Technical Memorandum

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Section 1: Introduction

The purpose of this technical memorandum is to evaluate potential water qualify facility (WQF) active treatment technologies for the 7th Avenue South drainage basin and recommend technologies for further assessment.

The South Park WQF project began in 2005, when Seattle Public Utilities (SPU) conducted an evaluation of options for providing water quality treatment to the 7th Avenue South drainage basin, also referred to as the South Park basin (SPU 2005). The WQF was intended to leverage drainage funds by taking advantage of a flood control pump station project that was also underway at that time (South Park Pump Station [PS]). The PS project was being developed to facilitate flood control in the South Park basin by pumping runoff from a 72-inch-diameter storm drain trunk line that collects runoff from the basin during high tide, allowing the trunk line to drain continuously to the Duwamish Waterway. At that time, it was recognized that the PS constituted a first step in alleviating flooding in the neighborhood; however additional local drainage improvements were also needed in the 70-acre lower basin to convey runoff to the main trunkline. The two projects progressed on parallel tracks until 2006 when they were merged because they were so dependent on one another. The plan at that time was to analyze the feasibility of two water quality treatment options (end-of-pipe treatment and divert and treat runoff from the industrial area in lower 70-acres of the basin) and then integrate the two projects during preliminary engineering (SPU, 2006)[1]. In 2007, following preliminary engineering, an end-of-pipe treatment facility using the StormFilter® cartridge-based passive filtration system was selected. By 2009, a 100 percent design had been developed. The 100 percent WQF design included an above ground vault containing 1,000 StormFilter® cartridges (11 cfs capacity) along with a 48-cfs flood control pump station.

Following completion of the 100 percent design, new information about the higher-than-expected cost of future operation and maintenance (O&M) requirements for StormFilter® cartridge technology led SPU to reevaluate the use of StormFilter® filtration and reconsider the active treatment technologies that had been eliminated during preliminary engineering due to cost and operations/maintenance concerns. A change stage gate 2 report was completed by SPU staff in 2012 that recommended changing to active treatment technologies. A chemically-enhanced sand filtration technology using chitosan was recommended in the Stage Gate 2 report, although it was recognized that another similar technology might be selected during design. AMC deferred a decision on the recommendation pending clarification of questions regarding 1) annual volume of stormwater treated, 2) financial constraints and impacts on other drainage projects, 3) policy questions regarding potential regulatory issues under the upcoming Integrated Plan, Lower Duwamish Waterway Source Control efforts, and NPDES structural retrofit requirements, and 4) consideration of an additional option that builds the pump station now and delays construction the water quality facility. To answer these questions, the South Park project team conducted additional analyses/workshops in 2013-2014, which are the basis of this technical memorandum.

In 2014, SPU submitted a Draft *Integrated Plan* (IP) (Brown and Caldwell et al., 2014) to the Washington State Department of Ecology (Ecology), which included an active-treatment South Park WQF as an alternative to allow SPU to defer some high unit cost combined sewer overflow (CSO) projects. Pollutant removal estimates reported in the IP for the South Park project were based on the expected performance of the chitosan-enhanced filtration technology as reported in the 2012 Change Business Case 2; however, a few minor changes were incorporated to provide a level of safety/comfort because the exact treatment technol-

[1] A third option, re-routing runoff from the highly industrial lower basin to the combined sewer and separating an equivalent residential area elsewhere in the neighborhood) was eliminated due cost.

ogy for the South Park project was still being evaluated when the IP was prepared.. The WQF is scheduled to be in operation in order to meet IP targets by 2025.

Updated hydrologic and hydraulic modeling of the required capacities for the PS and WQF has resulted in a wider disparity between the flood control PS capacity and the WQF capacity than that of the original, passive filtration design. Basin hydrologic and hydraulic modeling was presented in the *South Park Hydraulic Modeling Report* (Brown and Caldwell, 2014). Preliminary sizing for the WQF is presented in this memorandum (Section 5). As a result of this disparity between the PS and WQF flow, and the delay in constructing a PS in the combined PS/WQF scenario, it was recommended that the PS and WQF projects be separated. The rationale for separation of the projects and evaluation of PS options is presented in the *Final Phased Project and Pump Station Options* memorandum (Brown and Caldwell, 2014). In 2014, the SPU Asset Management Committee approved separation of the two projects.

This technical memorandum is organized as follows:

- Section 1 introduces the project and provides project background.
- Section 2 summarizes the original design.
- Section 3 discusses the technology screening and Value Analysis (VA) procedure used to identify candidate technologies.
- Section 4 compares the documented performance data and installation history of the candidate technologies.
- Section 5 discusses sizing of the WQF based on updates to hydrologic and hydraulic modeling.
- Section 6 develops and compares WQF options (including site layouts, cost estimates, and risks/benefits) based on the candidate technologies.
- Section 7 evaluates options.
- Section 8 presents recommendations for technologies for further evaluation.

Section 2: Prior Design

The prior WQF design involved a 1,000 cartridge StormFilter® system, a passive treatment technology manufactured by Contech® Engineered Solutions. Each filter cartridge consists of a cylindrical plastic housing filled with media. Influent flows under an outer baffle and then flows radially through the cartridge media to a perforated pipe in the center of the filter. An orifice plate limits the flow into the filter cartridge. Filtered water drains to a collection system. The system is offered with a range of media to target different constituents. To treat higher flows, multiple cartridges are arranged in a concrete basin. Each basin includes influent piping and a manifold underdrain system to collect filtered water. A StormFilter® cartridge is illustrated in Figure 2-1; a large existing installation comparable to the proposed 1,000-cartridge system at South Park is shown in Figure 2-3.

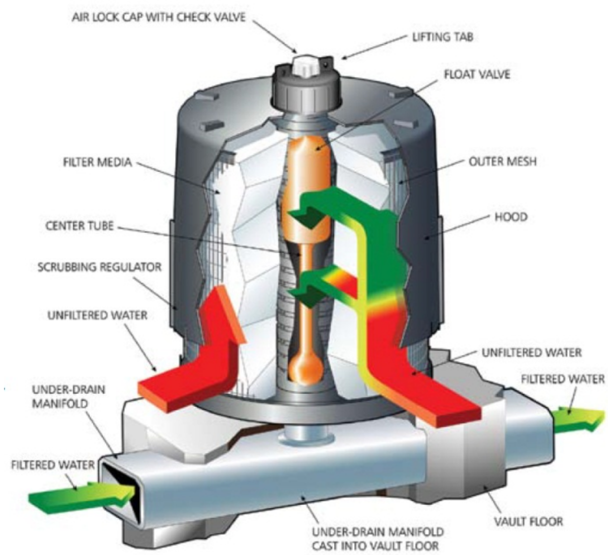

Figure 2-1. StormFilter® cartridge

Figure 2-2: Large above-ground vault installation[2]

The previous design consisted of four concrete treatment bays, with each bay containing 250 cartridges, and was sized for a treatment capacity of 11 cubic feet per second (cfs). Stormwater was pumped from the PS to a headbox where it entered the treatment bays through an influent distribution channel. Influent flowed through the filters, through an underdrain collection system, and to an effluent collection channel and chamber. During high flow periods, flows in excess of 11 cfs would flow over a weir and directly to the effluent collection chamber, where it would mix with treated effluent and exit the facility. Each bay was equipped with a mud drain, which allowed collected solids to be periodically drained to vaults accessible from the right-of-way southeast of the WQF in Riverside Drive.

The WQF capacity of 11 cfs was based on the annual runoff volume from the basin calculated using the Western Washington Hydrology Model (WWHM) basin model and the assumption that the basin would treat 83 percent of the annual runoff from the basin. SPU's standard for new development is treatment of 91 percent of runoff; however, retrofit projects do not have a required treatment volume. The 83 percent value was selected to come as close as possible to the 91 percent standard for new development, while still allowing the WQF to fit within the boundaries of the project site.

[2] Existing 600-cartridge StormFilter system installed at Seattle-Tacoma International Airport.

Section 3: Technology Screening and Value Analysis

This section describes the process, including the VA, by which candidate technologies were identified. Following the 2012 Change Business Case 2, which recommended use of an active treatment technology, a series of workshops and a value analysis (VA) were conducted to answer the questions raised during the 2012 AMC presentation.

3.1 Workshops

A series of workshops were conducted following the Change Business Case decision. These included a Problem Definition and Water Quality Workshop, the results of which influenced subsequent technology analysis. Workshop meeting minutes are included in Attachment A.

3.2 Technology Screening

To identify candidate technologies, a screening matrix was developed. The screening matrix evaluated a range of active treatment technologies that have been applied to stormwater, wastewater, or CSOs/wet weather treatment. Passive filtration or adsorption technologies were not considered; these are, in general, similar to the StormFilter® system in terms of removal rates and maintenance requirements.

The initial set of technologies was screened for fatal flaws that included low loading rates and corresponding large footprints that would prevent the system from fitting on the site, high mechanical complexity without any offsetting benefits, and a lack of performance data from stormwater installations. Technologies not eliminated in the fatal-flaw analysis were further screened using criteria that included the ability to expand, the ability to enhance treatment for dissolved metals removal, solid storage and handling requirements, chemical storage and handling requirements, and the ability to adapt to a wide range of influent total suspended solids (TSS) concentrations, as may be seen in stormwater runoff over the course of a rainfall event.

The active treatment technologies selected for further evaluation rely on a coagulation stage, followed by a separation stage. In the coagulation process, the electrostatic forces that keep suspended colloidal particles apart in water are neutralized by metal ions or other compounds, allowing the suspended colloids to collide and form larger particles that are more easily removed. Flocculation, the process of mixing to bring the coagulated particles together to form floc, may also be used, and may incorporate added polymer to bridge particles and add strength to the floc. The separation stage uses settling, filtration, or other methods to separate the coagulated and flocculated particles from the liquid stream.

The technologies selected for further evaluation included the following:

- **Ballasted sedimentation** consists of chemical dosing with a coagulant, as well as the addition of a ballasting material to influent stormwater during the coagulation/flocculation process. This is followed by sedimentation, which removes the solids from the water. The ballasting material creates heavy particles that settle quickly, allowing the sedimentation basins to have a smaller footprint than a conventional settling basin of comparable capacity. The settled material is processed to remove the ballasting material, which is recycled back to the process.
- **Chemically enhanced primary treatment** (CEPT) consists of coagulation/flocculation, followed by sedimentation.
- **Enhanced Filtration** consists of coagulation/flocculation followed by filtration.
- **Electrocoagulation** (EC) uses the same mechanism of coagulation as the other systems. However, rather than introducing coagulants through bulk chemical addition, metal ions are introduced directly into solu-

tion through the oxidation of a submerged metal anode. Coagulation/flocculation is followed by a separation process. EC can be used with a range of separation processes, including sedimentation, filtration, and other processes such as dissolved air flotation.

The screening matrix is included in Attachment B.

3.3 Value Analysis

A VA was performed for the project in February 2014. The purpose of a VA is to perform a high-level assessment and validation of early technical, life-cycle cost, schedule, and risk assumptions applying to the early concept options being considered. The focus of the study is on whether the right problems are being addressed and on what needs to be done, not on the details of how the solution will be implemented. The process and findings of the VA are documented in the *Value Analysis Study Report* (Säzän Group, 2014).

The VA generally confirmed the results of the technology screening. As a result of the VA, the following four candidate technologies were selected to move forward:

- Ballasted sedimentation
- CEPT
- Enhanced filtration using sand filters[3]
- EC

The VA also recommended reconsideration of passive bulk media filtration. Following the VA, an additional assessment of passive media filtration was documented in the *Media Filter Bed Evaluation* technical memorandum (Brown and Caldwell, 2014), This option was dropped from further evaluation because of the site footprint required (the available site would only fit an approximately 4.0 cfs system), the maintenance burden for removal and replacement of media and to clear accumulated solids, and because of potential unacceptable delays to the IP and Long Term Control Plan that could result from switching from a basic, active system as stated in these documents to a passive system.

Following the VA, CEPT, which was the lowest scoring technology, was dropped from further consideration. The worst performance for CEPT systems typically occurs at low suspended solids concentrations, such as would be present in stormwater following the first flush. Additionally, the variability in stormwater water quality over the course of a runoff event would require frequent adjustment of chemical dosing, which would be problematic at an unstaffed location. Further explanation is documented in the *Chemically Enhanced Primary Treatment* technical memorandum (Brown and Caldwell, 2014). The remaining three technology options are discussed in detail in Section 4.

3.4 Performance Criteria

A complete discussion of the methodology for selection of IP stormwater projects and development of the quantitative requirements for the WQF is outside the scope of this memorandum. Refer to the IP (Brown and Caldwell et al, 2014) for a complete discussion. The methodology can be summarized as follows:

- Identify candidate CSO projects for deferral as part of the Long Term Control Plan. Projects selected in the IP will be implemented, but will be initially deferred in favor of stormwater projects that confer a greater overall environmental benefit.
- Identify stormwater projects. Identification of stormwater projects included ranking receiving water bodies and identifying pollutants of concern, developing TSS loads for each stormwater basin, ranking

[3] Enhanced filtration technologies considered included sand filtration with conventional coagulants and chitosan, and cloth disc filtration with conventional coagulants. Cloth disc filters were eliminated from consideration during the VA (Säzän Group, 2014).

basins and characterizing priority basins, identifying projects in these basins, screening the project list, developing planning level costs for candidate projects, and conducting an initial ranking based on cost per kilogram of TSS removed.

- Estimate load reductions and exposures for all pollutants for candidate CSO and stormwater projects.
- Using a multi-objective decision analysis, select CSO projects for deferment as part of the Long Term Control Plan, and select stormwater projects for implementation as part of the IP.

The assumptions for industrial basin stormwater influent concentration and active treatment removal rates or effluent concentrations used to develop the WQF targets are documented in Chapters 3, 4, and 5 of Appendix F to the IP. While the initial sizing of the WQF in the IP was based on treatment of a percentage of the modeled 7th Avenue South basin runoff as described above, the water quality benefit is based on annual volume and load removals and not on a specific percentage of the runoff. The quantitative requirements for the WQF are to meet the annual removal targets in the IP. The median annual removal targets were selected as minimum design criteria for the WQF. Note that, while the values presented are the minimum design criteria, the flexibility to achieve higher load reductions may be beneficial. Removal targets are summarized in Table 3-1.

Table 3-1. South Park WQF Target Annual Minimum Pollutant Load Reduction for Selected Constituents [a]

Constituent	Annual load reduction		
	Lower Confidence Limit	Median	Upper Confidence Limit
Treated Runoff Volume (MG)	67	74	81
Total suspended solids (TSS) (kg)	21,000	25,000	29,000
Copper (total) (kg)	3.8	4.5	5.2
Copper (dissolved) (kg)	0.5	0.7	0.9
Zinc (total) (kg)	24	29	34
Zinc (dissolved) (kg)	9.4	14	19
Polychlorinated biphenyls (PCBs) (kg)	0.005	0.007	0.009
Oil and grease (kg)	450	700	950

a. *Draft IP, 2014.*

Section 4: Technology Comparison

This section discusses and compares the technology options resulting from the technology screening and VA.

4.1 Technology Options

Three technology options were identified: ballasted sedimentation, enhanced filtration, and EC. All three of these systems operate as continuous (rather than batch) treatment systems. These options are discussed in this section. This section also provides a brief overview of the installation history of each system. There are relatively few permanent, large-scale end-of-pipe stormwater treatment systems, and much of the installation history for enhanced filtration and EC comes from smaller-scale systems treating stormwater from an individual industrial site, or from construction stormwater treatment. Installation history for CSOs, sanitary sewer overflows (SSOs), wastewater in-plant wet weather or tertiary treatment, and drinking water treatment from surface water sources are all discussed where applicable. Large-scale, permanent installations for these applications are more widespread than permanent, large-scale end-of-pipe stormwater systems.

In general, the system manufacturers for all three candidate technologies claim that the performance targets for the WQF are within the capabilities of the systems and have submitted performance data from selected projects to substantiate these claims. Where possible, performance of systems was verified with a review of additional data. A limited pilot study of EC was conducted for the 7th Avenue South basin in 2012. The pollutant influent concentrations from that study are summarized in Table 4-1. These data are used in the performance evaluation of the candidate systems. For comparison, the lower confidence limit and upper confidence limit industrial runoff values used to develop the IP criteria are also shown:

Table 4-1. Influent Concentrations

Constituent	2012 EC Pilot Influent Concentrations [a]			IP Values for Industrial Runoff [b]		Units
	10th percentile	Mean	90th percentile	Lower Confidence Limit	Upper Confidence Limit	
TSS	34	93	166	58	177	mg/L
Copper (total)	15	30	48	14	39	µg/L
Copper (dissolved)	3.9	5.3	7.2	3	10	µg/L
Zinc (total)	75	125	182	133	258	µg/L
Zinc (dissolved)	21	31	42	133	258	µg/L
PCBs	0.01	0.049	0.094	0.004	0.029	µg/L
Oil	0.52	1.2	1.9	2.8	10	mg/L

a. *Based on 7 time-composited stormwater samples collected January-March, 2012 from a maintenance hole on S Riverside Dr near the downstream end of the 7th Ave S system.*

b. *Table 3-7, Appendix F, Draft Integrated Plan (Brown and Caldwell et al, 2014).*

This section also includes a discussion of the adaptability of each technology. This refers generally to the ability of each system to perform over a wide range of influent and operating conditions, and to accommodate future system changes.

Performance over a range of influent and operating conditions is a necessary characteristic of the selected technology, because the quality of influent stormwater can vary considerably over the course of a wet weather season. An example of this is the seasonal first flush, where the pollutant load of a runoff events occurring early in the season is greater than those occurring later. Individual runoff events may also exhibit a first flush, where pollutant load is weighted toward the beginning of the event hydrograph as a result of material accumulated on streets and surfaces being washed off by the initial rainfall. This is highly dependent on the sequence in which storms occur; for example, if storms occur in close succession, there is little to no first flush exhibited for the later storms. Accommodation of future change is desirable; regulations and requirements may change over the service life of the system. Note that the sizing of the system (described in Section 5 below) considers the future buildout condition of the 7th Avenue South basin, and adaptability does not necessarily mean the ability to increase volumetric capacity within the site footprint.

Additional design considerations common to all systems include solids handling and electrical service. These are discussed in Section 4.3 below.

The summary of each technology option concludes with an overview of system vendors. These overviews are not necessarily exhaustive, and there may be other vendors not discussed that are capable of providing similar systems of comparable performance and quality.

4.1.1 Ballasted Sedimentation

System Description. A typical ballasted sedimentation system consists of a series of mixing or reaction chambers followed by settling basins, and includes equipment to separate ballasting material from removed sludge. In the first chamber, the influent stormwater is dosed with coagulant. The chamber is sized to allow sufficient residence time for coagulation to occur. In the next series of chambers, a heavier ballasting material is added to facilitate rapid settling. The ballast material may be microsand or magnetite (a form of oxidized iron ore). Polymer may also be added to strengthen bonds between solids particles. The mixture then passes to a settling basin, where particles settle out of suspension, aided by the heavy ballast material. The ballasting effect increases the surface overflow rate of the basin, a measure of clarifier capacity, so that surface overflow rates of 80,000 gallons per day per square foot (gpd/ft^2) or greater are achievable, compared to 1,000 gpd/ft^2 for a conventional sedimentation basin and 20,000 gpd/ft^2 for CEPT. This allows for a much smaller footprint than that of a conventional sedimentation basin or CEPT basin of comparable capacity. The combined sludge and ballast material that settles is transferred to a mechanical recovery system that separates the ballast material from the sludge. The ballast material is recycled to the process, while the sludge is removed. Secondary pumps are typically required for the ballast recycle process, and small motors are also required for mixing. However, the main process stream can be configured to flow by gravity. A process flow diagram is shown in Figure 4-1.

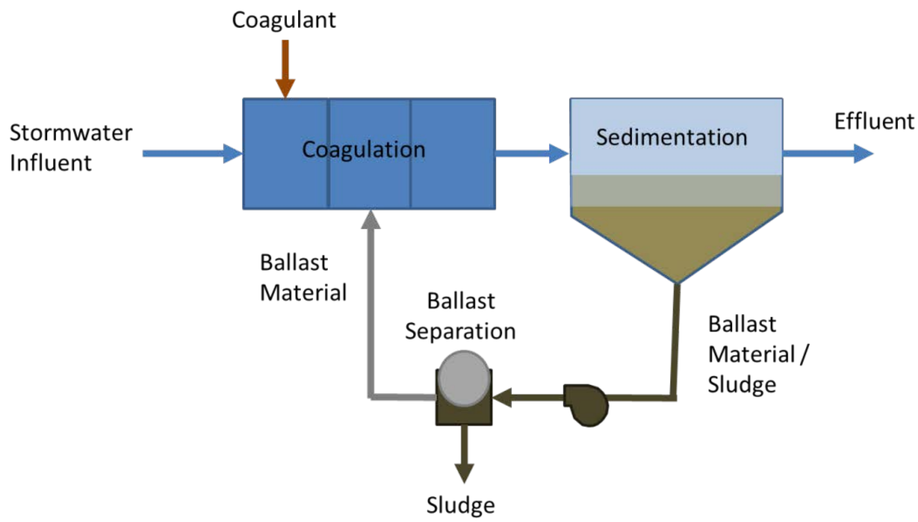

Figure 4-1. Ballasted sedimentation process flow diagram

A variation on the process (the Densadeg®, manufactured by Infilco Degremont) recycles a portion of the sludge, rather than using an introduced material such as microsand or magnetite. This system has a lower surface overflow rate and consequently larger site footprint than comparably sized systems with introduced ballast material, despite having similar costs. This system was eliminated from consideration due to the larger site footprint unknown quality of the sludge produced by the process when used with stormwater.

Stormwater Installation History. Ballasted sedimentation systems have been used in stormwater, although this use is not widespread. The systems have seen widespread use in CSOs, SSOs, wastewater tertiary treatment and in-plant wet weather applications, and drinking water treatment for surface water sources. There are many installations at the same scale as the WQF for these applications; refer to Section 6 for a discussion of WQF sizing. One notable installation is the Bremerton, Washington, standalone CSO treatment facility, with a capacity of 23 cfs (approximately 4 times the size of the WQF). The facility has been operational since 2003 and typically runs several times per year during large wet weather events. The facility regularly achieves 90 to 95 percent TSS removal.

Performance. Evoqua, manufacturer of a magnetite-based ballasted sedimentation system (CoMag), claims a typical TSS removal of 75 to 95 percent, and total copper and zinc removal rates ranging from 60 to 90 percent (Evoqua, personal communication).

Veolia Water Technologies, manufacturer of the Actiflo ballasted sedimentation system, which uses a silica sand ballast, claims similar performance (Veolia Water Technologies, personal communication). Data provided by the manufacturers support these claims.

The Bremerton, Washington, CSO facility has been operational since 2003, and treats CSO effluent during large storm events using the Actiflo process. Respective minimum (10th percentile), mean, and maximum (90th percentile) removal rates achieved by that system, from 2003–12, are as follows:

- TSS: 55, 74, and 93 percent
- Total copper: 82, 88, and 93 percent
- Total zinc: 67, 79, and 85 percent

The system has treated approximately 50 events during this time period. Based on these removal rates and the treatment volume of 74 million gallons per year (MG/yr) that was used in the IP analysis, the annual removal rates shown in Table 4-2 were calculated. The low value is based on the low removal and low influent concentration from Table 4-1, while the high value is based on the high removal and high influent concentration from Table 4-1. Note that dissolved copper and zinc data were not available for the Bremerton system.

Table 4-2. Estimated Annual Removal, Actiflo Ballasted Sedimentation

Constituent	Removal rate [a]			Estimated annual load removal (kg) [b]		
	Low	Mean	High	Low	Mean	High
TSS	55%	74%	93%	5,200	19,300	43,200
Copper (total)	82%	88%	93%	3	7	13
Copper (dissolved)	NA	NA	NA	NA	NA	NA
Zinc (total)	67%	79%	85%	14	28	43
Zinc (dissolved)	NA	NA	NA	NA	NA	NA
PCBs	NA	NA	NA	NA	NA	NA
Oil	NA	NA	NA	NA	NA	NA

NA – Not Available

a. *Bremerton CSO facility, 2003–12.*

b. *Assumes 74 MG/yr treatment volume. Low, mean, and high influent concentrations per 2012 EC pilot study.*

Adaptability. The ability to adjust treatment chemistries (coagulant and polymer type and dosage) provides a degree of adaptability to ballasted sedimentation systems. A typical operating strategy would select the chemicals used based on the expected influent characteristics and the constituents targeted for removal. The initial dosage would be selected to facilitate quick startup of the system. Dosages would be adjusted after startup (10-15 minutes) and set based on the maximum pollutant load expected. A third adjustment may be done after first flush. As noted above, the first flush is dependent upon the sequence and severity of storms. The same control parameters would be used to adjust the system performance to target additional constituents or more stringent effluent quality targets. Note that for any system dependent on coagulation / flocculation, the most challenging performance conditions occur at low suspended solids concentrations, when it is more difficult to induce coagulation.

Vendors. Ballasted sedimentation systems include Actiflo® (manufactured by Veolia Water Technologies), CoMag® (manufactured by Evoqua), and RapiSand® (manufactured by WesTech). Systems differ primarily in the method used to separate removed solids from the ballast material.

