for stormwater conveyance and filtration to be installed by others, and one standalone PLC electric panel with automatic controls, alarms, and alerts. The basic design and construction of this system was based on treating 2.25 acres of stormwater at a system flow rate of 100 gpm.

Stormwater enters the treatment system via a discharge pipe outfitted with a 2-horsepower submersible pump and is directed toward the pH monitoring station before being injected with NaOH. The stormwater is then captured in the 5,000-gallon storage tank and held until it is pumped to the 4-pod sand filtration system using a 5-HP centrifugal filtration pump. Following sand filtration, the stormwater is relayed through two 2,000-lb adsorption multi-media vessels containing a 50/50 blend of Hydrosoil HS-MT and virgin coconut granular activated carbon (GAC) before being discharged into receiving waters. Refer to the below diagram for basic design and construction elements of this system.

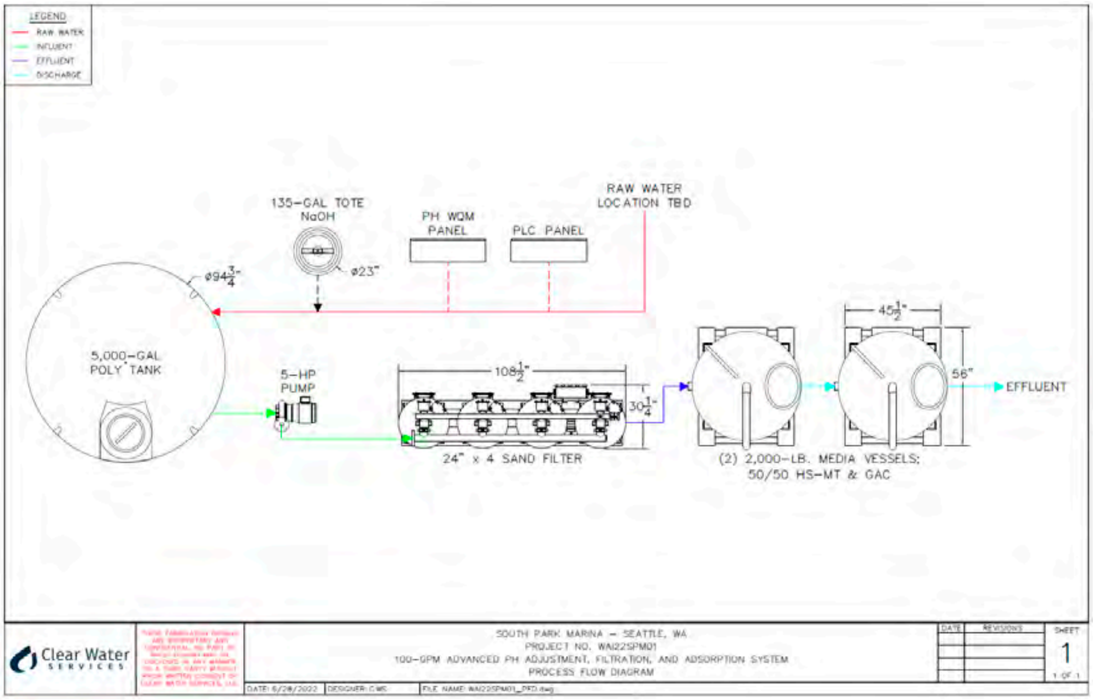

Figure D-3: Flow diagram for Alternative 2c: Installation of a Clear Water Services above-ground gravity filtration system to treat stormwater runoff in catchment area CA-01.

The types of media used in the treatment process includes:

- NaOH for moving soluble metal ions to insoluble metal ions to support removal through filtration/adsorption,
- Sand filter media in one 24” x 4” diameter pod sand filtration (gravel and 20-30 silica sand), and
- Adsorptive filter media comprised of 50 percent Hydrosoil HS-MT for total copper reduction and 50 percent virgin coconut GAC for zinc reduction.

Clear Water is confident that the proposed treatment equipment and adsorptive multi-media selection will be successful in achieving compliance with the site-specific benchmarks as required in the NPDES permit issued by Ecology. The results expected from the treatment process come from a similar boatyard in Seattle, Washington, using a 100 gpm filtration and adsorption treatment system. This system includes the same media proposed for South Park Marina. Performance sampling events at this representative boatyard demonstrate adequate reduction for the same contaminants of concern present at South Park Marina.

Since this technology has worked in another location with a similar configuration, the proposed treatment is reasonably expected to meet the permit benchmarks and limits. According to the Clear Creek Systems vendor, this technology is expected to reduce zinc concentrations in stormwater by 98 percent and copper by 92 percent, which will facilitate compliance with the permit benchmarks. In conclusion, we believe this alternative to be effective in treating stormwater runoff to below permit benchmarks. Therefore, installing a pressurized filtration system in CA-01 has proven to be a reasonably justified alternative as a proposed remedy for meeting permit benchmarks and limits.

3.3.1 Cost Estimate: Purchase, Delivery and Installation

Table D-9: Clear Water Systems Estimate for Purchase, Delivery and Installation of Alternative 2c

Treatment System Cost Matrix	
Submittals, Permitting & Engineering Support	$6K
100 GPM Automated pH Adjustment System + Filtration	$143K
Adsorption Multi-Media System: utilizing Hydrosoil HS-MT and GAC	$54K
System Installation & Commissioning	$26K
Assumes owner will provide loading/unloading and placement of equipment. Assumes owner will provide electrical connection (power) to the system as well as interconnecting conduit. Assumes owner will provide all conveyance structure and water conveyance to the treatment system. Also assumes owner will support all confined space work – excluded from this estimate.	
Total Treatment System Purchase:	**$229K[1]**

Note

[1] Leasing options are available.

3.3.2 O&M Considerations and Cost

Clear Water Services provided TIG with estimated annual O&M Costs of $9.3K which includes NaOH chemistry, annual PLC software licensing, annual data charges for modem use, project management and technician labor.

3.3.3 Estimated Total Alternative Cost

Table D-10: Estimated Total Alternative Cost

Purchase, Delivery, and Installation	CA-01 Infrastructure Upgrades	Indirect Costs	Tax	Total
$229K	$135K	$171K	$41K	$576K

3.4 Alternative 2d: Enpurion Coupled Pressurized Filtration Systems

Alternative 2d includes modifications to the stormwater conveyance system to route runoff to a new treatment facility upgradient of the SPM outfall. Enpurion provides above-ground passive sorption/ion-exchange filtration systems designed to remove concentrations of dissolved metals, including zinc and copper, to below benchmark standards. Enpurion also provides below-ground catch basins and compact downspout treatment units effective for the removal of heavy metals prior to treatment in their above-ground units. Enpurion recommends using four FlexFilter™ compact downspout units to capture zinc from the metal galvanized roof, six FlexBasin™ catch basin inserts, and three FlexMax™ above-ground treatment units. Placing Enpurion FlexSystem products in series provides the greatest value for the client to achieve compliance with benchmarks.

The first line of defense is at the point of collection for stormwater at catch basins. Within each catch basin, a FlexBasin™ will be deployed to provide treatment directly into storm drains by conveying stormwater through a series of mixed media formulations containing two pillows made of organic cellulose material activated absorb organics and particles, and one pillow made of organic cellulose material activated to absorb anionic suspended particles. Following treatment in the FlexBasin™, stormwater is routed to the FlexMax™ treatment system. Refer to the below diagram for basic design and construction elements of this system. The basic design and construction of this stormwater treatment system is based on treating 2.25 acres of stormwater runoff at a 94.5 gpm flow rate.

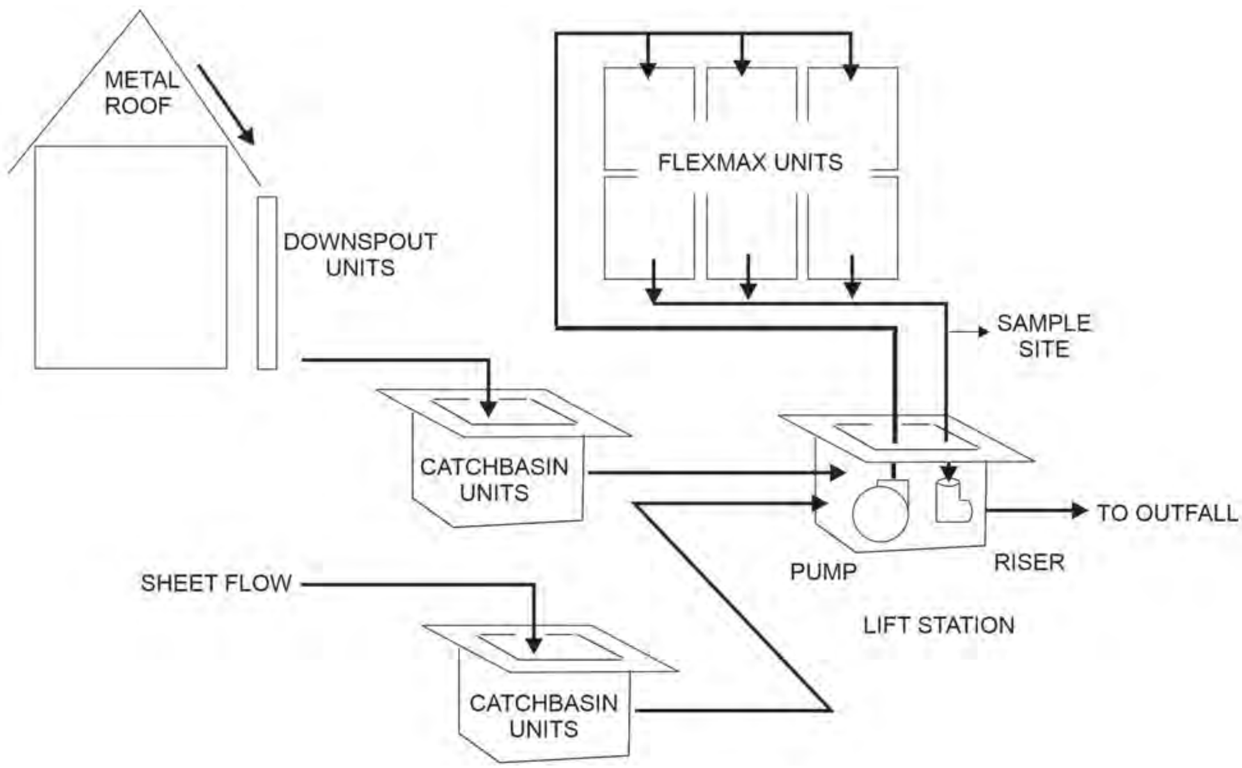

Figure D-4: Flow diagram for Alternative 2d: Installation of the Enpurion above-ground FlexSystem products to treat stormwater runoff in catchment area CA-01.

The types of media used in the treatment process is summarized below:

Table D-11: Media types used in Enpurion's Coupled Pressurized Filtration Systems

Media Type	Application	Treatment Category
Polypropylene Geotextile	FlexBasin technology and FlexMax treatment system	High particle and oil retention, mechanical filtration
Enpurion MT Media	FlexBasin and Downspout technology	Treats zinc, copper, iron and lead, emulsified and free petroleum hydrocarbons
Enpurion Bio-Blend Media	FlexBasin technology	Surface adsorption and bulk absorption of emulsified and free petroleum hydrocarbons
Enpurion ZnIX Media	FlexBasin and Downspout technology	High-capacity resin pillows for longer residence time and higher cation metals loading

The treatment efficiency or removal rating of a serial process is determined by the number of treatment units in the series. The efficiency of each treatment unit will vary and is usually determined by bench trials or estimated by Enpurion engineers. According to the Enpurion vendor, this technology is expected to reduce site stormwater concentrations by 90 percent for zinc and 98 percent for copper, which will facilitate compliance with the permit benchmarks. In conclusion, we believe this alternative to be effective in treating stormwater runoff to below permit benchmarks. Therefore, installing a coupled pressurized filtration system in CA-01 has proven to be a reasonably justified alternative as a proposed remedy for meeting permit benchmarks and limits.

3.4.1 Cost Estimate: Purchase, Delivery and Installation

Table D-12: Cost Estimate: Purchase, Delivery and Installation

Activity	Quantity	Rate	Amount
Flex Basin Ultra Frame (WA) – 18 x 24 x 18 Depth. Frame & Geotextile liner	6	$395	$2K
Flex Basin Large Pillow 20" x 24" – MT Media Formulation and Bio Char blend for metals treatment	12	$225	$3K
Flex Basin – High-Flow custom mesh liner. Design for larger tributary area	6	$50	$300
ZnIX Ion Exchange Pillow – Medium – Formulation for maximum zinc removal	6	$295	$2K

Activity	Quantity	Rate	Amount
ZnIX Ion-Exchange Downspout Technology – Compact Design. MT & ZnIX formulation for heavy metal removal	4	$2,995	$12K
Flex Max Above Ground Treatment Units, 3 x 405 – High flow (MACRO) THREE-Stage with internal drain manifold, media, overflow risers, header and polypropylene geotextile pre-filter – 48" x 52" x 150 "	3	$7,095	$21K
Delivery and Installation	1	$5.000	$5K
Upfront Cost		**Subtotal**	$45K
		Tax	$5K
		Total Upfront Cost	**$50K**[1]

Note

[1] This estimate does not include the cost of pumps. Enpurion recommends using two one-half-horsepower pumps, or one, one-horsepower pump.

3.4.2 O&M Considerations and Costs

Enpurion provided TIG with an estimated annual O&M cost of $29K for Alternative 2d. Additionally, since the system presented by Enpurion contains the highest number of discrete components (downspout filters, catch basin inserts, and an above-ground treatment system), TIG assumes regular maintenance of the system will be time intensive for Marina Staff, and presents the potential for more opportunities for a component of the system to fail or need to be fully replaced sooner than anticipated, which could increase the O&M costs to beyond the estimate provided.

3.4.3 Estimated Total Alternative Cost

Table D-13: Estimated Total Alternative Cost

Purchase, Delivery, and Installation	CA-01 Infrastructure Upgrades	Indirect Costs	Tax	Total
$50K	$135K	$171K	$21K	$377K

4. Additional Costs

4.1 Catchment Area Infrastructure Upgrades

Updates and modifications to the existing above- and below-ground drainage infrastructure will be implemented regardless of the chosen alternative. The catchment area infrastructure updates are required in order to address unknowns related to existing subsurface flow paths, as well as to allow for adequate capacity and installation of equipment (e.g., pumps) to transport runoff into the treatment system. Activities involve decommissioning existing stormwater lines, removal and replacement of catch basins, replacing stormwater lines between catch basins, and replacing stormwater lines between catch basins and the Duwamish River. Equipment, labor, excavation, and disposal is included in this cost table. This estimate assumes that fill material will meet specifications set by the City of Seattle, and does not include costs for permitting, special inspections for fill compaction testing, sampling, hardscape removal or replacement, temporary fencing, security guards, traffic control, or flagging.

Table D-14: Cost Summary for Catchment Area Infrastructure Upgrades

Task	Assumptions	Approximate Cost
Decommission existing stormwater lines	Grout, 6" diameter pipe, approx. 75 yards of controlled density fill (CDF). Includes a line pump for a day, time to create access points, and eco pans for cleaning at task completion.	$25K
Replace catch basin CB-2, remove catch basins CB-05 and CB-06 and replace with a single, new basin (larger) with a pump to move water into treatment system	Includes labor over multiple days for removal of existing basins, purchase of approx. 5' diameter basin with locking ring/cover, trucking, purchase, placement, and compaction of a gravel borrow type backfill and existing pan disposal.	$18K
Replace stormwater lines between CB-02 and new catch basins in locations CB-05 and CB-06	Includes Schedule 80 pipe, equipment, labor, excavation, and trucking and disposal of non-hazardous waste, installation of pipes, fittings, and sand collars at basins, and import, placement, and compaction of backfill.	$27K
Replace stormwater line between CB-05 and CB-06 and Duwamish River	Includes equipment, labor, excavation, trucking and disposal of non-hazardous waste, pipes, and fittings. Assumes tying into existing pope prior to shoreline.	$25K

Task	Assumptions	Approximate Cost
Install a 10' x 20' cement foundation	Assuming adequacy for each stormwater system alternative.	$20K
Replace the SPM Outfall	Can be done under a "maintenance upgrade" later.	TBD
Electrical improvements		$20K
	Total	$135K

4.2 Indirect Costs and Considerations

The following table details the indirect costs associated with each alternative, expressed as percentage of capital costs. Design includes the necessary engineering work to produce drawings for catchment area infrastructure updates as well as construction of the selected alternative. Permitting includes acquisition of all required city, state, and other municipal permits. Procurement includes all contracting and procurement activities to finalize bids for both the catchment area infrastructure updates as well as construction of the selected alternative. Construction management includes coordination with contractors and stormwater vendors prior to and during construction activities, as well as observation of construction activities. Construction closeout includes final documentation of construction activities. The percentages used for each of these indirect cost categories is approximate and based on professional experience.

Table D-15: Indirect Cost as a Percentage of Capital Costs

Activity	Costs
Average Cost of Purchase, Delivery, and Installation of Alternatives 2a–2d	$112K
Catchment Area Infrastructure Upgrade Cost	$135K
Total Average Capital Cost	$285K
Design (20%)	$57K
Permitting (15%)	$42K
Procurement (5%)	$14K
Construction Management (10%)	$29K
Construction Closeout (10%)	$29K
Total Indirect Costs	**$171K**

5. Cost Summary

The following table provides an estimated upfront cost overview for feasible treatment alternatives. This includes construction and installation of stormwater equipment, indirect costs, catchment area infrastructure, and an approximate Washington State tax rate of 11 percent. Indirect costs include civil engineering for the site, specifications and plans to procure a contractor, procurement, permitting, and construction management, observation, and closeout.

Table D-16: Estimated Costs Per Alternative Stormwater Treatment Method

Treatment Alternative	Treatment System Purchase, Delivery, Install	Indirect Costs	Catchment Area Infrastructure Update	Taxes	Total Project Cost
Alternative 2a	$101K	$171K	$135K	$26K	$433K
Alternative 2b	$220K	$171K	$135K	$40K	$566K
Alternative 2c	$229K	$171K	$135K	$41K	$576K
Alternative 2d	$50K	$171K	$135K	$21K[1]	$377K

Note

[1] Estimated tax was provided by the vendor in the cost estimate. This value represents the provided tax in addition to tax calculated on indirect costs and the sitewide infrastructure update.

6. Evaluation of Alternatives

To evaluate each of the proposed alternatives, TIG developed a ranking framework that assigns a value for each of the following metrics: technical effectiveness, initial cost, operations and maintenance (O&M) costs, and system ease of use. The four values are defined in table D-17 below. Following assignment of these values, TIG summed the individual metric values for each alternative, and the alternative with the highest overall score was selected as the preferred alternative.

Table D-17: Criteria Used for Evaluation of Treatment Alternatives

Value	Description			
	Technical Feasibility	**Initial Cost**	**O&M Costs**	**Ease of Use**
1	The alternative is technically infeasible	The alternative has the highest initial cost	The alternative has the highest O&M cost	The alternative is complicated to operate and maintain. It may have several components, including below-ground components, or require specialized training.
2	NA	The alternative has the second-highest initial cost	The alternative has the second-highest O&M cost	The alternative is somewhat complicated to operate and maintain. It may require specialized training for maintenance or contain a few different components.
3	NA	The alternative has the second-lowest initial cost	The alternative has the second-lowest O&M cost	The alternative is somewhat simple to operate and maintain. It may not require specialized training or contain only one or two components.
4	The alternative is technically feasible	The alternative has the lowest initial cost	The alternative has the lowest O&M cost	The alternative is simple to operate and maintain. It may be familiar to existing site workers or have only a few components or require minimal training.

Table D-18: Ranked Comparison of Treatment Alternatives

	Alternative 2a[1]	**Alternative 2b**	**Alternative 2c**	**Alternative 2d**
Technical Feasibility	4	4	4	4
Initial Cost	3	2	1	4
O&M Costs	2	3	4	1
Ease of Use	4	3	2	1
Total	**13**	**12**	**11**	**10**

Note

[1] Note, as is described at the end of Section 2.3 of this appendix, Alternative 1 was ruled out prior to the rankings due to the cost and logistical infeasibility of routing all of the site drainage to catchment area CA-02.

Based on the scores assigned in the table above, Alternative 2a is the preferred alternative. The preferred alternative is technically feasible, has the second-lowest upfront cost, the lowest O&M costs, and is the easiest to use since the site staff are already familiar with the technology, and one technician can service both of the systems present on the site at once (in cases when specialized maintenance is needed).

Appendix E

StormwateRx Supporting Materials

TIG environmental®
INVESTIGATIONS ▾ FORENSICS ▾ REMEDIATION

Stormwater Treatment System
Budgetary Estimate

stormwateRx a newterra company

Date:	June 15, 2022	Revision No. 0
Prepared for:	Erin O'Connell	
Project:	South Park Marina	
Project Site Address:	8604 Dallas Ave S, Seattle, WA, 98108	
Regional Manager/Point of Contact:	Chris Fromme, cfromme@newterra.com	
Prepared By:	Ted Lathrop, PE tlathrop@newterra.com	

System Design/Application Notes:

1. Site Design Parameters:
   a. Drainage Area: 2.5 acres
   b. Design Treatment Flow: 103 gpm
   c. Pollutant(s) of Concern: Zinc, Copper

2. Achieving the benchmarks or numeric action levels consistently requires implementation of best management practices (BMPs) including source control, structural and treatment BMPs. Treatment BMPs are not designed to operate in the absence of other BMPs.

3. Treatment BMPs require routine maintenance. See system operation and maintenance manual for details.

Section 1) Stormwater Treatment System

Qty	Product Number	Description
1	Aquip® Model 110SBE 	Aquip enhanced stormwater filtration system designed for a treatment flow rate of 110 gpm with an above-ground system footprint of 8.5' x 21'. System includes: ▪ Sealed tank structure with forklift pockets, two access ladders, up-flow pretreatment chamber with Omniplex media and integrated oil skimmer, and down-flow filtration chamber with layered inert and adsorptive biofiltration media for particulates, organics and dissolved pollutants removal ▪ Instantaneous and totalizing flow meter, flow control valve, adjustable head control, emergency overflow indicator, sample ports, and maintenance tool
1	Pump System	Design Storm Pump System includes: ▪ Simplex pump system: 1 HP (230V/1Ph/13A) pump operating at 103 gpm with less than 27 ft total dynamic head, including single float switches (qty 2) and check valve. A control panel is not included/required.
1	Startup & Training	Startup & Training includes: ▪ On-site assembly and installation oversight by a StormwateRx trained technician (2 man-days maximum) ▪ Operation and Maintenance Manual and training Note: Equipment assembly, installation and training must be completed during same visit. Delivery and installation to be scheduled a minimum two weeks in advance. ▪ Subsequent StormwateRx LLC representative visit charged at $125/hr plus expenses.

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Section 2) Customer Responsibilities

Aquip:

- Site preparation including, but not limited to providing 11'x19.5' level pad
- Placement of Aquip, provide operator and forklift with 48 inch spacing on center capable of 6500 lbs pick for receiving equipment and loading media

Pump System:

- Adequate overhead crane clearance for equipment installation
- Placement and installation of pump, floats, and pump plumbing
- Provide onsite labor (estimated 4 hours) for assembly of pump and bypass system

General:

- Receiving, unloading and storing the equipment; equipment to be kept clean of trash & debris until installation. Note: customer may be charged standby time if delivery truck is not offloaded within one hour of arrival
- Minimum vertical equipment clearance of 14' above surface for installation & maintenance
- Provide and install all piping and appurtenances (i.e. all plumbing to and from StormwateRx equipment)
- Provide and install seismic anchors, if required
- Seasoning media per StormwateRx guidelines
- Installation of electrical and plumbing components in conformance with applicable codes, if required
- Provide inlet (untreated) and outlet (treated) stormwater monitoring results to StormwateRx for system tuning, if required
- Water testing labor and lab fees, if required
- Response on approval of drawings (if required) within two weeks of being provided. If drawings are not approved, their contents are subject to price increase.
- Obtain all city, county, state, federal government and/or other permits for the site construction and operation of proposed system

Equipment Total:	$101,400
Total:	**$101,400**

Terms *:*

- This quotation and all products and services herein are subject and limited to the terms and conditions contained in StormwateRx's Standard Terms and Conditions of Sale, located at stormwaterx.com/quoteterms/. Issuance of any purchase orders in response to this Quote, or signature below, will be deemed acceptance of such terms.
- Prepaid & add (freight not included)
- State and local taxes not included

Payment Terms:

- 50% deposit required with confirming order
- 50% and taxes (if any) invoiced when product(s) ready to ship
- 50% restocking fee applies for all cancelled orders

Delivery:

- Normal = 12-14 weeks from receipt of order and deposit
- Delivery and installation to take place during Standard Business Hours.
- If product ready for delivery, but not accepted by customer, a storage fee of 2% of Equipment Total per month will apply.

Stormwater Treatment System Budgetary Estimate

Date:	June 15, 2022 Revision No. 0
Prepared for:	Erin O'Connell
Project:	South Park Marina
Project Site Address:	8604 Dallas Ave S, Seattle, WA, 98108
Regional Manager/Point of Contact:	Chris Fromme, cfromme@newterra.com
Prepared By:	Ted Lathrop, PE tlathrop@newterra.com

System Design/Application Notes:

1. Site Design Parameters:
   a. Drainage Area: 3.5 acres
   b. Design Treatment Flow: 144 gpm
   c. Pollutant(s) of Concern: Zinc, Copper
2. Achieving the benchmarks or numeric action levels consistently requires implementation of best management practices (BMPs) including source control, structural and treatment BMPs. Treatment BMPs are not designed to operate in the absence of other BMPs.
3. Treatment BMPs require routine maintenance. See system operation and maintenance manual for details.

Section 1) Stormwater Treatment System

Qty	Product Number	Description
1	Aquip® Model 160SBE 	Aquip enhanced stormwater filtration system designed for a treatment flow rate of 160 gpm with an above-ground system footprint of 8.5' x 29.5'. System includes: ▪ Sealed tank structure with forklift pockets, two access ladders, up-flow pretreatment chamber with Omniplex media and integrated oil skimmer, and down-flow filtration chamber with layered inert and adsorptive biofiltration media for particulates, organics and dissolved pollutants removal ▪ Instantaneous and totalizing flow meter, flow control valve, adjustable head control, emergency overflow indicator, sample ports, and maintenance tool
1	Pump System (pumping 2.5 acres to 1 acre basin)	Design Storm Pump System includes: ▪ Simplex pump system: 0.75 HP (230V/1Ph/10A) pump operating at 103 gpm with less than 15 ft total dynamic head, including single float switches (qty 2) and check valve. A control panel is not included/required.
1	Pump System (pumping 3.5 acres to filtration)	Design Storm Pump System includes: ▪ Simplex pump system: 1.5 HP (230V/3Ph/9.6A) pump operating at 144 gpm with less than 27 ft total dynamic head, including single float switches (qty 2) and check valve. A standard control panel is included/required.
1	Startup & Training	Startup & Training includes: ▪ On-site assembly and installation oversight by a StormwateRx trained technician (4 man-days maximum) ▪ Operation and Maintenance Manual and training Note: Equipment assembly, installation and training must be completed during same visit. Delivery and installation to be scheduled a minimum two weeks in advance. ▪ Subsequent StormwateRx LLC representative visit charged at $125/hr plus expenses.

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Section 2) Customer Responsibilities

Aquip:

- Site preparation including, but not limited to providing 11'x27.5' level pad
- Placement of Aquip, provide operator and forklift with 48 inch spacing on center capable of 7500 lbs pick for receiving equipment and loading media

Pump System:

- Adequate overhead crane clearance for equipment installation
- Placement and installation of pump, floats, and pump plumbing
- Provide onsite labor (estimated 4 hours) for assembly of pump and bypass system

General:

- Receiving, unloading and storing the equipment; equipment to be kept clean of trash & debris until installation. Note: customer may be charged standby time if delivery truck is not offloaded within one hour of arrival
- Minimum vertical equipment clearance of 14' above surface for installation & maintenance
- Provide and install all piping and appurtenances (i.e. all plumbing to and from StormwateRx equipment)
- Provide and install seismic anchors, if required
- Seasoning media per StormwateRx guidelines
- Installation of electrical and plumbing components in conformance with applicable codes, if required
- Provide inlet (untreated) and outlet (treated) stormwater monitoring results to StormwateRx for system tuning, if required
- Water testing labor and lab fees, if required
- Response on approval of drawings (if required) within two weeks of being provided. If drawings are not approved, their contents are subject to price increase.
- Obtain all city, county, state, federal government and/or other permits for the site construction and operation of proposed system

Equipment Total:	$136,100
Total:	**$136,100**
Buyback Existing Aquip 50 steel structure (Estimated)	**($5,000)**
Total:	**$131,100**

Terms *:*

- This quotation and all products and services herein are subject and limited to the terms and conditions contained in StormwateRx's Standard Terms and Conditions of Sale, located at stormwaterx.com/quoteterms/. Issuance of any purchase orders in response to this Quote, or signature below, will be deemed acceptance of such terms.
- Prepaid & add (freight not included)
- State and local taxes not included

Payment Terms:

- 50% deposit required with confirming order
- 50% and taxes (if any) invoiced when product(s) ready to ship
- 50% restocking fee applies for all cancelled orders

Delivery:

- Normal = 12-14 weeks from receipt of order and deposit
- Delivery and installation to take place during Standard Business Hours.
- If product ready for delivery, but not accepted by customer, a storage fee of 2% of Equipment Total per month will apply.

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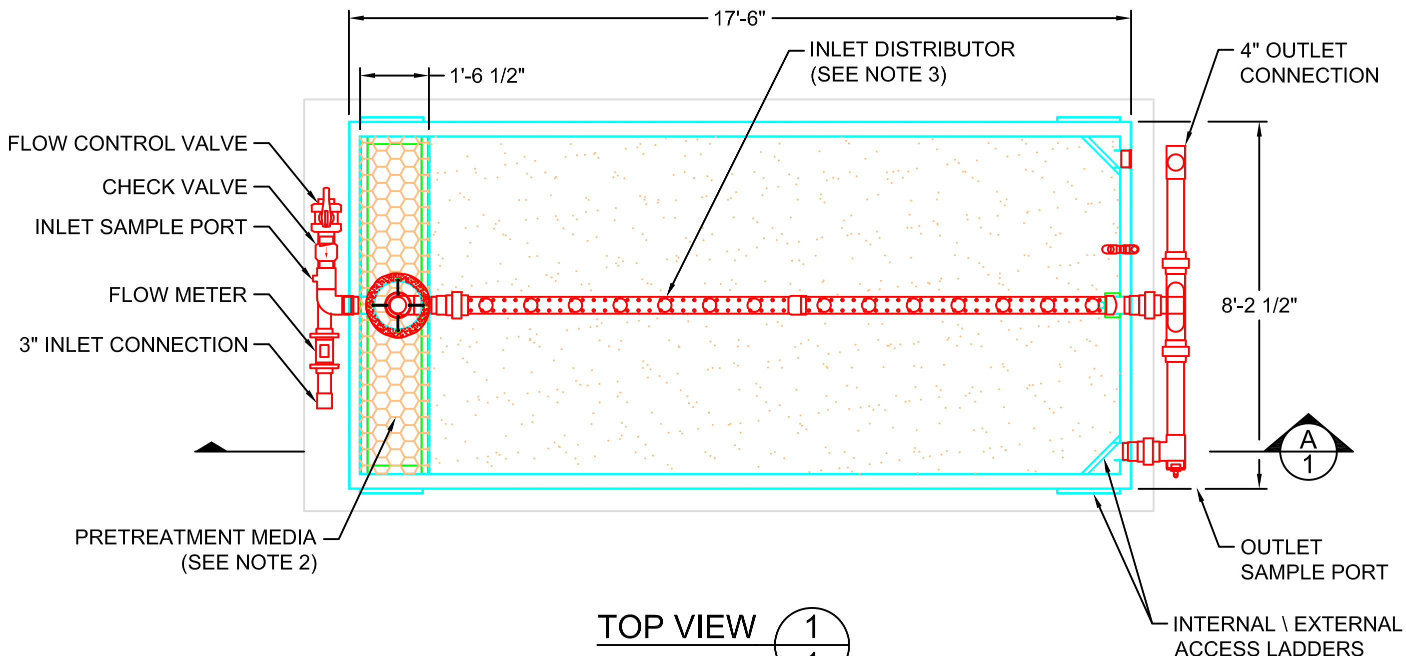
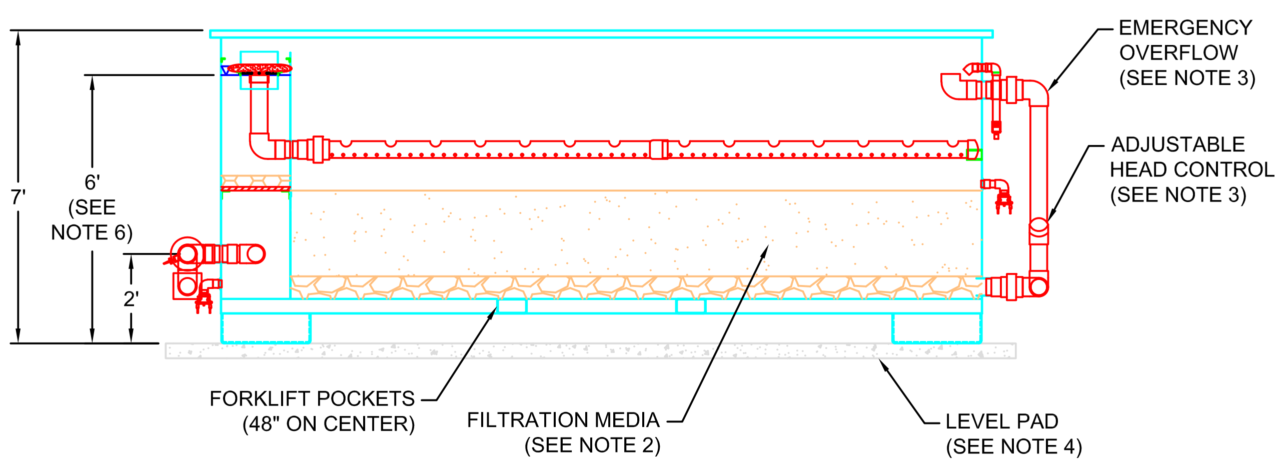
GENERAL NOTES

1. AQUIP® FILTRATION SYSTEM BY STORMWATERX LLC - PORTLAND, OREGON - 800.680.3543 (U.S. PATENT NO. 8,002,974).
2. PRETREATMENT AND FILTER MEDIA COMBINATION DEPENDENT ON POLLUTANT REMOVAL REQUIREMENTS. MODELS: SBE: OMNIPLEX & INERT/SORPTIVE MEDIA, SXI:SETTLING PRETREATMENT & INERT MEDIA.
3. INTERNAL APPURTENANCES BY STORMWATERX INCLUDING INLET AND OUTLET SAMPLE PORTS, INLET FLOW CONTROL & CHECK VALVES, INLET DISTRIBUTOR, UNDERDRAIN SYSTEM, EMERGENCY OVERFLOW AND ADJUSTABLE HEAD CONTROL.
4. SYSTEM REQUIRES LEVEL SURFACE FOR 17' x 8' FOOTPRINT AND LOAD BEARING CAPACITY OF 66,400 LBS.
5. INLET AND OUTLET PIPING CONNECTION SIZE AS NOTED. CONNECTION PIPING PROVIDED BY OTHERS. CENTER INLET STANDARD, INLET CONNECTION LEFT OR RIGHT (RIGHT SHOWN). OPTIONAL LEFT OR RIGHT OUTLET (LEFT OUTLET SHOWN).
6. THE OPERATING WATER SURFACE HEIGHT IS 6' ABOVE BOTTOM OF STRUCTURE.



TOP VIEW 1/1



SECTION VIEW A/1

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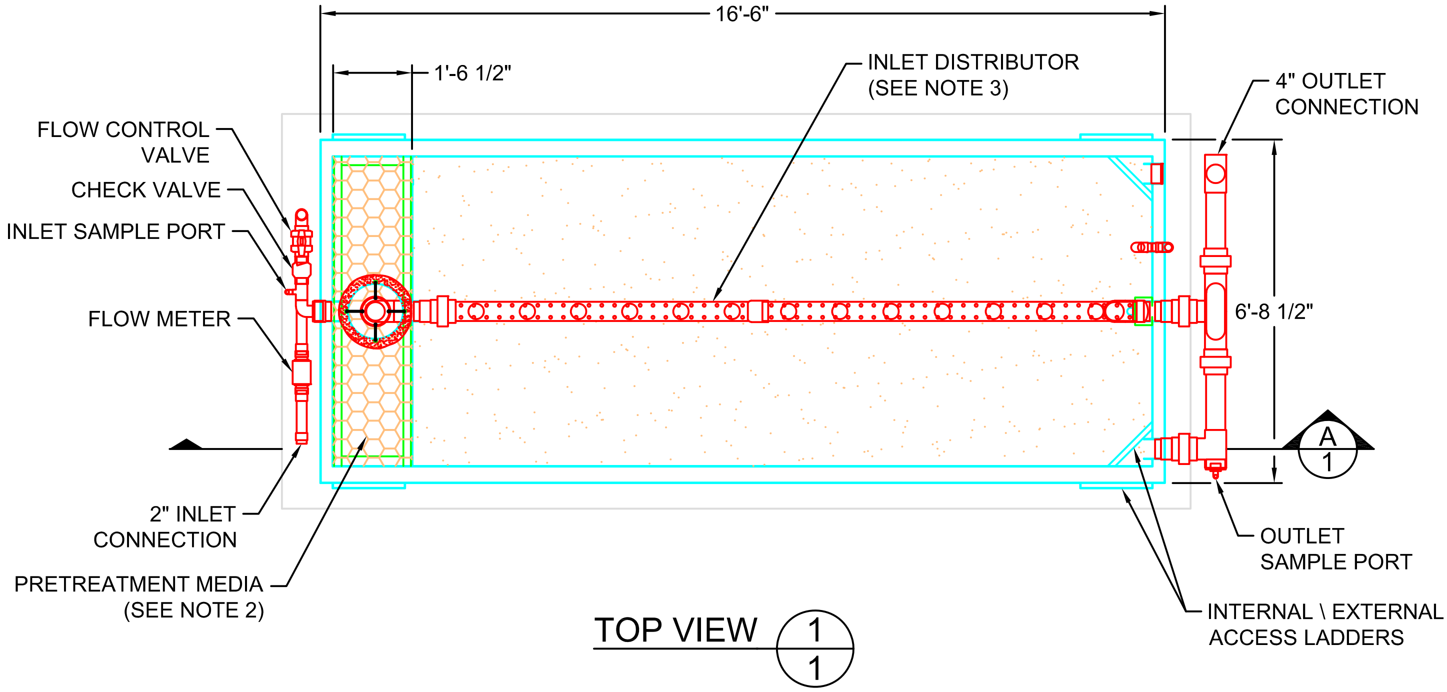
AQUIP MODEL 110S
STORMWATER FILTRATION SYSTEM
STANDARD DETAIL

DATE:	SCALE:	FILE NAME:	DRAWN:	CHECKED:
10/14/2021	NONE	SRX-AQUIP-110S-DTL	TL	RC

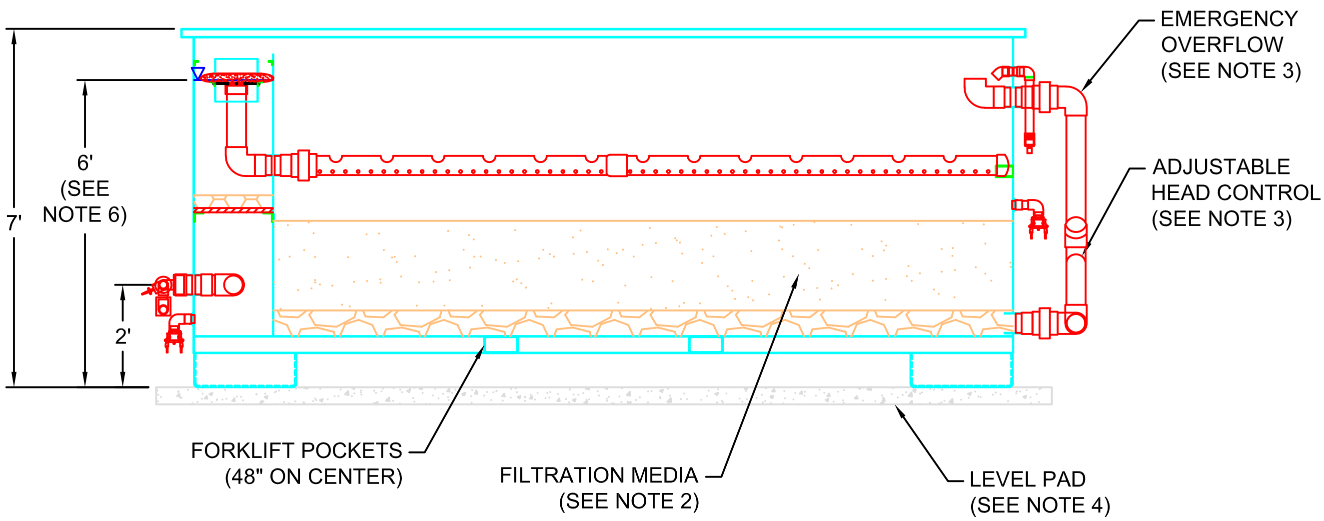
SHEET
1
1 OF 1

GENERAL NOTES

1. AQUIP® FILTRATION SYSTEM BY STORMWATERX LLC - PORTLAND, OREGON - 800.680.3543 (U.S. PATENT NO. 8,002,974).
2. PRETREATMENT AND FILTER MEDIA COMBINATION DEPENDENT ON POLLUTANT REMOVAL REQUIREMENTS. MODELS: SBE: OMNIPLEX & INERT/SORPTIVE MEDIA, SXI:SETTLING PRETREATMENT & INERT MEDIA.
3. INTERNAL APPURTENANCES BY STORMWATERX INCLUDING INLET AND OUTLET SAMPLE PORTS, INLET FLOW CONTROL & CHECK VALVES, INLET DISTRIBUTOR, UNDERDRAIN SYSTEM, EMERGENCY OVERFLOW AND ADJUSTABLE HEAD CONTROL.
4. SYSTEM REQUIRES LEVEL SURFACE FOR 16' x 6' FOOTPRINT AND LOAD BEARING CAPACITY OF 51,500 LBS.
5. INLET AND OUTLET PIPING CONNECTION SIZE AS NOTED. CONNECTION PIPING PROVIDED BY OTHERS. CENTER INLET STANDARD, INLET CONNECTION LEFT OR RIGHT (RIGHT SHOWN). OPTIONAL LEFT OR RIGHT OUTLET (LEFT OUTLET SHOWN).
6. THE OPERATING WATER SURFACE HEIGHT IS 6' ABOVE BOTTOM OF STRUCTURE.



TOP VIEW 1/1



SECTION VIEW A/1

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AQUIP MODEL 80S
STORMWATER FILTRATION SYSTEM
STANDARD DETAIL

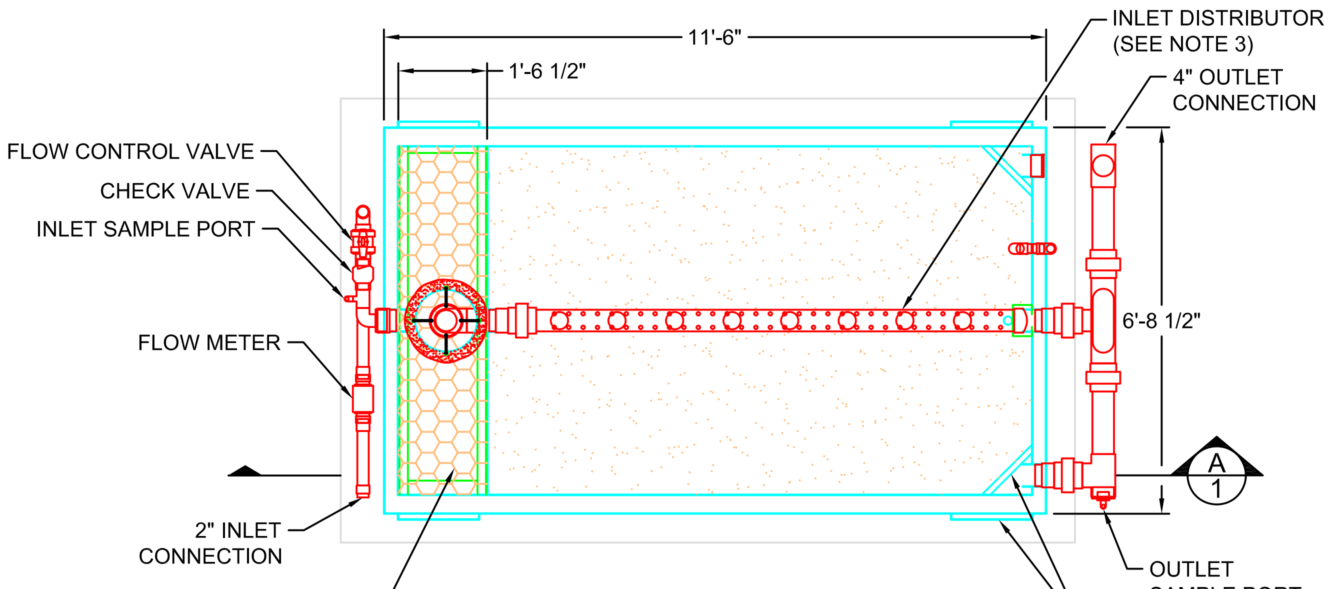
DATE:	SCALE:	FILE NAME:	DRAWN:	CHECKED:
10/14/2021	NONE	SRX-AQUIP-80S-DTL	TL	RC

SHEET 1

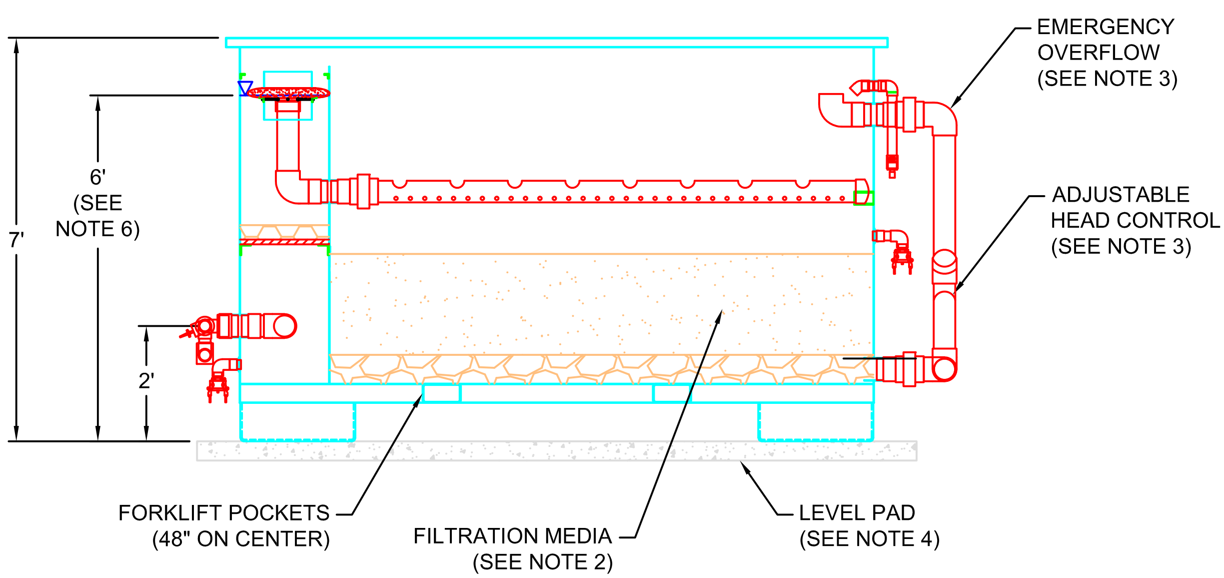
1 OF 1

GENERAL NOTES

1. AQUIP® FILTRATION SYSTEM BY STORMWATERX LLC - PORTLAND, OREGON - 800.680.3543 (U.S. PATENT NO. 8,002,974).
2. PRETREATMENT AND FILTER MEDIA COMBINATION DEPENDENT ON POLLUTANT REMOVAL REQUIREMENTS. MODELS: SBE: OMNIPLEX & INERT/SORPTIVE MEDIA, SXI:SETTLING PRETREATMENT & INERT MEDIA.
3. INTERNAL APPURTENANCES BY STORMWATERX INCLUDING INLET AND OUTLET SAMPLE PORTS, INLET FLOW CONTROL & CHECK VALVES, INLET DISTRIBUTOR, UNDERDRAIN SYSTEM, EMERGENCY OVERFLOW AND ADJUSTABLE HEAD CONTROL.
4. SYSTEM REQUIRES LEVEL SURFACE FOR 11' x 6' FOOTPRINT AND LOAD BEARING CAPACITY OF 34,600 LBS.
5. INLET AND OUTLET PIPING CONNECTION SIZE AS NOTED. CONNECTION PIPING PROVIDED BY OTHERS. CENTER INLET STANDARD, INLET CONNECTION LEFT OR RIGHT (RIGHT SHOWN). OPTIONAL LEFT OR RIGHT OUTLET (LEFT OUTLET SHOWN).
6. THE OPERATING WATER SURFACE HEIGHT IS 6' ABOVE BOTTOM OF STRUCTURE.