4.1.2 Enhanced Sand Filtration

System Description. Enhanced filtration consists of coagulation and flocculation followed by filtration. Sand filtration may use conventional metal ion coagulants, such as ferric chloride, alum, or polyaluminium chloride; chitosan, a biopolymer derived from crustacean shell material, may also be used. Stormwater enters the system and flows to a pretreatment basin for settling. Effluent from the basin is dosed with coagulant, and then flows to a series of basins for coagulation and flocculation. Effluent from these basins is dosed again with coagulant at a second dosing point, and is then pumped through sand filters. A monitoring system checks the sand filter effluent for pH, turbidity, and other water quality parameters. If discharge criteria are met, the effluent is discharged. If not, it is returned to the coagulation tanks for additional treatment. The sand filters are backwashed periodically to remove solids; a backwash settling tank separates the liquid from the solids sludge, and liquid is returned to the treatment process. Solids must also be periodically removed from the pretreatment basin.

One important process difference between conventional coagulation and coagulation with chitosan is the size of the coagulation basin required. Conventional contact basins are typically sized for 30 minutes of contact time or less, while Clear Water Services LLC, a chitosan system provider, recommends 60-90 minutes of contact time for chitosan (Clear Water, 2014). This increases the required size and footprint for this basin. As a result, a system designed specifically for conventional coagulants may not be compatible with chitosan due to the sizing of this basin.

A typical process flow diagram is shown in Figure 4-2.

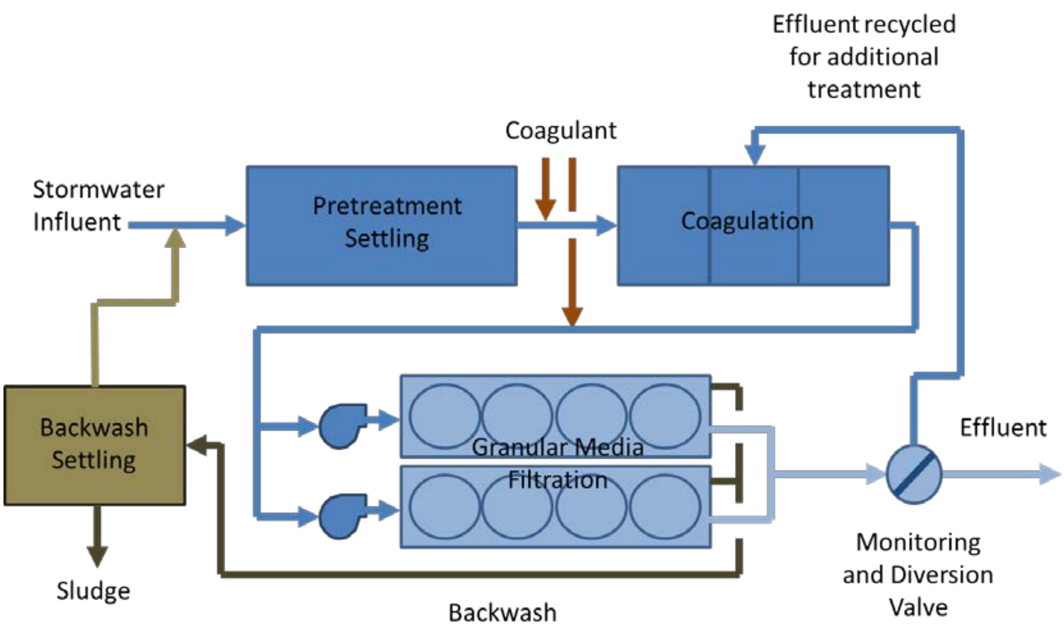

Figure 4-2. Enhanced filtration process flow diagram

Stormwater Installation History. Enhanced filtration is widely used in wastewater and industrial applications. Enhanced filtration with conventional coagulants has seen some application in stormwater; chitosan-enhanced sand filtration was developed for stormwater treatment. The majority of stormwater enhanced filtration installations are smaller-scale systems compared to the WQF (refer to Section 6 for a discussion of WQF sizing) and are focused on individual industrial or construction sites. The largest installation known to Brown and Caldwell (BC) is the North Boeing Field system in Seattle, Washington, with a capacity of 3.3 cfs. This facility has been operational since 2012, and was preceded by a smaller interim system. Boeing installed this system in response to an EPA order to remove PCBs from stormwater prior to discharge to the Duwamish Waterway. The discharge limits for this facility are 0.03 ug/L PCBs. .

Performance. Clear Water Services, LLC, a turnkey provider of enhanced filtration systems, claims that enhanced filtration with chitosan regularly achieve 95 percent TSS removal and effluent turbidity of 5 nephelometric turbidity units (NTU) or less (Clear Water Services, personal communication). Lead is almost completely removed. Copper and zinc removal is dependent on the proportion of dissolved metals to total metals. The system achieves 95 percent removal of particulate copper and zinc, while dissolved copper and zinc removal ranges from 25 to 75 percent. Data from the 2014 annual report for the North Boeing Field system (Landau, 2015) was reviewed in support of the vendor claims. Respective minimum (10th percentile), mean, and maximum (90th percentile) removal rates achieved by that system, from 2003–12, are as follows:

- TSS: 36, 88, and 97 percent
- Copper (total): 53, 81, and 89 percent
- Copper (dissolved): 15, 50, and 69 percent
- Zinc (total): 72, 84, and 93 percent
- Zinc (dissolved): 35, 77, and 89 percent
- PCBs: 35, 72, and 89 percent

Department of Ecology has shown similar metals removal ranges for conventional enhanced filtration (Ecology 2015), though these results are for smaller systems designed for individual industrial or construction sites.

Estimated low, mean, and high removal rates and estimated annual removals for the enhanced filtration system are shown in Table 4-3.

Table 4-3. Estimated Annual Removal, Enhanced Filtration

Constituent	Removal rate [a]			Estimated annual load removal (kg) [b]		
	Low	Mean	High	Low	Mean	High
TSS	36%	88%	97%	3,400	22,900	45,100
Copper (total)	53%	81%	89%	2.2	6.8	12.0
Copper (dissolved)	15%	50%	69%	0.16	0.74	1.4
Zinc (total)	72%	84%	93%	15	29	47
Zinc (dissolved)	35%	77%	89%	2.1	6.7	10.5
PCBs	35%	72%	89%	0.00099	0.010	0.024
Oil	NA	NA	NA	NA	NA	NA

NA – Not Available

a. *North Boeing Field Facility 2014 Fourth Quarter Progress Report, (Landau, 2015).*

b. *Assumes 74 MG/yr treatment volume. Low, mean, and high influent concentrations per 2012 EC pilot study.*

Adaptability. Like ballasted sedimentation, the primary parameter for control of the system is adjustment of treatment chemistries. This can include adjustment of pH or a change in the coagulant. An adsorptive media, such as granular activated carbon, can also be used in the filter system to enhance dissolved metal removal. Dosing rates can be adjusted during storm events. Adjustments are typically made by monitoring a surrogate parameter, such as turbidity, to approximate TSS.

Residence time in the pretreatment settling and coagulation tanks can also be adjusted, although this is limited by the capacity of the tank and the design flow rate. Note that for any system dependent on coagulation / flocculation, the most challenging performance conditions occur at low suspended solids concentrations, when it is more difficult to induce coagulation.

Vendors. Enhanced filtration differs from the other technologies under consideration in that it does not require the use of proprietary technology. The system components (granular media filters, tanks, pumps, and chemical handling equipment) are available from multiple manufacturers. Clear Water Services, LLC offers control modules that include chitosan storage, dosing pumps, piping, and controls in a packaged system. There are multiple vendors for chitosan and chitosan acetate products. Components for an enhanced filtration system using conventional chemical coagulants are widely available from multiple vendors.

4.1.3 Electrocoagulation

System Description. EC uses the same mechanism of coagulation as the other systems. However, rather than introducing coagulants through bulk chemical addition, metal ions are introduced directly into solution through the oxidation of a submerged metal (iron, aluminum, or a combination) anode. In a typical EC configuration, stormwater flows into a pretreatment sedimentation tank where large material settles out of suspension. Water then flows through banks of individual EC cells, where the oxidizing anode introduces metal ions into the solution. From the cells, the water flows into coagulation tanks, where the metal ions induce coagulation. Coagulated stormwater is pumped through media filters or another separation stage, such as a DAF. Filtered wastewater is discharged. Backwash and residuals from the separation stage flow to a separate tank, where solids settle. Decanted liquid is returned to the treatment process. A process flow diagram is shown in Figure 4-3.

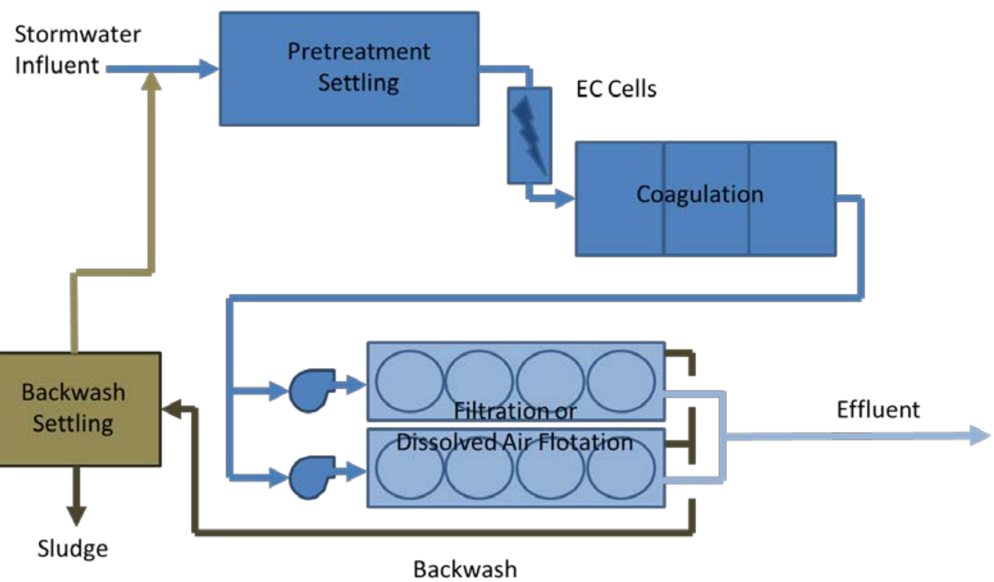

Figure 4-3. EC process flow diagram

Stormwater Installation History. EC has been used widely in stormwater. The majority of installations are at individual industrial sites. EC is also used for temporary construction stormwater treatment. It is not known whether a permanent, municipal stormwater installation on the scale of the WQF has been constructed and operated using EC technology.

No permanent installations of an EC system at the scale of the WQF were identified for stormwater or CSO treatment.

Performance. WaterTechtonics, an EC manufacturer, claims that its systems regularly achieve 80 to 90 percent reduction in TSS, effluent turbidity of 5 NTU or less, and greater than 95 percent removal of copper and zinc (WaterTechtonics, personal communication). The dissolved-phase removal rate for copper and zinc also exceeds 95 percent. The data submitted by the manufacturer support these claims.

SPU conducted a limited-duration pilot study of EC for the 7th Avenue South basin in 2012. Several different configurations were assessed, including three tests using a sand filter configuration (a fourth test also used a sand filter, but also included chitosan dosing and therefore not included in this discussion). One of the tests generated data outliers, with removal rates less than 50 percent for many constituents, and negative zinc removal rates. The other two sand filter tests generated data that were generally consistent with the other EC configurations tested. The removal rates from that test were as follows:

- TSS: 90 percent, 98 percent
- Total copper: 82 percent, 95 percent
- Dissolved copper: 37 percent, 80 percent
- Total zinc: 83 percent, 85 percent
- Dissolved zinc: 74 percent, 58 percent
- Motor oil range hydrocarbons: 89 percent, 90 percent

Based on these removal rates and a treatment volume of 74 MG/yr, the annual removal rates shown in Table 4-4 were calculated. Because available data were from a single test in the sand filter configuration, low and high removal rates were not calculated.

Table 4-4. Estimated Annual Removal, EC

Constituent	Removal rate [a]	Estimated annual load removal (kg) [b]		
		Low	Mean	High
TSS	94%	9,000	24,500	43,700
Copper (total)	89%	4	7	12
Copper (dissolved)	59%	0.64	0.88	1.2
Zinc (total)	84%	18	29	43
Zinc (dissolved)	66%	3.9	5.7	7.8
PCBs	NA	NA	NA	NA
Motor Oil Range Hydrocarbons	90%	130	300	480

NA – Not Available

a. *EC pilot, 2012. Average of two sand filter tests.*

b. *Assumes 74 MG/yr treatment volume. Mean influent concentrations per 2012 EC pilot study.*

Adaptability. Adjustable parameters in the operation of EC systems include the electrode material, cell current, and liquid stream conductivity. Electrode material is selected based primarily on bench-scale or pilot testing. Cell current and conductivity can be adjusted from event to event to optimize performance. Conductivity is adjusted by dosing the influent stream with a salt (sodium chloride) solution upstream of the EC cells. These three parameters in combination control the rate at which metal ions enter the solution, thereby controlling coagulation. While the current and conductivity can be adjusted on the fly during storms, the typical operating strategy is to set the current and target conductivity prior to operating and hold these parameters constant during storms.

Like enhanced filtration, residence time in the pretreatment settling and coagulation tanks can be adjusted, but is limited by the tank sizing and system flow rate. Note that for any system dependent on coagulation / flocculation, the most challenging performance conditions occur at low suspended solids concentrations, when it is more difficult to induce coagulation.

Vendors. A number of vendors produce EC systems. However, many of these vendors produce systems focused on the resource or process wastewater industries. For the stormwater market, WaterTechtonics is well established. WaterTechtonics manufactures the WaveIonics® EC system. SPU conducted a limited pilot test of this system for South Park in 2012. A relatively recent entry into the EC stormwater market is Enpurion. While different vendor systems operate using the same fundamental principles, systems are proprietary and are not interchangeable. The piping and mechanical arrangement for an EC WQF would need to be designed around a specific vendor.

4.2 Comparison

The primary goal of the WQF is to meet the pollutant removal targets discussed in Section 3. Pollutant removal is influenced by a number of parameters, including the influent concentrations, removal efficiencies, and treated volume. Table 4-5 summarizes the removal efficiencies and calculated effluent concentrations and compares these to assumed removal rates or effluent concentrations for active treatment in the IP.

Table 4-5. Calculated Pollutant Load Removals versus IP Targets, 74 MG/yr volume basis

Constituent	IP Target Annual Load Reduction			Ballasted Sedimentation			Enhanced Filtration			EC		
	LCL	Mean	UCL	Low	Mean	High	Low	Mean	High	Low	Mean	High
Total suspended solids (TSS) (kg)	21,000	25,000	29,000	5,200	19,300	43,200	3,400	22,900	45,100	9,000	24,500	43,700
Copper (total) (kg)	3.8	4.5	5.2	3	7	13	2.2	6.8	12	0.64	0.88	1.2
Copper (dissolved) (kg)	0.5	0.7	0.9	NA	NA	NA	0.16	0.74	1.4	4	7	12
Zinc (total) (kg)	24	29	34	14	28	43	15	29	47	18	29	43
Zinc (dissolved) (kg)	9.4	14	19	NA	NA	NA	2.1	6.7	10	3.9	5.7	7.8
Polychlorinated biphenyls (PCBs) (kg)	0.005	0.007	0.009	NA	NA	NA	0.00099	0.010	0.024	NA	NA	NA
Oil and grease (kg)	450	700	950	NA	NA	NA	NA	NA	NA	130	300	480

For TSS, total copper, and total zinc, the IP targets are generally within the performance range of all candidate systems. Additionally, if the system has capacity to treat greater than 74 MG/yr, load removal for TSS (or any pollutant) may be enhanced by treating additional flow. Additionally, the dissolved copper, dissolved zinc, and oil and grease IP targets are generally within the performance range of the enhanced filtration and EC systems. The PCB targets are generally within the performance range of the enhanced filtration system. Dissolved zinc is a potential area of concern for EC and should be further evaluated.

Data gaps exist for ballasted sedimentation for dissolved metals, oil and grease, and PCBs, for EC for PCBs, and for enhanced filtration for oil and grease. The *Pilot Testing Assessment* technical memorandum (Brown and Caldwell, 2014) presented the rationale for pilot-testing the candidate WQF systems. One goal of pilot testing is to confirm performance of a candidate system using the conditions that will be encountered by the full-scale installation. A second is to address data gaps for specific systems and pollutants. While the available performance data suggest that all three of the candidate systems discussed in this memorandum can meet the IP performance requirements, the data results from treatment applications where the influent water quality differ slightly from those from the 7th Avenue South basin runoff. For example, much of the data for CESF and EC are from controlled industrial sites, which can have different characteristics from runoff from streets. Much of the ballasted sedimentation data are from CSO applications. Pilot testing will provide the best assessment of the performance of the candidate systems at the range of influent water qualities that will be encountered by the WQF, and will address data gaps for key constituents such as dissolved metals, PCBs, and oil and grease.

4.3 Additional Considerations

Additional considerations include solids handling and electrical service.

4.3.1 Solids Handling

Solids handling is a consideration for all of the technology options under consideration, and the VA recommended an assessment of solids handling at the WQF. This was completed in the *Stormwater Solids Handling Alternative Evaluation* (Brown and Caldwell, 2014). The assessment recommended mechanical thickening and dewatering of solids on site, with dewatered solids hauled offsite for disposal. The liquids removed during these processes would be returned to the stormwater treatment system for treatment. The resulting solids would be approximately 20-25% solids by weight, equivalent to moist soil. Solids would be stored on site in a 10 cubic yard dumpster, and hauled away approximately every 3 days during storm events. The solids building will require an approximately 30-by-25-foot building onsite. All stormwater treatment technologies under consideration would use a similar system.

4.3.2 Electrical Service

The primary electrical loads in the previous design were associated with the flood control pumping station. With the new design, loads PS have increased, and the WQF contributes a significant electrical load. The flood control PS will require electrical service for four 100-hp flood control pumps, while the WQF will have an electrical load ranging from approximately 300 hp to 550 hp equivalent, including allowances a for lighting, signal and control, etc. Additionally, two 30-hp WQF influent pumps will need to be accounted for in either the PS or WQF electrical service. Based on a preliminary evaluation of the site power availability and requirements, the existing service would be marginally adequate for the PS. The existing electrical service is not adequate if the WQF influent pumps are included in the connected load for the pump station. An early action item for design of the pump station will be a site power evaluation, which will evaluate options for both separate services to the WQF and PS and a single combined service to the site.

The WQF service depends on the technology selected. Ballasted sedimentation would require a 300 kVA transformer, enhanced filtration would require a 500 kVA transformer, and EC would require a 750 kVA transformer. Transformer pads are approximately 6-feet by 6-feet. Transformers require 3-foot setbacks on the back and sides, and a 10-foot setback on the access panel side to allow fuses to be handled at a safe distance from the transformer using a hot stick. Transformer dimensions, including setbacks, would range from 10.5 feet to 12 feet wide and 19 feet long. The approximate space required for transformer pads, including setbacks, has been incorporated into site layouts (see Section 6).

Discussions with Seattle City Light have not been initiated regarding a single service versus separate power services to the site. The National Electrical Code (NEC) typically requires each building have a separate electrical service that powers all equipment within the structure, though the code allows the authority having jurisdiction to grant variances to this requirement.

Section 5: Water Quality Facility Sizing

This section describes the analysis used to size the WQF.

5.1 Runoff Modeling

Hydraulic and hydrologic modeling for the 7th Avenue South basin was performed using PC-SWMM, as described in the *South Park Hydraulic Modeling Report* (Brown and Caldwell, 2014). Using this model, a 35-year, 5-minute interval time series of runoff at the 72-inch-diameter trunk line outfall was generated. The runoff time series was generated using rainfall data from the RG16 (upper basin) and RG17 (lower basin) rainfall gauges, for the period from 1978–2013.

It should be noted that the modeled average annual basin runoff has increased relative to that used in the original design. The original design was based on the WWHM modeled annual runoff of 89 MG/yr; the IP criteria of 74 MG/yr corresponds to 83 percent of this value. The PC-SWMM model increased the average annual runoff to 143.5 MG/yr. The analysis presented in this section leads to a reduction in required peak capacity of the WQF relative to the original 11 CFS capacity. This is a result of the increase in runoff predicted by the PC-SWMM compared to previous modeling efforts. The WQF can treat a lower percentage of the total basin runoff and still meet the IP criteria of 74 MG/yr.

It should also be noted that the selection of stormwater projects in the IP is based on the contribution of significant water quality benefits relative to deferred Long Term Control Plan CSO projects. The calculation of the water quality benefit for stormwater projects in the IP is based on volumetric flow, mass load, and exposure reductions, and is not based on the treatment of a specific percentage of runoff. Therefore, while the percentage of total treated runoff from the basin is reduced, the annual volume basis sizing for the WQF (74 MG/yr) is not affected by the increase in predicted runoff from the basin in the PC-SWMM model. For discussion of the water quality benefit methodology, refer to the IP (Brown and Caldwell et al, 2014).

5.2 Runoff Event Analysis

This section describes the procedure used to analyze the runoff time series generated by the hydraulic and hydrologic model.

5.2.1 Runoff Event Parameters

Once modeling was completed, an Excel® macro was written that assessed the 35-year runoff series and identified runoff events using several user-defined parameters for either the runoff event or the WQF. These parameters are illustrated in Figure 5-1 and described below:

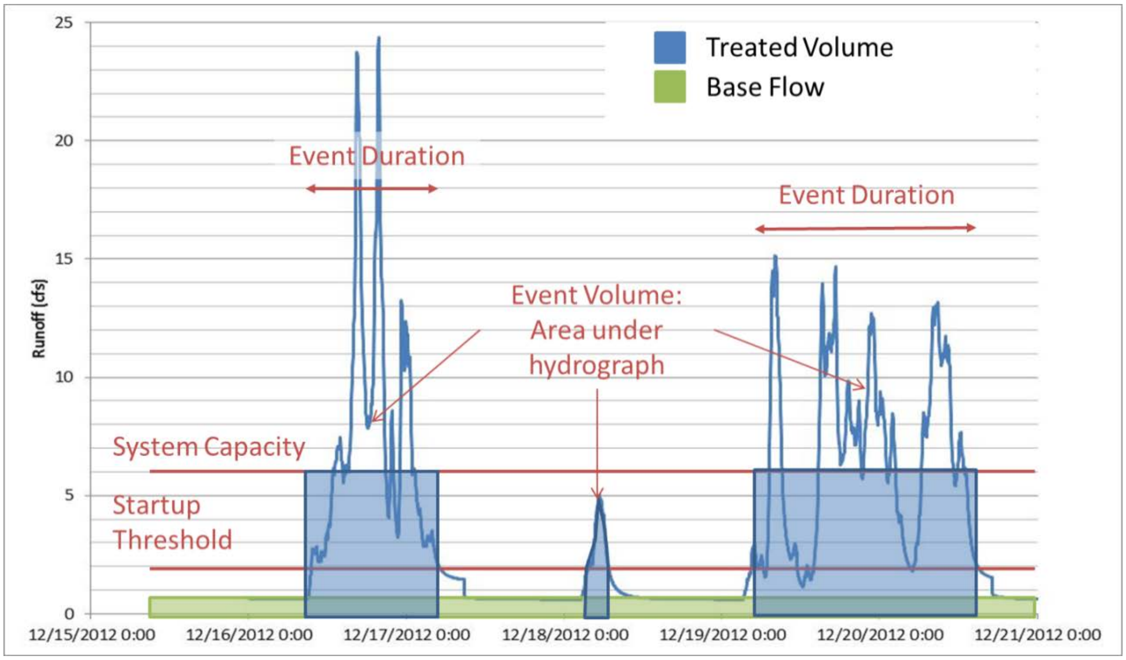

Figure 5-1. Runoff event parameters

- **System capacity** is the overall design capacity of the WQF. Flow rates below the system capacity can be treated by the WQF; flow rates above the system capacity must be bypassed.
- **Startup threshold** is the flow rate at which the WQF would begin treating runoff.
- **Base flow** is flow that is present continuously in the 72-inch-diameter trunk line. While it is not possible to exclude base flow from the treatment system during runoff events, it is used as a metric to calculate the percentage of the total treated volume that is composed of runoff. Because base flow is relatively clean, a secondary goal of the system operating strategy is to minimize the volume of base flow treated, as this requires part of the WQF's hydraulic treatment capacity but does not contribute significantly to the pollutant load removed.
- **Event volume** is the total volume of runoff, plus base flow, during a rainfall event. It is used to calculate the treated volume and the percentage of total runoff treated.
- **Event duration** is the time period of a runoff event. It is used, under certain conditions as described below, to calculate the treated volume during a runoff event. It is not used as a control parameter for the WQF, because this would require a predictive control system that anticipates the length of rainfall events. This level of sophistication in the control system was considered unlikely for the initial operation of the WQF.
- **Inter-event duration** is the length of time between when the influent flow rate falls below the startup threshold, and when the flow rate of the next runoff peak rises above the startup threshold. It is a part of the operating strategy of the WQF; because it is desirable to minimize the number of starts and stops of the treatment system. The treatment system will likely be programmed to run for a set period after the flow falls below the startup threshold, so that it is already operational if the influent flow fluctuates during a storm event. Expressed another way, the system would treat runoff peaks separated by a time period less than the inter-event duration as one treatment event. If the runoff peaks are separated by a time period longer than the inter-event duration, the system would shut down between treatment events. This is illustrated in Figures 5-2 and 5-3. Figure 5-2 shows the treated volumes if the inter-event

duration is less than the period between the two peaks, while Figure 5-3 shows the treated volume if the inter-event duration is longer than the period between the two peaks.