TOP VIEW 1/1



SECTION VIEW A/1

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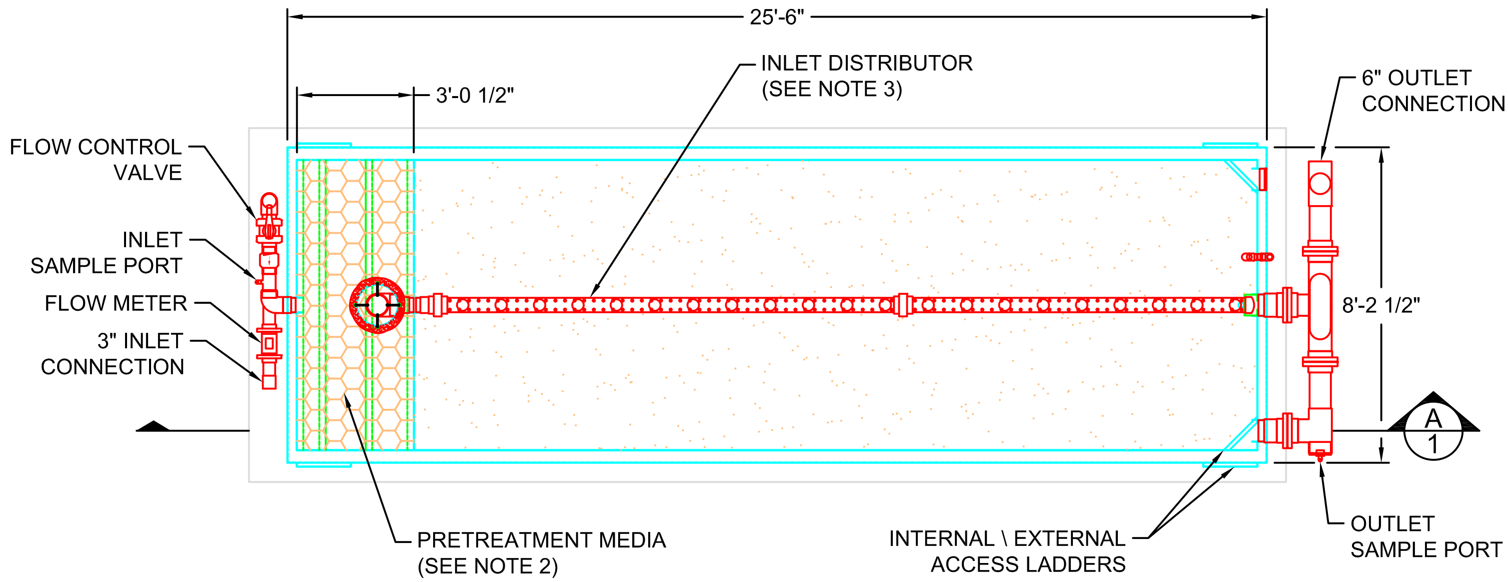
AQUIP MODEL 50S
STORMWATER FILTRATION SYSTEM
STANDARD DETAIL

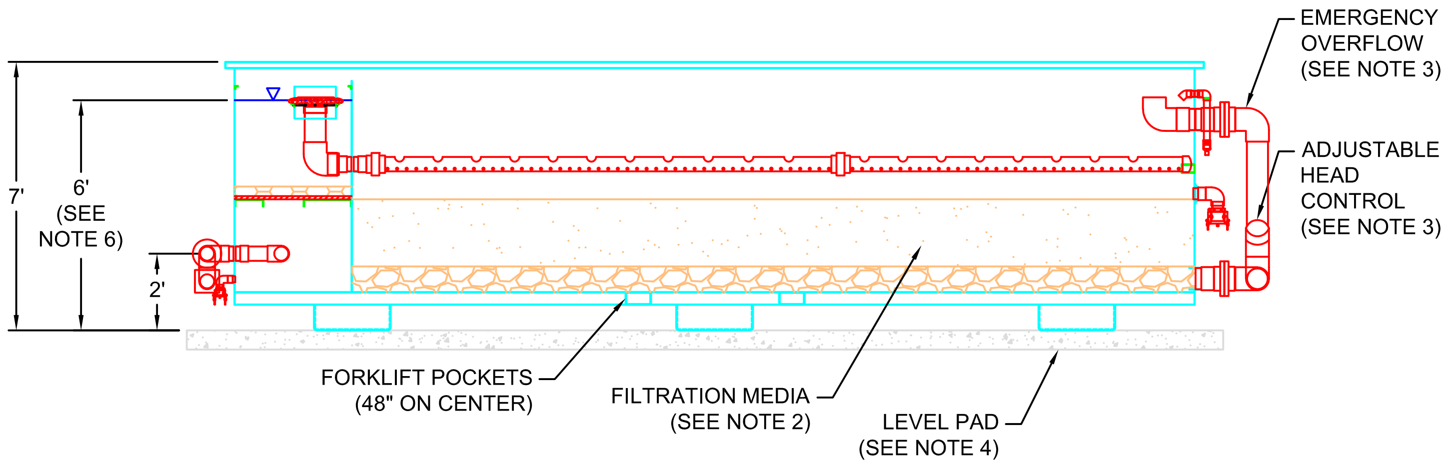
DATE:	SCALE:	FILE NAME:	DRAWN:	CHECKED:	SHEET
10/14/2021	NONE	SRX-AQUIP-50S-DTL	TL	RC	1
					1 OF 1

GENERAL NOTES

1. AQUIP® FILTRATION SYSTEM BY STORMWATERX LLC - PORTLAND, OREGON - 800.680.3543 (U.S. PATENT NO. 8,002,974).
2. PRETREATMENT AND FILTER MEDIA COMBINATION DEPENDENT ON POLLUTANT REMOVAL REQUIREMENTS. MODELS: SBE: OMNNIPLEX & INERT/SORPTIVE MEDIA, SXI:SETTLING PRETREATMENT & INERT MEDIA.
3. INTERNAL APPURTENANCES BY STORMWATERX INCLUDING INLET AND OUTLET SAMPLE PORTS, INLET FLOW CONTROL & CHECK VALVES, INLET DISTRIBUTOR, UNDERDRAIN SYSTEM, EMERGENCY OVERFLOW AND ADJUSTABLE HEAD CONTROL.
4. SYSTEM REQUIRES LEVEL SURFACE FOR 25' x 8' FOOTPRINT AND LOAD BEARING CAPACITY OF 97,000 LBS.
5. INLET AND OUTLET PIPING CONNECTION SIZE AS NOTED. CONNECTION PIPING PROVIDED BY OTHERS. CENTER INLET STANDARD, INLET CONNECTION LEFT OR RIGHT (RIGHT SHOWN). OPTIONAL LEFT OR RIGHT OUTLET (LEFT OUTLET SHOWN).
6. OPERATING WATER SURFACE HEIGHT IS 6' ABOVE BOTTOM OF STRUCTURE.



TOP VIEW 1/1



SECTION VIEW A/1

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AQUIP MODEL 160S
STORMWATER FILTRATION SYSTEM
STANDARD DETAIL

DATE:	SCALE:	FILE NAME:	DRAWN:	CHECKED:	SHEET
10/14/2021	NONE	SRX-AQUIP-160S-DTL	TL	RC	1
					1 OF 1

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	South Park
Site Name:	
Site Address:	
City:	
Report Date:	12/15/2022
Gage:	Seatac
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	1.000
Version Date:	2017/07/05
Version:	4.2.13

POC Thresholds

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

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
PARKING FLAT	2.5
Impervious Total	2.5
Basin Total	2.5

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
PARKING FLAT	2.5
Impervious Total	2.5
Basin Total	2.5

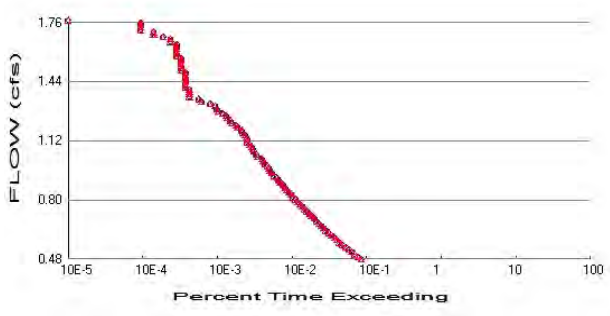
Element Flows To:

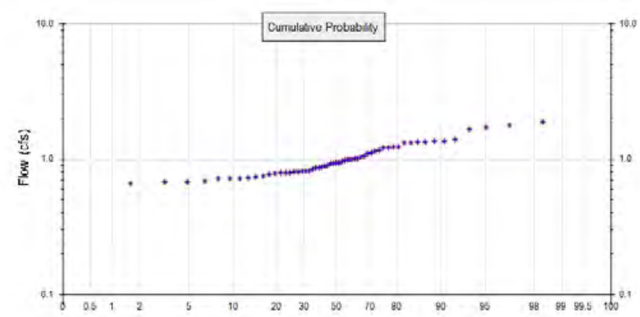
Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Analysis Results
POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0
Total Impervious Area: 2.5

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0
Total Impervious Area: 2.5

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.953162
5 year	1.203954
10 year	1.374349
25 year	1.595378
50 year	1.764547
100 year	1.937824

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.953162
5 year	1.203954
10 year	1.374349
25 year	1.595378
50 year	1.764547
100 year	1.937824

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	1.235	1.235
1950	1.334	1.334
1951	0.771	0.771
1952	0.686	0.686
1953	0.741	0.741
1954	0.775	0.775
1955	0.879	0.879
1956	0.865	0.865
1957	0.981	0.981
1958	0.792	0.792

1959	0.807	0.807
1960	0.792	0.792
1961	0.838	0.838
1962	0.730	0.730
1963	0.811	0.811
1964	0.795	0.795
1965	1.011	1.011
1966	0.676	0.676
1967	1.164	1.164
1968	1.324	1.324
1969	0.920	0.920
1970	0.888	0.888
1971	1.059	1.059
1972	1.093	1.093
1973	0.662	0.662
1974	0.966	0.966
1975	1.113	1.113
1976	0.748	0.748
1977	0.811	0.811
1978	0.991	0.991
1979	1.357	1.357
1980	1.218	1.218
1981	0.996	0.996
1982	1.405	1.405
1983	1.143	1.143
1984	0.721	0.721
1985	0.994	0.994
1986	0.861	0.861
1987	1.329	1.329
1988	0.806	0.806
1989	1.008	1.008
1990	1.699	1.699
1991	1.357	1.357
1992	0.714	0.714
1993	0.619	0.619
1994	0.673	0.673
1995	0.883	0.883
1996	0.940	0.940
1997	0.913	0.913
1998	0.925	0.925
1999	1.893	1.893
2000	0.942	0.942
2001	1.035	1.035
2002	1.208	1.208
2003	0.938	0.938
2004	1.771	1.771
2005	0.809	0.809
2006	0.715	0.715
2007	1.655	1.655
2008	1.333	1.333
2009	1.232	1.232

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	1.8927	1.8927
2	1.7709	1.7709
3	1.6986	1.6986

4	1.6552	1.6552
5	1.4046	1.4046
6	1.3572	1.3572
7	1.3569	1.3569
8	1.3340	1.3340
9	1.3332	1.3332
10	1.3290	1.3290
11	1.3239	1.3239
12	1.2345	1.2345
13	1.2320	1.2320
14	1.2176	1.2176
15	1.2076	1.2076
16	1.1644	1.1644
17	1.1432	1.1432
18	1.1130	1.1130
19	1.0933	1.0933
20	1.0591	1.0591
21	1.0352	1.0352
22	1.0105	1.0105
23	1.0083	1.0083
24	0.9961	0.9961
25	0.9938	0.9938
26	0.9915	0.9915
27	0.9810	0.9810
28	0.9661	0.9661
29	0.9421	0.9421
30	0.9399	0.9399
31	0.9382	0.9382
32	0.9251	0.9251
33	0.9203	0.9203
34	0.9127	0.9127
35	0.8879	0.8879
36	0.8833	0.8833
37	0.8789	0.8789
38	0.8647	0.8647
39	0.8613	0.8613
40	0.8381	0.8381
41	0.8112	0.8112
42	0.8105	0.8105
43	0.8093	0.8093
44	0.8074	0.8074
45	0.8063	0.8063
46	0.7955	0.7955
47	0.7923	0.7923
48	0.7916	0.7916
49	0.7751	0.7751
50	0.7711	0.7711
51	0.7484	0.7484
52	0.7408	0.7408
53	0.7302	0.7302
54	0.7211	0.7211
55	0.7149	0.7149
56	0.7141	0.7141
57	0.6860	0.6860
58	0.6757	0.6757
59	0.6729	0.6729
60	0.6621	0.6621
61	0.6185	0.6185

Duration Flows
The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.4766	1809	1809	100	Pass
0.4896	1646	1646	100	Pass
0.5026	1477	1477	100	Pass
0.5156	1349	1349	100	Pass
0.5286	1230	1230	100	Pass
0.5416	1108	1108	100	Pass
0.5546	1005	1005	100	Pass
0.5676	924	924	100	Pass
0.5807	854	854	100	Pass
0.5937	796	796	100	Pass
0.6067	728	728	100	Pass
0.6197	668	668	100	Pass
0.6327	611	611	100	Pass
0.6457	572	572	100	Pass
0.6587	534	534	100	Pass
0.6717	491	491	100	Pass
0.6847	451	451	100	Pass
0.6977	420	420	100	Pass
0.7108	389	389	100	Pass
0.7238	366	366	100	Pass
0.7368	339	339	100	Pass
0.7498	317	317	100	Pass
0.7628	296	296	100	Pass
0.7758	273	273	100	Pass
0.7888	256	256	100	Pass
0.8018	239	239	100	Pass
0.8148	222	222	100	Pass
0.8278	208	208	100	Pass
0.8409	196	196	100	Pass
0.8539	181	181	100	Pass
0.8669	171	171	100	Pass
0.8799	161	161	100	Pass
0.8929	148	148	100	Pass
0.9059	139	139	100	Pass
0.9189	135	135	100	Pass
0.9319	122	122	100	Pass
0.9449	113	113	100	Pass
0.9579	108	108	100	Pass
0.9710	105	105	100	Pass
0.9840	100	100	100	Pass
0.9970	93	93	100	Pass
1.0100	87	87	100	Pass
1.0230	84	84	100	Pass
1.0360	73	73	100	Pass
1.0490	71	71	100	Pass
1.0620	65	65	100	Pass
1.0750	63	63	100	Pass
1.0880	62	62	100	Pass
1.1010	58	58	100	Pass
1.1141	54	54	100	Pass
1.1271	54	54	100	Pass
1.1401	52	52	100	Pass
1.1531	50	50	100	Pass

1.1661	46	46	100	Pass
1.1791	45	45	100	Pass
1.1921	40	40	100	Pass
1.2051	38	38	100	Pass
1.2181	33	33	100	Pass
1.2311	32	32	100	Pass
1.2442	29	29	100	Pass
1.2572	28	28	100	Pass
1.2702	25	25	100	Pass
1.2832	22	22	100	Pass
1.2962	21	21	100	Pass
1.3092	20	20	100	Pass
1.3222	17	17	100	Pass
1.3352	13	13	100	Pass
1.3482	12	12	100	Pass
1.3612	9	9	100	Pass
1.3743	9	9	100	Pass
1.3873	9	9	100	Pass
1.4003	9	9	100	Pass
1.4133	8	8	100	Pass
1.4263	8	8	100	Pass
1.4393	8	8	100	Pass
1.4523	8	8	100	Pass
1.4653	8	8	100	Pass
1.4783	8	8	100	Pass
1.4913	8	8	100	Pass
1.5044	7	7	100	Pass
1.5174	7	7	100	Pass
1.5304	7	7	100	Pass
1.5434	7	7	100	Pass
1.5564	7	7	100	Pass
1.5694	7	7	100	Pass
1.5824	6	6	100	Pass
1.5954	6	6	100	Pass
1.6084	6	6	100	Pass
1.6214	6	6	100	Pass
1.6344	6	6	100	Pass
1.6475	6	6	100	Pass
1.6605	5	5	100	Pass
1.6735	5	5	100	Pass
1.6865	4	4	100	Pass
1.6995	3	3	100	Pass
1.7125	3	3	100	Pass
1.7255	2	2	100	Pass
1.7385	2	2	100	Pass
1.7515	2	2	100	Pass
1.7645	2	2	100	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.3074 acre-feet
On-line facility target flow:	0.4062 cfs.
Adjusted for 15 min:	0.4062 cfs.
Off-line facility target flow:	0.2295 cfs.
Adjusted for 15 min:	0.2295 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

Model Default Modifications

Total of 0 changes have been made.

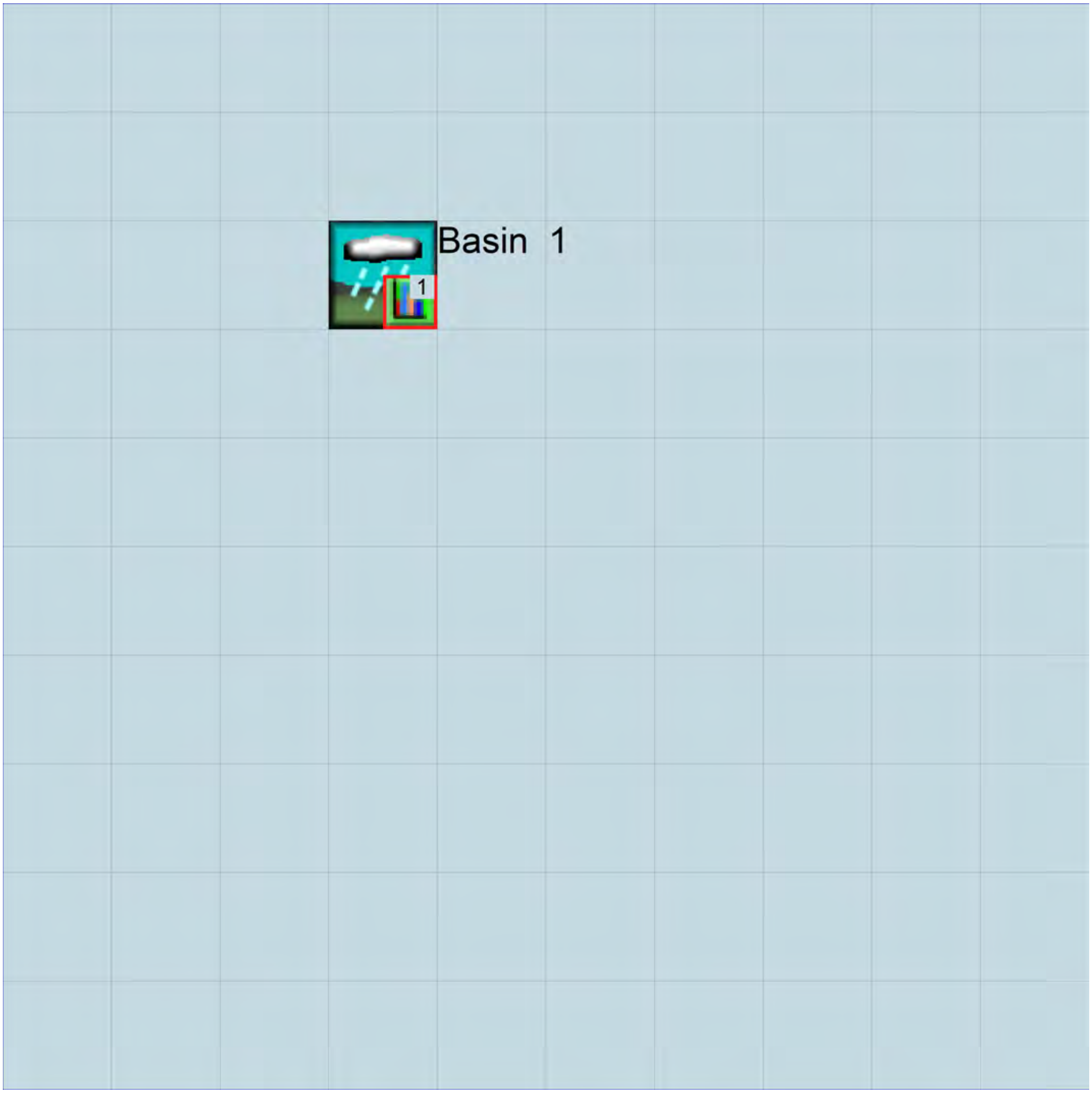
PERLND Changes

No PERLND changes have been made.

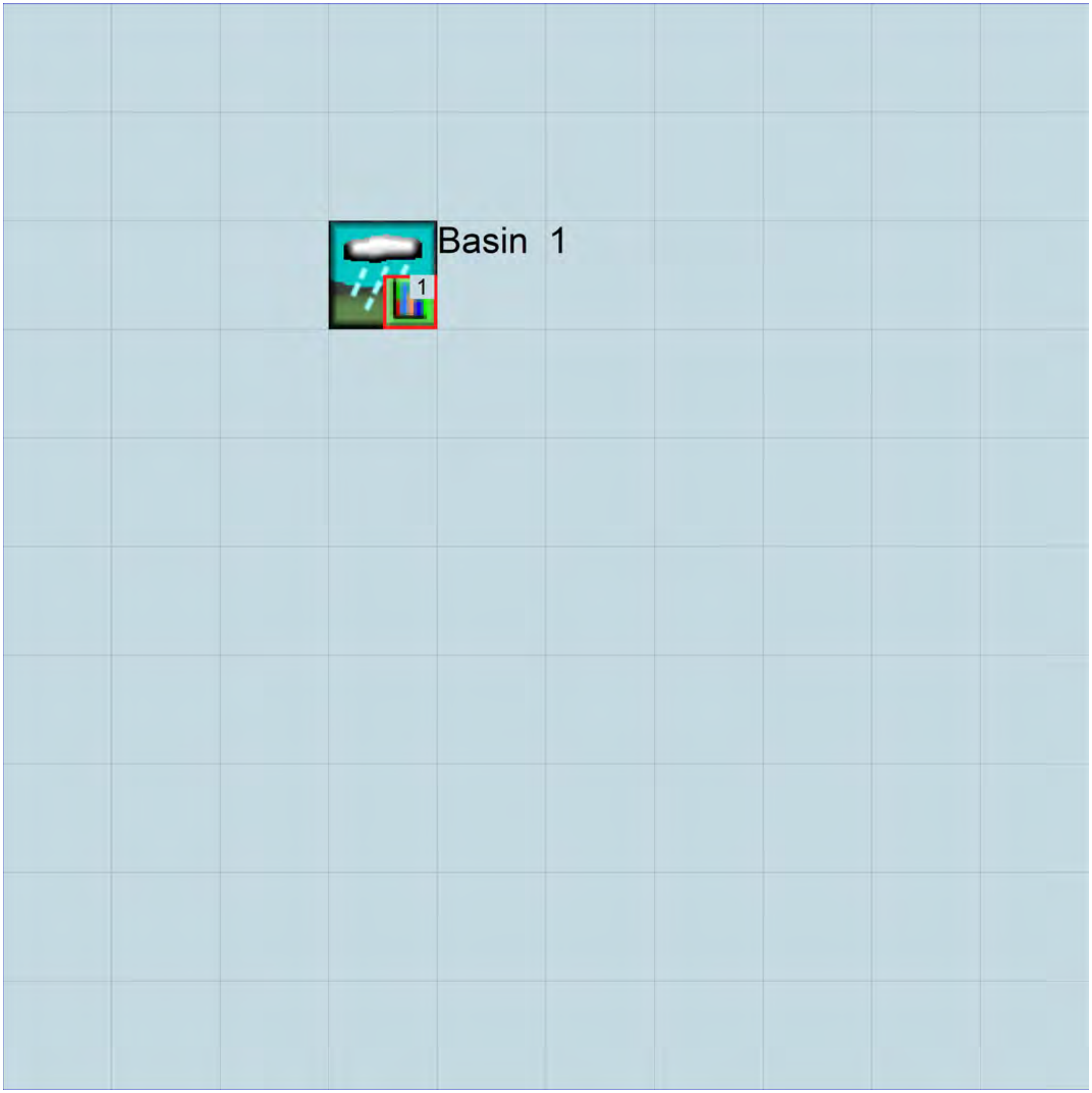
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

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

OPN SEQUENCE
    INGRP              INDELT 00:15
      IMPLND      11
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                    MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                            User  t-series Engl Metr ***
                                             in  out           ***
  END GEN-INFO
  *** Section PWATER***

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

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

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

```
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
  END PWAT-PARM4

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

END PERLND

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

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

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

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

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

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

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

END IMPLND
```

```
SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
IMPLND  11                         2.5     COPY   501     15

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

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



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

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

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

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

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

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

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1              PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1              IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
```

```
END EXT SOURCES

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

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

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

OPN SEQUENCE
    INGRP              INDELT 00:15
      IMPLND      11
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                   MAX                   1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                           in  out           ***
  END GEN-INFO
  *** Section PWATER***

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

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

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

```
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
  END PWAT-PARM4

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

END PERLND

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

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

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

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

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

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

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

END IMPLND
```

```
SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
IMPLND  11                         2.5     COPY   501     15

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

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



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

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

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

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

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

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

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1              PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1              IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
```

```
END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

Legal Notice

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Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

Appendix F

Clear Creek Systems Case Studies and Supporting Materials

TIG environmental®
INVESTIGATIONS ▾ FORENSICS ▾ REMEDIATION

June 28, 2022

To: Erin O'Connell
Project Scientist
TIG Environmental
1050 SW 6th Avenue, Suite 2155
Portland, OR 97204
CELL: (203) 246 – 7427

RE: Preliminary Industrial Stormwater Treatment System Proposal – South Park Marina, Seattle, WA

Dear Ms. O'Connell,

Clear Creek Systems, Inc. (CCS) is pleased to present this preliminary proposal for an industrial stormwater treatment system at the South Park Marina facility in Seattle, WA. We have based this preliminary proposal on the information provided to us, our discussions, and our experience on similar projects. As previously discussed, CCS recommends conducting a limited bench scale treatability test to validate the effectiveness of the proposed treatment methodology.

About Clear Creek Systems, Inc.

CCS is a leading water treatment services company that has been surpassing client expectations for over 25 years. Our services include treatment system design, equipment fabrication, system installation, training, and ongoing operations and maintenance support. We have designed and installed water treatment systems with capacities ranging from less than 10 gallons-per-minute (gpm) to over 4,000 gpm for treatment of a wide range of contaminants including but not limited to total suspended solids (TSS), heavy metals, hydrocarbons, nitrates, and many others. Our success lies in our ability to move seamlessly from treatment system design and fabrication trough field installation and operations. We offer true turnkey service throughout the life of the project.

Basis Of Design

This proposal is based on the following design criteria:

- 2.25-acre site (90-95% impervious)
- Estimated offline treatment flow rate ≈ 100 gpm
- Permit benchmarks – Zn = 90 µg/L and Cu = 147 µg/L
- Water quality monitoring data provided by TIG Environmental
- Value engineering principles – reliably and consistently meeting benchmarks at the lowest cost
- Long-term performance with low maintenance requirements and expense
- Constrain footprint requirements
- Experience on other similar sites (Attachment 1)
- Bench scale treatability testing result from a site in South Seattle (see below)

Clear Creek Systems

Water Treatment Approach

Based on our experience with similar facilities, CCS is proposing a conventional water treatment approach for this project which includes the following general treatment steps:

Gravity Settling → Mechanical Filtration → Adsorptive Media → Ion Exchange → Discharge

The pollutant removal mechanism of each process is as follows:

Treatment Step	Target Pollutants	Removal Mechanism
Gravity Settling	Settleable Solids & Filter Backwash	Gravimetric separation of solids
Mechanical Filtration	TSS & Turbidity	Pressurized mixed media filtration
Adsorptive Media	Hydrocarbons & Metals	Adsorption
Ion Exchange	Dissolved Metals	Ion Exchange (Na for Cu & Zn)

The treatment system process flow description is as follows:

1. Site stormwater is collected in a lift station(s) and directed to either an underground vault or above grade tank(s) for gravity settling.

2. Settled stormwater is pumped (7.5-hp pump) from the settling tank to the filtration system via a float-controlled filtration pump.

3. A deep bed pressurized mixed media filter (anthracite, sand, garnet, & gravel) provides filtration down to approximately 5 microns. The mixed media filter includes an automatic backwashing system to clean the media when necessary to ensure optimal performance at all times. Backwash water is routed back to the setting vault/tank.

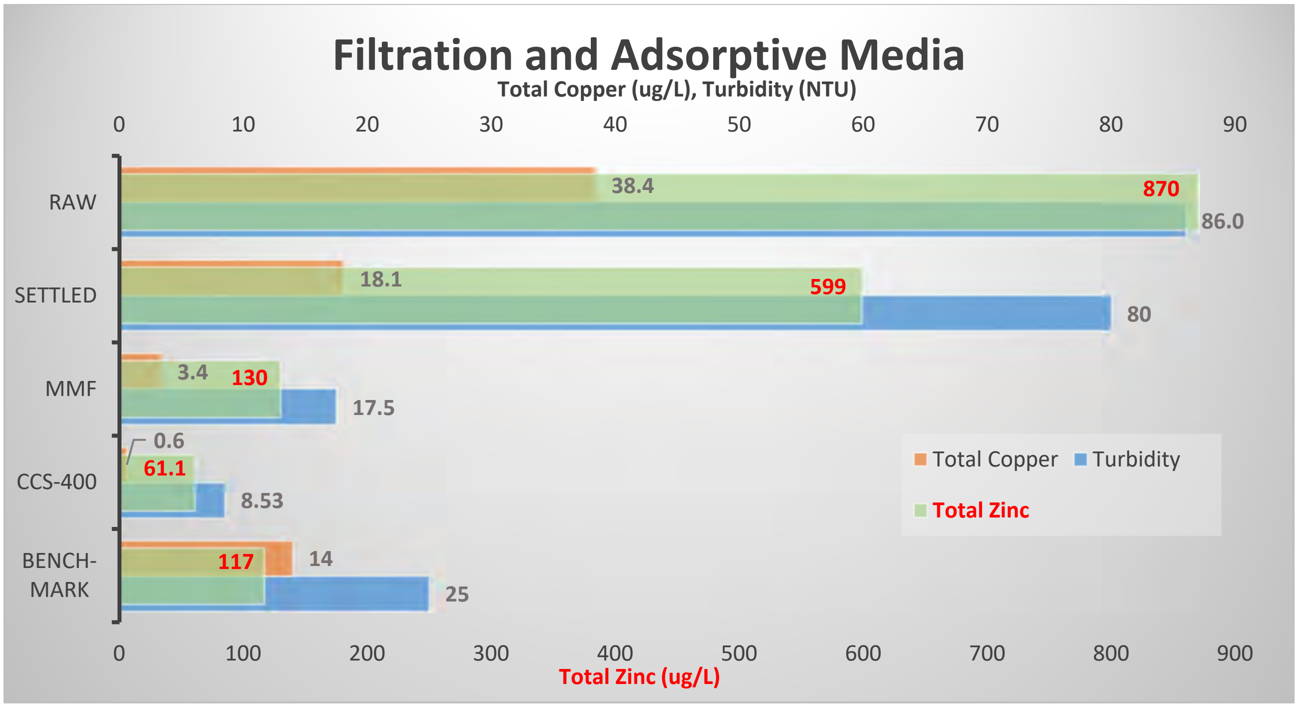
4. Effluent from the mixed media filter is routed to a pressurized adsorptive media vessel containing CCS 400 (a proprietary blend of carbon and activated zeolite) for reduction of hydrocarbons and metals. The adsorptive media vessel includes a manual backwash system.

5. Effluent from the adsorptive media vessel is routed to the ion exchange vessel containing Metlock IX resin (cation exchange resin) for reduction of dissolved metals. The ion exchange media vessel includes a manual backwash system.

6. Treated water is discharged to receiving waters.

Bench test results from a site near the South Park Marina are included below. _**Please note that the data below does not include ion exchange media to further enhance performance.**_ Ion exchange resin was added to the South Park Marina treatment system due to high percentages of dissolved metals.

Clear Creek Systems



MMF – Mixed Media Filtration

Stormwater Treatment System Attributes

The proposed stormwater treatment system has the following attributes:

- Small footprint ≈ 6' x 20' with below grade vault & 15' x 20' with above ground tanks
- Auto backwashing mixed media filter to reduce maintenance requirements
- CCS 400 adsorptive media (Attachment 2)
- Metlock ion exchange resin (Attachment 2)
- Similar design to other Ecology-permitted installations including Nordlund boats, McNeil Island, and Rainier Petroleum (Attachment 1)
- Similar design to other CCS treatment systems including NASSCO Shipyard and Charleston Shipyard (attachment 1)

Budget Estimate ≈ $220,000

The budget estimate includes:

- Treatment system equipment (2) 5,000-gallon settling tanks, 7.5-hp filtration system pump with panel, auto backwashing deep bed mixed media filter with 12.56 sf of filtration surface area, (2) 72 cf, media vessels, interconnecting plumbing, pressure gauges, and (3) flow meters
- Filtration system media including inert mixed media pack, 3,000 lbs of CCS 400, and 50 cf of Metlock ion exchange resin
- Delivery and installation of the treatment system

Rental or Rent – Purchase Option

CCS can offer a similar treatment system on a long-term rental basis or a contracted rent purchase agreement. The pricing associated with these options are directly related to the duration of the rental period. Please reach out to me to discuss the assumed rental duration.

Operations & Maintenance

The automatic backwashing mixed media filter greatly reduces the need for hands on routine system maintenance. CCS recommends monthly system maintenance requiring approximately 4 hours. Media lifespan, based on other similar installations is on the order of 5 years.

Conclusion

Thank you for the opportunity to provide this preliminary proposal for an industrial stormwater treatment system at the South Park Marina in Seattle, WA. This proposal includes a very robust treatment approach that has proven successful on many similar CCS projects. Although the capital expenditure is high compared to other technologies, the performance and low operating cost are far superior. We look forward to the opportunity to discuss our proposal in more detail and to answer and question that you may have.

Sincerely,

Jason Ziemer, CPSWQ, CPESC
Clear Creek Systems, Inc.
253-670-4054
jziemer@clearcreeksystems.com

Attachments:

1) Project Profiles
2) Media Cut Sheets

Industrial Stormwater

MARINE BOATYARD – Pierce County, WA

Services Provided

- Emergency Response to 3rd Party Lawsuit
- Water Treatment System Rental
- System Design Support
- Custom System Automation
- System Maintenance & Monitoring

Technology Provided

- Chitosan Enhanced Sand Filtration
- Adsorptive Media & Ion Exchange Media
- 50 gallons-per-minute
- Remote System Operations & SCADA Capabilities

Project Statistics

- 1 – Acre Site
- Discharge to Marine Waters
- Pollutants: Turbidity, Cu, Zn, Pb

Project Summary

CCS received an urgent call from the facility owner's representative with the need to immediately install an industrial stormwater treatment system to mitigate terms of a third party Clean Water Act lawsuit. CCS worked with the project owner and the owner's engineer to develop an interim compliance strategy which included implementation of a temporary rental stormwater treatment system.

CCS deployed a full-scale treatment system to the facility within 48-hours of receiving a signed contract to perform the work. The stormwater treatment system required custom upgrades associated with electronic interface for tidal flow control to the system and remote automation. The treatment system featured full automation complete with SCADA and remote system operations.

Offices in WA, OR, CA, and MD
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www.clearcreeksystems.com

Clear Creek Systems

Industrial Stormwater

SHIPYARD FACILITY – San Diego, CA

Services Provided

- Laboratory Treatability Testing
- Fast Track Design and Mobilization
- System Design / Build
- System Maintenance & Monitoring

Technology Provided

- Mechanical Filtration
- Polishing Adsorptive Media
- Pressurized Backwash System
- Full Automation & Telemetry
- 350 gallons-per-minute

Project Statistics

- Discharge to Marine Waters
- Target Pollutants: Turbidity, Metals, Organics, Hydrocarbons
- Commissioned in 2010
- Over 1 Billon Gallons Treated

Project Summary

A ship manufacturing facility was facing a permitting crunch for their stormwater runoff. The facility was not reliably meeting pollutant discharge requirements under their existing permit, and an upcoming revised permit was scheduled to drop benchmarks to even lower values. Additionally, the site infrastructure had numerous hydrostatic relief wells that would often pull highly saline groundwater from the bay, and this salinity limited options for both passive and active treatment.

CCS performed multiple pilot tests on facility discharge water and found that a multi-step treatment train with adsorptive media and ion exchange resins could reliably meet benchmark requirements. A full-scale system was designed around this modeled treatment and installed on a rush basis, and the facility met requirements of the new permit before its scheduled release date.

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Clear Creek Systems

Industrial Stormwater

MARINE VESSEL MANUFACTURER – Tacoma, WA

Services Provided

- Permitting
- In-House Bench Testing
- Water Treatment Plan Submittal
- System Design / Build
- Long-term O&M Assistance

Technology Provided

- Mechanical Filtration
- Ion Exchange Resin Treatment
- 100 gallons-per-minute

Project Statistics

- 2.5 – Acre Site
- Discharge to Marine Waters
- Pollutants: NTU, Cu, Zn
- 100% Compliance

Project Summary

This small family business was very environmentally conscious and worked tirelessly to keep their lot clean. But even with proper BMP implementation and good cleaning practices, the facility was still failing to meet benchmarks on dissolved metals. When their environmental manager realized that they needed a more robust solution, he contacted CCS to design a treatment solution that targeted the problem metals.

CCS provided an initial bench test on a grab sample of the site's stormwater runoff, and found that a system with primary filtration and ion exchange resin would meet their required benchmarks. The system was installed in an existing building on their property, allowing them to utilize as much of their yard space as possible. CCS continues to provide the client with long-term O&M assistance, and the facility has remained in compliance since the system's delivery date.

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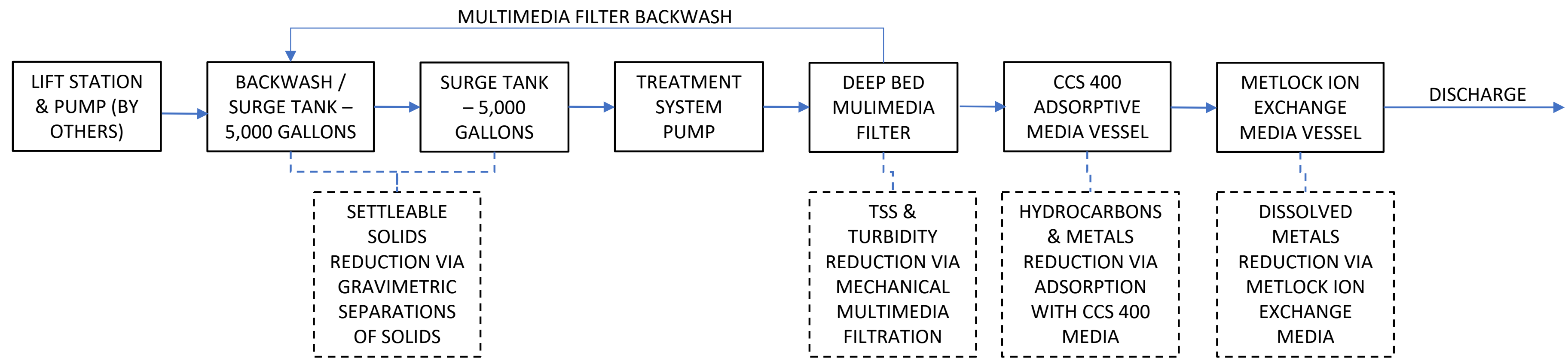
Clear Creek Systems



NOTES

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Adsorptive Media	Hydrocarbons & Metals	Adsorption
Ion Exchange	Dissolved Metals	Ion Exchange (Na for Cu & Zn)

Jason Ziemer, CPSWQ, CPESC
Clear Creek Systems, Inc.
140 County Line Road SW, Suite 101
Pacific, WA 98047
253.670.4054
jziemer@clearcreeksystems.com

PROCESS FLOW DIAGRAM

SOUTH PARK MARINA

NOTES

The treatment system process flow description is as follows:

1. Site stormwater is collected in a lift station(s) and directed to either an underground vault or above grade tank(s) for gravity settling.
2. Settled stormwater is pumped (7.5-hp pump) from the settling tank to the filtration system via a float-controlled filtration pump.
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5. Effluent from the adsorptive media vessel is routed to the ion exchange vessel containing Metlock IX resin (cation exchange resin) for reduction of dissolved metals. The ion exchange media vessel includes a manual backwash system.
6. Treated water is discharged to receiving waters.

ATTACHMENT 1

PROJECT PROFILES

Industrial Stormwater

MARINE VESSEL MANUFACTURER – Tacoma, WA

Services Provided

- Permitting
- In-House Bench Testing
- Water Treatment Plan Submittal
- System Design / Build
- Long-term O&M Assistance

Technology Provided

- Mechanical Filtration
- Ion Exchange Resin Treatment
- 100 gallons-per-minute

Project Statistics

- 2.5 – Acre Site
- Discharge to Marine Waters
- Pollutants: NTU, Cu, Zn
- 100% Compliance

Project Summary

This small family business was very environmentally conscious and worked tirelessly to keep their lot clean. But even with proper BMP implementation and good cleaning practices, the facility was still failing to meet benchmarks on dissolved metals. When their environmental manager realized that they needed a more robust solution, he contacted CCS to design a treatment solution that targeted the problem metals.

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Industrial Stormwater

MARINE BOATYARD – Pierce County, WA

Services Provided

- Emergency Response to 3rd Party Lawsuit
- Water Treatment System Rental
- System Design Support
- Custom System Automation
- System Maintenance & Monitoring

Technology Provided

- Chitosan Enhanced Sand Filtration
- Adsorptive Media & Ion Exchange Media
- 50 gallons-per-minute
- Remote System Operations & SCADA Capabilities

Project Statistics

- 1 – Acre Site
- Discharge to Marine Waters
- Pollutants: Turbidity, Cu, Zn, Pb

Project Summary

CCS received an urgent call from the facility owner's representative with the need to immediately install an industrial stormwater treatment system to mitigate terms of a third party Clean Water Act lawsuit. CCS worked with the project owner and the owner's engineer to develop an interim compliance strategy which included implementation of a temporary rental stormwater treatment system.

CCS deployed a full-scale treatment system to the facility within 48-hours of receiving a signed contract to perform the work. The stormwater treatment system required custom upgrades associated with electronic interface for tidal flow control to the system and remote automation. The treatment system featured full automation complete with SCADA and remote system operations.

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Clear Creek Systems

Industrial Stormwater

BULK FUELING FACILITY – Seattle, WA

Services Provided

- Laboratory Treatability Testing
- Permitting Assistance
- Fast Track Design and Mobilization
- System Design / Build
- System Maintenance & Monitoring

Technology Provided

- Mechanical Filtration
- Polishing Adsorptive Media
- System Automation
- 50 gallons-per-minute

Project Statistics

- 1.2 – Acre Site
- Discharge to Marine Waters
- Target Pollutants: Turbidity, Metals
- Commissioned in 2016

Project Summary

A bulk fueling facility contacted CCS to assist with their stormwater discharges. The staff maintained a good BMP schedule and kept their site clean, but still had issues with elevated metals in their runoff. They found themselves targeted by a citizen suit under the Clean Water Act, and had to fast track their solution to meet consent decree requirements.

CCS worked with their facility and an outside engineering firm to upgrade their infrastructure and provide an active treatment system within 120 days. Bench testing showed that simple mechanical filtration followed by a polishing adsorptive media lowered all pollutants to non-detect ranges, and a system was designed around this treatment train. All equipment design and mobilization tasks were completed within the 120-day timeframe, satisfying the deadlines set out by the consent decree.

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Clear Creek Systems

Industrial Stormwater

SHIPYARD FACILITY – San Diego, CA

Services Provided

- Laboratory Treatability Testing
- Fast Track Design and Mobilization
- System Design / Build
- System Maintenance & Monitoring

Technology Provided

- Mechanical Filtration
- Polishing Adsorptive Media
- Pressurized Backwash System
- Full Automation & Telemetry
- 350 gallons-per-minute

Project Statistics

- Discharge to Marine Waters
- Target Pollutants: Turbidity, Metals, Organics, Hydrocarbons
- Commissioned in 2010
- Over 1 Billon Gallons Treated

Project Summary

A ship manufacturing facility was facing a permitting crunch for their stormwater runoff. The facility was not reliably meeting pollutant discharge requirements under their existing permit, and an upcoming revised permit was scheduled to drop benchmarks to even lower values. Additionally, the site infrastructure had numerous hydrostatic relief wells that would often pull highly saline groundwater from the bay, and this salinity limited options for both passive and active treatment.

CCS performed multiple pilot tests on facility discharge water and found that a multi-step treatment train with adsorptive media and ion exchange resins could reliably meet benchmark requirements. A full-scale system was designed around this modeled treatment and installed on a rush basis, and the facility met requirements of the new permit before its scheduled release date.