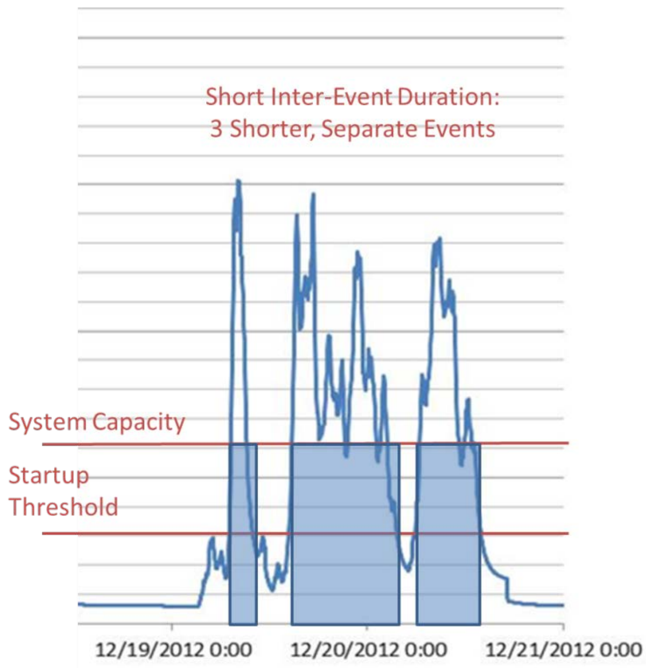

Figure 5-2. Inter-event duration less than period between peaks

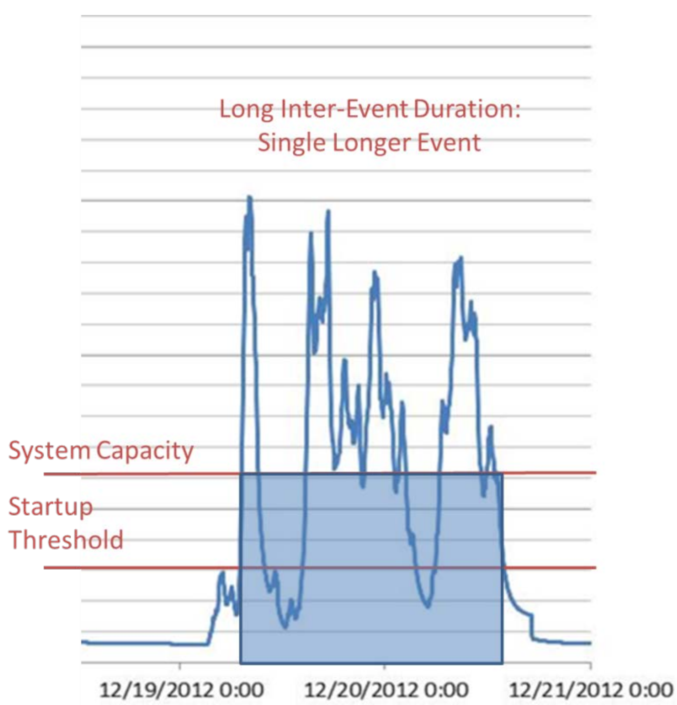

Figure 5-3. Inter-event duration greater than period between peaks

5.2.2 Treatment Volume Calculation

The macro calculated the treated volume of each runoff event according to the following rules:

- If the peak flow of an event was less than the system capacity, the treated volume was equal to the event volume.
- If the peak flow of an event was greater than the system capacity, the treated volume was equal to the system capacity multiplied by the event duration. This is an approximation, as it assumes that there is a sufficient volume of water in the 72-inch-diameter trunk line to treat at a constant rate even if the hydrograph falls below the system capacity.
- Because both of the conditions above include base flow, treated base flow was calculated as the event duration times the base flow rate (set at 0.6 cfs, based on SPU staff input [Brown and Caldwell, 2014]). Treated base flow was subtracted from the treated volume to give the treated runoff volume.

The macro was also programmed to calculate the rising limb volume, the volume of a runoff event that is bypassed before the runoff flow rate reaches the startup threshold. This parameter is important due to first-flush effects, where the pollutant load during a runoff event is weighted toward the start of the hydrograph. This is illustrated in Figure 5-4.

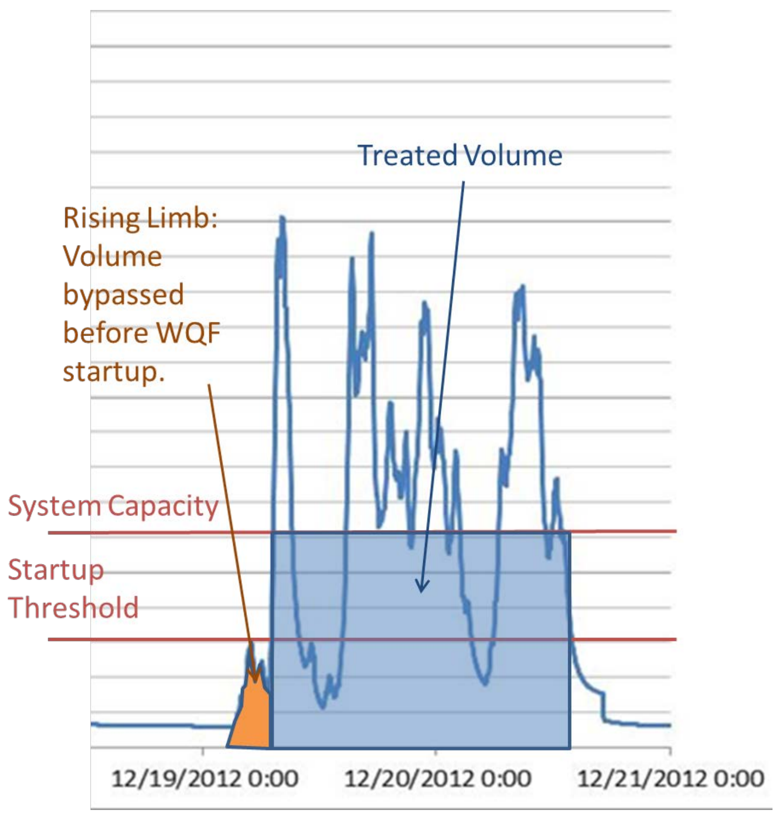

Figure 5-4. Rising limb volume

5.3 Evaluated Scenarios

Using the procedure described above, an initial screening analysis was performed to identify the approximate range for each parameter. Following this initial screening, combinations of different parameters were tested in the following ranges:

- System capacities at 4.5 cfs, 6 cfs, 9 cfs, and 12 cfs
- Inter-event durations of 1, 2, and 3 hours
- Startup thresholds of 1.0 cfs, 2.0 cfs, and 3.0 cfs.

5.4 Results

5.4.1 Treated Volume

Table 5-1 shows the annual treated volume in million gallons per year for the different parameter combinations. Table 5-2 shows the same data in terms of percentage of annual runoff. Green highlighted cells show parameter combinations that meet or exceed 74 MG/yr, the IP volumetric treatment criteria.

Table 5-1. Average Runoff Treated, MG [a]

	Inter-event duration (hours)	Start threshold (cfs) [b]	4.5 cfs system	6 cfs system	9 cfs system
Operating Parameters	1	1	94.9	110.5	125.8
		2	79.6	96.1	114.5
		3	66.6	83.0	102.8
	2	1	99.8	114.6	128.5
		2	84.0	96.1	117.4
		3	71.1	87.6	106.8
	3	1	103.6	117.6	130.3
		2	87.3	103.4	119.4
		3	75.0	91.5	109.6

Green highlighted cells meet or exceed IP criteria of 74 MG/yr..

NA: Parameter set not tested.

a. *Based on hydrologic and hydraulic model of 7th Avenue South Basin, 1978–2013, RG16 and RG17 rain gauges. Total average annual basin runoff is 143.5 MG/yr.*

b. *Average base flow equals 0.6 cfs.*

Table 5-2. Average Runoff Treated, Percentage of Average Annual [a]

Operating Parameters: Inter-event duration (hours)	Start threshold (cfs) [b]	4.5 cfs System	6 cfs System	9 cfs System	12 cfs System [c]
1	1	67%	77%	88%	NA
	2	56%	67%	80%	NA
	3	47%	58%	72%	NA
2	1	70%	80%	90%	92%
	2	59%	67%	82%	86%
	3	50%	61%	74%	80%
3	1	73%	82%	91%	NA
	2	61%	72%	83%	NA
	3	52%	64%	76%	NA

Green highlighted cells meet or exceed IP criteria of 74 MG/yr; 74 MG/yr corresponds to 51.5% of average annual runoff.

NA: Parameter set not tested.

a. *Based on hydrologic and hydraulic model of 7th Avenue South Basin, 1978–2013, RG16 and RG17 rain gauges. Total average annual basin runoff is 143.5 MG/yr.*

b. *Average base flow equals 0.6 cfs.*

c. *Limited evaluation at 12 cfs was performed to assess the effect of a larger system size on the base flow volume treated and rising limb volume bypassed; see Tables 5-3 and 5-4.*

Based on the treated volume analysis, the 6 cfs system can meet or exceed the IP flow criteria of 74 MG/yr at a range of parameter combinations. This provides several degrees of freedom to optimize the system in response to changed criteria or field conditions. An annual treatment capacity exceeding the IP criteria provides a safety factor for meeting the pollutant load reduction targets. Pollutant load removal is influenced by the treated volume, the influent concentration of a pollutant, and the system's removal efficiency for that pollutant. In the event that the selected treatment system does not achieve the planned pollutant removal efficiencies or influent concentrations are lower than expected, the annual volume treated can be increased so that the pollutant load reduction targets are met.

Reducing the system size to 4.5 cfs would reduce the WQF project and annual O&M costs. However, reducing the system size to 4.5 cfs requires a lower startup threshold or higher inter-event duration, reducing the degrees of freedom available for system optimization and reducing the safety factor for pollutant load removal. Operating with a longer inter-event duration also presents a tradeoff between treating base flow and capture of the rising limb volume of storm events. With a longer inter-event duration, proportionally more base flow is treated since the system operates for longer periods between storms. However, it also increases the likelihood that the system will be running when the subsequent storm occurs, in which case the entire rising limb and first flush is treated. With a higher capacity system, more of the first flush can be treated, reducing the need to make this tradeoff between base flow treatment and first flush capture.

Similarly, increasing the system size would add flexibility for optimization and add to the pollutant load removal safety factor. However, this comes at the expense of added project and annual O&M costs. It also increases the system footprint, which may affect the ability of some of the candidate systems to fit on the project site, or may require add to design and construction costs if a non-standard configuration is required to fit the system on the site. These added costs do not appear to provide a significant benefit, since the 6 cfs is already capable of providing a significant (greater than 20 percent) safety factor relative to the required IP treatment volume.

Based on this analysis, 6 cfs was selected as the preliminary size for the system. The sizing confirmation checks described in the following sections were performed assuming a 6 cfs system. It should be noted that, while a 6 cfs system was the preferred sizing of the scenarios evaluated, sizing was performed in this memorandum primarily to develop a basis for site layouts and cost estimates. 6 cfs does not necessarily represent an optimum sizing, and system size should be further analyzed in the Options Analysis.

5.4.2 Sizing Confirmation

Using the procedure described above, a preliminary sizing of 6 cfs was selected for the WQF. Two confirmation checks were performed for the 6 cfs system: a base flow analysis and a rising limb analysis.

5.4.2.1 Base Flow

The base flow analysis is intended to check the percentage of the treated volume that is composed of base flow. Treatment of excessive amounts of base flow is undesirable. Because base flow is relatively clean, treating base flow adds to the hydraulic load and operating costs for the WQF without significantly contributing to the pollutant load removal. If the system treats excessive base flow, a larger system should be considered. A larger system can achieve the required 74 MG/yr treatment by treating comparatively fewer, but larger, runoff events, thereby decreasing the treated base flow contribution.

Base flow treatment for a 6 cfs system and a range of parameter combinations is summarized in Table 5-3. Treated base flow for 4.5 cfs and 9 cfs systems for selected parameter combinations are also shown for comparison.

Table 5-3. Base Flow Treated

System capacity (cfs)	Inter-event (hrs)	Start threshold (cfs)	Total treated volume (MG) [a]	Treated storm runoff (MG) [a]	Treated base flow (MG)	Base flow as % of total treated
4.5	2	1	108.9	99.8	9.1	8.4%
		2	88.3	84.0	4.3	4.9%
		3	73.2	71.1	2.1	2.9%
6	1	1	121.1	110.5	10.6	8.7%
		2	102.1	96.1	6.0	5.9%
		3	86.3	83.0	3.3	3.8%
	2	1	127.0	114.6	12.4	9.7%
		2	102.1	96.1	6.0	5.9%
		3	91.7	87.6	4.1	4.5%
	3	1	131.4	117.6	13.9	10.5%
		2	111.3	103.4	7.9	7.1%
		3	96.3	91.5	4.8	5.0%
9	2	1	144.2	128.5	15.7	10.9%
		2	127.8	117.4	10.5	8.2%
		3	114.1	106.8	7.4	6.5%

a. *Total treated volume equals base flow plus stormwater runoff. Total treated storm runoff excludes base flow.*

The treated base flow contribution for the 6 cfs system was not considered excessive, and is comparable in terms of percentage of runoff treated to larger and smaller systems.

5.4.2.2 Rising Limb

The rising limb volume is the volume of a runoff event that is bypassed before the runoff flow rate reaches the startup threshold. This parameter is important due to first-flush effects, where the pollutant load during a runoff event is weighted toward the start of the hydrograph. If the bypassed rising limb volume large enough to impact the ability to treat the event first flush, a system that operates with lower startup thresholds or longer inter-event duration should be considered. Since increasing the inter-event duration and decreasing the startup threshold will generally increase the annual volume treated by the system, checking the rising limb volume bypassed may indicate that a smaller system should be considered.

Bypassed rising limb volume for a 6 cfs system and a range of parameter combinations is summarized in Table 5-3. Bypassed for 4.5 cfs and 9 cfs systems for selected parameter combinations are also shown for comparison.

Table 5-4. Bypassed Rising Limb Flow

Capacity (cfs)	Inter-event (hrs)	Start threshold (cfs)	Total treated volume (MG)	Bypassed rising limb volume (MG)	Bypassed rising limb as % of treated volume
4.5	2	1	108.9	0.0	0.0%
		2	88.3	1.4	1.6%
		3	73.2	3.3	4.6%
6	1	1	121.1	0.1	0.0%
		2	102.1	1.7	1.6%
		3	86.3	3.8	4.5%
	2	1	127.0	0.0	0.0%
		2	102.1	1.7	1.6%
		3	91.7	3.3	3.6%
	3	1	131.4	0.0	0.0%
		2	111.3	1.3	1.1%
		3	96.3	3.0	3.2%
9	2	1	144.2	0.0	0.0%
		2	127.8	1.4	1.1%
		3	114.1	3.3	2.9%

The bypassed rising limb volume for the 6 cfs system was comparable in terms of percentage of bypassed volume larger and smaller systems.

5.4.3 Sizing Conclusions

Of the evaluated scenarios, the 6 cfs system most closely matches the IP targets without unnecessary excess capacity. This sizing was performed to develop site footprint requirements and costs, and should be considered preliminary. Sizing should be refined during Options Analysis. During Options Analysis, the standard sizing of process units by candidate manufacturers should be taken into account; WQF capacities that use manufacturer standard sizing to the maximum extent practicable should be evaluated. Additionally, sizing should be considered in the broader context of the selected delivery method; some delivery methods may not require specification of a system capacity.

Annual runoff treatment for a 6 cfs system operating with a 2-hour inter-event duration and 2 cfs startup threshold is summarized in Figures 5-5 and 5-6. Figure 5-5 summarizes the number of runoff events per year in a given event volume range (note that there may be multiple rainfall events in a given day), while Figure 5-6 summarizes the annual flow contribution for the same event ranges.

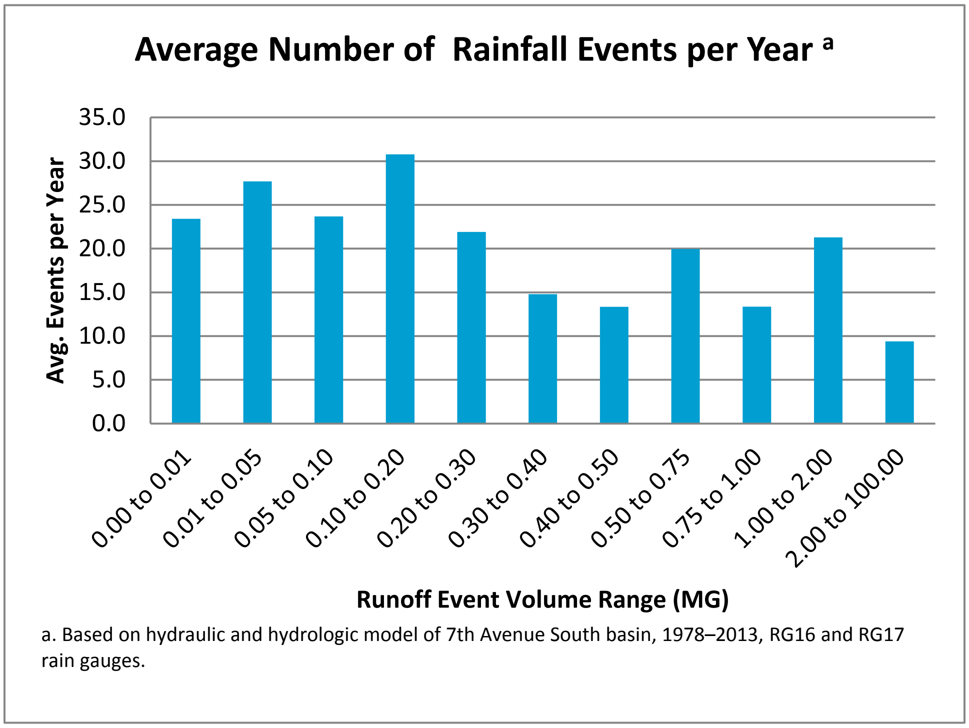

Figure 5-5. Treated flow summary, number of events

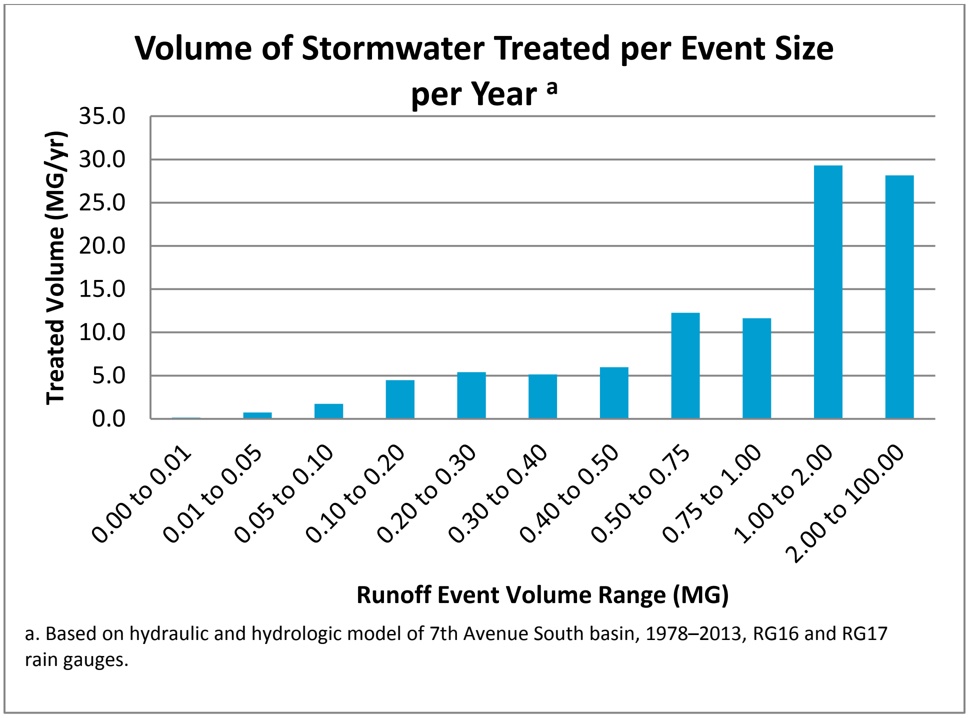

Figure 5-6. Treated flow summary, volume

The charts illustrate that, while the system will treat a large number of relatively small runoff events under the design parameters, the large majority of the treated flow results from 30 to 50 relatively mid-range events each year. Note that the range from 2.0 to 100.0 MG volume includes a wide range of storms. For very large storms, significant volumes are bypassed. This is illustrated in the scatter plot in Figure 5-7, showing the relationship between peak event size and treated volume.

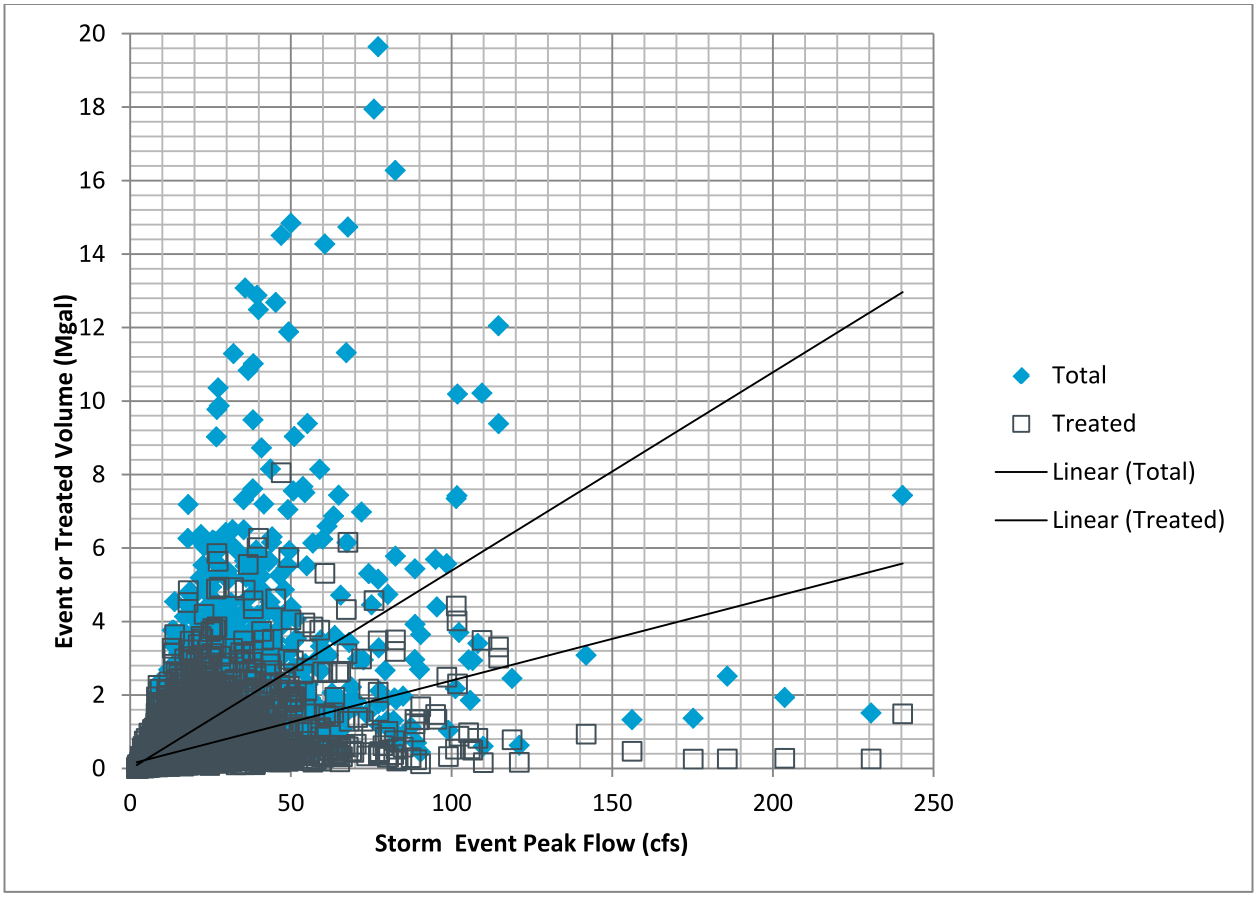

Figure 5-7. Total and treated flow by peak event size.

Section 6: Water Quality Facility Options

WQF options were developed based on the technology selection described in Sections 2 through 4 above and on the system sizing described in Section 5 above. This section describes WQF options. A site plan and cost estimate are presented for each option.

Construction cost estimates (2014 dollars) are based on vendor-provided equipment costs and BC estimates of construction cost. Estimates are Association for the Advancement of Cost Engineering (AACE) Class 5. The Basis-of-Estimate report, detailed estimate, and vendor costs are included in Attachment C. Project costs are developed from the construction cost estimates using SPU's Estimating Guidelines. A crosswalk table relating the detailed estimates to the project costs shown is included in Attachment D. A summary estimate of total costs is included in Attachment E.

Operations (2014 dollars) costs include contracted labor at a rate of $90 per hour for 600 hours/yr, power, consumables such as chemicals, and treatment and disposal costs for sludge. All systems may be started and stopped remotely and may have automated chemical dosing adjustments, but will require staffing for solids loading, regular operator rounds and scheduled maintenance, chemical deliveries, and troubleshooting. Solids costs are estimated in the *Stormwater Solids Handing Alternative Evaluation* technical memorandum (Brown and Caldwell, 2014). Maintenance costs (2014 dollars) include the labor and equipment costs to maintain, repair, or replace equipment, and for routine scheduled maintenance operations such as cleaning. Maintenance costs are estimated at 3.5 percent of the equipment cost annually.

6.1 Option 1: Ballasted Sedimentation

6.1.1 Site Plan

A ballasted sedimentation site plan is shown in Figure 6-1.

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Figure 6-1. Option 1: Ballasted sedimentation layout

6.1.2 Cost Estimate

The capital and project cost estimate for Option 1 is shown in Table 6-1. O&M costs are shown in Table 6-2.

Table 6-1. Option 1: Ballasted Sedimentation Capital and Project Cost (Class 5)		
Cost item description	Quantity	Estimated cost (2014 dollars)
Ballasted sedimentation WQF	---	$5,858,000
Sitework	---	*$827,000*
Ballasted sedimentation major equipment		*$1,100,000*
Liquid treatment structural, electrical, and misc. mechanical	---	*$1,970,000*
Solids Facility	---	*$1,203,000*
Contractor markups	---	*$758,000*
Allowance for indeterminates	0%	$0
WQF line item pricing	---	$5,858,000
Adjustment for market conditions	0%	$0
Construction bid amount	---	$5,858,000
Sales tax	9.5%	$556,000
Construction contract amount	---	$6,414,000
Crew construction costs	5%	$321,000
Miscellaneous hard costs	5%	$321,000
Construction cost total	---	$7,056,000
Soft costs	49%	$3,457,000
Property acquisition costs	---	$0
Base cost total	---	$10,513,000
Contingency reserve	*35%*	$3,680,000
Management reserve	*20%*	$2,103,000
Project reserves	---	$5,782,000
Project cost	---	$16,295,000

Table 6-2. Ballasted Sedimentation Operating Costs						
Item	Capacity	Units	Operating quantity	Units	Unit cost (2014 dollars)	Annual cost (2014 dollars)
Contract labor	---	---	600 [b]	hours	$90.00	$54,000
WQF feed pumps [a]	30	hp	27,964	kWh	$0.070	$2,000
Mixers [a]	25	hp	23,303	kWh	$0.070	$1,600
Drum separator [a]	1.5	hp	1,398	kWh	$0.070	$100
Sludge pumps [a]	9	hp	8,389	kWh	$0.070	$600
Electrical demand charge	65.5	hp	---	---	---	$3,600
Consumables [c]	---	---	---	---	---	$9,400
Solids treatment and disposal [d]	---	---	---	---	---	$43,000
Maintenance [e]	---	---	---	---	---	$43,000
Annual O&M Cost						$157,100

a. *Operating costs assume 750 hours/year operation and 60% motor efficiency.*

b. *Assumes 20 hours/week for 7 months.*

c. *Consumables include coagulant, polymer, caustic for pH adjustment, and ballast material replacement. See vendor quote in Attachment C.*

d. *See Stormwater Solids Handing Alternative Evaluation technical memorandum (Brown and Caldwell, 2014).*

e. *Assumes 3.5% of equipment cost of $1,222,000. See Attachment C.*

6.2 Option 2: Enhanced Sand Filtration

6.2.1 Site Plan

An enhanced filtration site plan is shown in Figure 6-2.

Figure 6-2. Option 2: Enhanced filtration layout

6.2.2 Cost Estimate

The capital and project cost estimate for Option 2 is shown in Table 6-3. O&M costs are shown in Table 6-4.

Table 6-3. Option 2: Enhanced Filtration Capital and Project Cost (Class 5)

Cost item description	Quantity	Estimated cost (2014 dollars)
Enhanced Filtration WQF	---	$6,832,000
Sitework	---	*$1,145,000*
Enhanced filtration major equipment	---	*$1,286,000*
Liquid treatment structural, electrical, and misc. mechanical	---	*$2,318,000*
Solids Facility	---	*$1,203,000*
Contractor Markups	---	*$880,000*
Allowance for indeterminates	0%	$0
WQF line item pricing	---	$6,832,000
Adjustment for market conditions	0%	$0
Construction bid amount	---	$6,832,000
Sales tax	9.5%	$649,000
Construction contract amount	---	$7,481,000
Crew construction costs	5%	$374,000
Miscellaneous hard costs	5%	$374,000
Construction cost total	---	$8,229,000
Soft costs	49%	$4,032,000
Property acquisition costs	---	$0
Base cost total	---	$12,261,000
Contingency reserve	*35%*	$4,291,000
Management reserve	*20%*	$2,452,000
Project reserves	---	$6,744,000
Project cost	---	$19,005,000

Table 6-4. Enhanced Filtration Operating Costs.						
Item	Capacity	Units	Operating quantity	Units	Unit cost (2014 dollars)	Annual cost (2014 dollars)
Contract labor	---	---	600 [b]	hours	$90.00	$54,000
WQF feed pumps [a]	30	hp	27,964	kWh	$0.070	$2,000
Pretreat tank pump [a]	75	hp	69,909	kWh	$0.070	$4,900
Filter pumps (4x30 hp) [a]	120	hp	111,855	kWh	$0.070	$7,800
Electrical demand charge	225	hp	---	---	---	$12,400
Consumables [c]	---	---	---	---	---	$60,000
Solids treatment and disposal [d]	---	---	---	---	---	$43,000
Maintenance [e]	---	---	---	---	---	$45,000
Annual O&M Cost						$229,000

a. *Operating costs assume 750 hours/year operation and 60% motor efficiency.*

b. *Assumes 20 hours/week for 7 months.*

c. *Consumables include chitosan acetate, caustic, Clear Water Services software license, and filter media. See vendor quote in Attachment C.*

d. *See Stormwater Solids Handing Alternative Evaluation technical memorandum (Brown and Caldwell, 2014).*

e. *Assumes 3.5% of equipment cost of $1,286,000. See Attachment C.*

6.3 Option 3: Electrocoagulation

6.3.1 Site Plan

An EC site plan is shown in Figure 6-3.

Figure 6-3. Option 3: EC layout

6.3.2 Cost Estimate

The capital and project cost estimate for Option 3 is shown in Table 6-5. O&M costs are shown in Table 6-6.

Table 6-5. Option 3: EC Capital and Project Cost (Class 5)

Cost item description	Quantity	Estimated cost (2014 dollars)
EC WQF	---	$8,067,000
Sitework	---	*$898,000*
EC major equipment	---	*$2,122,000*
Liquid treatment structural, electrical, and misc. mechanical	---	*$2,794,000*
Solids Facility	---	*$1,203,000*
Contractor Markups	---	*$1,050,000*
Allowance for indeterminates	0%	$0
WQF line item pricing	---	$8,067,000
Adjustment for market conditions	0%	$0
Construction bid amount	---	$8,067,000
Sales tax	9.5%	$766,000
Construction contract amount	---	$8,833,000
Crew construction costs	5%	$442,000
Miscellaneous hard costs	5%	$442,000
Construction cost total	---	$9,717,000
Soft costs	49%	$4,761,000
Property acquisition costs	---	$0
Base cost total	---	$14,478,000
Contingency reserve	*35%*	$5,067,000
Management reserve	*20%*	$2,896,000
Project reserves	---	$7,963,000
Project cost	---	$22,440,000

.

Table 6-6. EC Operating Costs						
Item	Capacity	Units	Operating quantity	Units	Unit cost (2014 dollars)	Annual cost (2014 dollars)
Contract labor	---	---	600 [b]	hours	$90.00	$54,000
WQF feed pumps [a]	30	hp	27,964	kWh	$0.070	$2,000
Pretreat tank pump [a]	75	hp	69,909	kWh	$0.070	$4,900
Electrical demand charge	225	hp	---	---	---	$12,400
WQF energy cost [c]	---	---	102	MG/yr	$0.17 per 1,000 gallons	$12,600
Consumables [c]	---	---	102	MG/yr	$1.65 per 1,000 gallons	$122,000
Solids treatment and disposal [d]	---	---	---	---	---	$43,000
Maintenance [e]	---	---	---	---	---	$74,000
Annual O&M Cost						$309,400

a. *Operating costs assume 750 hours/year operation and 60% motor efficiency.*

b. *Assumes 20 hours/week for 7 months.*

c. *Consumables include EC cells and conductivity adjustment chemicals. See vendor quote in Attachment C.*

d. *See Stormwater Solids Handing Alternative Evaluation technical memorandum (Brown and Caldwell, 2014).*

e. *Assumes 3.5% of equipment cost of $2,122,000. See Attachment C.*

6.4 Option Comparison

Table 6-7 summarizes the costs of the options. Option 1: ballasted sedimentation has the lowest cost in terms of both construction/project cost and operating cost. This is due in part to the smaller footprint of the system; a smaller footprint results in lower costs for ground improvements and for the construction of structural elements, especially large storage tanks.. Option 3: EC has the highest cost in terms of both construction and project cost. This is due to the larger system footprint, higher initial equipment cost, and higher consumable cost.

Table 6-7. Option Cost Comparison			
Estimate	Option 1: Ballasted sedimentation	Option 2: Enhanced Filtration	Option 3: EC
Construction contract amount (2014 dollars)	$6.4M	$7.8M	$8.8M
Project cost (2014 dollars)	$16.3M	$19.0M	$22.4M
Annual O&M cost (2014 dollars)	$157,000	$229,000	$309,000

M = millions.

Section 7: Evaluation and Recommendations

The comparison of options is summarized in Table 7-1.

Table 7-1. Option Comparison Summary			
Criteria	Option 1: Ballasted sedimentation	Option 2: Enhanced filtration	Option 3: EC
Complexity of operation	Highest	Medium	Lowest
Automation requirements	System start / stop, chemical dose adjustment	System start / stop, chemical dose adjustment	System start / stop
Staffed operation requirements	Solids handling, regular rounds, scheduled maintenance, troubleshooting, chemical deliveries	Solids handling, regular rounds, scheduled maintenance, troubleshooting, chemical deliveries	Solids handling, regular rounds, scheduled maintenance, troubleshooting
Performance relative to IP criteria	Meets TSS and total metals Data gaps for dissolved metals, oil, PCBs	Meets IP criteria	Meets TSS, total metals, dissolved copper Dissolved zinc not met in current data set; requires further evaluation Data gap PCBs
Chemical handling	Yes	Yes	Minimal
Construction contract amount (2014 dollars)	$6.4M	$7.8M	$8.8M
Project cost (2014 dollars)	$16.3M	$19.0M	$22.4M
Annual O&M cost (2014 dollars)	$157,000	$229,000	$309,000
Manufacturer contract operations available	Yes	Yes	Yes

The estimated construction contract amount for EC ($8.8M) exceeds that of ballasted sedimentation ($6.4M) by $2.4M, and exceeds the estimated construction contract amount for enhanced filtration ($7.8M) by $1.0M. The estimated project cost for EC ($22.4M) exceeds the estimated project cost for ballasted sedimentation ($16.3M) by $6.1M, and exceeds the estimated project cost for enhanced filtration ($19.0M) by $3.4M. AACE Class 5 estimates are typically considered to have a low accuracy range of -20 to -50 percent and a high accuracy range of +30 to +100 percent. While the difference between the estimates is within the range of accuracy, it is likely that overall costs for EC will be higher than those for the other two options. Additionally, the annual operating cost for EC ($309,000) is considerably higher than that for ballasted sedimentation ($157,000) or enhanced filtration ($229,000).

In addition to cost differences, the EC system requires a larger site footprint than the ballasted sedimentation system. The footprints for EC and enhanced filtration are comparable. While the EC and enhanced filtration systems appear to fit on the site based on the conceptual site layout, they leave considerably less site arrangement flexibility than the ballasted sedimentation layout. Constrained site layouts can lead to higher construction costs if non-standard arrangements or construction is required to fit within a site layout.

Pilot testing is discussed in Section 4 above and in the *Pilot Testing Assessment* technical memorandum (Brown and Caldwell, 2014). There are two primary purposes for pilot testing: to confirm performance using the same conditions that would be encountered by the full-scale installation, and to collect data to be used in the design of the full-scale installation. It is recommended candidate systems be considered for a wet weather season pilot test. The enhanced filtration pilot should include testing with both chitosan and conventional chemical coagulants. While the performance data for candidate systems suggest that they will be capable of meeting the performance requirements for the WQF, a wet weather season pilot will provide the best representation of the range of influent water quality conditions that will be encountered by the WQF. Additionally, this will address data gaps where performance data is not readily available, particularly for dissolved metals and PCBs. This will help identify any unanticipated performance issues with these systems. Pilot testing of multiple systems is recommended as a result of the critical path of the WQF. The schedule objective for the WQF is to have the system online by 2023, so that there are two seasons of operational optimization before the system must meet the IP targets in 2025. If only one of the candidate systems is pilot tested and unanticipated performance problems are encountered, performing a pilot test on a second system will require another year, and may put the schedule at risk. A side-by-side pilot allows for a performance-based selection between the candidate systems, and provides the data necessary for design of either system so the project can proceed on schedule.

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Attachment A: Problem Definition and Water Quality Workshop Meeting Minutes

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Meeting Minutes

Prepared for: Seattle Public Utilities
Project Title: South Park Pump Station and Water Quality Facility
Project No.: 133662

Purpose of Meeting: Water Quality Workshop
Date: November 5, 2013
Meeting Location: SMT 4540
Time: 2:30 p.m.
Minutes Prepared by: Josh Johnson, Brown and Caldwell

Attendees:

Bruce Ball, BC
Kevin Buckley, SPU
Sheila Harrison, SPU
Josh Johnson, BC
Darin Johnson, BIS Consulting
Andrew Lee, SPU
Jeff Massie, SPU
Steffran Neff, BC
Kate Rhoads, SPU
Susan Saffery, SPU
Beth Schmoyer, SPU
David Schuchardt, SPU
Tim Skeel, SPU
Theresa Wagner, City Attorney's Office
Ingrid Wertz, SPU
Laura Wishik, City Attorney's Office

cc:

Summary

<Note: Meeting notes are based on fairly complex and technical discussions at workshop. There may be instances where more accurate information is available in previous business cases.>

- Introductions
- Review Workshop purpose and goals
  - Review, update, and confirm problem statement and drivers
  - Identify / discuss any additional considerations
- Project History:
  - Stormwater projects in the City were historically (until '90's) primarily for flood control.
  - With NPDES permit in late '90's and requirements that kicked in in 2000's, projects with receiving water discharge had to address water quality.

- Basin study of 7th Ave. S. in early '00's determined the basin would be difficult to retrofit, and end-of-pipe treatment with drainage control was best option for addressing water quality.
- 7th Ave. S. basin background:
  - Most industrialized basin on Duwamish.
  - Includes a number of industries with untreated discharges to storm system.
  - Superfund sediment cleanup in receiving water.
  - It was initially thought that code requirements related to City projects would require significant treatment (more discussion later during Drivers discussion).
- 2005 – PDP 1. Looked at options including piecemeal treatment with drainage improvements, regional treatment, diversion and treatment of the lower industrial basin, and a swap option with a combined sewer project. Selected regional end-of-pipe treatment.
- 2008 – PDP 2. Looked at treatment options. Screened out traditional options that were a poor fit, technologies that did not scale well (i.e. small packaged systems intended for individual construction or industrial sites), and technologies that were not mature for stormwater at the time (including chemically-enhanced primary treatment [CEPT] and ballasted sedimentation). Selected Stormfilters as preferred option and proceeded with design.
- When results from large scale Stormfilter installations (Port of Seattle, City of Olympia, other SPU projects) became available, it became apparent that maintenance requirements would be more intensive than initially projected.
- 2012. Some of the technologies initially evaluated were more mature for stormwater applications. Initiated a comparison of active technologies to Stormfilters.
  - Evaluated electrocoagulation (EC), CEPT, chitosan-enhanced sand filtration (CESF), and ballasted sedimentation.
  - Ballasted sed. and EC were expensive. CEPT and CESF were comparable cost-wise.
  - Operations and maintenance: CEPT would require hiring operators; maintenance contracts are available from CESF vendors.
  - Sizing: No specific standard applies to sizing for retrofits. System was sized as close to code requirement as possible:
    - Code requires 80% TSS removal efficiency and treatment of 91% of average annual volume.
    - System sized for 80% removal, for approximately 80%-83% of average annual volume.
- Question: Was source tracing done in basin?
  - Yes. Less than 10% of the flow from the basin is from permitted industrial discharges. Some sources have been found, but they will be difficult to control. Facilities with known sources and/or high risk were put on high-priority list for reinspection every 2 years.

- Question: What are the constituents of concern?
  - Low-level PCBs, arsenic, and other metals have been identified. Water quality is similar to other industrial basins.
- Clarification: Further explanation of 80% removal / 83% total flow:
  - All flow below the design flow rate (11 cfs) is treated. 11 cfs equals 83% of the total basin flow; treatment removes 80% of TSS from this flow.
  - Flow exceeding 11 cfs bypasses treatment.
  - 91% of flow corresponds to treatment of everything smaller than a 6-month design storm.
  - 83% of flow corresponds approximately to 1-3 bypassing storm events per year.

- Problem Statement:

The draft problem statement discussed at workshop is in bold below. The discussion of the problem statement at workshop follows. A post-workshop action item is to update the problem definition based on discussion.

- **The City has deferred compliance with its Stormwater Code, which was triggered by the 4th and Trenton and S Portland St projects.**

- **As part of the Integrated Plan, the City is committing to construct a facility that will provide treatment equivalent to an active, basic treatment system at 11 cfs flow rate at this location.**

- **Runoff from the 7th Avenue Basin is currently released untreated through the 7th Ave outfall, contributing to water quality pollution and potential sediment recontamination in the Duwamish River. Contaminants of concern to be addressed by the facility are those associated with solids and includes contaminants of concern for the Superfund clean-up (e.g, PCBs). A potential contaminant of concern is dissolved metals, which will be evaluated during Options Analysis.**

  - Discussion related to Deferred compliance:
    - 4th and Trenton project was built without providing water quality treatment required by Code, and Portland Street project is being designed without Code required water quality treatment. Code compliance on these projects was deferred to 7th Ave. S.
  - Discussion related to Integrated Plan (IP) requirement to build 11 cfs active, basic treatment system at South Park location:
    - Basic treatment requires 80% removal of TSS from 91% of total flow. Enhanced treatment adds requirement 50% removal of dissolved metals.
    - IP gives the option of replacing low benefit, high cost CSO projects in favor of stormwater projects with greater overall benefit.
    - IP criteria is 'significant environmental benefit' in terms of load and exposure.

        - South Park is one of three stormwater projects identified for IP (other two are natural drainage and street sweeping):
            - Most significant 'delta' – difference between benefit of the South Park project and the low benefit of the CSO projects it replaces.
            - Active treatment and 11 cfs help meet goals of the IP.
            - If proposed, will become a requirement after Integrated Plan (IP) is approved by EPA.
            - Question: How did we get to the active treatment and 11 cfs IP requirement?
                - 11 cfs was what would fit on the site with Stormfilter design.
                - Included in IP based on this initial sizing; part of the IP approach was to leverage projects that were already underway or were partially complete.
            - **Action Item: Update the language in the problem statement to be less qualitative. Determine if quantitative criteria (e.g., kg pollutant removed per year) is more appropriate for problem statement than type of treatment and flow rate.**
    - Discussion related to Contaminants of concern: Solids, including those associated with the Superfund cleanup, and potentially dissolved metals.
- Drivers:
    - Code requirement for water quality treatment:
        - Pump station was original project driver – supports improvements to lower basin drainage for flood control.
        - Code at the time would have required significant treatment volume as a result of improvements to lower basin.
        - Changes to be made as part of code updates will revise threshold criteria for projects requiring treatment:
            - In current code requirement is more stringent than what was required by Ecology. Criteria resulted in many small, not cost-effective facilities.
            - Street sweeping was implemented – source control provided more benefit than small water quality projects.
            - Planned update to code is to change threshold criteria to that required by Ecology. Thus, code required water quality treatment for future drainage improvements to lower basin is no longer a driver.
    - Integrated Plan driver – discussed earlier during Problem Statement discussion.
    - Lower Duwamish source control:
        - More definition during the past year – driver is to prevent recontamination in Superfund area.
        - City is getting ready to submit draft source control plan to Ecology.

    - Regulatory mechanism (enforceable document) not clear yet; may be permits, MTCA order, or something else.
    - Will be renegotiated every 5 years. Expected to become more stringent after each 5-year period.
    - Outfalls may get numerical effluent limits.
    - Question: What does 'source control' mean in this context?
        - 'Source' means source to the Duwamish (i.e. outfall), not runoff sources upstream in the basin. The City is ultimately responsible for what comes out of the outfall.
    - Ecology has been clear in its desire for regional, end-of-pipe treatment of street runoff.
    - Moving toward more stringent levels in sediments and surface water, especially for PCBs.
- Water Quality Standards / Sediment Management Standards
    - Ecology moving toward human health water quality criteria based on fish consumption and bioaccumilative toxins. When adopted, they will be very difficult to attain.
    - Dissolved metals:
        - Industrial Stormwater General Permit has metals limits. Reasonable to expect that limits are coming for municipal.
        - Federal agencies are looking at dissolved metal impacts on salmon.
    - Question: Is the driver here a regulatory requirement, or that water quality improvement is a good idea?
        - Not regulatory yet, and effectiveness of dissolved metals treatment on beneficial uses is not clear. Federal requirements for dissolved copper in Coho habitat will likely be the biggest driver in this area.
        - Human health requirements are already stringent. Fish consumption rate-based levels will make them more so.
    - Question: Does enhanced treatment solve a problem, or is it a necessary but not sufficient condition to meeting regulations?
        - It addresses some pollutants, but does not solve the problem in and of itself. It's a 'piece of the pie'.
        - Will help make progress toward meeting water quality standards.
        - Contaminant concentrations in outfall effluent are not currently monitored, so it will be hard to document improvement. Upstream / downstream water quality can be monitored to show the effectiveness of the treatment facility. Ecology is pushing monitoring under Duwamish cleanup.
        - Currently, no numerical limits in municipal permit; however, meeting water quality standards <u>is</u> a requirement. City is generally considered in compliance if taking steps in the right direction.

        - Regulators will require the City to do what it practically can.
  - Cost:
    - Cost is a driver.
    - Technology, phasing, and ownership are all variables that can reduce lifecycle costs.
    - Will be reexamining some technologies, since costs have changed as technologies have become more mature for stormwater.
  - Other Drivers
    - TMDL may be implemented in future.
    - NPDES permit renewal in 2019 will likely have more prescriptive retrofit requirements.
  - What is missing?
    - Liability – recontamination of Superfund site can increase the City's liability for cleanup costs.
- Closing: Next meeting will develop VA options, objectives, and trends.

Action Required

The following are a list of actions required as a result of the meeting discussion:

1. Update problem statement to be less qualitative in terms of what is required for the IP. Determine if quantitative criteria (e.g., kg pollutant removed per year) is more appropriate for problem statement than type of treatment and flow rate.. **Assigned Person(s):** Andrew Lee; **Response Required:** TBD

Attachment B: Screening Matrix

Technology Screening

Screening criteria:

- **Application history.** Eliminate systems without established records of stormwater or CSO treatment.
- **Sizing.** Eliminate systems with low loading rates and corresponding large sizes; site will not accommodate large footprint systems.
- **Performance.** Eliminate systems with known performance issues or where operational criteria are not suited to intermittent stormwater flows.
- **Mechanical complexity.** Highly mechanically complex systems are not suited to remote installations without advanced instrumentation and control systems, which add to overall cost. Eliminate systems where mechanical complexity is not offset by other benefits.