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Clear Creek Systems

Industrial Stormwater

MARINE VESSEL MAINTENANCE FACILITY – Charleston, OR

Services Provided

- In-House Bench Testing
- Water Treatment Plan Submittal
- Interim System Rental
- Fast Track Fabrication / Installation
- Long-term O&M Assistance

Technology Provided

- Chitosan Enhanced Sand Filtration
- Adsorptive Media Filtration
- Ion Exchange Treatment
- 300 gallons-per-minute
- System Automation & SCADA Capabilities

Project Statistics

- 12 – Acre Site
- Discharge to 303(d) water body
- Pollutants: TSS, Cu, Zn, Bacteria

Project Summary

A marine vessel maintenance facility had filtration BMP's in place for runoff pollutants generated by their day-to-day operations. Their existing BMP's were effective, but not robust enough to meet benchmarks. Their consultant drafted a 40% design for their required system, put the project to bid, and CCS was awarded the contract in early 2017.

CCS worked with the facility and their consultant to finalize the treatment system design, tailoring the system to be more reliable with the unique pollutant load in their runoff water. CCS provided an interim system as a stopgap to eliminate benchmark exceedances during the permanent system design stage, and is currently in the process of fabricating and delivering a permanent, automated system which is designed to reduce all pollutants to non-detect levels.

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ATTACHMENT 2

MEDIA CUT SHEETS

MEDIA FILTRATION

CCS Metlock™

- CATIONIC EXCHANGE RESIN - CHELATING RESIN
- HIGH EFFICIENCY HEAVY METALS REMOVAL FOR INDUSTRIAL STOMWATER TREATMENT APPLICATIONS – TARGETS ZINC & COPPER

CCS Metlock media is a macroporous chelating resin designed for heavy metals removal. It has a proven track record of removing heavy metals to low parts per billion levels on a range of influent water quality—including high total dissolved solids conditions. Specific applications include high capacity reduction of heavy metals including zinc, copper, and lead.

TECHNICAL SPECFICATIONS

- Polymer Structure: Macroporous Crosslinked Polymer
- Ionic Form – as shipped: Sodium – Na+, Magnesium – Mg+ or Calcium – CA+
- Moisture Retention: 55% to 65%
- Mean Diameter: 0.6mm to 0.75mm
- Shipping Weight: 47 lbs/ft3 to 50 lbs/ft3
- Temperature limit: 70 C (158 F)
- pH limitations: 6-11

Clear Creek Systems, Inc
4101 Union Ave • Bakersfield CA 93305
(877) 324-9634 • (661) 324-9634 • FAX (661) 322-4206
www.clearcreeksystems.com

CCS-400™ Adsorptive Media for Metals

FEATURES

- Proprietary blend of mixed media
- High surface area for maximum absorption
- Designed for liquid phase applications
- Suitable for hydraulic transfers
- Metal selective media for brackish water
- Backwash capable for extended life

APPLICATIONS

- Heavy metals removal
- Contaminant removal
- Hydrocarbon removal
- Use as polishing step to other filter media
- Construction, Industrial, Remediation

Clear Creek Systems, Inc.
140 County Line Road SW, Suite 101 • Pacific, WA 98047
(877) 324-9634 • (206) 695-2120 • FAX (253) 872-6809
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Clear Creek Systems

Case Study: Oregon Boatyard Treatment Retrofit

Association of Environmental Geologists | Seminar Series

March 06, 2020

Jason Ziemer | Industrial Stormwater Program Manager

https://clearcreeksystems.com

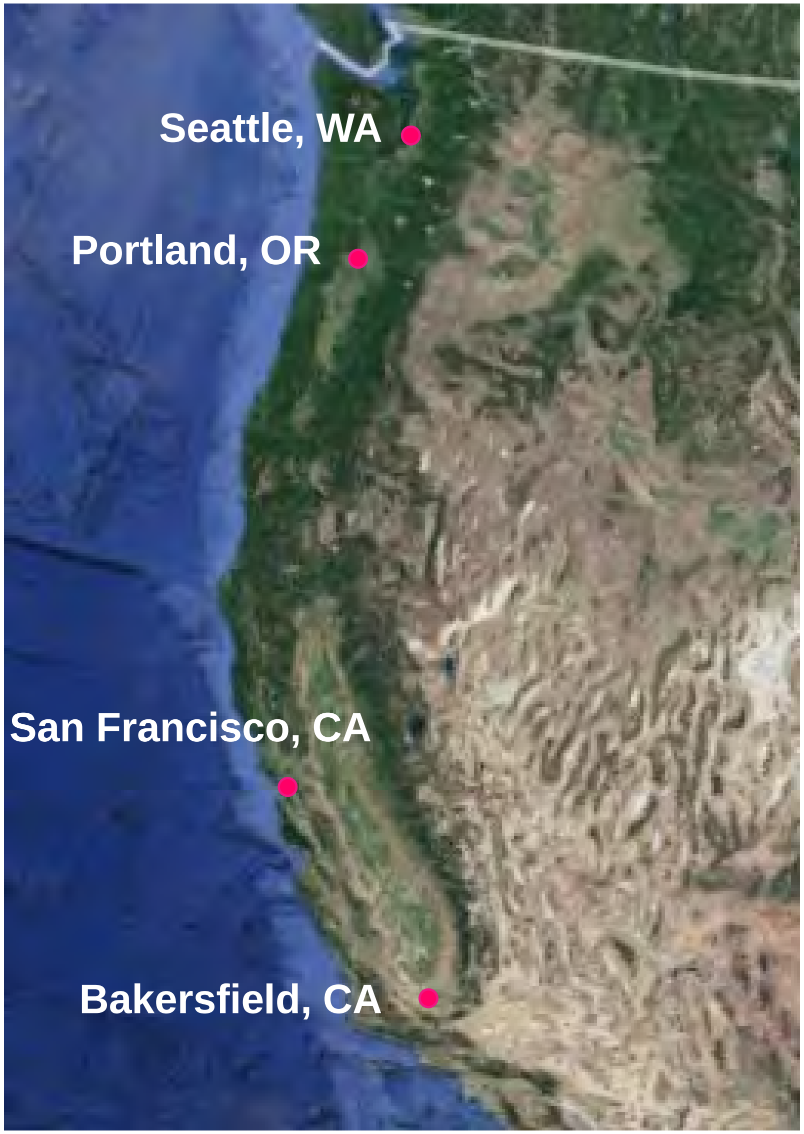
Presentation Overview

Stormwater Treatment Retrofit Case Study

1. Site and project overview
2. System design preparation process
3. Treatment overview
4. Onsite results

Clear Creek Systems, Inc.

- Founded in 1994
- ≈ 60 employees
  - 36 FTE
- West-Coast offices located in WA, OR & CA
- Technology – based solutions
- Focused primarily on pump and treat
- Typically team to turnkey
- Delivering case-by-case, best-fit technologies



Industrial stormwater projects - Last 5 years

Industrial Facility and Location	Site Evaluation	SWPPP Review	In-House Bench Testing	In-Field Pilot Testing	System Feasability and Cost Analysis	Hydrology Modelling	Permitting Assistance	Treatment System Design / Build	Interim / Emergency System Rental	Fast Track Design and Mobilization	System Fabrication and Installation	SCADA Control and Monitoring	Long-Term O&M Assistance
Asphalt Batch Plant | Tacoma, WA	x				x			x		x	x		x
Bulk Fueling Facility | Seattle, WA	x	x	x		x	x		x		x	x		x
Concrete Recycling Facility | Renton, WA	x		x		x						x		x
Container Transfer Facility | Seattle, WA	x		x		x			x		x	x	x	
Contractor's Equipment Lot | Aberdeen, WA	x		x		x	x		x		x	x	x	x
Galvanizing Facility | Portland, OR	x	x	x		x	x	x	x	x	x			
Heavy Equipment Manufacturer | Portland, OR	x	x	x		x	x		x			x		
Heavy Equipment Rental Lot | Newark, CA	x	x	x		x	x	x	x			x		x
Heavy Equipment Rental Lot | Portland, OR	x	x	x		x	x	x	x		x	x		x
Heavy Equipment Rental Lot | Tacoma, WA	x	x	x		x	x	x	x		x	x		x
Intermodal Shipping Facility | Seattle, WA	x		x		x		x	x			x	x	x
Intermodal Shipping Facility | Tacoma, WA	x		x	x	x			x	x	x		x	x
Locomotive Repair Facility | Tacoma, WA	x		x		x	x		x			x	x	x
Maintenance Boatyard | Steilacoom, WA	x		x	x				x	x	x			
Marine Vessel Manufacturer | San Diego, CA	x		x	x	x			x			x		x
Marine Vessel Manufacturer | Tacoma, WA	x		x		x			x			x		x
Marine Vessel Maintenance Facility | Coos Bay, OR	x		x		x			x	x	x	x	x	x
Metal Recycler | Eureka, CA	x		x	x	x	x		x			x		x
Metal Recycler | Seattle, WA	x	x	x		x	x	x	x			x		x
Metal Shredder / Recycler | Seattle, WA	x		x	x	x				x			x	
Petrochemical Manufacturer | Tacoma, WA	x				x			x	x		x		x
Sand and Gravel Facility | Aberdeen, WA	x	x	x		x	x	x	x			x	x	x
Sand and Gravel Facility | Fremont, Seattle, WA	x	x	x		x	x	x	x			x	x	x
Sand and Gravel Facility | Longview, WA	x	x	x		x	x	x	x			x	x	x
Timber Facility | Cloverdale, CA	x		x		x	x		x			x	x	x

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Industrial stormwater projects - Last 5 years

Facility and Location		
Maintenance Boatyard | Steilacoom, WA	x	
Marine Vessel Manufacturer | San Diego, CA	x	
Marine Vessel Manufacturer | Tacoma, WA	x	
Marine Vessel Maintenance Facility | Coos Bay, OR	x	
Metal Recycler | Eureka, CA	x	
Metal Recycler | Seattle, WA	x	x
Metal Shredder / Recycler | Seattle, WA	x	
Petrochemical Manufacturer | Tacoma, WA	x	

Industrial Facility and Location	Site Evaluation	SWPPP Review	In-House Bench Testing	In-Field Pilot Testing	System Feasability and Cost Analysis	Hydrology Modelling	Permitting Assistance	Treatment System Design / Build	Interim / Emergency System Rental	Fast Track Design and Mobilization	System Fabrication and Installation	SCADA Control and Monitoring	Long-Term O&M Assistance
Sand and Gravel Facility | Fremont, Seattle, WA	x	x	x		x	x	x	x			x	x	x
Sand and Gravel Facility | Longview, WA	x	x	x		x	x	x	x			x	x	x
Timber Facility | Cloverdale, CA	x		x		x	x		x			x	x	x

Clear Creek Systems

Boatyard project overview

Clear Creek Systems

Boatyard project overview

ditions and issues

th multiple outfalls

nded, painted, and stored onsite

d (<5µm) pollutants and metals

atment:

atment vaults w/ media cartridges

(fine sediment and metals) leading to

enchmark exceedances and bypasses

Project preparation process

1. **Perform site walk and sample capture**
2. **Create site pollutant portfolio**
3. **Perform bench testing**
4. **Analyze percent reductions**
5. **Analyze all other obtained information**
6. **Design and price system**

Project preparation process

1. **Perform site walk and sample capture**
2. Create site pollutant portfolio
3. Perform bench testing
4. Analyze percent reductions
5. Analyze all other obtained information
6. Design and price system

Site walk and sample capture

Technical staff deployed for evaluation of:

- Existing site conditions
- Site pollutant sources
- Treatment system feasibility

110-gallon representative stormwater sample collected for analysis and testing

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Project preparation process

1. Perform site walk and sample capture
2. **Create site pollutant portfolio**
3. Perform bench testing
4. Analyze percent reductions
5. Analyze all other obtained information
6. Design and price system

Create site pollutant portfolio

"Pollutants of concern"

- Permitted pollutants
- Other constituents
  - Site-specific
  - Dissolved solids
  - Dissolved metals
  - Particle size splits

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Resultant pollutant portfolio

Above benchmarks

- Total suspended solids (75 mg/L)
- Total copper (280 µg/L)
- Total zinc (420 µg/L)
- Fecal coliform (200 CFU/L)

Pollutants of concern

- Total dissolved solids (380 mg/L)
- Particulate solids sub-5.0 µm

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Project preparation process

1. Perform site walk and sample capture
2. Create site pollutant portfolio
3. **Perform bench testing**
4. Analyze percent reductions
5. Analyze all other obtained information
6. Design and price system

Bench testing procedures – treatment process

Remove solids load

- Mechanical filtration (sand, mixed media)
- Chemical treatment (coagulants / flocculants)
- Combination of the two

Remove ultrafine and dissolved load

- Adsorptive media (carbon, specialty media)
- Ion exchange (multiple proprietary blends)
- Combination of the two

Bench testing procedures

Qualitative (jar testing)

- Evaluate chemical treatment
- Determine dose rates
- Visual results only

Quantitative (column testing)

- Chemical treatment
- Mechanical filtration
- Adsorptive treatment

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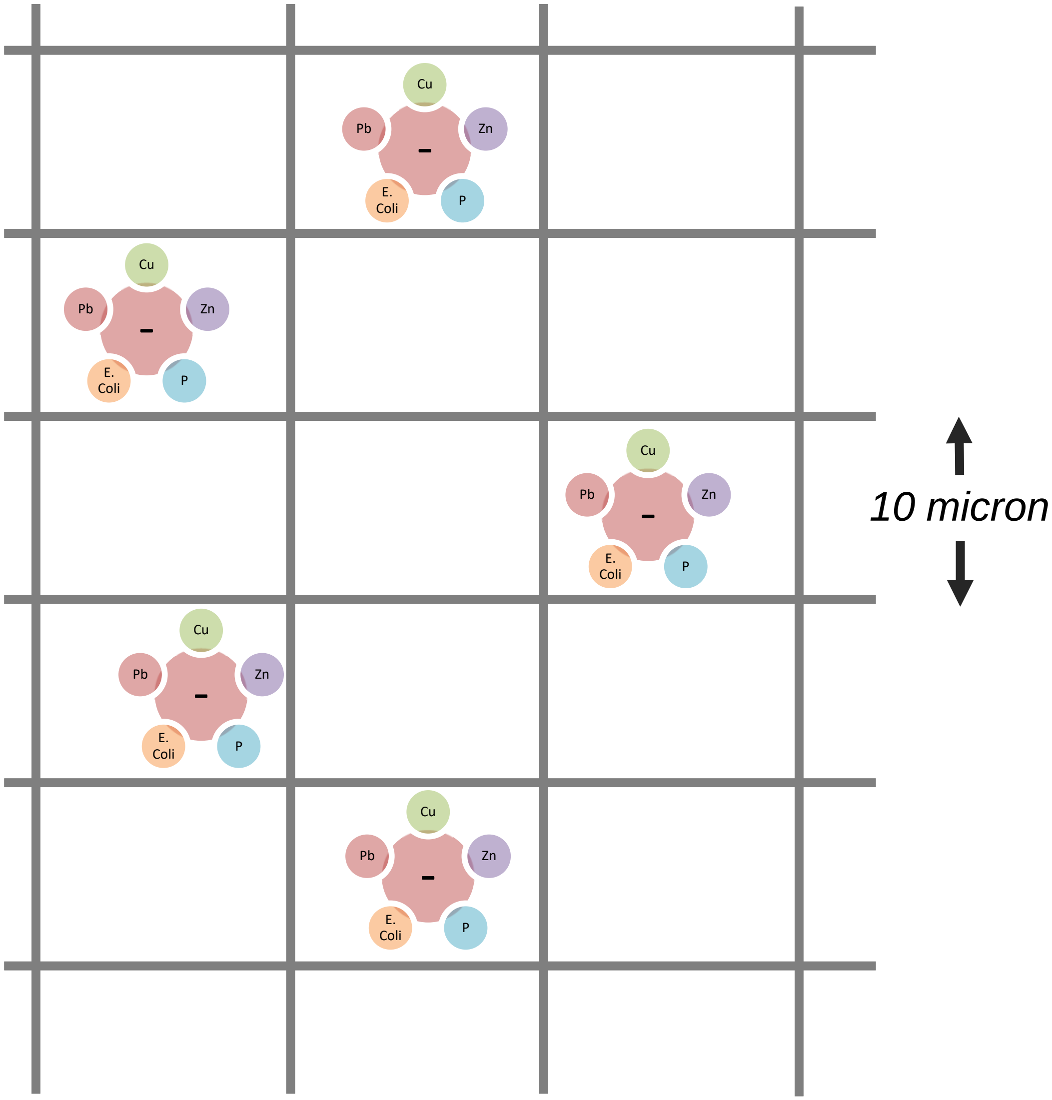
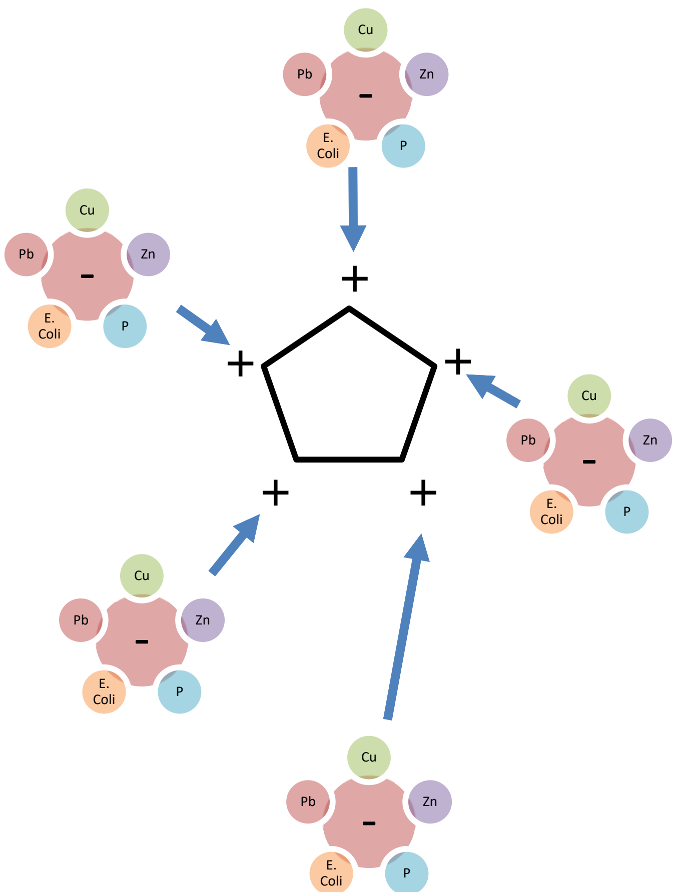
Treatment Process - Flocculation





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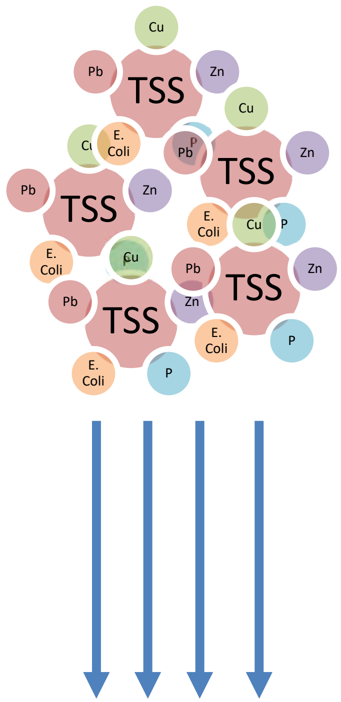
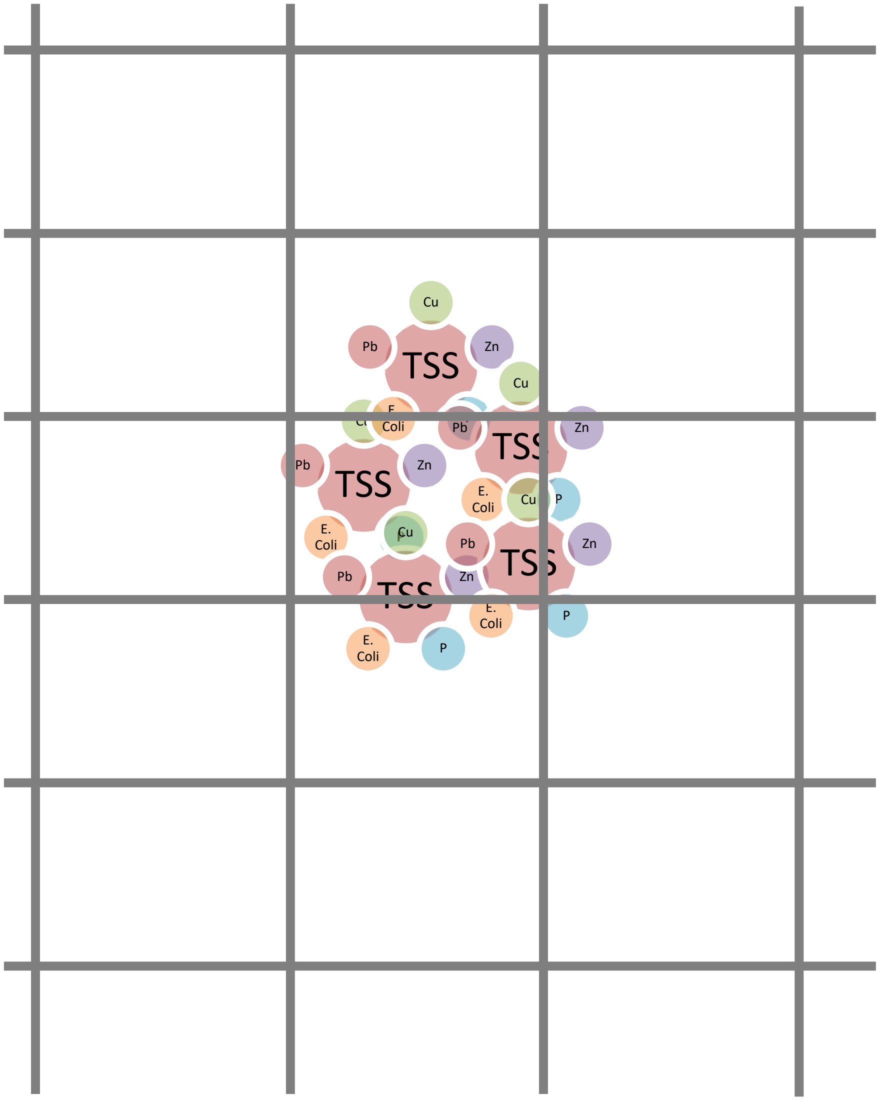
Treatment Process - Flocculation