South Park – Water Quality Facility – Technology Screening									
State of Development	System	Treatment Process		Example Vendors / Systems	Installations			Recommended Action	Notes
		Coagulation / Flocculation / Coprecipitation	Separation		Storm-water*	Wastewater – CSO or Wet Weather	Other (industrial, potable, etc.)		
Established	Passive Filtration / Adsorption	NA	Active media filter (activated alumina, iron-based, perlite, etc.)	Baysaver – BayFilter Contech – StormFilter Imbrium Systems – Stormceptor	Yes	No	No	Drop from further consideration	Drop per workshop decision to focus on active treatment. Workshop discussion points included: • Passive treatment O&M requirements based on Port of Seattle installation were greater than anticipated. • Active technologies are more mature for stormwater than when they were originally considered. • Site size would allow for treatment of ~80% of total runoff based on StormFilter design. New facility code at the time required treatment of 91% of total flow. (Note: SPU decision to size retrofit as if it is a new facility.) • Integrated Plan is being developed assuming active treatment; the facility is proposed to replace low-benefit, high-cost CSO projects and must meet criteria of 'significant environmental benefit'.
			Adsorptive media (zeolite / perlite / GAC)	Contech – StormFilter Aquashield – Aqua-Filter StormwaterRX – Aquip Suntree Technologies – SkimBoss	Yes	No	No		
			Ion exchange	Freytech – EcoStorm Plus	Yes	No	No		
			Biological media (peat, compost, etc.)	Contech – StormFilter APT – APTSorb	Yes	No	No		
	CEPT	Coagulant (alum, iron salts, PAC) + polymer	Clarification	WetSep Non-vendor installations	Yes	Yes	Yes	Proceed with further evaluation	Selection rationale: - Established technology for CSO and wet weather treatment. - Packaged systems designed for construction stormwater are available. Issues to be addressed: - Efficiency decreases at low influent concentrations, particularly for stormwater. Need to evaluate whether basic treatment criteria can be met.
	Enhanced Filtration	Coagulant (alum, iron salts, PAC) + polymer	Conventional media filter	Aqua-Aerobic – AquaABF Siemens – GraviSand Non-vendor installations	Yes	Yes	Yes	Drop from further evaluation	Low loading rates for conventional filters result in large unit sizes which are unlikely to fit the site.
			Upflow continuous backwash filter	Parkson - Dynasand Westech – SuperSand	Yes	Yes	Yes	Proceed with further evaluation	Selection rationale: - Gravity fed – compatible with previously developed site layout. Issues to be addressed: - Need to evaluate removal efficiency at low concentrations. - Size may be issue for compact site footprint.
			Pressurized sand filter	Purus (packaged system)	Yes	Yes	Yes	Proceed with further	Selection rationale:

				Aquatech Hydroflo Loprest Severn-Trent Roberts				evaluation	- Established technology with multiple vendors. Issues to be addressed: - Need to evaluate removal efficiency at low concentrations. - Not gravity fed and may require second set of feed pumps; increases mechanical complexity and electrical load. This becomes important when considering electrical service upgrades for future expansion.
			Pulsed or moving bed filter	Misco – Pulsed bed filters Siemens – Hydro-Clear Sand Filter	No	Yes	Yes	Drop from further consideration	Footprint; high mechanical complexity relative to sand filtration without footprint/backwash benefits of disc filters.
			Pressurized disc filter	Arkal – Spin Klin Gardner-Denver / Nash	Yes	Yes	Yes	Drop from further consideration	Footprint; high mechanical complexity relative to sand filtration without footprint/backwash benefits of disc filters.
			Gravity disc filter	Aqua-Aerobic - MegaDisk Siemens – Forty-X Veolia/Kruger – Hydrotech	Yes	Yes	Yes	Proceed with further evaluation	Selection rationale: - Has been installed in pure stormwater applications. - High loading rates / low backwash rates relative to granular media; beneficial for compact site footprint. Issues to be addressed: - Need to determine whether mechanical complexity allows for remote site automation. - At high loadings, frequent backwashing reduces capacity. - Need to evaluate disc replacement O&M. Discs are proprietary for individual vendors.
		Chitosan or chitosan + conventional coagulant	Upflow continuous backwash or pressurized sand filter	Clean Water Compliance Water Tectonics Clear Creek Systems Dungeness Environmental	Yes	No	Yes	Proceed with further evaluation	Selection rationale: - Established for stormwater, including large end-of-pipe systems. - Chelating properties of chitosan may enhance metals removal. - Vendor O&M contracts available. Issues to be addressed: - Systems requiring separate sedimentation and filtration may require large site footprints.
Innovative / Adaptive Use	Compressible Media Filtration	Coagulant (alum, iron salts, PAC) + polymer	Compressible media	Schreiber – Fuzzy Filter WWETCO – FlexFilter	Yes	Yes	Yes	Drop from further consideration	Installed systems have observed high backwash flow rates and lower than expected loading rates due to filter blinding.
	Ballasted High-Rate Clarification	Coagulant (alum, iron salts, PAC) + polymer	Ballasted sedimentation	Veolia/Kruger – Actiflo IDI – Densadeg Siemens - CoMag	Yes	Yes	Yes	Proceed with further evaluation	Selection rationale: - Established technology for CSO and wet weather treatment - Increasing use in stormwater applications. - Gravity fed – compatible with previously developed site layout. Issues to be addressed - Cost. - Complexity of automation for remotely operated site. - Startup time – may miss first flush if system cannot start quickly for storm events.
	Electrocoagulation	Electrocoagulation	Upflow continuous backwash or pressurized filter	Water Tectonics – Waveionics OilTrap Kaselco Powell Water Recovery	Yes	No	Yes	Proceed with further evaluation	Selection rationale: - Established for stormwater (typically for smaller applications) and industrial wastewater / produced water / mining sectors. - Pilot tested at the site. Issues to be addressed: - Cost. - Requires separation stage (filtration or clarification) that must be coordinated.
	Adsorptive Clarification	Coagulant (alum, iron salts, PAC) + polymer	Clarification with adsorptive media	Siemens – Trident HS Westech – Tricon	No	Yes	Yes	Drop from further consideration	Adaptive technology that has not been applied for stormwater.

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	Biologically active filtration	Various	GAC with biofilm	?	No	Yes	Yes	Drop from further consideration	Continuous flow required to sustain biologically active film. Difficult to implement in stormwater applications without a regular base flow.
	Ion exchange	NA	Ion exchange resin	Aquatech Siemens	Yes	Yes	Yes	Drop from further consideration	Mechanically complex and costly; stormwater applications are geared toward heavily impacted site-specific industrial stormwater.
Emerging	Enhanced filtration with active media	Iron salts	Upflow continuous backwash filter with reactive media (HFO coated sand)	Blue Water Technologies – BlueCat / BluePro	No	No	No	Drop from further consideration	Emerging technology that has not been applied to stormwater. HFO is primarily intended for nutrient removal. Vendor literature states that the system can be applied for arsenic removal and may remove other metals depending on water chemistry.

* Includes site-specific systems for treatment of construction and industrial stormwater.

Next Steps for Technology Evaluation

1. Confirm recommendations from screening and select technologies for further evaluation.
2. Complete installation lists and contact owners / operators.
3. Evaluate process mechanical engineering considerations for applications of technologies to Water Quality Facility:
    a. Expandability – footprint, power requirements, ability to expand modularly, etc.
    b. Enhancement – can the process be enhanced for dissolved metals removal, or would this require a second treatment stage?
    c. Solids handling and storage.
    d. Chemical storage.
    e. Controllability – ability to operate system over a range of influent characteristics over the course of a storm event.
4. Evaluate performance:
    a. Conventional pollutants. Differentiate data from end-of-pipe stormwater applications vs. CSO or wet-weather wastewater applications.
    b. Toxic pollutants:
        i. Organics – PCBs and cPAHs.
        ii. Metals – total and dissolved copper, zinc, and lead.
        iii. Others?

Candidate Technologies – Installations and Engineering Considerations									
Technology	Example Vendors / Systems	Issues to be Addressed	Installations		Evaluation Criteria				
			Stormwater	Wet Weather / CSO	Expansion	Enhancement for dissolved metals removal	Solids Handling and Storage	Chemical Purchase, Storage, and Handling	Controllability
CEPT	WetSep (packaged system) Non-vendor installations	Efficiency decreases at low influent concentrations, particularly for storm-water. Need to evaluate whether basic treatment criteria can be met.	No large-scale installa-tions identified; Ecology has found WetSep system functionally equivalent to CESF for construction site stormwater within certain parameters.	Hartford, CT (in design) Northeast Ohio Regional Sewer District (3 installa-tions in design), Cleveland, OH Columbia Boulevard Treatment Plant, Portland, OR Tacoma North Plant, Tacoma, WA Brightwater Treatment Plant, Woodinville, WA	Units can be added modularly. Chemical storage and handling should be sized for buildout. Generally low power requirements; power feed can be sized for buildout.	Some enhancement achievable through adjust-ment of coagulant / polymer. >50% removal may require additional treatment stage.	Clarifier sludge suitable for vault storage.	Requires storage and handling for coagulant (alum, iron salts, PAC) + polymer.	Performance at low and high solids loads should be evaluated. Efficacy drops as TSS concentration decreases. Depending on duration of storm event, a large portion of the flow from a given storm may have TSS concentrations below the level where CEPT is effective.
Enhanced Filtration (chemical – granular media)	Packaged: StormwateRX – Aquip/Purus Pressure sand: Aquatech Hydroflo Gravity – continuous backwash: Parkson - Dynasand Westech – SuperSand	Packaged: Need to evaluate removal efficiency at low concentrations. Size may be issue for compact site footprint. Pressure sand: Need to evaluate removal efficiency at low concentrations. Not gravity fed and may require second set of feed pumps; increases mechanical complexity and electrical load. This becomes important when considering	Packaged: Calbag Metals, Portland, OR JT Marine, Battleground, WA Sanitary Service Company, Bellingham, WA Canal Boatyard, Seattle, WA Pressure sand: Metal recycler, Los	Packaged: NA; Aquip/Purus system designed for stormwater treatment. Pressure sand: No large-scale installations identified; common in drinking water, industrial wastewater, and oilfield services. Continuous backwash: Boca Raton, FL	Units can be added modularly. Chemical storage and handling should be sized for buildout. Packaged and gravity systems have low power consumption; size power for buildout. Pressurized systems likely require backwash pumps and filter feed pumps, resulting in high power	Some enhancement achievable through adjust-ment of coagulant / polymer. >50% removal may require additional treatment stage.	Backwash water may require backwash clarifier.	Requires storage and handling for coagulant (alum, iron salts, PAC) + polymer.	Performance at low and high solids loads should be evaluated. Generally adaptable to a range of TSS concentrations, although this may require monitoring of solids concenra-tions for control of coagulant dosing.

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		electrical service upgrades for future expansion. Gravity – continuous backwash: Need to evaluate removal efficiency at low concentrations. Size may be issue for compact site footprint.	Angeles, CA Continuous backwash: Refinery stormwater	Peach Lake, NY Kitsap County, WA	consumption. Phasing of electrical feed should be considered. Backwash clarifier should be sized for buildout.				
Enhanced Filtration (chemical – cloth disc)	Aqua-Aerobic - MegaDisk Siemens – Forty-X Veolia/Kruger – Hydrotech	Need to determine whether mechanical complexity allows for remote site automation. At high loadings, frequent backwashing reduces capacity. Need to evaluate disc replacement O&M. Discs are proprietary for individual vendors.	Bagsvaerd, Copenhagen, Denmark Brunnen, Switzerland Neufeld-Wankdorf, Bern, Switzerland Pfaffensteig, Bern, Switzerland Richmond, TX (in construction)	Inverness, FL Lake City, FL Fox Metro WRD, Oswego, IL Oconomowoc, WI	Units can be added modularly. Chemical storage and handling should be sized for buildout. Low power consumption; size power for buildout. Backwash clarifier (if required) should be sized for buildout.	Some enhancement achievable through adjustment of coagulant / polymer. >50% removal may require additional treatment stage.	Low backwash volumes with higher solids concentrations relative to sand filtration. Backwash clarifier may not be required.	Requires storage and handling for coagulant (alum, iron salts, PAC) + polymer.	Performance at low and high solids loads should be evaluated. Some installations have reported significant increases in backwash frequency at high TSS concentrations or with large particles. Frequent need to backwash reduces filter loading capacity.
Enhanced Filtration (chitosan – granular media)	Clean Water Compliance Water Tectonics Clear Creek Systems Dungeness Environmental	Systems requiring separate sedimentation and filtration may require large site footprints.	Roseville, CA Oceanside, CA (construction) San Diego County, CA North Boeing Field, Seattle, WA Port of Seattle 3rd Runway (construction), SeaTac, WA	None identified; systems in use for groundwater treatment and industrial wastewater.	Units can be added modularly. Chemical storage and handling should be sized for buildout. Packaged and gravity systems have low power consumption; size power for buildout. Pressurized systems likely require backwash pumps and filter feed pumps, resulting in high power consumption. Phasing of electrical feed should be considered. Backwash clarifier should be sized for buildout.	CESF exhibits generally good (>50%) dissolved metals removal through chelation. Removal can be enhanced with coprecipitation using conventional coagulants.	Backwash water may require backwash clarifier.	Requires storage and handling chitosan product; multiple vendors currently operating. May require storage and handling for coagulant (alum, iron salts, PAC).	Performance at low and high solids loads should be evaluated. Generally adaptable to a range of TSS concentrations, although this may require monitoring of solids concentrations for control of coagulant dosing.
Ballasted High-Rate Clarification	Veolia/Kruger – Actiflo IDI – Densadeg Siemens - CoMag	Cost. Complexity of automation for remotely operated site. Startup time – may miss first flush if system cannot start quickly for storm events.	Limoges, Haute-Vienne, France Meru Station, Oise, France Saint-Chamond, Loire, France Boeing, Los Angeles, CA	Lawrence, KS Salem, OR St Bernard Parish, LA Bremerton, WA Port Orchard, WA Tacoma, WA	Units can be added modularly. Chemical storage and handling should be sized for buildout. Low power consumption; size power for buildout.	Some enhancement achievable through adjustment of coagulant / polymer. >50% removal may require additional treatment stage.	Clarifier sludge suitable for vault storage.	Requires storage and handling for coagulant (alum, iron salts, PAC) + polymer.	Performance at low and high solids loads should be evaluated. Generally adaptable to a range of TSS concentrations, although this may require monitoring of solids concentrations for control of coagulant dosing.
Electrocoagulation	Water Tectonics – Waveionics OilTrap Kaselco Powell Water Recovery	Cost. Requires separation stage (filtration or clarification) that must be coordinated.	Pure Metal Galvanizing, Brantford, Ontario, Canada ELG Metals, Houston, TX Tesoro Refinery, Anacortes, WA American Steel, Kent, WA Aleutian Spray Fisheries (construction), Seattle, WA	None identified; systems in use in industrial process water, oilfield, and mining applications.	Process units, including EC modules, can be added modularly. Phasing of electrical feed should be considered, especially if pressure sand filtration is incorporated into the separation stage. Backwash clarifier, if required, should be sized for buildout.	EC exhibits generally good (approx. 50%) dissolved metals removal. Process can be adjusted somewhat by controlling conductivity through salt addition and voltage. However, system is generally dependent on manufacturer advances in EC cell technology. Additional enhancement of	Solids handling dependent on separation stage selected. If granular media filtration is used, backwash water may require backwash clarifier. If clarification is used, sludge is suitable for vault storage. Manufacturer claims state that sludge is lower volume compared to	Minimal chemical storage and handling; EC cells replace conventional coagulants.	Performance at low and high solids loads should be evaluated. Generally adaptable to a range of TSS concentrations. Conductivity is monitored online for control of coagulant dosing. Coagulation controllable through voltage and conductivity adjustments through salt addition.

			SPU Pilot Project, Seattle, WA			metals removal would require carbon.	conventional coagulation.		

Attachment C: Basis-of-Estimate and Vendor Costs

Memorandum

Date: March 27, 2014
To: Bruce Ball, Seattle
From: Teakia Sabb/Jay Laba, Raleigh
Reviewed by: Butch Matthews, Jacksonville
Project No.: 135668-007-***

Subject: SPU South Park Soil Remediation
Preliminary Design Completion
Basis of Estimate of Probable Construction Cost

The Basis of Estimate Report and supporting estimate reports for the subject project are attached. Please call me if you have questions or need additional information.

TS:jl

Enclosures (3):

1. Basis of Estimate Report
2. Summary Estimate
3. Detailed Estimate

Basis of Estimate Report

SPU South Park Soil Remediation

Introduction

Brown and Caldwell (BC) is pleased to present this opinion of probable construction cost (estimate) prepared for the South Park Pump Station and Water Quality Facility in Seattle, Washington.

Summary

This Basis of Estimate contains the following information:

- Scope of work
- Background of this estimate
- Class of estimate
- Estimating methodology
- Direct cost development
- Indirect cost development
- Bidding assumptions
- Estimating assumptions
- Estimating exclusions
- Allowances for known but undefined work
- Contractor and other estimate markups

Scope of Work

This estimate includes the ground improvements and the construction of a pump station and a water quality treatment facility. It represents estimate for pump station and water quality facility alternatives.

Background of this Estimate

In a previously submitted 90 and 5-percent estimates dated June 2009 and March 2012, respectively, BC's estimating team presented estimates of probable costs based on documents furnished to the Estimating and Scheduling Group (ESG), and on the overall market conditions at that time. As a result of refinements in the projects, the sizes and scopes of features in the projects have changed and have now moved back into the preliminary planning stages. These changes are reflected in the current estimate.

The attached estimates of probable construction costs are based on documents dated January 2014, received by the ESG. These documents are described as 5 percent complete based on the current project progression, additional or updated scope and/or quantities, and ongoing discussions with the project team. Further information can be found in the detailed estimate reports.

Class of Estimate

In accordance with the Association for the Advancement of Cost Engineering International (AACE) criteria, this is a Class 4 estimate. A Class 4 estimate is defined as a Planning Level or Design Technical Feasibility Estimate. Typically, engineering is from 1 to 15 percent complete. Class 4 estimates are used to prepare planning level cost scopes or to evaluate alternatives in design conditions and form the base work for the Class 3 Project Budget or Funding Estimate.

Expected accuracy for Class 4 estimates typically range from -30 to +50 percent, depending on the technological complexity of the project, appropriate reference information and the inclusion of an appropriate contingency determination. In unusual circumstances, ranges could exceed those shown.

Estimating Methodology

This estimate was prepared using quantity take-offs, vendor quotes and equipment pricing furnished either by the project team or by the estimator. The estimate includes direct labor costs and anticipated productivity adjustments to labor, and equipment. Where possible, estimates for work anticipated to be performed by specialty subcontractors have been identified.

Construction labor crew and equipment hours were calculated from production rates contained in documents and electronic databases published by R.S. Means, Mechanical Contractors Association (MCA), National Electrical Contractors Association (NECA), and Rental Rate Blue Book for Construction Equipment (Blue Book).

This estimate was prepared using BC's estimating system, which consists of a Windows-based commercial estimating software engine using BC's material and labor database, historical project data, the latest vendor and material cost information, and other costs specific to the project locale.

Direct Cost Development

Costs associated with the General Provisions and the Special Provisions of the construction documents, which are collectively referred to as Contractor General Conditions (CGC), were based on the estimator's interpretation of the contract documents. The estimates for CGCs are divided into two groups: a time-related group (e.g., field personnel), and non-time-related group (e.g., bonds and insurance). Labor burdens such as health and welfare, vacation, union benefits, payroll taxes, and workers compensation insurance are included in the labor rates. No trade discounts were considered.

Indirect Cost Development

Excise sales tax has been applied to the total probable contract value. A percentage allowance for contractor's home office expense has been included in the overall rate markups. The rate is standard for this type of heavy construction and is based on typical percentages outlined in Means Heavy Construction Cost Data.

The contractor's cost for builders risk, general liability and vehicle insurance has been included in this estimate. Based on historical data, this is typically two to four percent of the overall construction contract amount. These indirect costs have been included in this estimate as a percentage of the gross cost, and are added after the net markups have been applied to the appropriate items.

Bidding Assumptions

The following bidding assumptions were considered in the development of this estimate.

1. Bidders must hold a valid, current Contractor's credentials, applicable to the type of project.

2. Bidders will develop estimates with a competitive approach to material pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions or any other unplanned costs.
3. Estimated costs are based on a minimum of four bidders. Actual bid prices may increase for fewer bidders or decrease for a greater number of bidders.
4. Bidders will account for General Provisions and Special Provisions of the contract documents and will perform all work except that which will be performed by traditional specialty subcontractors as identified here:
   – Electrical
   – HVAC systems

Estimating Assumptions

As the design progresses through different completion stages, it is customary for the estimator to make assumptions to account for details that may not be evident from the documents. The following assumptions were used in the development of this estimate.

1. Contractor performs the work during normal daylight hours, nominally 7 a.m. to 5 p.m., Monday through Friday, in an 8-hour shift. No allowance has been made for additional shift work or weekend work.
2. Contractor has complete access for lay-down areas and mobile equipment.
3. Equipment rental rates are based on verifiable pricing from the local project area rental yards, Blue Book rates and/or rates contained in the estimating database.
4. Contractor markup is based on conventionally accepted values that have been adjusted for project-area economic factors.
5. Major equipment costs are based on both vendor supplied price quotes obtained by the project design team and/or estimators, and on historical pricing of like equipment.
6. Process equipment vendor training using vendors' standard Operations and Maintenance (O&M) material, is included in the purchase price of major equipment items where so stated in that quotation.
7. Bulk material quantities are based on manual quantity take-offs.
8. There is sufficient electrical power to feed the specified equipment. The local power company will supply power and transformers suitable for this facility.
9. Soils are of adequate nature to support the structures. No piles have been included in this estimate.
10. There shall be a metal roof and aluminum doors on the electrical building.
11. Trenched piping shall be covered at a depth of 4 feet.
12. The concrete slab for the chemical building shall be 12'' thick with a 1'' overhang on top of 18'' of bedding material.
13. The solid storage building shall be 12' below grade.

Estimating Exclusions

The following estimating exclusions were assumed in the development of this estimate.

1. Hazardous materials remediation and/or disposal.
2. O&M costs for the project with the exception of the vendor supplied O&M manuals.
3. Utility agency costs for incoming power modifications.
4. Permits beyond those normally needed for the type of project and project conditions.

Allowances for Known but Undefined Work

The following allowances were made in the development of this estimate.

1. Electrical and Instrumentation

Contractor and Other Estimate Markups

Contractor markup is based on conventionally accepted values which have been adjusted for project-area economic factors. Estimate markups are shown in Table 1.

Table 1. Estimate Markups

Item	Rate (%)
Net Cost Markups	
Labor (employer payroll burden)	10
Materials and process equipment	8
Equipment (construction-related)	8
Subcontractor	5
Material Shipping and Handling	2
Escalation to Midpoint of Construction	13.5
Gross Cost Markups	
Contractor General Conditions	10
Start-up, Training and O&M	2
Construction Contingency	30
Builders Risk, Liability and Auto Insurance	2
Performance and Payment Bonds	1.5
Sales Tax (Excise-Gross Receipts-Contract Value)	9.5

Labor Markup

The labor rates used in the estimate were derived chiefly from the latest published State Prevailing Wage Rates. These include base rate paid to the laborer plus fringes. A labor burden factor is applied to these such that the final rates include all employer paid taxes. These taxes are FICA (which covers social security plus Medicare), Workers Comp (which varies based on state, employer experience and history) and unemployment insurance. The result is fully loaded labor rates. In addition to the fully loaded labor rate, an overhead and profit markup is applied at the back end of the estimate. This covers payroll and accounting, estimator's wages, home office rent, advertising and owner profit.

Materials and Process Equipment Markup

This markup consists of the additional cost to the contractor beyond the raw dollar amount for material and process equipment. This includes shop drawing preparation, submittal and/or re-submittal cost, purchasing and scheduling materials and equipment, accounting charges including invoicing and payment, inspection of received goods, receiving, storage, overhead and profit.

Equipment (Construction) Markup

This markup consists of the costs associated with operating the construction equipment used in the project. Most GCs will rent rather than own the equipment and then charge each project for its equipment cost. The equipment rental cost does not include fuel, delivery and pick-up charges, additional insurance requirements on rental equipment, accounting costs related to home office receiving invoices and payment. However, the crew rates used in the estimate do account for the equipment rental cost. Occasionally, larger contractors will have some or all of the equipment needed for the job, but in order to recoup their initial purchasing cost they will charge the project an internal rate for equipment use which is similar to the rental cost of equipment. The GC will apply an overhead and profit percentage to each individual piece of equipment whether rented or owned.

Subcontractor Markup

This markup consists of the GC's costs for subcontractors who perform work on the site. This includes costs associated with shop drawings, review of subcontractor's submittals, scheduling of subcontractor work, inspections, processing of payment requests, home office accounting, and overhead and profit on subcontracts.

Sales Tax (Excise-Gross Receipts-Contract Value)

This is the tax that the contractor must pay according to state and local taxation laws. The percentage is based on state, county and local rates in place at the time the estimate was prepared. The percentage is applied to the total anticipated contract value.

Contractor Startup, Training, and O&M Manuals

This cost markup is often confused with either vendor startup or owner startup. It is the cost the GC incurs on the project beyond the vendor startup and owner startup costs. The GC generally will have project personnel assigned to facilitate the installation, testing, startup and O&M Manual preparation for equipment that is put into operation by either the vendor or owner. These project personnel often include an electrician, pipe fitter or millwright, and/or I&E technician. These personnel are not included in the basic crew makeup to install the equipment but are there to assist and trouble shoot the startup and proper running of the equipment. The GC also incurs a cost for startup for such things as consumables (oil, fuel, filters, etc.), startup drawings and schedules, startup meetings and coordination with the plant personnel in other areas of the plant operation.

Builders Risk, Liability, and Vehicle Insurance

This percentage comprises all three items. There are many factors which make up this percentage, including the contractor's track record for claims in each of the categories. Another factor affecting insurance rates has been a dramatic price increase across the country over the past several years due to domestic and foreign influences. Consequently, in the construction industry we have observed a range of 0.5 to 1 percent for Builders Risk Insurance, 1 to 1.25 percent for General Liability Insurance, and 0.85 to 1 percent for Vehicle Insurance. Many factors affect each area of insurance, including project complexity and contractor's requirements and history. Instead of using numbers from a select few contractors, we believe it is more prudent to use a combined 2 percent to better reflect the general costs across the country. Consequently, the actual cost could be higher or lower based on the bidder, region, insurance climate, and on the contractor's insurability at the time the project is bid.

Material Shipping and Handling

This can range from 2 to 6 percent, and is based on the type of project, material makeup of the project, and the region and location of the project. Material shipping and handling covers delivery costs from vendors, unloading costs (and in some instances loading and shipment back to vendors for rebuilt equipment), site paper work, and inspection of materials prior to unloading at the project site. BC typically adjusts this percentage by the amount of materials and whether vendors have included shipping costs in the quotes that were used to prepare the estimate. This cost also includes the GC's cost to obtain local supplies; e.g., oil, gaskets and bolts that may be missing from the equipment or materials shipped.

Escalation to Midpoint for Labor, Materials and Subcontractors

In addition to contingency, it is customary for projects that will be built over several years to include an escalation to midpoint of anticipated construction to account for the future escalation of labor, material and equipment costs beyond values at the time the estimate is prepared. For this project, the anticipated rate of escalation is 13.5 percent per annum.

The estimated construction time for this project is 121 months, exclusive of unusual weather or site conditions delays. Construction is anticipated to start June 2016 and complete June 2023. The escalation factors used in this estimate are calculated from the date the estimate is finalized to the anticipated midpoint of construction at approximately 51 months from the date of this estimate.

Construction Contingency

The contingency factor covers unforeseen conditions, area economic factors, and general project complexity. This contingency is used to account for those factors that can not be addressed in each of the labor and/or material installation costs. Based on industry standards, completeness of the project documents, project complexity, the current design stage and area factors, construction contingency can range from 10 to 50 percent.

Performance and Payment Bonds

Based on historical and industry data, this can range from 0.75 to 3 percent of the project total. There are several contributing factors including such items as size of the project, regional costs, contractor's historical record on similar projects, complexity and current bonding limits. BC uses 1.5 percent for bonds, which we have determined to be reasonable for most heavy construction projects.

DETAILED ESTIMATE REPORT

SPU South Park Soil Remediation - Water Facitilities Alternatives >5% Design Level

Project Number:	135668-007-***
BC Project Manager:	Bruce Ball
BC Office:	Seattle
Estimate Original Issue Date:	March 27, 2014
Lead Estimator:	Teakia Sabb/Jay Laba
Estimate QA/QC Reviewer:	Butch Matthews
Estimate QA/QC Date:	March 20, 2014

PROCESS LOCATION/AREA INDEX

~~1000 - CEPT~~
~~2000 - ENHANCED FILTRATION (SAND PRESSURE)~~
3000 - ENHANCED FILTRATION (CHITOSAN)
~~4000 - ENHANCED FILTRATION (DISC FILTERS)~~
5000 - BALLASTED SEDIMENTATION
6000 - EC (FILTRATION)
~~7000 - EC (CLARIFICATION)~~

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	ENHANCED FILTRATION (CHITOSAN)									
	01 - SITEWORK									**5,614**
	01590 - Construction Aids									
	01590400 - General equipment rental without operators									
6900D	Rent water tank trailer w/pumped discharge, 5000 gallon capacity - Rent per month	1.5	mnth			1,325.00			1,325.00	1,988
6900D	Rent water tank trailer w/pumped discharge, 5000 gallon capacity - Rent per month 8 MH	8.0	hours	453.33					453.33	3,627
	Construction Aids Total									**5,614**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	01 - SITEWORK									**1,139,603**
	01590 - Construction Aids									
	01590400 - General equipment rental without operators									
7030B	**Rent trench box, 3000 lbs 6' x 8' - Rent per day**	**2.0**	**days**			**84.50**			**84.50**	**169**
	Construction Aids Total									**169**
	02000 - Site Civil Work									
	02010 - Fire hydrants									
0040	ALLOWANCE - site civil including pavement, fencing, misc parking, barriers, vault, etc.	1.0	lsum	32,745.21	95,882.70	17,635.74	36,369.30		182,632.95	182,633
0140	ALLOWANCE - yard piping	1.0	lsum	154,530.00	220,420.00	47,335.50		0.01	422,285.51	422,286
	02460 - Hauling									
0051	ALLOWANCE - Disposal of lead contaminated soil, quote	1.0	LSUM				111,090.00		111,090.00	111,090
	02490 - Erosion control									
0040	ALLOWANCE - Erosion control	1.0	lsum	3,589.26	1,489.66				5,078.93	5,079
	02560 - Drainage									
0010	ALLOWANCE - Sediment collection system, tanks, swales, and pond, allowance	1.0	lsum	5,386.67	9,888.00	1,072.00			16,346.67	16,347
	02840 - Landscaping									
0320	Landscaping, subcontract	1.0	lsum				26,162.00		26,162.00	26,162
	Site Civil Work Total									**763,596**
	02200 - Site Preparation									
	02220330 - Selective Demolition, Dump Charges									
9999	**Dump Charge, typical urban city, fees only, bldg constr mat'ls**	**343.7**	**ton**					**33.00**	**33.00**	**11,341**
	Site Preparation Total									**11,341**
	02300 - Earthwork									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02315120 - Backfill, Structural									
4420	Backfill, structural, common earth, 200 H.P. dozer, 300' haul, from existing stockpile, excludes compaction	10,715.8	L.C.Y.	1.01		1.85			2.86	30,600
	02315310 - Compaction, General									
7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	9,717.2	E.C.Y.	2.08		0.17			2.26	21,928
	02315424 - Excavating, Bulk Bank Measure									
4400	Excavating, bulk bank measure, in sheeting or cofferdam, with all other equipment, minimum	10,582.5	B.C.Y.	6.04		7.60			13.64	144,306
	02315492 - Hauling									
0009	Loading Trucks, F.E. Loader, 3 C.Y.	4,909.6	cuyd	0.76		1.24			2.00	9,840
9498	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 18 C.Y. 8 wheel truck, cycle 20 miles, 45 MPH, excludes loading equipment	4,909.6	L.C.Y.	2.96		5.46			8.41	41,305
	02315610 - Excavating, Trench									
1000	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 10' to 14' deep, excludes sheeting or dewatering	376.5	B.C.Y.	1.79		1.96			3.75	1,412
	02315640 - Utility Bedding									
0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	1,652.6	L.C.Y.	9.12	31.50	2.50			43.12	71,266
	Earthwork Total									**320,658**
	11000 - Equipment									
	11100 - Pumps miscellaneous									
0270	Bypass pump, portable, diesel powered, 10" discharge	12.0	week	1,546.26	1,447.55				2,993.81	35,926
0331	Bypass pump operation, 2 cks @ 2 hr (night shift), per 24 hour day	20.0	days	395.67					395.67	7,913
	Equipment Total									**43,839**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02 - STRUCTURAL									1,113,143
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
6610	Scaffolding, steel tubular, heavy duty shoring for elevated slab forms, floor area, rent/month of materials only, to 14'-8" high	20.0	Csf		43.00				43.00	860
	Temporary Facilities & Controls Total									860
	02200 - Site Preparation									
	02220330 - Selective Demolition, Dump Charges									
9999	**Dump Charge, typical urban city, fees only, bldg constr mat'ls**	**506.3**	**ton**					**33.00**	**33.00**	**16,709**
	Site Preparation Total									16,709
	02300 - Earthwork									
	02315120 - Backfill, Structural									
4420	**Backfill, structural, common earth, 200 H.P. dozer, 300' haul, from existing stockpile, excludes compaction**	**40.2**	**L.C.Y.**	**1.01**		**1.85**			**2.86**	**115**
	02315310 - Compaction, General									
7500	**Compaction, 2 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**36.2**	**E.C.Y.**	**1.76**		**0.42**			**2.18**	**79**
7520	**Compaction, 3 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**102.3**	**E.C.Y.**	**2.64**		**0.63**			**3.28**	**335**
7540	**Compaction, 4 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**306.8**	**E.C.Y.**	**3.53**		**0.85**			**4.37**	**1,342**
	02315492 - Hauling									
0009	**Loading Trucks, F.E. Loader, 3 C.Y.**	**506.3**	**cuyd**	**0.76**		**1.24**			**2.00**	**1,015**
9498	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 18 C.Y. 8 wheel truck, cycle 20 miles, 45 MPH, excludes loading equipment**	**506.3**	**L.C.Y.**	**2.96**		**5.46**			**8.41**	**4,260**
	02315610 - Excavating, Trench									
0060	**Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering**	**445.3**	**B.C.Y.**	**4.75**		**2.04**			**6.79**	**3,024**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02315640 - Utility Bedding									
0100	**Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction**	**356.8**	**L.C.Y.**	**9.12**	**31.50**	**2.50**			**43.12**	**15,385**
	Earthwork Total									**25,554**
	03100 - Concrete Forms & Accessories									
	03110420 - Forms In Place, Elevated Slabs									
1500	C.I.P. concrete forms, elevated slab, flat plate, plywood, 15' to 20' high ceilings, 4 use, includes shoring, erecting, bracing, stripping and cleaning	2,000.0	SF	6.06	1.25				7.31	14,614
	03110445 - Forms In Place, Slab On Grade									
3050	**C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**360.6**	**sfca**	**4.45**	**0.80**				**5.25**	**1,894**
3550	**C.I.P. concrete forms, slab on grade, depressed, edge, wood, 12" to 24" high, 4 use, includes erecting, bracing, stripping and cleaning**	**573.0**	**LF**	**11.10**	**0.80**				**11.90**	**6,816**
	03110455 - Forms In Place, Walls									
2550	**C.I.P. concrete forms, wall, job built, plywood, 8 to 16' high, 4 use, includes erecting, bracing, stripping and cleaning**	**11,240.0**	**sfca**	**7.59**	**0.66**				**8.25**	**92,718**
	03150860 - Waterstop									
0600	**Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide**	**1,375.0**	**LF**	**4.05**	**4.94**				**8.99**	**12,360**
	Concrete Forms & Accessories Total									**128,403**
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									
0602	**Reinforcing Steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**85,485.5**	**lb**	**0.57**	**0.50**				**1.07**	**91,150**
0702	**Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**55,481.6**	**lb**	**0.40**	**0.50**				**0.90**	**50,063**
2000	**Reinforcing steel, unload and sort, add to base**	**77.9**	**ton**	**41.24**		**7.45**			**48.68**	**3,794**
2210	**Reinforcing steel, crane cost for handling, average, add**	**77.9**	**ton**	**44.23**		**8.06**			**52.29**	**4,075**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
2450	**Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**13,904.4**	**lb**	**1.64**	**0.55**				**2.19**	**30,439**
	Concrete Reinforcement Total									179,521
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**Structural concrete, ready mix, normal weight, 4000 psi, includes local aggregate, sand, Portland cement (Type I) and water, delivered, excludes all additives and treatments**	**632.6**	**CY**		**102.00**				**102.00**	**64,521**
	03310700 - Placing Concrete									
1500	Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes leveling (strike off) & consolidation, excludes material	61.7	CY	22.37		4.99			27.35	1,689
4650	**Structural concrete, placing, slab on grade, pumped, over 6" thick, includes leveling (strike off) & consolidation, excludes material**	**397.4**	**CY**	**19.36**		**4.31**			**23.68**	**9,408**
5350	**Structural concrete, placing, walls, pumped, 15" thick, includes leveling (strike off) & consolidation, excludes material**	**173.5**	**CY**	**30.07**		**6.63**			**36.70**	**6,365**
	03350300 - Finishing Floors									
0150	**Concrete finishing, floors, basic finishing for unspecified flatwork, bull float, manual float & broom finish, includes edging and joints, excludes placing, striking off & consolidating**	**12,942.4**	**SF**	**0.78**					**0.78**	**10,133**
	03350350 - Finishing Walls									
0150	**Concrete finishing, walls, carborundum rub, wet, includes breaking ties and patching voids**	**115,960.3**	**SF**	**2.92**					**2.92**	**338,444**
	Cast-In-Place Concrete Total									430,560
	04800 - Masonry Assemblies									
	04810100 - Brick Veneer									
B301	8" CMU enterior walls w/ Brick Veneer	2,140.0	sqft	21.19	11.90	0.59			33.68	72,084
	Masonry Assemblies Total									72,084
	05300 - Metal Deck									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	05310300 - Metal Decking									
2900	Metal roof decking, steel, open type B wide rib, galvanized, under 50 Sq, 1-1/2" D, 18 gauge	1,130.0	SF	0.65	2.91	0.04			3.60	4,066
	Metal Deck Total									**4,066**
	05500 - Metal Fabrications									
	05530300 - Floor Grating, Aluminum									
0132	Access Platform	100.0	SF	70.50	123.00	5.05			198.55	19,855
	Metal Fabrications Total									**19,855**
	13120 - Pre-Engineered Structures									
	13128700 - Pre-Engineered Steel Buildings									
0150	Pre-engineered Aluminum Building 80'X53', 14' high, incl. anchor bolts	4,240.0	SF	16.22	23.35	13.49			53.06	224,974
	Pre-Engineered Structures Total									**224,974**
	15400 - Plumbing Fixtures & Equipment									
	15418600 - Sinks									
6790	Bathroom - complete	1.0	EA	3,543.80	7,013.64				10,557.44	10,557
	Plumbing Fixtures & Equipment Total									**10,557**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	03 - MECHANICAL								$1,571,481	~~808,338~~
	05500 - Metal Fabrications									
	05580950 - Miscellaneous Fabrication									
0020bc	Pump mounting base plate, complete w/ anchor bolts, 8 sf	3.0	each	779.81	1,745.73				2,525.54	7,577
	Metal Fabrications Total									**7,577**
	09900 - Paints & Coatings									
	09910641 - B & C Coatings									
0020bc	Pipe Painting - 16" dia to PS, B & C coating system E-2 (Epoxy, metal pipe)	418.7	sqft	1.83	2.22				4.05	1,696
	Paints & Coatings Total									**1,696**
	11000 - Equipment									
	11000100 - Process Equipment									
0170	Tank, polymer storage 1500	1.0	each	961.78	4,440.00				5,401.78	5,402
0550	Mixer, 2500 gpm, 15HP	6.0	each	2,099.83	18,000.00				20,099.83	120,599
0700	Filter Pump, 1000-gpm	4.0	EA	7,627.60	21,000.00				28,627.60	114,510
1120	Sand Filter Skid, 1000-gpm	3.0	EA	6,749.75	47,000.00			1,244.08	54,993.83	164,981
	11000400 - Slide gates									
0080	Hydraulic structures, slide gate, ab & grout,48" x 48"	3.0	each	1,917.53	5,000.00	429.33			7,346.86	22,041
	11000600 - Chemical Tanks									
0190	Tank, caustic 500gal	1.0	each	620.05	2,675.00				3,295.05	3,295
0190	Tank, ferric choride 3000gal	1.0	each	1,536.15	4,900.00				6,436.15	6,436
	11000800 - Chemical Metering Pumps									
0401do	Pump, peristaltic hose, 0.25gpm, ferric	2.0	each	982.05	10,244.00				11,226.05	22,452
0401do	Pump, peristaltic hose, 0.1gpm, caustic	2.0	each	686.98	6,250.00				6,936.98	13,874
0401do	Pump, peristaltic hose, 0.60gpm, ferric	2.0	each	982.05	23,500.00				24,482.05	48,964
	Equipment Total									~~522,555~~

$1,285,698 per Clear Water Services 8/7/14 quote

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	15050 - Basic Materials & Methods									
	15050010 - Miscellaneous Mechanical									
0008	Allowance - Piping, Building Service/Domestic	1,130.0	SF	2.78	3.45	0.55			6.78	7,661
0009	Allowance - Fire Protection	1,130.0	SF	5.05	5.33				10.38	11,729
0009	Allowance - Piping, chemical system	1.0	lsum	9,500.00	16,500.00	3,500.00			29,500.00	29,500
0009	Allowance - Pipe Supports	1.0	lsum	14,000.00	17,500.00	3,500.00			35,000.00	35,000
	Basic Materials & Methods Total									**83,891**
	15200 - Process Piping									
	15200030 - Pipe, Ductile Iron									
0440B	Piping, water dist, DI, cement lined, 18' L, restrained jt, 24" dia	150.0	LF	19.86	77.59	3.60			101.05	15,158
0450B	Piping, water dist, DI, cement lined, 18' L, restrained jt, 30" dia	200.0	LF	21.99	112.21	3.60			137.80	27,560
0450B	**Piping, water dist, DI, cement lined, 30" dia**	**220.0**	**lnft**	**21.99**	**112.21**	**3.60**			**137.80**	**30,316**
0470B	Piping, water dist, DI, cement lined, 18' L, restrained jt, 42" dia	80.0	LF	29.08	211.75	4.80			245.63	19,651
	15200280 - Valves, Plug									
0330	Valves, semi-steel, lubricated plug valve, flanged, 200 psi, 24" pipe	8.0	EA	1,494.07	7,805.00				9,299.07	74,393
	Process Piping Total									**167,078**
	15700 - Heating/Ventilating/Air Conditioning Equipment									
	15700100 - HVAC Allowance									
0010	Allowance - HVAC	1,130.0	sqft	5.54	8.20	1.65			15.39	17,391
	Heating/Ventilating/Air Conditioning Equipment Total									**17,391**
	15950 - Testing/Adjusting/Balancing									
	15955700 - Piping, Testing									
0380	Pipe testing, nondestructive hydraulic pressure test, isolate, 1 hour hold, 20"-48" dia, up to 1000LF	1.0	EA	8,152.00					8,152.00	8,152
	Testing/Adjusting/Balancing Total									**8,152**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	04 - ELECTRICAL & INSTRUMENTATION									**920,010**
	17150 - Instrumentation/Controls									
	17150000 - Instrumentation/Controls									
0010	Allowance - Electrical & Instrumentation	1.0	lsum				920,010.00		920,010.00	920,010
	Instrumentation/Controls Total									**920,010**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	BALLASTED SEDIMENTATION									
	01 - SITEWORK									**5,614**
	01590 - Construction Aids									
	01590400 - General equipment rental without operators									
6900D	Rent water tank trailer w/pumped discharge, 5000 gallon capacity - Rent per month	1.5	mnth			1,325.00			1,325.00	1,988
6900D	Rent water tank trailer w/pumped discharge, 5000 gallon capacity - Rent per month 8 MH	8.0	hours	453.33					453.33	3,627
	Construction Aids Total									**5,614**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	01 - SITEWORK									**821,870**
	01590 - Construction Aids									
	01590400 - General equipment rental without operators									
7030B	Rent trench box, 3000 lbs 6' x 8' - Rent per day	1.0	days			84.50			84.50	85
	Construction Aids Total									**85**
	02000 - Site Civil Work									
	02010 - Fire hydrants									
0040	ALLOWANCE - site civil including pavement, fencing, misc parking, barriers, vault, etc.	1.0	lsum	32,745.21	95,882.70	17,635.74	36,369.30		182,632.95	182,633
0140	ALLOWANCE - yard piping	1.0	lsum	154,530.00	220,420.00	47,335.50		0.01	422,285.51	422,286
	02460 - Hauling									
0051	ALLOWANCE - Disposal of lead contaminated soil, quote	1.0	LSUM				5,520.00		5,520.00	5,520
	02490 - Erosion control									
0040	ALLOWANCE - Erosion control	1.0	lsum	3,589.26	1,489.66				5,078.93	5,079
	02560 - Drainage									
0010	ALLOWANCE - Sediment collection system, tanks, swales, and pond, allowance	1.0	lsum	5,386.67	9,888.00	1,072.00			16,346.67	16,347
	02840 - Landscaping									
0320	Landscaping, subcontract	1.0	lsum				26,162.00		26,162.00	26,162
	Site Civil Work Total									**658,026**
	02200 - Site Preparation									
	02220330 - Selective Demolition, Dump Charges									
9999	**Dump Charge, typical urban city, fees only, bldg constr mat'ls**	**160.0**	**ton**					**33.00**	**33.00**	**5,281**
	Site Preparation Total									**5,281**
	02300 - Earthwork									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02315120 - Backfill, Structural									
4420	Backfill, structural, common earth, 200 H.P. dozer, 300' haul, from existing stockpile, excludes compaction	2,634.4	L.C.Y.	1.01		1.85			2.86	7,523
	02315310 - Compaction, General									
7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	2,482.9	E.C.Y.	2.08		0.17			2.26	5,603
	02315424 - Excavating, Bulk Bank Measure									
4400	Excavating, bulk bank measure, in sheeting or cofferdam, with all other equipment, minimum	2,580.9	B.C.Y.	6.04		7.60			13.64	35,194
	02315492 - Hauling									
0009	Loading Trucks, F.E. Loader, 3 C.Y.	2,286.4	cuyd	0.76		1.24			2.00	4,582
9498	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 18 C.Y. 8 wheel truck, cycle 20 miles, 45 MPH, excludes loading equipment	2,286.4	L.C.Y.	2.96		5.46			8.41	19,236
	02315610 - Excavating, Trench									
1000	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 10' to 14' deep, excludes sheeting or dewatering	186.1	B.C.Y.	1.79		1.96			3.75	698
	02315640 - Utility Bedding									
0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	969.4	L.C.Y.	9.12	31.50	2.50			43.12	41,804
	Earthwork Total									114,640
	11000 - Equipment									
	11100 - Pumps miscellaneous									
0270	Bypass pump, portable, diesel powered, 10" discharge	12.0	week	1,546.26	1,447.55				2,993.81	35,926
0331	Bypass pump operation, 2 cks @ 2 hr (night shift), per 24 hour day	20.0	days	395.67					395.67	7,913
	Equipment Total									43,839