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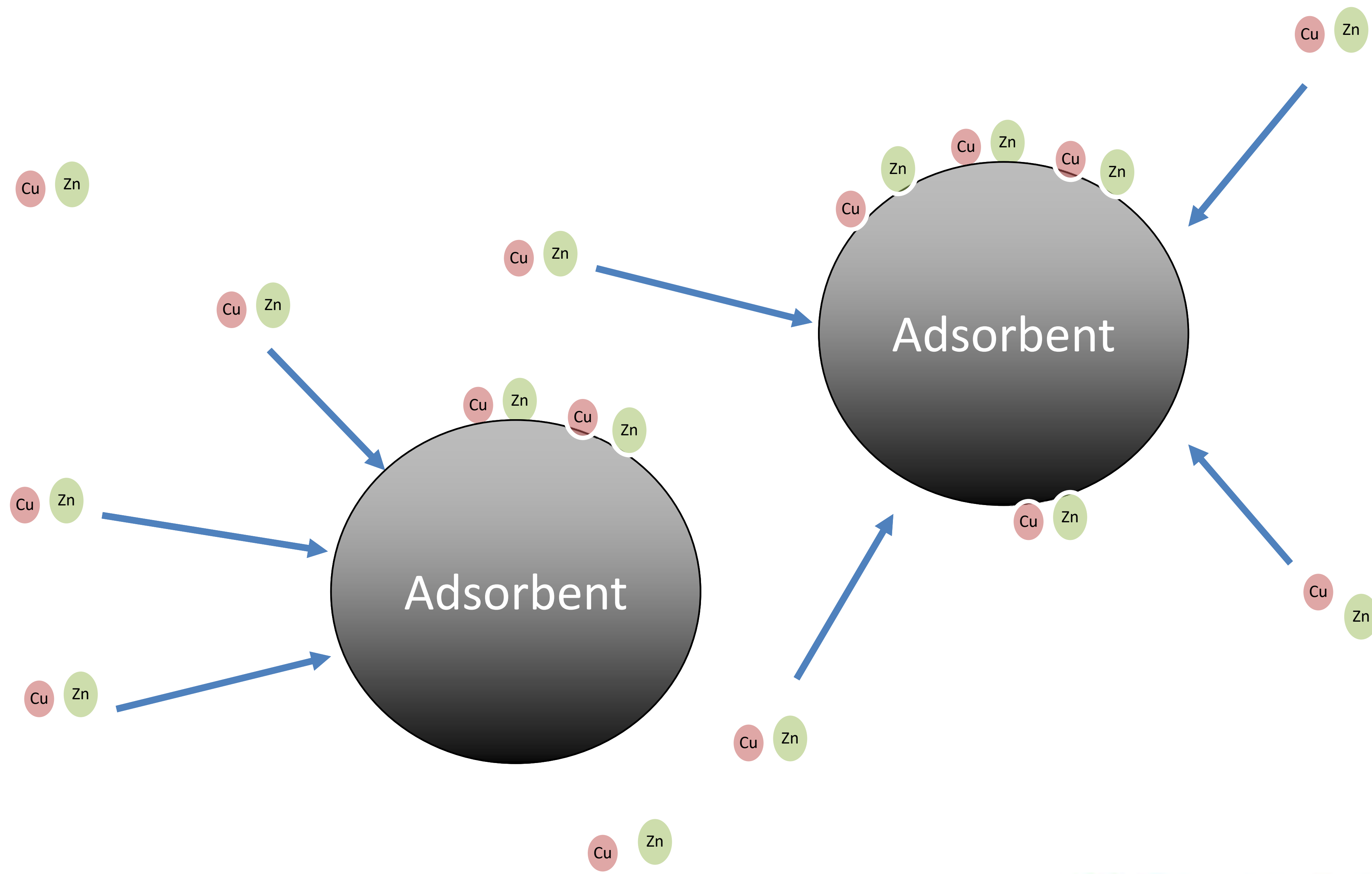
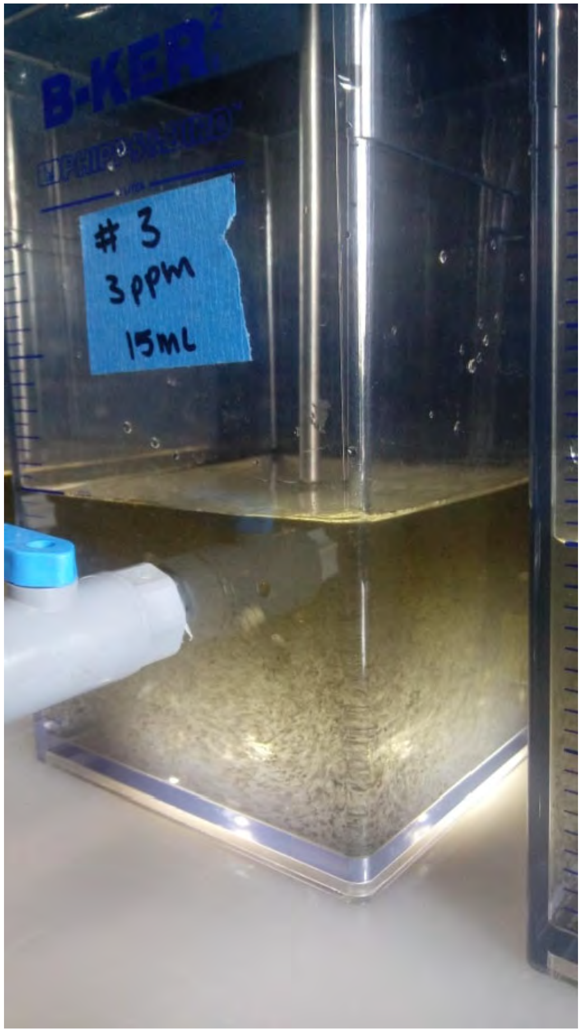
Treatment Process - Adsorption

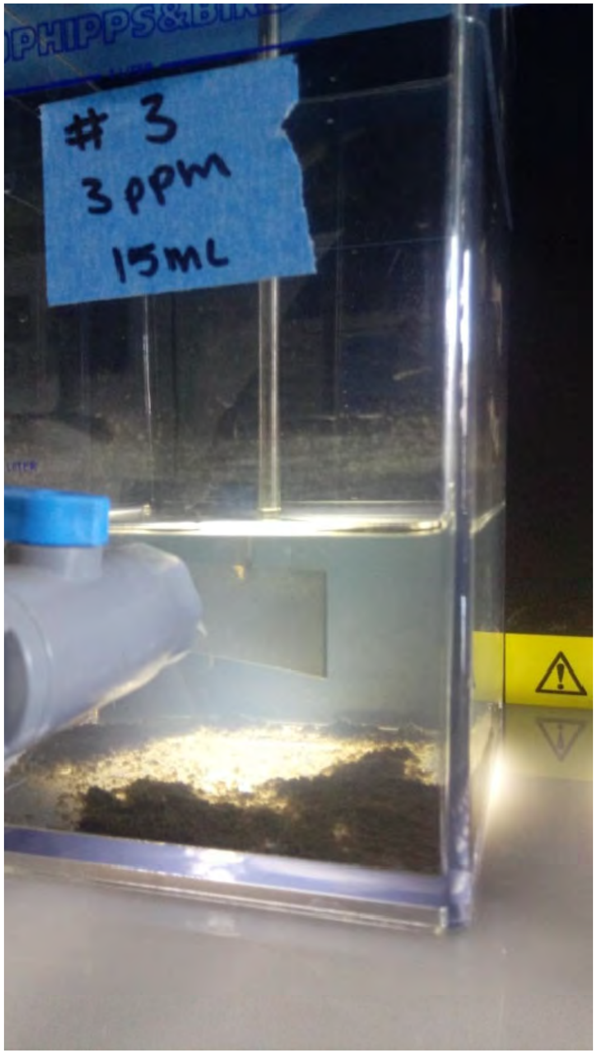


Bench testing photos

Clear Creek Systems

Bench testing photos





Clear Creek Systems

Project preparation process

1. Perform site walk and sample capture
2. Create site pollutant portfolio
3. Perform bench testing
4. **Analyze percent reductions**
5. Analyze all other obtained information
6. Design and price system

Analyze percent reductions (bench test results)

Sample ID	pH	NTU	Total Copper	Total Lead	Total Zinc	TSS	Fecal Coliform
Unit	S.U.	NTU	ug/L	ug/L	ug/L	mg/L	CFU/L
RAW	6.88	89.7	280	10.5	420	53	200
CESF	6.76	1.63	45.6	0.2	224	1.5	4
AM1	7.17	1.07	25.7	0.2	2.5	0.8	4
AM2	7.14	1.48	0.7	0.2	0.3	1.6	4
IX1	6.81	0.87	0.6	0.2	3.6	0.5	4
IX2	6.43	2	0.6	0.2	0.25	0.5	4
UV	6.97	2.33				0.5	4

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Analyze percent reductions (bench test results)

Raw water showed elevated metals / TSS

Treated water sub 1.0 ug/L on metals / TSS

Dissolved metals not chelated with CESF

Particle load too high for adsorption alone

Dissolved load too high for CESF alone

Clear Creek Systems

Project preparation process

1. Perform site walk and sample capture
2. Create site pollutant portfolio
3. Perform bench testing
4. Analyze percent reductions
5. **Analyze all other obtained information**
6. Design and price system

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Analyze other obtained information

Site characteristics

- Multiple outfalls
- Single centralized treatment feasible

Water characteristics

- Elevated TDS and fecal coliform
- TSS too fine to capture with typical filters

Other characteristics

- *New permit being issued* – future-proofing

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Project preparation process

1. Perform site walk and sample capture
2. Create site pollutant portfolio
3. Perform bench testing
4. Analyze percent reductions
5. Analyze all other obtained information
6. **Design and price system**

Design and price system

1. **Determine flow rates of individual DBs**
2. **Determine flow rate of centralized system**
3. **Determine chemical treatment (chitosan)**
4. **Determine adsorptive media (CCS-400)**
5. **Size all equipment appropriately**

   Sand filter sizing and adsorption contact time
6. **Obtain ancillary pricing for client delivery**
7. **Install final system upon approval**

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Treatment System – 300 gpm CESF w/ CCS-400

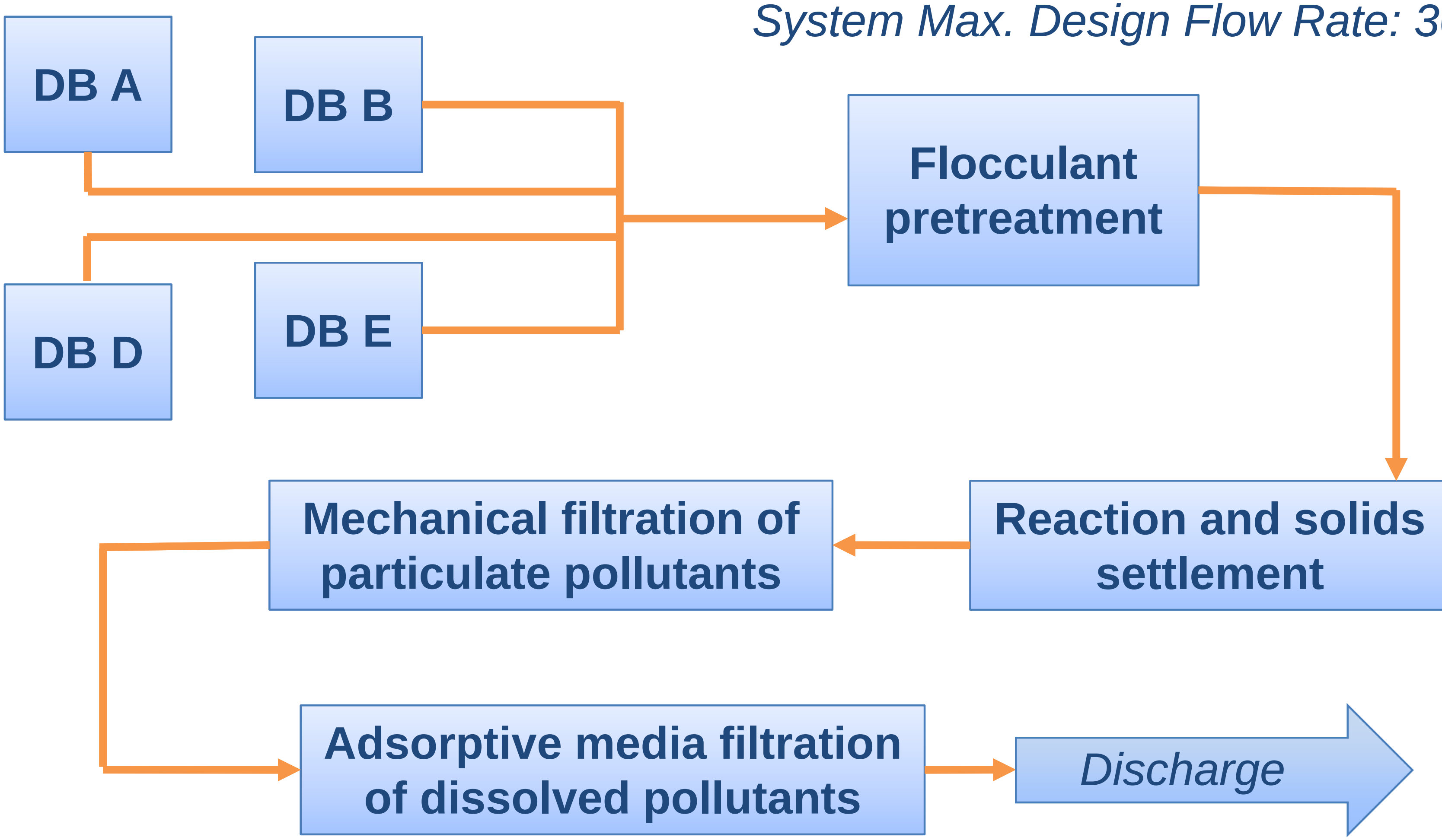
Clear Creek Systems

Treatment System – 300 gpm CESF w/ CCS-400

1. Utilize existing DB vaults for storage
2. Pump from vaults to centralized treatment
3. Chitosan pretreatment ahead of storage
4. Pump from storage through sand filter
5. Adsorption after sand filtration
6. Direct discharge to marine waters

Treatment Process Box Diagram

System Max. Design Flow Rate: 300 gpm



Clear Creek Systems

Treatment System – 300 gpm CESF w/ CCS-400

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Why this design and layout?

- Effectively reduces TSS load
- Effectively reduces dissolved metals
- Least impacted by TDS/hardness
- Single treatment point – smaller footprint
- Single treatment point – lower cost
- Robust treatment process
- Results proven in bench testing

Final system results

~$365,000 buy-in for equipment (in 2016)

~$9,000 – 13,000 / yr for O&M

~10,500,000 gallons/year treated

Approximately 1,800 sq. ft. footprint

All benchmarks met since installation

No impact on site operations

CCS assists as needed with O&M

Thank you for your time

jziemer@clearcreeksystems.com | 253.670.4054

Presentation available for delivery in pdf format upon request

Clear Creek Systems

Appendix G

Clear Water Systems Supporting Materials

TIG environmental®
INVESTIGATIONS ▾ FORENSICS ▾ REMEDIATION

Clear Water SERVICES

A *fluid* approach to water treatment.

2525 West Casino Rd Ste 7A, WA 98204 • (425) 412-5700 • clearwaterservices.com

ESTIMATE OF PROBABLE COSTS - JUNE 28, 2022

South Park Marina; Treatment System Design, Manufacturing and Installation Proposal

ESTIMATE TO PROVIDE AND INSTALL A 100-GPM ADVANCED WATER TREATMENT SYSTEM IN SEATTLE, WA

Task/Description		Quantity	Unit	Unit Price	Estimated Project Cost	Notes
Submittals, Permitting and Engineering Support						
Submittals & CM	O&M Manual	1	LS	$ 2,784	$ 2,784	Lump Sum for initial document preparation and two copies of original documents, requested revisions charged at actual hours at $133/hr.
	Site Specific HASP & Training	1		$ 1,064	$ 1,064	Assumes HAZWOPER 40-Hour Training is sufficient
	Engineering & Design Support	1		$ 2,128	$ 2,128	Drawings, Sizing and Controls Engineering for development of O&M
				Task Total	**$ 5,976**	
100 GPM Automated pH Adjustment & Filtration/Adsorption Treatment System						
100-GPM Control and Chemical Injection Options	PLC Based Stand-Alone Remote Control and Remote Access Panel	1	EA	$ 78,000	$ 78,000	Clear Water has provided an alternative to treatment system controls as a stand-alone panel on Unistrut. This ala cart panel includes a secondary water quality monitoring panel specific only to influent pH as to monitor and support pH adjustment operations. No other data recording and/or chemical injection options are included in this option.
	Remote Access, Allen Bradley PLC-Based System. Includes: Monitoring Instrumentation, Data Collection, Alarm & Remote Telemetry System, Remote Control, Chemical Dosing Systems, Air Compressor, Fail-Safe Valving System, and Heating.	1	EA	$ 165,750	$ -	Fully Automated & Customized Control System based on specific site conditions. GULD compliant. Secure double door locking mechanism. Also includes a lab bench, storage, sampling and secondary containment. Capable of incorporated up to three (3) chemistries as a built-in contingency. Requires 480 volt, 100amp, 3-phase service. Electrical permit and inspection requirements not included in cost. Power to the system provided by others.
Sand Filtration System	24" x 4-Pod Yardney Sand Filter Unit w/ Pressure Sustaining Valve	1	EA	$ 29,700	$ 29,700	One (1) 24" x 4-pod sand filter with air-activated auto backflushing mechanism and controls.
		1	EA	$ 1,890	$ 1,890	Includes one (1) pressure sustaining valve
Sand Filter Pump	5 HP Centrifugal Pump. Spec'd for 100 GPM at 100' of TDH	1	EA	$ 6,250	$ 6,250	Estimate: Actual pump sizing based on final system design and final TDH. Includes recirculation pump from clean water storage to treatment system.
Pretreatment Pump	2 HP Submersible Pump: Spec'd for 100 GPM at 50' of TDH	1	EA	$ 4,375	$ 4,375	
Interconnected Plumbing	Schedule 80 PVC, Tank Level Sensors, Valves, Freeze Control Drains, and Misc. Fittings	1	EA	$ 13,500	$ 13,500	Estimate: Includes piping from the stormwater collection treatment tanks to the system; system to disc., recirc. and backflush.
Storage Tank	5,000-Gallon Up-Right Poly Tank	1	EA	$ 8,450	$ 8,450	Includes the addition of one (1) 5,000 gallon open-top poly tank for up-front pH adjustment and particulate settling prior to filtration and adsorption.
				Equipment Total	**$ 142,165**	**Equipment Capital**
Adsorption Multi-Media (AMM)						
Carbon System 2,000# Vessels	2,000# Vessels	2	LS	$ 20,925	$ 41,850	Includes the addition of two (2) 2,000-lb. multimedia vessels to achieve 10-minutes of contact time. Adsorptive multi-media chosen based on relative experience with similar industrial projects.
	Sch 80 PVC Manifold System	1	LS	$ 6,500	$ 6,500	Each vessel would require a manifold for backflush control and lead/lag configuration control. Schedule 80 manifold system needed for backflush option.
Carbon Filtration System Media	Initial Adsorptive Filter Media	1	LS	$ 9,984	$ 9,984	Assumes 10-minutes of contact time is sufficient for metals reduction through the selection of 50/50 Hydrosil HS-MT and virgin coconut granular activated carbon (GAC). Cost only valid for 30 days.
				Equipment Total	**$ 58,334**	**MMFA Add-On Capital**
Treatment System Delivery, Installation & Commissioning						
Mobilization, Setup & Commissioning	Equipment Transport: Panels, 24x4 Sand Filter Skid, Tanks, Associated Pumps and Interconnecting Plumbing.	1	LS	$ 11,900	$ 11,900	Lump Sum: Based on previous experience with treatment system mobilization. Interconnecting plumbing lengths based on system location within 50 feet of tanks and 100 feet of discharge.
	System Installation, Start-up, Hydraulic Optimization and Programming	1		$ 13,256	$ 13,256	
	Initial Sand Filter Media	1		$ 940	$ 940	Initial sand filter media for one (1) 24 inch diameter, 4 pod sand filter.
				Install Total	**$ 26,096**	

Sub-Totals	**Submittals & CM**	**$ 5,976**	No state sales tax included.
	Capital Equipment	**$ 200,499**	
	Set-Up	**$ 26,096**	
Total	**Project Total**	**$ 232,571**	

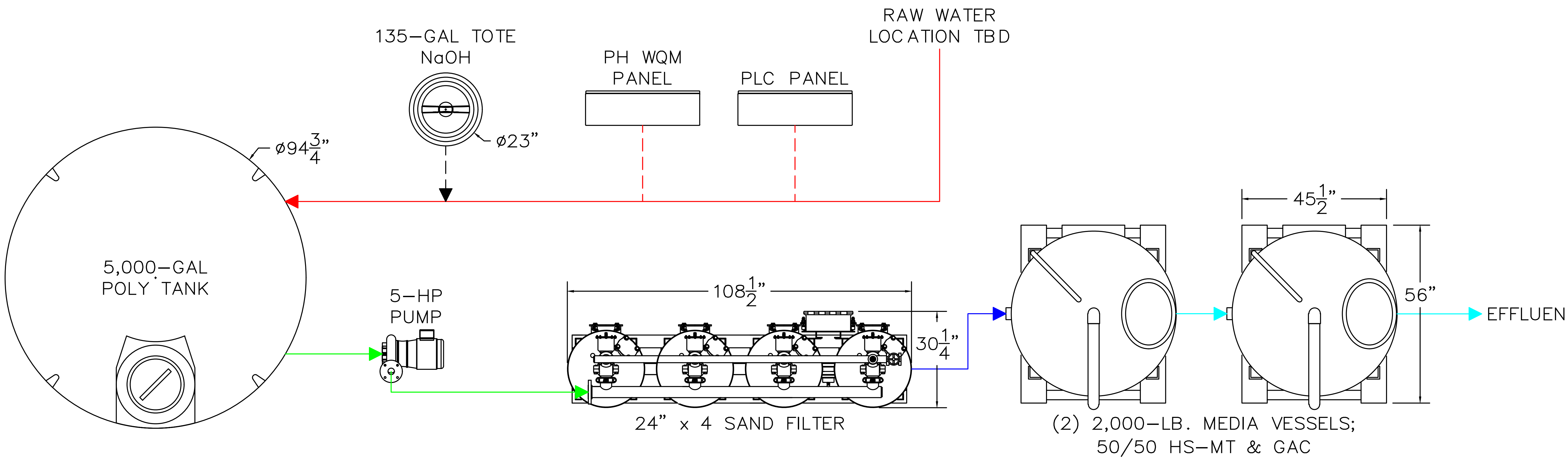
Exclusions:	**System Power, Demobilization, System Reconfiguration and/or Upgrade Costs**

Estimate valid for 7 days. Typical equipment Lead Time 12-14 Weeks from receipt of downpayemt. Due to supply chain issues outside our control Clear Water will update equipment lead times upon NTP.

Typical Payment Terms: NET 30	**1) 50% Deposit Due upon Notice to Proceed**
	2) 40% Monthly Progress Billing (Proportionate to Equipment Delivery Date)
	3) 10% within 30 days of Completed Installation
	4) System mobilization billed as needed during mobilization period, phased billing until 100% system installation is complete.

LEGEND

- RAW WATER
- INFLUENT
- EFFLUENT
- DISCHARGE



Clear Water SERVICES

SOUTH PARK MARINA – SEATTLE, WA
PROJECT NO. WAI22SPM01
100–GPM ADVANCED PH ADJUSTMENT, FILTRATION, AND ADSORPTION SYSTEM
PROCESS FLOW DIAGRAM

DATE	REVISIONS

SHEET 1
1 OF 1

DATE: 6/28/2022 | DESIGNER: CWS | FILE NAME: WAI22SPM01_PFD.dwg

Appendix H

Enpurion Supporting Materials

SOUTH PARK MARINA

DESIGN GUIDE &
OPERATIONS AND MAINTENANCE MANUAL

ENPURION STORMWATER TREATMENT SYSTEMS

REVISED – JULY 2022
www.enpurion.com

ABOUT ENPURION® TREATMENT TECHNOLOGIES

Stormwater runoff is the greatest source of water pollution in the developed world. As a result, regulations and stormwater pollutant limits continue to grow ever more stringent. ENPURION® stormwater treatment technologies are designed to provide maximum flexibility and ease of use while ensuring environmental protection and compliance with stormwater regulations. Enpurion FlexSystem™ treatment solutions are simple, require minimal infrastructure and are available in multiple configurations:

1) Above-ground FlexMax™ treatment and downspout units
2) Compact FlexFilter™ downspout treatment units, media tubes and pillows
3) FlexBasin™ Catch Basin Inserts (CBI's)

The key to FlexSystem™ is the interchangeable treatment technology used in pillows for each application. Enpurion chemical engineers have developed ion-exchange and sorption technologies in easy-to-use pillows that capture pollutants before they are released into the environment. Each technology is configured with layers filled with one of several different treatment media. Above-ground treatment systems can be configured in Enpurion's patented serial process to achieve virtually any treatment goal at any flow rate.