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02 - STRUCTURAL									**896,061**
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
6610	Scaffolding, steel tubular, heavy duty shoring for elevated slab forms, floor area, rent/month of materials only, to 14'-8" high	19.9	Csf		43.00				43.00	855
	Temporary Facilities & Controls Total									**855**
	02200 - Site Preparation									
	02220330 - Selective Demolition, Dump Charges									
9999	Dump Charge, typical urban city, fees only, bldg constr mat'ls	116.8	ton					33.00	33.00	3,855
	Site Preparation Total									**3,855**
	02300 - Earthwork									
	02315120 - Backfill, Structural									
4420	Backfill, structural, common earth, 200 H.P. dozer, 300' haul, from existing stockpile, excludes compaction	15.5	L.C.Y.	1.01		1.85			2.86	44
	02315310 - Compaction, General									
7500	Compaction, 2 passes, 24" wide, 6" lifts, walk behind, vibrating roller	14.0	E.C.Y.	1.76		0.42			2.18	30
7520	Compaction, 3 passes, 24" wide, 6" lifts, walk behind, vibrating roller	23.8	E.C.Y.	2.64		0.63			3.28	78
7540	Compaction, 4 passes, 24" wide, 6" lifts, walk behind, vibrating roller	71.3	E.C.Y.	3.53		0.85			4.37	312
	02315492 - Hauling									
0009	Loading Trucks, F.E. Loader, 3 C.Y.	116.8	cuyd	0.76		1.24			2.00	234
9498	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 18 C.Y. 8 wheel truck, cycle 20 miles, 45 MPH, excludes loading equipment	116.8	L.C.Y.	2.96		5.46			8.41	983
	02315610 - Excavating, Trench									
0060	Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering	109.0	B.C.Y.	4.75		2.04			6.79	740
	02315640 - Utility Bedding									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	82.9	L.C.Y.	9.12	31.50	2.50			43.12	3,573
	Earthwork Total									5,994
	03100 - Concrete Forms & Accessories									
	03110420 - Forms In Place, Elevated Slabs									
1500	C.I.P. concrete forms, elevated slab, flat plate, plywood, 15' to 20' high ceilings, 4 use, includes shoring, erecting, bracing, stripping and cleaning	1,987.5	SF	6.06	1.25				7.31	14,522
	03110445 - Forms In Place, Slab On Grade									
3050	**C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning**	**311.4**	**sfca**	**4.45**	**0.80**				**5.25**	**1,636**
3550	**C.I.P. concrete forms, slab on grade, depressed, edge, wood, 12" to 24" high, 4 use, includes erecting, bracing, stripping and cleaning**	**719.5**	**LF**	**11.10**	**0.80**				**11.90**	**8,559**
	03110455 - Forms In Place, Walls									
2550	**C.I.P. concrete forms, wall, job built, plywood, 8 to 16' high, 4 use, includes erecting, bracing, stripping and cleaning**	**13,950.0**	**sfca**	**7.59**	**0.66**				**8.25**	**115,073**
	03150860 - Waterstop									
0600	**Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide**	**1,598.0**	**LF**	**4.05**	**4.94**				**8.99**	**14,365**
	Concrete Forms & Accessories Total									154,155
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									
0602	**Reinforcing Steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**59,843.7**	**lb**	**0.57**	**0.50**				**1.07**	**63,809**
0702	**Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories**	**68,848.0**	**lb**	**0.40**	**0.50**				**0.90**	**62,124**
2000	**Reinforcing steel, unload and sort, add to base**	**72.8**	**ton**	**41.24**		**7.45**			**48.68**	**3,546**
2210	**Reinforcing steel, crane cost for handling, average, add**	**72.8**	**ton**	**44.23**		**8.06**			**52.29**	**3,809**
2450	**Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**16,601.3**	**lb**	**1.64**	**0.55**				**2.19**	**36,343**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	Concrete Reinforcement Total									169,631
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**Structural concrete, ready mix, normal weight, 4000 psi, includes local aggregate, sand, Portland cement (Type I) and water, delivered, excludes all additives and treatments**	**495.4**	**CY**		**102.00**				**102.00**	**50,531**
	03310700 - Placing Concrete									
1500	Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes leveling (strike off) & consolidation, excludes material	61.3	CY	22.37		4.99			27.35	1,678
4650	**Structural concrete, placing, slab on grade, pumped, over 6" thick, includes leveling (strike off) & consolidation, excludes material**	**218.8**	**CY**	**19.36**		**4.31**			**23.68**	**5,180**
5350	**Structural concrete, placing, walls, pumped, 15" thick, includes leveling (strike off) & consolidation, excludes material**	**215.3**	**CY**	**30.07**		**6.63**			**36.70**	**7,900**
	03350300 - Finishing Floors									
0150	**Concrete finishing, floors, basic finishing for unspecified flatwork, bull float, manual float & broom finish, includes edging and joints, excludes placing, striking off & consolidating**	**7,974.9**	**SF**	**0.78**					**0.78**	**6,244**
	03350350 - Finishing Walls									
0150	**Concrete finishing, walls, carborundum rub, wet, includes breaking ties and patching voids**	**131,389.5**	**SF**	**2.92**					**2.92**	**383,476**
	Cast-In-Place Concrete Total									455,009
	04800 - Masonry Assemblies									
	04810100 - Brick Veneer									
B301	8" CMU enterior walls w/ Brick Veneer	2,140.0	sqft	21.19	11.90	0.59			33.68	72,084
	Masonry Assemblies Total									72,084
	05300 - Metal Deck									
	05310300 - Metal Decking									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
2900	Metal roof decking, steel, open type B wide rib, galvanized, under 50 Sq, 1-1/2" D, 18 gauge	1,130.0	SF	0.65	2.91	0.04			3.60	4,066
	Metal Deck Total									**4,066**
	05500 - Metal Fabrications									
	05530300 - Floor Grating, Aluminum									
0132	Access Platform	100.0	SF	70.50	123.00	5.05			198.55	19,855
	Metal Fabrications Total									**19,855**
	15400 - Plumbing Fixtures & Equipment									
	15418600 - Sinks									
6790	Bathroom - complete	1.0	EA	3,543.80	7,013.64				10,557.44	10,557
	Plumbing Fixtures & Equipment Total									**10,557**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	03 - MECHANICAL								$1,375,762	~~936,365~~
	05500 - Metal Fabrications									
	05580950 - Miscellaneous Fabrication									
0020bc	Pump mounting base plate, complete w/ anchor bolts, 8 sf	3.0	each	779.81	1,745.73				2,525.54	7,577
	Metal Fabrications Total									**7,577**
	09900 - Paints & Coatings									
	09910641 - B & C Coatings									
0020bc	Pipe Painting - 16" dia to PS, B & C coating system E-2 (Epoxy, metal pipe)	418.7	sqft	1.83	2.22				4.05	1,696
	Paints & Coatings Total									**1,696**
	11000 - Equipment									
	11000100 - Process Equipment									
0170	Tank, polymer storage 1500	1.0	each	961.78	4,440.00				5,401.78	5,402
0719	Filter System, Actiflo Package System, 3.5 mgd unit, complete	~~3.0~~	~~each~~	~~6,220.96~~	~~214,000.00~~				~~220,220.96~~	~~660,663~~
						$1,100,000 per CoMag 8/25/14 quote				
	11000400 - Slide gates									
0080	Hydraulic structures, slide gate, ab & grout,48" x 48"	3.0	each	1,917.53	5,000.00	429.33			7,346.86	22,041
	11000600 - Chemical Tanks									
0190	Tank, caustic 500gal	1.0	each	620.05	2,675.00				3,295.05	3,295
0190	Tank, ferric choride 3000gal	1.0	each	1,536.15	4,900.00				6,436.15	6,436
	11000800 - Chemical Metering Pumps									
0401do	Pump, peristaltic hose, 0.25gpm, ferric	2.0	each	982.05	10,244.00				11,226.05	22,452
0401do	Pump, peristaltic hose, 0.1gpm, caustic	2.0	each	686.98	6,250.00				6,936.98	13,874
0401do	Pump, peristaltic hose, 0.60gpm, ferric	2.0	each	982.05	23,500.00				24,482.05	48,964
	Equipment Total								$1,222,464	~~783,127~~
	15050 - Basic Materials & Methods									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	15050010 - Miscellaneous Mechanical									
0008	Allowance - Piping, Building Service/Domestic	1,130.0	SF	2.78	3.45	0.55			6.78	7,661
0009	Allowance - Fire Protection	1,130.0	SF	5.05	5.33				10.38	11,729
0009	Allowance - Piping, chemical system	1.0	lsum	9,500.00	16,500.00	3,500.00			29,500.00	29,500
0009	Allowance - Pipe Supports	1.0	lsum	14,000.00	17,500.00	3,500.00			35,000.00	35,000
	Basic Materials & Methods Total									**83,891**
	15200 - Process Piping									
	15200030 - Pipe, Ductile Iron									
0450B	**Piping, water dist, DI, cement lined, 30" dia**	**265.0**	**lnft**	**21.99**	**112.21**	**3.60**			**137.80**	**36,517**
	15200031 - Fittings, Ductile Iron									
0120	Piping, water dist, DI, 90< bend or elbow, 30" dia	3.0	each	603.63	1,825.00	102.23			2,530.86	7,593
	Process Piping Total									**44,110**
	15700 - Heating/Ventilating/Air Conditioning Equipment									
	15700100 - HVAC Allowance									
0010	Allowance - HVAC	1,130.0	sqft	0.54	8.20	1.65			10.39	11,741
	Heating/Ventilating/Air Conditioning Equipment Total									**11,741**
	15950 - Testing/Adjusting/Balancing									
	15955700 - Piping, Testing									
0380	Pipe testing, nondestructive hydraulic pressure test, isolate, 1 hour hold, 20"-48" dia, up to 500LF	1.0	EA	4,224.35					4,224.35	4,224
	Testing/Adjusting/Balancing Total									**4,224**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	04 - ELECTRICAL & INSTRUMENTATION									**797,970**
	17150 - Instrumentation/Controls									
	17150000 - Instrumentation/Controls									
0010	Allowance - Electrical & Instrumentation	1.0	lsum				797,970.00		797,970.00	797,970
	Instrumentation/Controls Total									**797,970**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	EC (FILTRATION)									
	01 - SITEWORK									**5,614**
	01590 - Construction Aids									
	01590400 - General equipment rental without operators									
6900D	Rent water tank trailer w/pumped discharge, 5000 gallon capacity - Rent per month	1.5	mnth			1,325.00			1,325.00	1,988
6900D	Rent water tank trailer w/pumped discharge, 5000 gallon capacity - Rent per month 8 MH	8.0	hours	453.33					453.33	3,627
	Construction Aids Total									**5,614**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	01 - SITEWORK									**892,817**
	01590 - Construction Aids									
	01590400 - General equipment rental without operators									
7030B	**Rent trench box, 3000 lbs 6' x 8' - Rent per day**	**2.0**	**days**			**84.50**			**84.50**	**169**
	Construction Aids Total									**169**
	02000 - Site Civil Work									
	02010 - Fire hydrants									
0040	ALLOWANCE - site civil including pavement, fencing, misc parking, barriers, vault, etc.	1.0	lsum	32,745.21	95,882.70	17,635.74	36,369.30		182,632.95	182,633
0140	ALLOWANCE - yard piping	1.0	lsum	154,530.00	220,420.00	47,335.50		0.01	422,285.51	422,286
	02460 - Hauling									
0051	ALLOWANCE - Disposal of lead contaminated soil, quote	1.0	LSUM				18,400.00		18,400.00	18,400
	02490 - Erosion control									
0040	ALLOWANCE - Erosion control	1.0	lsum	3,589.26	1,489.66				5,078.93	5,079
	02560 - Drainage									
0010	ALLOWANCE - Sediment collection system, tanks, swales, and pond, allowance	1.0	lsum	5,386.67	9,888.00	1,072.00			16,346.67	16,347
	02840 - Landscaping									
0320	Landscaping, subcontract	1.0	lsum				26,162.00		26,162.00	26,162
	Site Civil Work Total									**670,906**
	02200 - Site Preparation									
	02220330 - Selective Demolition, Dump Charges									
9999	**Dump Charge, typical urban city, fees only, bldg constr mat'ls**	**180.2**	**ton**					**33.00**	**33.00**	**5,946**
	Site Preparation Total									**5,946**
	02300 - Earthwork									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02315120 - Backfill, Structural									
4420	Backfill, structural, common earth, 200 H.P. dozer, 300' haul, from existing stockpile, excludes compaction	3,885.2	L.C.Y.	1.01		1.85			2.86	11,095
	02315310 - Compaction, General									
7000	Compaction, around structures and trenches, 2 passes, 18" wide, 6" lifts, walk behind, vibrating plate	3,579.8	E.C.Y.	2.08		0.17			2.26	8,078
	02315424 - Excavating, Bulk Bank Measure									
4400	Excavating, bulk bank measure, in sheeting or cofferdam, with all other equipment, minimum	3,621.3	B.C.Y.	6.04		7.60			13.64	49,381
	02315492 - Hauling									
0009	Loading Trucks, F.E. Loader, 3 C.Y.	2,574.3	cuyd	0.76		1.24			2.00	5,159
9498	Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 18 C.Y. 8 wheel truck, cycle 20 miles, 45 MPH, excludes loading equipment	2,574.3	L.C.Y.	2.96		5.46			8.41	21,658
	02315610 - Excavating, Trench									
1000	Excavating, trench or continuous footing, common earth, 1-1/2 C.Y. excavator, 10' to 14' deep, excludes sheeting or dewatering	376.5	B.C.Y.	1.79		1.96			3.75	1,412
	02315640 - Utility Bedding									
0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	1,743.2	L.C.Y.	9.12	31.50	2.50			43.12	75,173
	Earthwork Total									171,956
	11000 - Equipment									
	11100 - Pumps miscellaneous									
0270	Bypass pump, portable, diesel powered, 10" discharge	12.0	week	1,546.26	1,447.55				2,993.81	35,926
0331	Bypass pump operation, 2 cks @ 2 hr (night shift), per 24 hour day	20.0	days	395.67					395.67	7,913
	Equipment Total									43,839

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02 - STRUCTURAL									1,412,370
	01500 - Temporary Facilities & Controls									
	01540750 - Scaffolding									
6610	Scaffolding, steel tubular, heavy duty shoring for elevated slab forms, floor area, rent/month of materials only, to 14'-8" high	19.9	Csf		43.00				43.00	855
	Temporary Facilities & Controls Total									855
	02200 - Site Preparation									
	02220330 - Selective Demolition, Dump Charges									
9999	**Dump Charge, typical urban city, fees only, bldg constr mat'ls**	**594.4**	**ton**					**33.00**	**33.00**	**19,615**
	Site Preparation Total									19,615
	02300 - Earthwork									
	02315120 - Backfill, Structural									
4420	**Backfill, structural, common earth, 200 H.P. dozer, 300' haul, from existing stockpile, excludes compaction**	**47.9**	**L.C.Y.**	**1.01**		**1.85**			**2.86**	**137**
	02315310 - Compaction, General									
7500	**Compaction, 2 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**43.1**	**E.C.Y.**	**1.76**		**0.42**			**2.18**	**94**
7520	**Compaction, 3 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**120.1**	**E.C.Y.**	**2.64**		**0.63**			**3.28**	**393**
7540	**Compaction, 4 passes, 24" wide, 6" lifts, walk behind, vibrating roller**	**360.2**	**E.C.Y.**	**3.53**		**0.85**			**4.37**	**1,575**
	02315492 - Hauling									
0009	**Loading Trucks, F.E. Loader, 3 C.Y.**	**594.4**	**cuyd**	**0.76**		**1.24**			**2.00**	**1,191**
9498	**Cycle hauling(wait, load,travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 25 min load/wait/unload, 18 C.Y. 8 wheel truck, cycle 20 miles, 45 MPH, excludes loading equipment**	**594.4**	**L.C.Y.**	**2.96**		**5.46**			**8.41**	**5,001**
	02315610 - Excavating, Trench									
0060	**Excavating, trench or continuous footing, common earth, 1/2 C.Y. excavator, 1' to 4' deep, excludes sheeting or dewatering**	**523.4**	**B.C.Y.**	**4.75**		**2.04**			**6.79**	**3,555**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	02315640 - Utility Bedding									
0100	Fill by borrow and utility bedding, for pipe and conduit, crushed stone, 3/4" to 1/2", excludes compaction	418.9	L.C.Y.	9.12	31.50	2.50			43.12	18,063
	Earthwork Total									30,009
	03100 - Concrete Forms & Accessories									
	03110420 - Forms In Place, Elevated Slabs									
1500	C.I.P. concrete forms, elevated slab, flat plate, plywood, 15' to 20' high ceilings, 4 use, includes shoring, erecting, bracing, stripping and cleaning	1,987.5	SF	6.06	1.25				7.31	14,522
	03110445 - Forms In Place, Slab On Grade									
3050	C.I.P. concrete forms, slab on grade, edge, wood, 7" to 12" high, 4 use, includes erecting, bracing, stripping and cleaning	398.8	sfca	4.45	0.80				5.25	2,095
3550	C.I.P. concrete forms, slab on grade, depressed, edge, wood, 12" to 24" high, 4 use, includes erecting, bracing, stripping and cleaning	700.0	LF	11.10	0.80				11.90	8,327
	03110455 - Forms In Place, Walls									
2550	C.I.P. concrete forms, wall, job built, plywood, 8 to 16' high, 4 use, includes erecting, bracing, stripping and cleaning	13,560.0	sfca	7.59	0.66				8.25	111,856
	03150860 - Waterstop									
0600	Waterstop, PVC, ribbed, with center bulb, 3/8" thick x 9" wide	1,559.0	LF	4.05	4.94				8.99	14,014
	Concrete Forms & Accessories Total									150,815
	03200 - Concrete Reinforcement									
	03210600 - Reinforcing In Place									
0602	Reinforcing Steel, in place, slab on grade, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	79,543.5	lb	0.57	0.50				1.07	84,814
0702	Reinforcing Steel, in place, walls, #3 to #7, A615, grade 60, incl labor for accessories, excl material for accessories	66,951.2	lb	0.40	0.50				0.90	60,413
2000	Reinforcing steel, unload and sort, add to base	82.1	ton	41.24		7.45			48.68	3,999
2210	Reinforcing steel, crane cost for handling, average, add	82.1	ton	44.23		8.06			52.29	4,295

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
2450	**Reinforcing steel, in place, dowels, deformed, A615, grade 60, longer and heavier, add**	**16,601.3**	**lb**	**1.64**	**0.55**				**2.19**	**36,343**
	Concrete Reinforcement Total									**189,864**
	03300 - Cast-In-Place Concrete									
	03310220 - Concrete, Ready Mix Normal Weight									
0300	**Structural concrete, ready mix, normal weight, 4000 psi, includes local aggregate, sand, Portland cement (Type I) and water, delivered, excludes all additives and treatments**	**662.9**	**CY**		**102.00**				**102.00**	**67,615**
	03310700 - Placing Concrete									
1500	Structural concrete, placing, elevated slab, pumped, 6" to 10" thick, includes leveling (strike off) & consolidation, excludes material	61.3	CY	22.37		4.99			27.35	1,678
4650	**Structural concrete, placing, slab on grade, pumped, over 6" thick, includes leveling (strike off) & consolidation, excludes material**	**392.3**	**CY**	**19.36**		**4.31**			**23.68**	**9,287**
5350	**Structural concrete, placing, walls, pumped, 15" thick, includes leveling (strike off) & consolidation, excludes material**	**209.3**	**CY**	**30.07**		**6.63**			**36.70**	**7,679**
	03350300 - Finishing Floors									
0150	**Concrete finishing, floors, basic finishing for unspecified flatwork, bull float, manual float & broom finish, includes edging and joints, excludes placing, striking off & consolidating**	**12,836.3**	**SF**	**0.78**					**0.78**	**10,050**
	03350350 - Finishing Walls									
0150	**Concrete finishing, walls, carborundum rub, wet, includes breaking ties and patching voids**	**194,460.0**	**SF**	**2.92**					**2.92**	**567,555**
	Cast-In-Place Concrete Total									**663,864**
	04800 - Masonry Assemblies									
	04810100 - Brick Veneer									
B301	8" CMU enterior walls w/ Brick Veneer	3,360.0	sqft	21.19	11.90	0.59			33.68	113,179
	Masonry Assemblies Total									**113,179**
	05300 - Metal Deck									

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	05310300 - Metal Decking									
2900	Metal roof decking, steel, open type B wide rib, galvanized, under 50 Sq, 1-1/2" D, 18 gauge	2,000.0	SF	0.65	2.91	0.04			3.60	7,196
	Metal Deck Total									**7,196**
	13120 - Pre-Engineered Structures									
	13128700 - Pre-Engineered Steel Buildings									
0150	Pre-engineered Aluminum Building 80'X53', 15' high, incl. anchor bolts	4,240.0	SF	17.38	25.02	13.49			55.89	236,974
	Pre-Engineered Structures Total									**236,974**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	03 - MECHANICAL								$ 2,456,713	~~1,179,541~~
	09900 - Paints & Coatings									
	09910641 - B & C Coatings									
0020bc	Pipe Painting - 16" dia to PS, B & C coating system E-2 (Epoxy, metal pipe)	418.7	sqft	1.83	2.22				4.05	1,696
	Paints & Coatings Total									**1,696**
	11000 - Equipment									
	11000100 - Process Equipment									
0550	Mixer, 2500 gpm, 10HP	3.0	each	1,732.92	16,000.00				17,732.92	53,199
0700	Filter Pump, 1000-gpm	4.0	EA	7,627.60	21,000.00				28,627.60	114,510
1120	Sand Filter Skid, 1000-gpm	3.0	EA	6,749.75	47,000.00			1,244.08	54,993.83	164,981
	11000400 - Slide gates									
0080	Hydraulic structures, slide gate, ab & grout,48" x 48"	3.0	each	1,917.53	5,000.00	429.33			7,346.86	22,041
	11000600 - Chemical Tanks									
0190	Tank - HDPE, 2,000 gal, caustic	1.0	each	2,230.86	11,472.71	1,120.00			14,823.57	14,824
	11001000 - Pumps miscellaneous									
0340	Packaged Booster Pump Station System - 25HP Pumps	2.0	EA	7,285.77	227,316.00	3,234.88			237,836.65	475,673
	Equipment Total								$2,122,400 per WaterTectonics Estimate, 8/1/14	~~845,228~~
	15050 - Basic Materials & Methods									
	15050010 - Miscellaneous Mechanical									
0009	Allowance - Pipe Supports	1.0	lsum	14,000.00	17,500.00	3,500.00			35,000.00	35,000
	Basic Materials & Methods Total									**35,000**
	15200 - Process Piping									
	15200030 - Pipe, Ductile Iron									
0430B	Piping, water dist, DI, cement lined, 18' L, restrained jt, 20" dia	150.0	lnft	18.44	57.19	3.00			78.63	11,795

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
0440B	Piping, water dist, DI, cement lined, 18' L, restrained jt, 24" dia	150.0	LF	19.86	77.59	3.60			101.05	15,158
0450B	**Piping, water dist, DI, cement lined, 18' L, restrained jt, 30" dia**	**300.0**	**LF**	**21.99**	**112.21**	**3.60**			**137.80**	**41,340**
0450B	**Piping, water dist, DI, cement lined, 30" dia**	**220.0**	**lnft**	**21.99**	**112.21**	**3.60**			**137.80**	**30,316**
0470B	Piping, water dist, DI, cement lined, 18' L, restrained jt, 42" dia	80.0	LF	29.08	211.75	4.80			245.63	19,651
	15200280 - Valves, Plug									
0320	**Valves, semi-steel, lubricated plug valve, flanged, 200 psi, 20" pipe**	**11.0**	**each**	**1,863.73**	**6,850.00**				**8,713.73**	**95,851**
0330	Valves, semi-steel, lubricated plug valve, flanged, 200 psi, 24" pipe	8.0	EA	1,494.07	7,805.00				9,299.07	74,393
	Process Piping Total									**288,504**
	15950 - Testing/Adjusting/Balancing									
	15955700 - Piping, Testing									
0380	Pipe testing, nondestructive hydraulic pressure test, isolate, 1 hour hold, 20"-48" dia, up to 1000LF	1.0	EA	9,113.00					9,113.00	9,113
	Testing/Adjusting/Balancing Total									**9,113**

Item	Item Description	Qty	Unit	Labor $/ Unit	Mat $/ Unit	Equip $/ Unit	Sub $/ Unit	Other $/ Unit	Total $/ Unit	Total $ Net Cost
	04 - ELECTRICAL & INSTRUMENTATION									**1,047,105**
	17150 - Instrumentation/Controls									
	17150000 - Instrumentation/Controls									
0010	Allowance - Electrical & Instrumentation	1.0	lsum				##########		##########	1,047,105
	Instrumentation/Controls Total									**1,047,105**

SPU South Park Soil Remediation - Water Facitilities Alternatives >5% Design Level

Category	Percent	Amount	Hours
~~Construction Contingency~~	~~30.00 %~~	~~1,357,983~~	
~~**Subtotal**~~		~~**5,884,594**~~	
~~Bldg Risk, Liability Auto Ins.~~	~~2.00 %~~	~~117,692~~	
~~**Subtotal**~~		~~**6,002,286**~~	
~~Bonds~~	~~1.50 %~~	~~90,034~~	
~~**Subtotal**~~		~~**6,092,321**~~	
~~Sales Tax (Excise)~~	~~9.50 %~~	~~578,770~~	
~~**Subtotal**~~		~~**6,671,091**~~	
~~**Total ENHANCED FILTRATION (SAND PRESSURE)**~~		~~**6,671,091**~~	

ENHANCED FILTRATION (CHITOSAN) Totals

Category	Percent	Amount	Hours
Labor	**4.66 %**	~~**1,217,341**~~ $1,293,655 per Clear Water	**,588.4**
Material	**5.19 %**	~~**1,353,891**~~ $2,040,719 per Clear Water	
Subcontractor	**4.19 %**	**1,093,631**	
Equipment	**1.11 %**	**290,063**	**6,261.4**
Other	**0.12 %**	**31,782**	
User			
Net Costs		**3,986,708**	
Labor Mark-up	10.00 %	121,734	
Material/Process Equipment Mark-up	8.00 %	108,311	
Construction Equipment Mark-up	8.00 %	23,205	
Subcontractor Mark-up	5.00 %	54,682	
Material Shipping & Handling	2.00 %	15,095	
Escalation to Midpoint	13.50 %	533,915	

Category	Percent	Amount	Hours
Subtotal		**4,843,650**	
Contractor General Conditions	10.00 %	484,365	
Subtotal		**5,328,015**	
Start-up, training, O & M	2.00 %	20,506	
Subtotal		**5,348,520**	
Construction Contingency	30.00 %	1,604,556	
Subtotal		**6,953,077**	
Bldg Risk, Liability Auto Ins.	2.00 %	139,062	
Subtotal		**7,092,138**	
Bonds	1.50 %	106,382	
Subtotal		**7,198,520**	
Sales Tax (Excise)	9.50 %	683,859	
Subtotal		**7,882,380**	
Total ENHANCED FILTRATION (CHITOSAN)		**7,882,380**	

ENHANCED FILTRATION (DISC FILTERS) Totals

Category	Percent	Amount	Hours
Labor	**5.04 %**	**1,315,995**	**20,246.1**
Material	**3.82 %**	**998,211**	
Subcontractor	**3.75 %**	**978,851**	
Equipment	**0.53 %**	**138,962**	**4,647.3**
Other	**0.04 %**	**9,468**	
User			
Net Costs		**3,441,487**	
Labor Mark-up	10.00 %	131,599	

SPU South Park Soil Remediation - Water Facitilities Alternatives >5% Design Level

Category	Percent	Amount	Hours
Material/Process Equipment Mark-up	8.00 %	79,857	
Construction Equipment Mark-up	8.00 %	11,117	
Subcontractor Mark-up	5.00 %	48,943	
Material Shipping & Handling	2.00 %	8,439	
Escalation to Midpoint	13.50 %	463,323	
Subtotal		**4,184,765**	
Contractor General Conditions	10.00 %	418,477	
Subtotal		**4,603,242**	
Start-up, training, O & M	2.00 %	11,465	
Subtotal		**4,614,707**	
Construction Contingency	30.00 %	1,384,412	
Subtotal		**5,999,118**	
Bldg Risk, Liability Auto Ins.	2.00 %	119,982	
Subtotal		**6,119,101**	
Bonds	1.50 %	91,787	
Subtotal		**6,210,887**	
Sales Tax (Excise)	9.50 %	590,034	
Subtotal		**6,800,922**	
Total ENHANCED FILTRATION (DISC FILTERS)		**6,800,922**	

BALLASTED SEDIMENTATION Totals

Category	Percent	Amount	Hours
Labor	**3.97 %**	~~**1,037,510**~~ $1,081,444 per Evoqua quote	**54.8**
Material	**5.42 %**	~~**1,415,105**~~ $1,810,508 per Evoqua quote	
Subcontractor	**3.32 %**	**866,021**	
Equipment	**0.50 %**	**130,108**	**4,504.6**

SPU South Park Soil Remediation - Water Facitilities Alternatives >5% Design Level

Category	Percent	Amount	Hours
Other	**0.03 %**	**9,136**	
User			
Net Costs		**3,457,880**	
Labor Mark-up	10.00 %	103,751	
Material/Process Equipment Mark-up	8.00 %	113,208	
Construction Equipment Mark-up	8.00 %	10,409	
Subcontractor Mark-up	5.00 %	43,301	
Material Shipping & Handling	2.00 %	17,236	
Escalation to Midpoint	13.50 %	465,580	
Subtotal		**4,211,365**	
Contractor General Conditions	10.00 %	421,136	
Subtotal		**4,632,501**	
Start-up, training, O & M	2.00 %	23,415	
Subtotal		**4,655,916**	
Construction Contingency	30.00 %	1,396,775	
Subtotal		**6,052,691**	
Bldg Risk, Liability Auto Ins.	2.00 %	121,054	
Subtotal		**6,173,745**	
Bonds	1.50 %	92,606	
Subtotal		**6,266,351**	
Sales Tax (Excise)	9.50 %	595,303	
Subtotal		**6,861,654**	
Total BALLASTED SEDIMENTATION		**6,861,654**	

SPU South Park Soil Remediation - Water Facitilities Alternatives >5% Design Level

Category	Percent	Amount		Hours
EC (FILTRATION) Totals				
Labor	**5.46 %**	~~**1,426,389**~~	$1,554,106 per WT quote	**23,105.9**
Material	**6.67 %**	~~**1,741,737**~~	$2,891,192 per WT quote	
Subcontractor	**4.32 %**	**1,128,036**		
Equipment	**0.81 %**	**211,991**		**5,200.1**
Other	**0.11 %**	**29,293**		
User				
Net Costs		**4,537,446**		
Labor Mark-up	10.00 %	142,639		
Material/Process Equipment Mark-up	8.00 %	139,339		
Construction Equipment Mark-up	8.00 %	16,959		
Subcontractor Mark-up	5.00 %	56,402		
Material Shipping & Handling	2.00 %	22,567		
Escalation to Midpoint	13.50 %	608,601		
Subtotal		**5,523,953**		
Contractor General Conditions	10.00 %	552,395		
Subtotal		**6,076,348**		
Start-up, training, O & M	2.00 %	30,657		
Subtotal		**6,107,006**		
Construction Contingency	30.00 %	1,832,102		
Subtotal		**7,939,107**		
Bldg Risk, Liability Auto Ins.	2.00 %	158,782		
Subtotal		**8,097,889**		
Bonds	1.50 %	121,468		

SPU South Park Soil Remediation - Water Facitilities Alternatives >5% Design Level

Category	Percent	Amount	Hours
Subtotal		**8,219,358**	
Sales Tax (Excise)	9.50 %	780,839	
Subtotal		**9,000,197**	
Total EC (FILTRATION)		**9,000,197**	
EC (CLARIFICATION) Totals			
Labor	**4.93 %**	**1,285,677**	**20,210.0**
Material	**5.70 %**	**1,489,175**	
Subcontractor	**3.93 %**	**1,024,781**	
Equipment	**0.53 %**	**137,956**	**4,664.5**
Other	**0.06 %**	**16,874**	
User			
Net Costs		**3,954,464**	
Labor Mark-up	10.00 %	128,568	
Material/Process Equipment Mark-up	8.00 %	119,134	
Construction Equipment Mark-up	8.00 %	11,036	
Subcontractor Mark-up	5.00 %	51,239	
Material Shipping & Handling	2.00 %	17,873	
Escalation to Midpoint	13.50 %	531,575	
Subtotal		**4,813,889**	
Contractor General Conditions	10.00 %	481,389	
Subtotal		**5,295,278**	
Start-up, training, O & M	2.00 %	24,280	
Subtotal		**5,319,558**	

Ballasted Sedimentation Vendor Information

Johnson, Josh

From: Bill Reilly <bill@whreilly.com>
Sent: Monday, August 25, 2014 1:46 PM
To: Johnson, Josh
Cc: Kim Batiste
Subject: FW: Operating parameters for SPU - South Park system - Lower Duwamish, WA CoMag
Attachments: Lower Duwamish WA CoMag Proposal - 2014 08 14.pdf

Josh,

I'm told you may not have received this so I am resending it to you. Please let me know if you have any questions.