Catch basin treatment presents unique problems and opportunities. While CBIs are universally applicable, the residence time in the treatment unit and efficiency is limited by site conditions. Enpurion FlexBasin™ CBIs require careful design and the selection of media layers is critical to achieve maximum efficiency. CBIs are often used as the first line of defense when used with other technologies and are a great starting point for treatment strategy. Clients are encouraged to experiment with alternative pillow configurations to achieve the best treatment and value.

Using Enpurion FlexSystem™ above-ground series, downspout units and catch-basin inserts are a proven solution to stormwater management. Stormwater professionals can use the design guidelines to understand how Enpurion FlexSystem™ is designed for appropriate flow rate, treatment media and redundancy for parking lots, roofs, outside materials storage, and industrial activity.

Enpurion FlexMax™ Downspout Unit

Enpurion FlexFilter™ Downspout Unit

Where space is a concern, Enpurion's treatment technologies can be deployed in FlexFilter™ compact downspout systems. Areas like truck bays have historically been difficult to access with point-of-generation treatment. Enpurion high-capacity Ion-exchange media and mineral medias have been developed to manage roof runoff in less than ONE SQUARE FOOT of space per treatment unit.

The FlexFilter™ units, like all Enpurion FlexSystem™ products can be modified in an infinite number of ways, with a variety of media pillows and treatment technologies to meet every site-specific goal. FlexFilter can be configured in sections up to twelve feet in height or configured in parallel to achieve any flow rate and any treatment goal. Because the media can be rapidly changed and optimized, every engineer or site manager can optimize their systems to achieve the desired treatment goals.

The first line of defense is often at the point of collection for stormwater. That's where Enpurion FlexBasin™ can be deployed to provide treatment directly in the storm drains. The FlexBasin is the most versatile, highest performing catch basin insert (CBI) available. Because the FlexSystem pillows are simple to use and maintain, stormwater compliance is much easier than with any other technology.

Enpurion FlexBasin™ pillows can be configured for suspended solids, zinc, copper, nutrients like phosphorus and nitrates, and even pH buffering. The deployment is simple, and media changes are fast and easy. Further, the pillow fabrics can be configured specifically for site conditions to ensure the longest life and greatest possible value.

Enpurion FlexBasin™ Storm Drain Filter

For areas with high flow and high influent concentrations of pollutants, Enpurion FlexMax™ treatment systems can be used to manage any virtually any flow rate and any pollutant. The key to the FlexMax™ system is serial processing – the ability to use as many units as needed to achieve treatment goals. Because each unit can be stacked up to three high and configured with as many series as needed for the hydraulic load.

Enpurion FlexMax™ Above-Ground Treatment System

The image above shows a FlexSystem™ designed with two series of six FlexMax™ units, with a water quality (WQ) design flow rate 150 GPM and 90% reduction in zinc, and 98% reduction in oils and grease.

The following DESIGN GUIDE with the OPERATIONS AND MAINTENANCE MANUAL will help customers, engineers and site managers understand the advantages, options, and limitations for each of the FlexSystem™ technologies.

A sample list of standard media and fabrics is shown in the following Table 1. This list is not exhaustive, and additional technologies can be deployed where indicated. As always, Enpurion Engineers are available to assist and answer questions during the evaluation, specification, and operation of your FlexSystem™ treatment unit.

MATERIAL	SPECIFICATION	APPLICATION
Enpurion MT Media	Organic cellulose material activated to cation exchange to 0.78 EQ / Kg - absorbs organics and particles	Treatment for zinc, copper, iron and lead, emulsified and free petroleum hydrocarbons
Enpurion MX Media	Calcium based mineral blend formulated for pH buffer to equilibrium 8.5 SU	Treats acidic or basic influent, captures phosphorus, copper and other nutrients
Enpurion Bio-Blend Media	Activated organic cellulose, biochar and granular activated carbon loading up to 0.25 L/kg media	Surface adsorption and bulk absorption of emulsified and free petroleum hydrocarbons
Enpurion ZnIX Media	Commercial cation exchange resin (water softener) with exchange capacity =1.8 EQ/kg	High-capacity resin pillows for longer residence times and higher cation metals loading
Enpurion CLR Media	Organic cellulose material activated to absorb anionic suspended particles	Muddy or turbid water with silicate clays or silts, used in conjunction with MX pillows
Polypropylene Geotextile	Heavy polypropylene felt liner, available in 4 oz to 8 oz weights	High particle and oil retention, mechanical filtration
Fiber-Reinforced Screen	FRP fabric allows open flow	Better for heavy oil in influent to prevent blinding of PP fabrics
Polyethylene Fine Screen	Fine mesh for high flow	High flow with fine media, used where emulsified oils or fine particles dominate
Natural Open Weave Fabric	Jute or burlap pillow liners	Used for target pollutants, or where compostable pillows are needed
Oil-Absorbent Poly Pads	White poly topper pads, often deployed as top layer at oily locations	Used to protect media pillows, or as field serviceable maintenance item

TABLE 1 – FlexSystem™ Materials

SOUTH PARK MARINA ENPURION FLEXSYSTEM™ DESIGN

SYSTEM DESIGN CONSIDERATIONS

The design for the SPM Enpurion FlexSystem™ treatment unit must consider three primary aspects:

1) The pollutant to be treated and influent concentration (see TABLE 1)
2) Its treatment goal and/or discharge limits (BYGP Benchmarks)
3) The physical space, flow rates and hydraulics (2.25 Acre at 42 GPM per Acre)

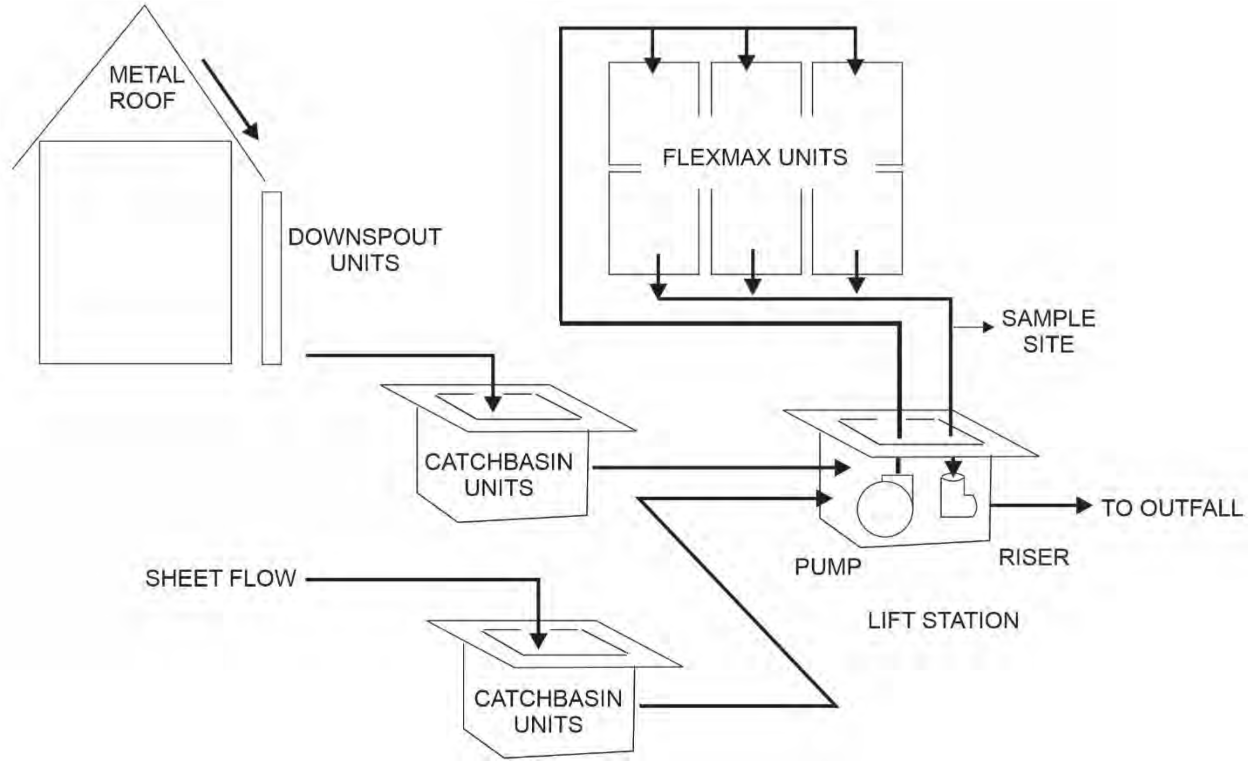
Enpurion FlexSystem™ for South Park Marina (SPM) is be designed for copper and zinc at the OFFLINE WQ DESIGN FLOW for 2.25 acres. The current target pollutant is based on the BOATYARD GENERAL PERMIT (BYGP). The primary treatment goal will be achieved by serial processes to address heavy metals, turbidity and suspended solids. Catch basins are limited by their physical size and tributary area, so these have design limits as a function or tributary area. Note these are only guidelines – actual results may vary.

Analyte	Units	Count	Min	Max	Mean
Total Copper	ug/L	12	67	300	150
Total Zinc	ug/L	12	85	1900	590
Dissolved Copper	ug/L	10	33.5	320	90
Dissolved Zinc	ug/L	10	58	1800	440
Total Suspended Solids	mg/L	12	4	130	23.30
pH	SU	4	6.75	6.91	6.83

TABLE 1 - SPM POLLUTANT DATA

The treatment systems are comprised of a combination of passive sorption / ion-exchange units, including the following:

1) Four FlexFilter™ compact downspout units to capture zinc from metal roofs\
2) Six FlexBasin™ Catch Basin Inserts \
3) Three series FlexMax™ above ground treatment units.



SOUTH PARK MARINA (SPM) BLOCK DIAGRAM

Subsurface collection and pumping to the above ground system will be provided by others.

The materials of construction are polypropylene, aluminum and PVC, and media is comprised of agricultural products processed with food-grade materials, ion exchange materials, biopolymers, activated mineral media, and enhanced with activated carbon and biochar. FlexSystem™ pillows are deployed in layers so designed to achieve desired treatment goals. Media may be combined or blended as indicated by site conditions and hydraulics.

Placing Enpurion FlexSystem products in series provides the greatest value for the client to achieve compliance with benchmarks. The serial process is characterized by the block diagram below. In the case of SPM, the series may be comprised of 1) downspout units, 2) catch basin units and 3) FlexMax above-ground Treatment units.

SERIAL PROCESSES

A generic serial process is shown in Figure 1

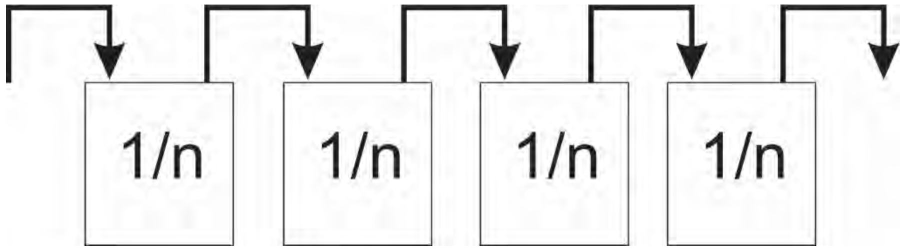


FIGURE 1 – Generic Serial Process

The treatment efficiency or removal rating of a serial process is determined by the number of treatment units in the series. The efficiency of each treatment unit will vary, and is usually determined by bench trials or estimated by Enpurion engineers. The target effluent concentration for **m** units in series with a nominal removal efficiency of (1/**n**) is found by the approximation

$$C_{final} = (1/n)^m$$

For example, imagine a low concentration influent that required 80% removal, or a final concentration less than 0.2 of the influent and assuming a nominal single pass flow rating of 50% (1/2). To achieve the treatment goal, the final concentration is estimated by:

½ = 50%	(0.5x of original concentration)
½ x ½ = 75%	(0.25 of original concentration)
½ x ½ x ½ = 87.5%	(0.125 or original concentration)

To achieve the desired treatment goal, three treatment units are required in series. Note that removal rating varies with application and is a strong function of residence time. For a serial process is limited to the design flow rate for a single unit.

DESIGN RULE: REMOVAL RATING IS PROPORTIONAL TO CONTACT TIME

The design volumes for Enpurion FlexSystem are as follows:

SYSTEM	NOM DIMENSIONS	CUBIC FEET	GALLONS
FlexMax	4 x 4 x 4’	60	405
FlexFilter	4 x 3.5 x 3.5’	50	250
FlexFilter	8” DIA x 1’	0.28 / linear ft	2 / linear ft.
FlexBasin	2 x 1.5 x 2’ min	6	42

TABLE 2 – FlexSystem Volumetric Capacities

FLEXMAX PARALLEL PROCESS

The SPM system will be comprised of downspout units, catch basin inserts (CBIs) with a final stage treatment using FlexMax above ground units configured in parallel to achieve the desired flow rate and treatment goal. The flow per unit is limited by the residence time determined by the influent concentration and desired treatment goal.

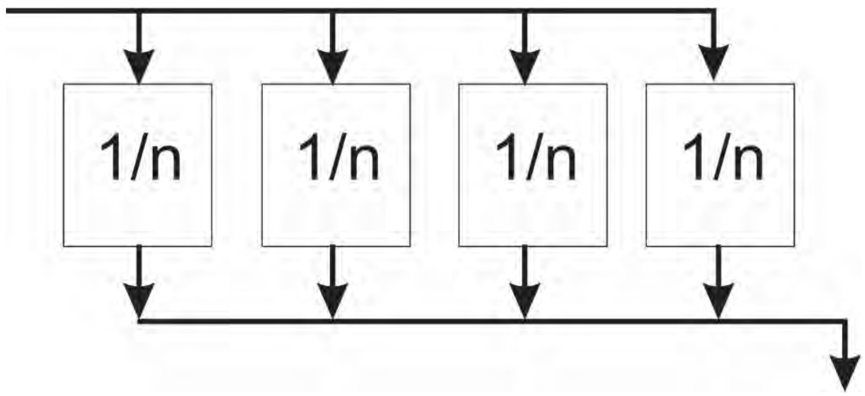


FIGURE 2 – Parallel Configuration

The design removal for a parallel system is the effective removal of a single unit at a reduced flow rate. As with the serial process, the effective removal rating is a strong function of the residence time in contact with treatment media. The design flow rate is the sum of the design flows for each unit.

CONTACT TIME = FLOW RATE / VOLUME OF TREATMENT MEDIA

GENERIC PUMPING SYSTEMS

High flow rate and high contact time can be achieved by adding processes above ground. Pumping systems must provide for OFFLINE WQ DESIGN FLOW To deliver stormwater from a sump, a typical lift station is shown in FIGURE 3. Stormwater is pumped from the basin or sump into the treatment units, and treated water is returned to a riser as shown. When storm intensity exceeds off-line WQ design flow (Typically about 0.09 inches per hour) the excess flow will overflow to the riser and be mixed with the treated water.

enpurion

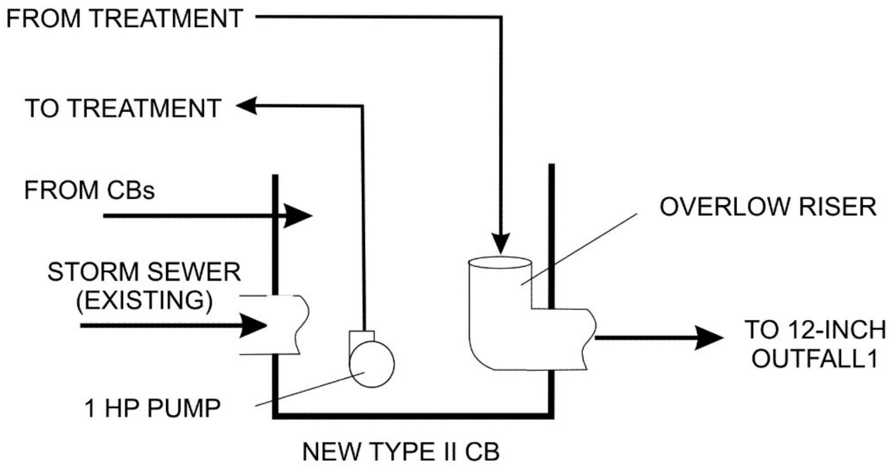


FIGURE 3 – Typical Lift Station

The FlexFilter downspout units are to be added at all galvanized metal roofs – initial estimates are for FOUR downspout units – these are subject to change following site inspection. These are shown in the image on Page 3 of this guide.

The FlexMax above ground units are specified as three units, two high configured in parallel – providing 1800 gallons of treatment volume for the 95 GPM of flow – for a nominal contact time of 20 minutes. An example of a similar installation of treatment units is shown on page 4.

The final design specification will depend on determination of sources of heavy metals, and the mathematics of design for a downspout unit are identical to those on the above-ground treatment units. The roof area defines the flow rate – and each unit must be designed for either on-line (100%) treatment of roof flow or "off-line" such that a small percentage of the flow is by-passed during high flow events. Since pollutant concentration from roofs generally decreases with increasing flow, most Enpurion downspout systems are designed with overflows to ensure maximum residence time and treatment capacity during the majority of storm events.

In lieu of stacking treatment units, the FlexFilter™ downspout unit can be constructed in sections as tall as 12' in height to achieve the desired treatment goal. Design flows are as with other systems, the primary discharge is at the base of the unit and design flow determined by the diameter of the discharge pipe and the hydraulic head in the filter body. Note that friction losses are significant at higher flow rates, but the maximum flow design basis can be approximated by the orifice equation.

Media selection for FlexFilter™ must consider pressure drop when determining the number of units. For high flow conditions, increasing the height will increase hydraulic head and flow, but adding multiple units in parallel on a given downspout is a viable option for extreme flow conditions (multi-acre roofs with high influent concentration). IF high roofs are primary sources of zinc, FlexMax units are recommended over the FlexFilter DS Units.

FLEXBASIN™ CATCH BASIN INSERTS

By their nature, catch basin inserts are the quickest and easiest treatment option, but their small size limits the residence time and removal efficiency that can be achieved. There are rules of thumb for design, but in the case of SPM the CBIs are part of the serial treatment system and will provide incremental improvement prior to final above ground treatment. In general, a focus on operational and structural best management practices (BMPs) must still be part of the compliance strategy, along with end-of-pipe treatment to augment the CBIs.

FIGURE 7 – FLEXBASIN™ CATCH BASIN INSERT SHOWN WITH FOUR PILLOWS

Treating multiple parameters may also limit the space available for each pollutant of concern – for example treating phosphorus and zinc could reduce the efficiency of both.

PART II – OPERATIONS AND MAINTENANCE

2. UPDATES TO O&M MANUAL

The following is a generic O&M Manual that will support Enpurion FlexSystem treatment. The manual may be updated from time to time to reflect changes in equipment, site conditions or regulatory requirements as indicated. The O&M portion of the manual may be updated with site specific information where appropriate.

PLANT TYPE, SITE DESCRIPTION AND FLOW CHARACTERISTICS

The Level III strategy at SOUTH PARK MARINA is comprised of the following elements:

1. Collection of stormwater runoff from main industrial site *(use reference figures and add site map), add design flow if appropriate.)*

    a. FlexFilter Downspout Units treat zinc from galvanized roofs

    b. *FlexBasin™ Catch Basin Filters basins are installed in high traffic areas throughout the site.*

    c. FlexMax units provide end-of-pipe treatment at offline WQ design flow

2. Additional Enpurion FlexSystem™ treatment media include the following:

    a. Enpurion MT – cellulose-based ion exchange media
    b. ZnIX pillows – for high concentration zinc sources
    c. Mineral media for mechanical filtration and pH buffer
    d. Media used for each parameter, (eg. ZnIX pillows, MT Pillows and Mineral Media)
    e. Results to be expected comply with BYGP as follows:
        i. Zinc of 70 mcg/L
        ii. Copper to 50 mcg/L
        iii. TSS to 30 mg/L

3C. MAINTAINING FLEXSYSTEM™ STORMWATER TREATMENT UNITS

All Facility catch basins shall be visually inspected periodically. Catch basin inserts (CBIs) at the site ensure low levels of pollutant entering the conveyances, where the standard Enpurion FlexSystem™ unit assures final treatment and compliance with benchmarks.

Evidence of standing water in the basin, build-up of materials at or around the berms (if present) and accumulation of particulate or debris in or around the basins indicate maintenance is required.

- Excess debris should be removed, and media pillows turned where indicated.
- Pillow top pads should be replaced as indicated to ensure uniform flow
- Pillows fouled with oil should be replaced
- Sample ports cleaned periodically by removing pillows and cleaning sample basin

Surface of FlexMax and FlexFilter units should be inspected monthly.

- Excess debris should be removed, and media pillows turned where indicated.
- Pillow top pads should be replaced as indicated to ensure uniform flow.
- Spray bars should be inspected to ensure uniform distribution
- Pillows should be replaced when signs of occlusion are apparent, especially on top
- For serial processes, rotate bins periodically, replacing all of the media in the final bin and moving the fresh pillows forward in the series
- Schedule media pillow replacement commensurate with test data

3D. FACILITY WATER QUALITY AND BEST MANAGEMENT PRACTICES (BMPs)

Frequent inspection of the site and areas around treatment units and CBIs is recommended.

- Ensure periodic sweeping
- Verify record keeping in SWPPP
- Cover or remove potential sources of pollution
- Secondary containment for all liquids and mobile solids
- Remove debris and oily buildup whenever flow is inhibited.
- Change polypropylene pads when indicated.

Other structural and operational stormwater quality best management practices must be in-place at the site: CBIs, frequent sweeping and good housekeeping practices, cleaning of catch basins and conveyances, appropriate use of catch basin inserts, and where practical, covering of potential sources of pollution. These shall continue as indicated in the SWPPP.

The effectiveness of the operational BMPs is considered critical to long term success of the Treatment BMPs deployed at the site.

4. STORMWATER FLOWS AND SITE CONDITIONS

The site is assumed to be entirely impervious. The total area treated by the proposed treatment system is 2.25 acres. Individual catch basins can treat up to one acre of impervious surface. Off-line WQ design Flow for the site is estimated as 94.5 GPM.

5. COMPLIANCE AND STORMWATER POLLUTION PREVENTION PLANS

SPM has prepared a Stormwater Pollution Prevention Plan (SWPPP) which is available under separate cover.

There are three classes of best management practices (BMPs): operational, structural, and treatment. Operational BMPs are management practices that prevent or reduce pollutants from entering stormwater. Examples include housekeeping practices, inspections and corrective actions, source reduction, covering potential sources with tarps or inside of building structures, preventive maintenance procedures, spill prevention and cleanup, employee training, and performance incentives. Structural BMPs are physical and often permanent changes in a facility that prevent stormwater from contacting pollutants or keep pollutants from entering stormwater. Treatment BMPs are systems, operations, devices, or facilities that are designed to remove pollutants after they have been introduced to stormwater. These BMPs are briefly summarized below.

5B. OPERATIONAL BMPS AND STRUCTURAL BMPS

Based on a preliminary review of the operational and structural controls, SPM BMPs consist of the following:

1. Frequent sweeping of the parking lot and product management areas.
2. Periodic cleaning of catch basins and conveyances.
3. Installing and maintaining appropriate sediment trapping dams near CBs where indicated.
4. Inspection and maintenance of the site, including spill and drip cleanup where indicated.
5. Maintenance of the new stormwater treatment system and conveyances.

5C NOMINAL TREATMENT SYSTEM GOALS

The standard Enpurion FlexSystem treatment has been shown to meet the facility's stormwater requirements for compliance with the Boatyard General Permit benchmark levels.

PARAMETER	BENCHMARK
Total Copper	< 0.050 mg/l
Total Zinc	< 0.090 mg/l
Total Oil and Grease	< 10 mg/l
Total Suspended Solids	< 30 mg/l
pH Range	5.5 – 9.0 SU

TABLE 3 - SITE BENCHMARKS

Treatment Process Description – e.g. The geometry of the treatment units is such that the water to be treated will pass through six cubic feet of media that effectively reduces suspended solids and dissolved heavy metals before discharge. Additional treatment units may be added to enhance performance in the event that contaminants or concentrations change significantly.

DESIGN CRITERIA, CAPACITY AND SIZING ((WAC 173-240-080 4(d))

The treatment system is design to treat the facility's runoff and to meet benchmark contamination levels for the combined volume of the treated and untreated flows.

Typical Values for Enpurion MT treatment systems are in compliance with turbidity, copper and zinc. TSS concentration is expected to decrease with increasing flow and will vary with site conditions, so thorough and consistent operational BMPs are required to achieve benchmarks for TSS. Implementation of operational BMPs will ensure the performance is met. Combined flows from treatment unit and bypass, when combined will meet BYGP benchmark parameters.

Note that where indicated, water can be pumped from the sump to the separate elements of the treatment system, flowing by gravity through the Enpurion treatment units in each series. Treated water then flows by gravity to the system discharge conveyance and then it flows by gravity to the riser in the sump then to the outfall.

Chemically, the systems use an engineered bio-mass material, which converts cellulose to a chelating form of ion exchange material. The product uses only organic sources of cellulose, deionized, ultrapure water, and food-grade chemicals to create the ion exchange media. The theoretical maximum sorption rate is on the order of 17 grams of divalent heavy metals per liter of material.

The first container in series captures most of the pollutants. The final unit is generally relatively clean and performs a polishing function to ensure high pollutant removal. Systems are carefully monitored on start-up to determine the appropriate rate of regeneration.

PROVISION FOR BYPASS ((WAC 173-240-080 4(e))

The bypass provision at the submersible pump locations is used to divert flows greater than the water quality storm at the collection sump to the outfall. Excess water will overflow the riser when flows exceed 95 GPM. The overflow riser is of sufficient diameter and elevation required to achieve capacity for the 100-year storm per Western Washington Stormwater Manual, Volume III, Figure 3.2.16, Riser Inflow Curves, on page 3-63.

The entire capacity of the pumps will be transferred to the treatment system without significant over-topping.

OPERATION DURING MAINTENANCE PROCEDURES ((WAC 173-240-080 4(f))

The power to the lift pumps and lift modules shall be turned off at the panel during maintenance procedures. The maintenance of the system will be performed during dry periods to avoid any untreated bypass. Due to the simplicity of the system, no additional preparation or provisions are necessary. Maintenance procedures are typically an hour or less.

SAMPLING AND LABORATORY PROCEDURES (WAC 173-240-080 4(g))

Compliance monitoring shall be accomplished by sampling the combined flow of three series at the outfall. Intermediate samples from any of the series may be taken to assess efficacy of the individual series – although it is expected that the three series should perform comparably throughout their service life.

Sampling procedures, chains of custody and laboratory protocols shall be followed per the SPM SWPPP.

RECORD KEEPING **(**(WAC 173-240-080 4(h))

Records of all daily, weekly and monthly inspections shall be retained n the SWPPP records binder. Copies of all data and analyses shall be retained and labels as to location, date, time and conditions during the sampling event.

Maintenance Schedule (WAC 173-240-080 4(i))

DAILY – spot checks during rain events to ensure system is operational and flows adequate without over-topping

WEEKLY – Detailed site inspection to ensure operational and structural BMPS are complete

- Excess debris should be removed, and media pillows turned where indicated.
- Pillow top pads should be replaced as indicated to ensure uniform flow
- Pillows fouled with oil should be replaced
- Observe and note any leaks or potential piping failures
- Inspect media surface for debris or oils that may inhibit flow.

MONTHLY – Same as Weekly, PLUS

- Stir the top of the media on first two columns to break up any oily clumps on surface.
- Verify operation of the float valves and switches (if present)

QUARTERLY – Same as Monthly, PLUS

- Inspect Sump Pumps (where present) for proper location, integrity and to prevent fouling
- Replace media pillows or columns as indicated by manufacturer
- Sample ports cleaned periodically by removing pillows and cleaning sample basin
- Verify operation of float switches (if present) and valve positions

SAFETY CONSIDERATIONS (WAC 173-240-080 4(j))

(1) All power should be shut down at the panel before servicing any pumps or electrical components. Follow proper Lock-out / Tag-out procedures

(2) Water may contain pathogens and cannot be considered potable. Do NOT drink. Do not eat media.

(3) Columns should be considered confined spaces, and entry is regulated under 29 CFR 1910

SPARE PARTS INVENTORY (WAC 173-240-080 4(k))

All spare parts and replacement media is maintained by the manufacturer and provided under a monthly maintenance agreement.

EMERGENCY PLANS AND PROCEDURES (WAC 173-240-080 4(l))

Spill Collection and Emergencies

Basic operations for the system provide some measure of emergency spill response and spill capture. In the event of a major spill into the tributary area, capture before the material can enter the catch basins and storm system, using sorbent materials, pads or other appropriate means.

If a spill reaches the catch basins, the storm system can be used to capture up to 5 gallons of spilled material. If a spill reaches the storm system, shut off the power at the panel immediately to prevent discharge of hazardous materials. In the event of highly flammable materials entering the storm system (e.g. gasoline) turn off the power and call the appropriate emergency response personnel (Fire Dep't or Hazardous Materials Contractor).

Physical Provision for Oil and Hazardous Material Spill Control

Any significant oil spills that create flows less than the sub-basin's water quality storm will be collected by the storm drainage system and pumped to the treatment system. The catch basins provide the ability to collect spills and act as an oil/water separator to the extent there is phase separation between the species. The collected material is then transferred to the treatment system. If considered as a series of tanks, each with 3-4 feet of media, a spill has a formidable pathway prior to release. MT is proven to be effective at absorbing oils and other polar and semi-polar pollutants. These materials will foul the media and which will then require replacement.

Enpurion MT

Excellence by design

Cellulosic treatment media for metals, TSS, and phosphates

Proven Results

- Reduces heavy metals
- Targets phosphorus and other nutrients
- WA Dep't of Ecology TAPE CULD approval for Advanced Treatment
- Sorbs emulsified oils
- 100% organic and food-grade ingredients
- Does not re-release or leach pollutants
- Solids pass TCLP and Fish BioAssay
- Natural, sustainable solution made from food-grade products

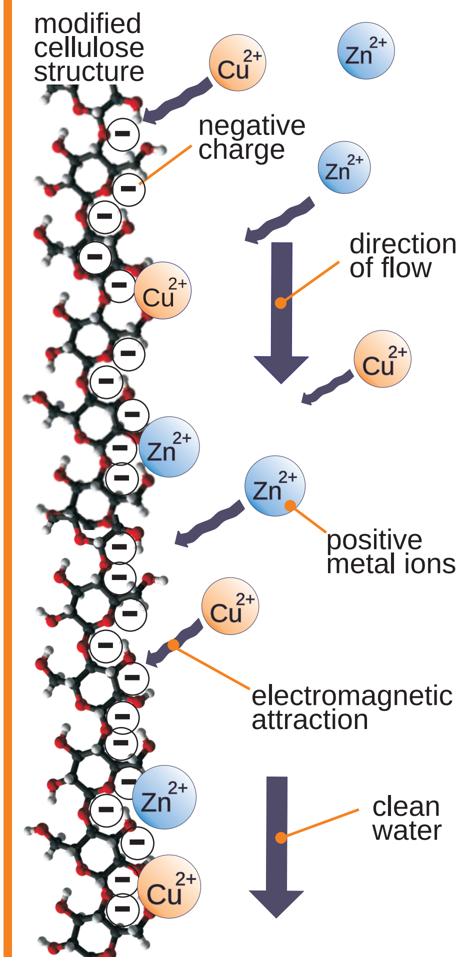
Advantages

- Passive system with low power demand
- Compact and flexible with up to 75 GPM per series
- Scalable and modular
- Can be configured for any flow or concentration

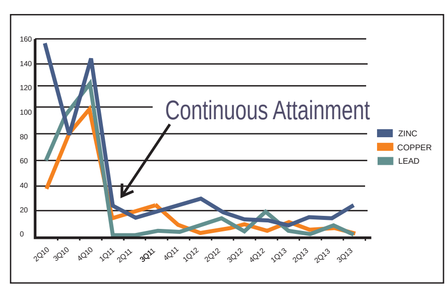
Applications

- Stormwater treatment
- Industrial wastewater
- Remediation systems
- Construction de-watering
- Landfill leachate

How does the Enpurion MT system work?



Typical results



RAINIER BALLISTICS - TACOMA, WA

enpurion

info@enpurion.com
US PATENT NO 9,085,474 B2

www.enpurion.com

Enpurion FlexBasin™

NEW!

Stormwater pillows offer low-cost, versatile and effective treatment

Proven Results

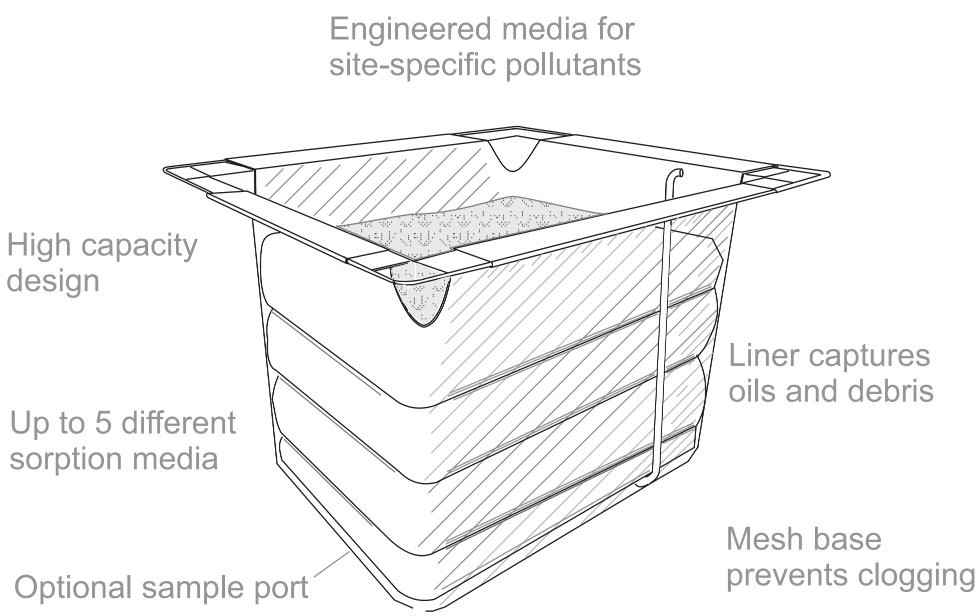
- Select engineered media for specific pollutants
- Pick textiles for influent characteristics
- Reduce heavy metals
- Capture turbidity and suspended solids
- Eliminate emulsified oils and hydrocarbons
- Change pillows to adapt to site conditions instantly
- Manage your own maintenance quickly, easily and cost-effectively

Advantages

- Flexible and effective stormwater treatment
- Low-cost, easy to use and maintain
- Scalable and modular
- Can be configured for any combination or pollutant

Applications

- Parking lots
- High traffic areas
- Production and material storage areas



Combine engineered media pillow materials to fit your site's needs

Enpurion MT media for metals and oils

Enpurion MX media for phosphorus, pH

Enpurion BioBlend for organics

ZnIX ion exchange for zinc, and copper

Enpurion CLR for turbidity and TSS

Target pollutants:

- ✓ Zinc & copper
- ✓ Turbidity & pH
- ✓ Pb, Al and Fe
- ✓ Phosphorus
- ✓ Emulsified oils
- ✓ Suspended solids

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253-922-8823

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FlexBasin™ Materials Menu

Enpurion MT metals treatment media	Organic cellulose material activated to cation exchange to 0.78 EQ / Kg - absorbs organics and particles	Treatment for zinc, copper, iron and lead, emulsified and free petroleum hydrocarbons
Enpurion MX media for phosphorus, pH	Calcium based mineral blend formulated for pH buffer to equilibrium 8.5 SU	Treats acidic or basic influent, captures phosphorus, copper and other nutrients
Enpurion BioBlend for organics and oils	Organic cellulose, bio-char and granular activated carbon loading up to 0.25 L/kg media	Surface adsorption and bulk absorption of emulsified and free petroleum hydrocarbons
ZnIX ion exchange for zinc, and copper	Commercial cation exchange resin (water softener) with exchange capacity =1.8 EQ/kg	High capacity resin pillows for longer residence times and higher cation metals loading
Enpurion CLR for turbidity and TSS	Organic cellulose material activated to absorb anionic suspended particles	Muddy or turbid water with silicate clays or silts, used in conjunction with MX pillows
Polypropylene geotextile	Heavy polypropylene felt liner	High particle and oil retention
Open weave fiber screen	FRP fabric allows open flow	Better for heavy oil in influent
Oil absorbent pads	White poly topper pads	Used to protect media pillows
Polyethylene fine screen	Fine mesh for high flow	High flow with fine media
Natural fiber geotextile	Jute or burlap pillow liners	Used for compostible pillows

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Lean Environment Inc.
4500-A 15th Street E
Tacoma, WA 98424 US
(425) 922-9141
michael@leanenvironment.com
www.enpurion.com

Estimate

ADDRESS
TIG Environmental

SHIP TO
TIG Environmental

ESTIMATE # 21114
DATE 07/05/2022

DATE	ACTIVITY	QTY	RATE	AMOUNT
	Flex Basin Large Pillow 20" x 24" - MT Media Formulation & Bio Char blend for Metals Treatment	18	225.00	4,050.00T
	Zn-IX ION Exchange Pillow MEDIUM Formulation for maximum Zinc removal	18	295.00	5,310.00T
	ZnIX Ion-Exchange Downspout Technology - MAINTENANCE Compact Design. MT & ZnIX formulation for Heavy Metal Removal	4	1,500.00	6,000.00T
	DOWNSPOUT UNIT 405 GAL 1 STAGE POLY MACRO 48"X 52"X 50"	6	2,650.00	15,900.00T
	MAINTENANCE DISCOUNT- 15%	1	-4,689.00	-4,689.00T

ANNUAL MAINTENANCE

SUBTOTAL	26,571.00
TAX	2,630.53
TOTAL	**$29,201.53**

Accepted By

Accepted Date

Please make check payable to:
Lean Environment, Inc,
4500A 15th St. E
Tacoma, WA 98424

Lean Environment Inc.
4500-A 15th Street E
Tacoma, WA 98424 US
(425) 922-9141
michael@leanenvironment.com
www.enpurion.com

Estimate

ADDRESS
TIG Environmental

SHIP TO
TIG Environmental

ESTIMATE # 21113
DATE 07/18/2022
EXPIRATION DATE 12/31/2022

DATE	ACTIVITY	QTY	RATE	AMOUNT
	Flex Basin Ultra Frame (WA) - 18 x 24 x18 Depth. Frame & Geotextile liner	6	395.00	2,370.00T
	Flex Basin Large Pillow 20" x 24" - MT Media Formulation & Bio Char blend for Metals Treatment	12	225.00	2,700.00T
	Flex Basin - High-Flow Custom Mesh Liner Design for larger tributary area	6	50.00	300.00T
	Zn-IX ION Exchange Pillow MEDIUM Formulation for maximum Zinc removal	6	295.00	1,770.00T
	ZnIX Ion-Exchange Downspout Technology - Compact Design. MT & ZnIX formulation for Heavy Metal Removal	4	2,995.00	11,980.00T
	FlexMax Above Ground Treatment units, 3 x 405. High Flow (MACRO) THREE-Stage with internal drain manifold, media, overflow risers, header and polypropylene geotextile pre-filter 48" X 52" X 150"	3	7,095.00	21,285.00T
	Delivery & Installation	1	5,000.00	5,000.00T

UPFRONT COST

SUBTOTAL	45,405.00
TAX	4,495.10
TOTAL	**$49,900.10**

Accepted By

Accepted Date

Please make check payable to:
Lean Environment, Inc,
4500A 15th St. E
Tacoma, WA 98424

Appendix I

WWHM Design Criteria

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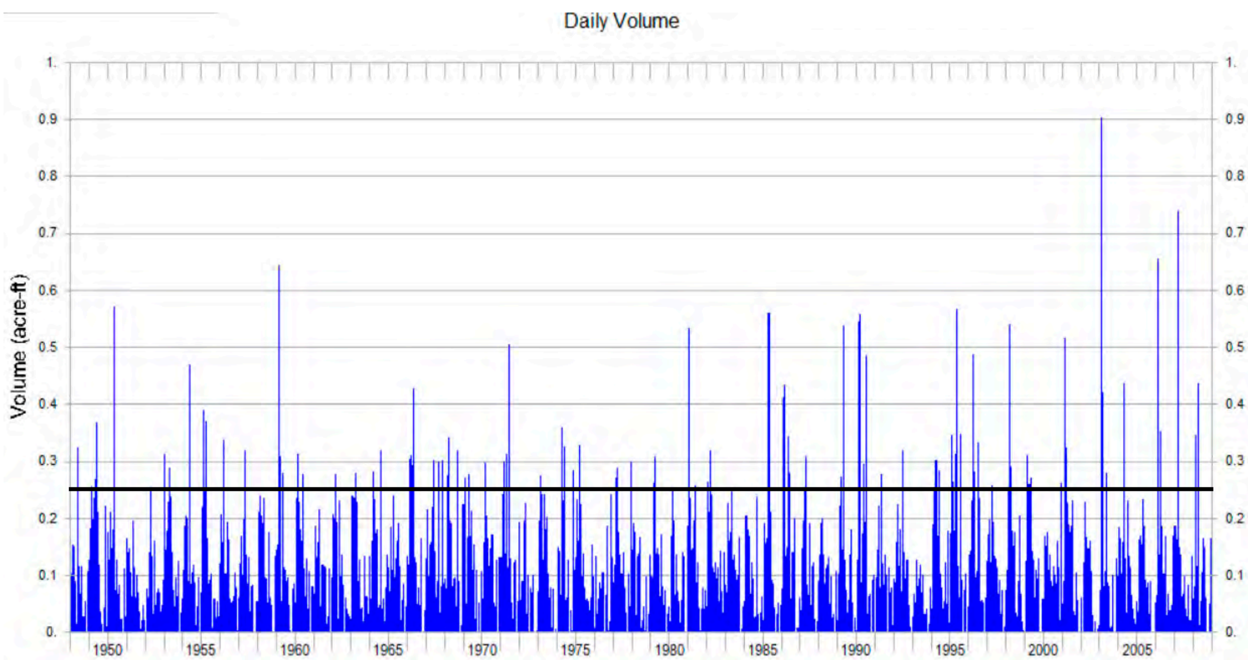
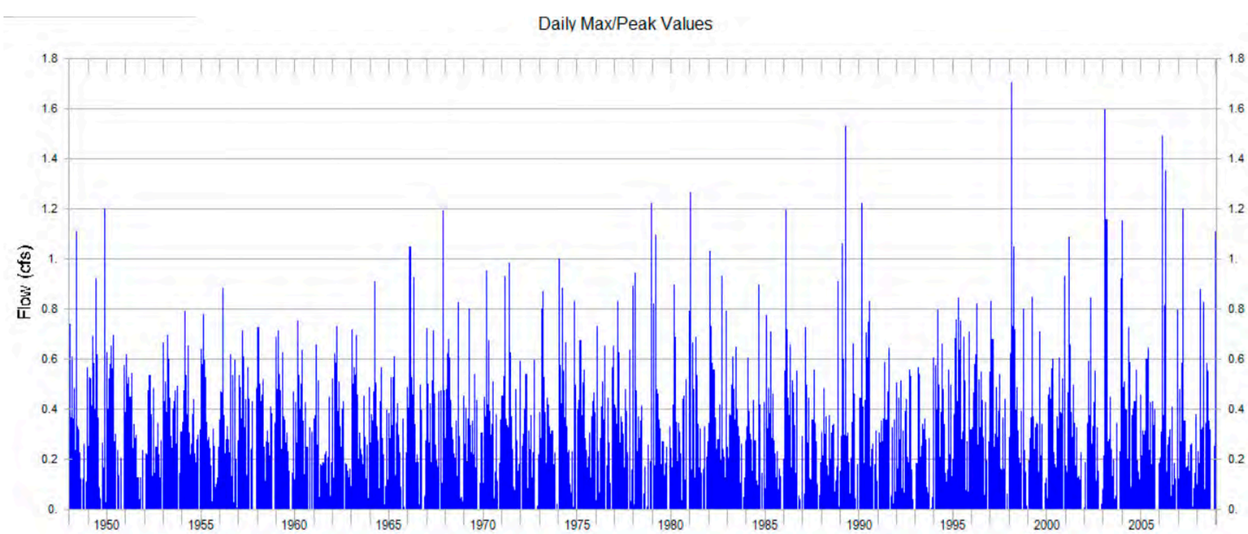
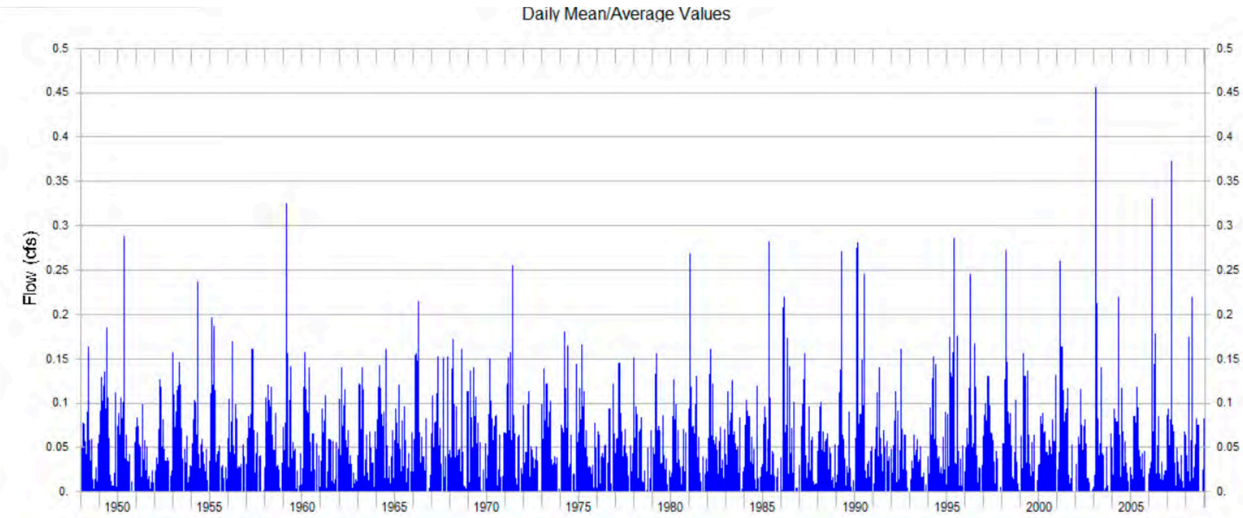
INVESTIGATIONS ▾ FORENSICS ▾ REMEDIATION

1. Western Washington Hydrology Model

In addition to the single event evaluation, TIG reviewed representative historical precipitation data for the Site using the Western Washington Hydrology Model (WWHM) (Ecology 2016b; Labib 2016). Daily volume, peak-flow, and average flow for stormwater runoff from the Site was evaluated using precipitation data from Seattle-Tacoma International Airport in an unmitigated (predeveloped) runoff scenario assuming impervious “parking” basin conditions. The figures below show available data from WWHM as of 2016. The black line shows the single event evaluation in the context of the continuous precipitation data.







2. References

Ecology (Washington State Department of Ecology). 2016b. Western Washington Hydrology Model 2012.

Labib, Foroozan (Washington State Department of Ecology). 2016. Western Washington Hydrology Model 2012.