Thanks.

Bill

Bill Reilly | Wm. H. Reilly & Co.
503-223-6197 Office | 503-223-0845 Fax | 503-314-8386 Cell
Bill@whreilly.com

From: <Antonneau>, Nathan Antonneau <nathan.antonneau@evoqua.com>
Date: Thursday, August 14, 2014 at 1:23 PM
To: Bill Reilly <bill@whreilly.com>
Subject: FW: Operating parameters for SPU - South Park system - Lower Duwamish, WA CoMag

Bill,

Please find the attached CoMag™ System proposal.

Updates from the last revision:

- flow was lowered from 7.1 MGD to 3.9 MGD.
- number of trains reduced from three (3) to two (2), and
- flash tank mixer was added to Evoqua's scope.

Updated budget price is $1.1M. The price has not been included in the proposal.

Let us know if you need anything else.

Thank you,

Nathan Antonneau, P.E.

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Waukesha, WI 53188

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EVOQUA
WATER TECHNOLOGIES

LOWER DUWAMISH, WA COMAG™ CONCEPTUAL PROPOSAL

BROWN AND CALDWELL

August 2014

2607 N. Grandview Blvd., Suite 130 Waukesha, WI 53188

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CONTENTS

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EVOQUA COMAG™ SYSTEM SUMMARY

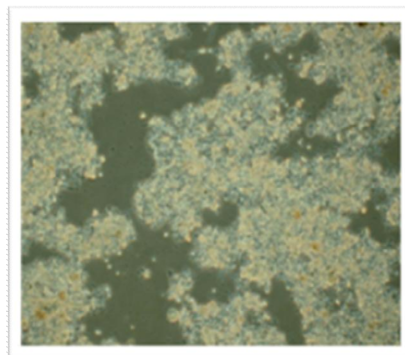
1 BASIS OF PROPOSAL

This budgetary proposal provided by Evoqua is based on the design information provided to date. Many factors, which may as yet be unknown, can affect the actual equipment and operating requirements of a fully installed and fully operational system. These factors include, but are not limited to, materials of construction, level of operational automation, degree of redundancy, spare parts, scope of equipment and services.

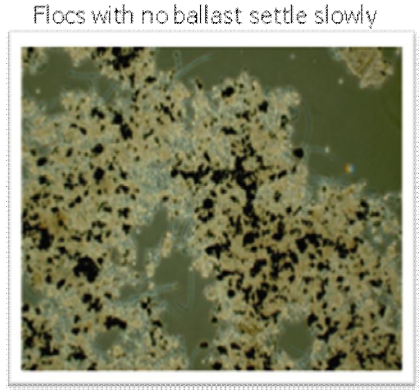
Reviewers of this proposal should clearly understand the CoMag system described in this proposal is preliminary and should not be deemed definitive or to obligate Evoqua. Instead this proposal should serve as a guideline for the decision makers in their evaluation of the relative value of CoMag compared to other solids removal treatment solutions.

2 COMAG PROCESS OVERVIEW

The CoMag Treatment System is an innovative and proven technology for the removal of solids, heavy metals and other particulate or precipitated contaminants. CoMag is capable of achieving solids removal levels that approach, and in many cases equal, the removal performance of ultra filtration membranes. The CoMag process, as shown in Figure 1 below, is based on conventional coagulation and flocculation, but uses an innovative ballast material which differentiates the process from other technologies. The ballast material is magnetite (Fe_3O_4), which is a fully inert, high specific gravity (5.2), finely ground, non-abrasive, iron ore.



Flocs with no ballast settle slowly



Ballasted flocs settle rapidly and reliably

Through simple mixing, the magnetite is infused into the metal hydroxide floc, thereby significantly increasing the specific gravity of the floc. When the magnetite infused flocs are introduced to the CoMag clarifier, the flocs settle 20 to 60 times faster than conventional flocs or those infused with micro-sand. Rapid settling enables CoMag systems to employ much smaller and less expensive clarifiers.

Unlike other ballasted clarification systems, CoMag recycles settled solids from the clarifier back to the reaction tanks to increase nucleation sites, enhance precipitation kinetics and promote sweep floc. The result is superior solids removal and more efficient chemical use.

The magnetite ballast is recovered from the waste sludge magnetically with almost no energy consumption and returned to the treatment system with very little magnetite loss, thereby keeping operating costs low.

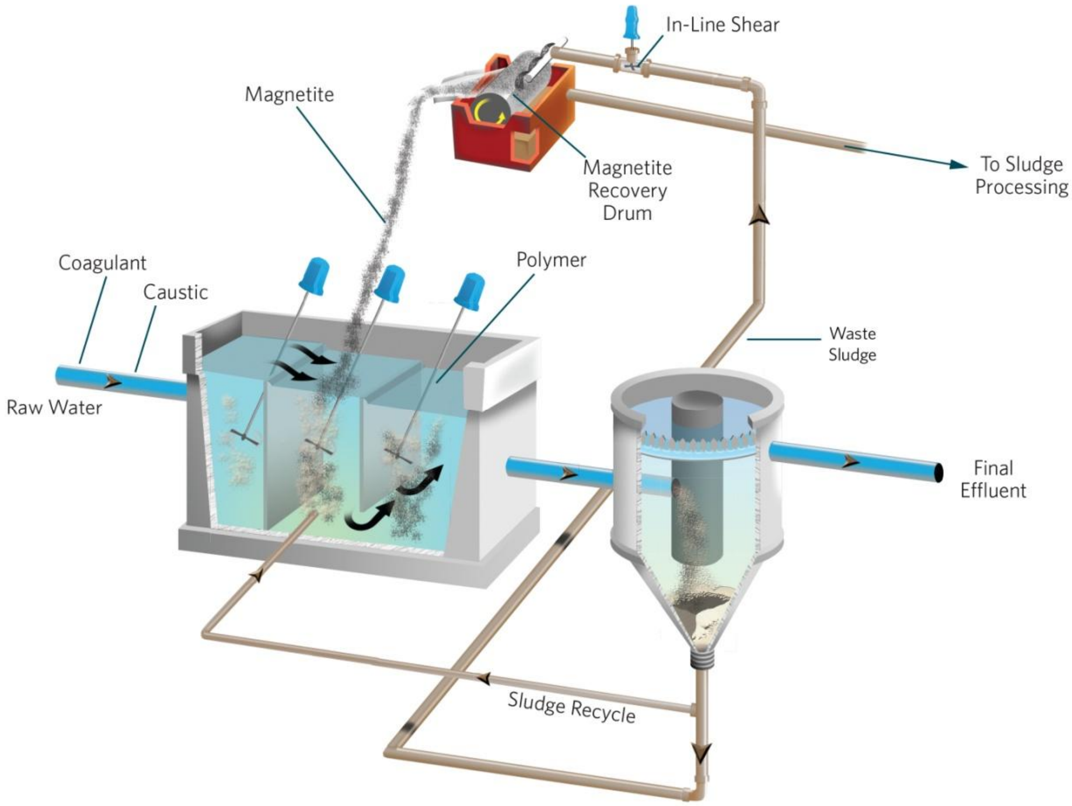


Figure 1: CoMag Treatment Process

2.1 Detailed Description

Depending on the plant's hydraulic profile, influent to the CoMag system can either be pumped or flowed by gravity. An influent flow meter is used upstream of the CoMag system to monitor incoming flow and to control the dose of coagulant being metered into the system. The CoMag system is capable of operating with commonly used coagulants including aluminum sulfate, ferric chloride, or PAC. The proposed method for coagulant addition is a flash mix tank.

Coagulation and flocculation occur in the CoMag system reaction tanks. Unlike conventional coagulation and flocculation with other ballasted systems the use of magnetite in the CoMag™

process allows for relatively short reaction times (HRT) because the process does not require development of large flocs for settling. Each CoMag reaction tank is equipped with a VFD controlled mixer to allow for optimal mixing conditions.

Magnetite serves two major functions:

1. With its high specific gravity (SG) of 5.2 (in contrast micro-sands have SG of 2.7), magnetite increases the weight of the metal hydroxide floc (unballasted chemical floc has SG of just over 1.0) and significantly increases its settling velocity;

2. Magnetite is attracted to a magnet which enables it to be recovered using a simple magnetic drum and recycled back to the reaction tanks.

After coagulation and the infusion of magnetite, polymer is added to consolidate the floc just prior to settling in the clarifier. CoMag works well in multiple clarifier configurations including cone, circular and rectangular designs.

Settled sludge from the clarifier flows to the recycle and waste sludge pump systems. A large and variable portion of the solids underflow is conveyed back to the reaction tanks by a recycle sludge pump. These recycled solids greatly improve the flocculation process by increasing the mass of solids in contact with the precipitate.

The remainder of the settled sludge is pumped through a sludge shear system which breaks up the floc particles and creates a mixture in which the ballast particles are no longer physically attached to the floc. This slurry flows over a magnetic drum separator that magnetically captures the ballast and returns it to the process. The metal hydroxide and precipitated sludge flows to the sludge system for further processing and disposal.

The CoMag™ system is designed for automated operation. A PLC, located inside the control panel, manages the CoMag™ treatment system under normal operations. Various field instruments provide the raw data needed for process control. The PLC continuously monitors the instrument signals and, based on the programmed control logic and set points, adjusts the chemical feed rates, turns the pumps on and off, and makes other process changes.

3 COMAG™ COMPARATIVE BENEFITS AND ADVANTAGES

The benefits and advantages of CoMag over competitive technologies are multiple:

- ✓ **Low capital/installation costs**: CoMag's high-rate, ballasted clarification technology enables the use of small foot print, solids reaction and clarification tanks that have relatively low fabrication and construction costs.

- ✓ **Low operating costs:** CoMag employs the same coagulation and flocculation processes as most other chemical treatment systems: chemical and power consumption are also about the same. CoMag's advantage comes from ease of operation, no lamellas to clean, no media to plug or foul, and no abrasion to increase maintenance costs.

- ✓ **Non-abrasive ballast:** CoMag's ballast is less abrasive than micro-sand and hence, reduces wear and tear on mixers, pumps, and other treatment components. In 4+ years of operation at our seminal plant in Concord, Mass., operators have seen no wear on the equipment including the impellers of the plant's sludge pumps.

- ✓ **Reliable components:** CoMag components and fundamental processes have been proven in over 40 years of industrial operation; they can readily be purchased on the open market. CoMag advantage is its simplicity; it is not a "Black Box" technology.

- ✓ **Flexible and robust operation:** With its internal solids recycle increasing nucleation sites, enhancing precipitation kinetics and promoting sweep floc, CoMag's treatment efficiency actually improves when an upset in the up-stream systems discharges excess solids. Hence, the system can process wide ranges of flows and loads with almost no effect on contaminant removal performance or operational stability.

- ✓ **Flexibility of coagulant type:** CoMag produces high quality effluent with alum, ferric chloride, ferric sulfate or polyaluminum chloride (PAC). A facility is thereby free to determine which coagulant makes the most sense for its needs without concern for performance loss.

In summary, CoMag offers a simple, reliable, and highly effective process that easily handles highly variable flows and solids loads.

4 DESIGN SUMMARY

Table 1 summarizes the design basis for the proposed CoMag system.

Table 1: Design Basis

Parameter	Units	Design
Design Flow	MGD	3.9
Maximum Influent Total Suspended Solids	mg/L	400
Design Average Influent Total Suspended Solids	mg/L	95
Average Effluent Total Suspended Solids	mg/L	10

Table 2 summarizes the preliminary process parameters for the proposed CoMag system.

Table 2: Preliminary Process Parameters

Parameter	Design
Number of Treatment Trains	1 Duty, 1 Standby
Ballast Reaction Tank (T-1)	10.5′ × 10.5′ × 10.5′ SWD
Polymer Reaction Tank (T-2)	6′ × 6′ × 10.5′ SWD
Clarifier (One per train)	20′ diameter (10′ SWD)

5 SCOPE OF SUPPLY

5.1 Evoqua Scope of Supply

In evaluating the relative value of CoMag to other systems we encourage the decision-makers to assess the fully installed and fully operational economics of CoMag and its competitors. We often find at this stage of the evaluation, costs can vary greatly depending upon the scope of supply proposed by competing vendors; and price advantages at this stage can often be reversed when required components of a competitive solution are placed outside an equipment vendors' scope of supply.

Item	Quantity
Influent pH sensor and controller	1
Flash mix tank mixer	1
Reaction tank mixers – *top mount*	4
Reaction tank level switch	2
Clarifier internals	2
Sludge blanket level sensor	2
Effluent turbidimeter	2
Sludge pump (Return sludge / waste sludge)	1 Duty, 2 Standby
Recycle sludge flow meter	2
RAS flow control valve	2
Waste sludge flow meter	2

Item	Quantity
WAS flow control valve	2
Sludge shear mixer	1
Magnetic recovery drum separator	1
Magnetic recovery drum level switches	2
Magnetite concentration meter	1
PLC control panel	1

5.2 Items Provided by Others

Item
Influent feed flow meter
Flash mix tank
Ballast reaction tank T-1
Polymer reaction tank T-2
Clarifier tank
Magnetite
Power Panel including Motor Starters and VFDs.
Coagulant feed system
Caustic feed system
Polymer feed system
Compliance permitting and approval (Federal, State and/or local)
Detail shop fabrication drawings
Electrical, hydraulic, or pneumatic controls unless specifically noted
Engineering and supervision of all equipment and labor for civil works
Laboratory, shop, or field testing other than supervision of start-up testing
Taxes, bonds, fees, permits, lien waivers, licenses, etc.

Item
Tools or spare parts
Unloading of equipment and protected storage of equipment at jobsite
Utilities connections
Adhesives, adhesive dispensers, grout, mastic & anti-seize compounds
Anchor bolts and/or expansion anchors unless otherwise noted
Base slabs, equipment mounting pads, or shims
Concrete work of any sort, grout, mastic, sealing compounds, shims
Demolition, removal, or transfer of anything that is existing
Engineering, permitting, and surveying
Equipment lifting hoists, cranes, or other lifting devices
Field surface preparation and/or painting
Floor grating, stairways, ladders, platforms, handrailing unless noted
Installation of equipment
Interconnecting materials external to enclosures such as cable, pressure taps, tubing, etc.
Labor for field testing
Lubricants, grease piping, grease guns
Modifications to existing equipment or structures
Pipe supports and hangers for piping
Piping, pumps, valves, wall sleeves, gates, drains, weirs, baffles not mentioned
Plumbing associated with waste disposal, floor drains, and/or emergency and safety wash stations
PVC solvent weld materials
Conduit or wiring in the field
Cable trays, fittings, and supports
Power to Evoqua supplied equipment
Supply and installation of building power, lighting, main service disconnects and control panels

Item
Supply, installation and control of a remote telemetry system (SCADA) to monitor and control the operation of the system and overall plant operation other than CoMag Control System
Underwriters Laboratory inspection of electrical controls

6 OPERATION AND MAINTENANCE REQUIREMENTS

The estimated operation and maintenance requirements listed below are based on past experience at other CoMag installations. Project specific O&M requirements will be defined after completion of jar testing and/or a comprehensive pilot testing program. The quantities listed herein are estimates and do not represent a warranty or guarantee. The actual requirements might differ due to differences in the influent wastewater characteristics and the manner by which the system is operated.

6.1 Electrical Loads

Table 3 lists the motor horsepower for equipment supplied by Evoqua. The pump motors are based on typical hydraulics and are subject to approval of the layout. Motors greater than 0.5 HP are 460-volt, 3-phase, 60 Hz, high efficiency and inverter duty unless noted otherwise. Motors less than or equal to 0.5 HP are 120-volt, 1-phase, 60 Hz, unless noted otherwise.

The total connected power equals the number of motors multiplied by the nameplate motor power. The estimated operating power (which is less than the nameplate) in kilowatt-hours is calculated for average design flows (ADF), the number of motors in use at ADF, and the design operating period. It does not include small electrical loads associated with electrically actuated valves and similar demands.

Table 3: CoMag Electrical Loads

Load	Qty	Motor HP	Connected HP	Qty at ADF	Operating HP at ADF
Mixer – Flash mix tank	1	3.0	3.0	1	2.25
Mixer – Ballast reaction tank	2	7.5	15.0	1	5.60
Mixer – Polymer reaction tank	2	1.5	3.0	1	1.10

Load	Qty	Motor HP	Connected HP	Qty at ADF	Operating HP at ADF
Clarifier drive[1]	2	1.0	2.0	1	0.75
Sludge shear mixer	1	2.0	2.0	1	1.5
Magnetic drum separator	1	1.5	1.5	1	1.10
Sludge pump	3	3.0	9.0	1	2.25
Total Loads					14.55

6.2 Chemical Use

Table 4 lists the estimated chemical doses to achieve the treatment goals listed in the design basis. The concentrations of coagulant are based on typical performance seen at other facilities. Different coagulants are listed; only one would be used.

The ballast use assumes operation of the ballast recovery equipment. A small amount of ballast is lost in the waste sludge. The make-up ballast can be manually added once daily. The table lists the typical amount.

Table 4: Chemical Doses and Consumption

Chemical	Dose
Coagulant	
Ferric Chloride (40%)	2 - 4 mg/L as Fe
Alum (48.5%)	2 - 3 mg/L as Al
Ballast	Make-up 10 lbs per MG
Polymer dry	0.5 - 1.0 mg/L
Caustic (pH adjustment)[2]	Varies

[1] Clarifier drive HP may change based on clarifier design chosen.

[2] Caustic dose depends on the alkalinity in the influent wastewater, the treatment goals, and the operating pH. It varies significantly, with some plants needing little or none and other plants needing more.

6.3 Sludge

The amount of sludge produced by the CoMag system will depend on the influent solids, coagulant type and dose, the flow, and operating conditions. Table 5 lists the estimated sludge production for each of the coagulant doses listed in Table 4. Metal hydroxide solids typically have some water of hydration attached. The total sludge production will be the sum of the metal hydroxide solids and the influent suspended solids (TSS).

Under normal operating conditions, the total solids concentration of the waste sludge will range from 0.2% to 1.0%, with 0.5% being typical.

Table 5: Sludge Production

Coagulant	Sludge Production
Ferric chloride (40%)	2.3 lb/lb $FeCl_3$
Alum (48.5%)	3.2 lb/lb Alum

7 SUPPORT SERVICES

Evoqua will provide the following services:

Installation and Pre-Commissioning: Services of a representative to visit the site for up to 4 days to assist the contractor during installation. Additionally, Evoqua will provide the services of a representative for up to 5 days verify the installation of CoMag™ system and ancillary systems prior to startup and to check that the installation complies with design requirements; adjust and test equipment.

Pre-Commissioning: **Checkout, Startup and Testing**: Evoqua will provide the services of a representative for up to 10 days for startup of the CoMag™ system following successful completion of the pre-commissioning inspection. During startup and testing Evoqua shall tune the treatment process so that it operates in accordance with the design requirements.

Training: Evoqua will provide a qualified trainer to conduct a training course for operating staff. The training period, of up to a total of 16 hours of normal working time, shall start after the system is functionally and installation is completed. The field instructions shall cover all of the items contained in the operating and maintenance instructions, as well as demonstrations of routine maintenance operations.

Technical and Operational Support: Evoqua shall provide for 5 days of supports services to review and evaluate the performance of the CoMag System.

8 BUDGETARY PRICING

The budgetary price for the Evoqua CoMag system, as defined herein, including process and design engineering, field services, and equipment supply: **see email.**

The scope of supply and pricing are based on Evoqua standard equipment selection, standard terms of sale and warranty terms as described herein. Any variations from these standards may affect this budgetary quotation. Additionally, please note this budgetary quotation is for review and informational purposes only and does not constitute an offer for acceptance.

This price makes no provision for taxes, tariffs, duties, permitting fees and other fees and charges that are not made explicit above.

All pricing is quoted at FOB, Factory (full freight allowed). No taxes, regulatory fees or other costs related to the procurement and installation of the system are included.

Appendices

A. Frequently Asked CoMag Questions

B. Typical Drawings

APPENDIX A – FREQUENTLY ASKED QUESTIONS

1. **GENERAL QUESTIONS ABOUT MAGNETITE, THE FUNDAMENTAL ELEMENT USED IN COMAG TO INCREASE SETTLING RATES AND RELIABILITY.**

Q. What is magnetite?

A. Magnetite is fully oxidized iron ore (Fe_3O_4). It is completely inert; it cannot rust; it doesn't degrade with time or usage; it has no effect on biological floc; and it is not magnetic itself; i.e., it doesn't stick to metal. If you have ever played with an "Etch-a-Sketch," the material inside the toy is magnetite.

Q. How does magnetite improve the performance of clarifiers and biological treatment systems?

A. Magnetite is a very dense material with a specific gravity of 5.2. By comparison the specific gravity of water is 1.0; a chemical hydroxide floc is fractionally over 1.0; and a biological floc is ≈1.25. By infusing magnetite into either a chemical or biological floc, the specific gravity is increased by 50 to 100%; thereby significantly increasing the settling rate of the floc and gaining consistent control of the sludge blanket in the clarifier and greater stability for the whole system.

Q. Is magnetite readily available?

A. Yes, magnetite is mined and processed at multiple sites around the world. In the USA, Evoqua has identified multiple vendors that will provide magnetite to our specifications.

Q. What is the cost of magnetite?

A. Magnetite is very inexpensive, ranging from $0.20 to $0.50 per pound delivered, depending on the location of the distributor and the facility. Moreover, since the recovery rates of magnetite in CoMag systems are so high, daily consumption is very low; so much so that in assessing the operating cost of a CoMag system, the ongoing cost of magnetite is of no consequence.

Q. Is the magnetite abrasive? Does magnetite cause excessive wear to pumps?

A. Unlike micro-sand, a ballast used by our competitors, Evoqua specified magnetite is so fine that it has the consistency of talcum powder. Hence, it is much less abrasive and doesn't cause abnormal wear and tear on a treatment systems pumps, mixers, valves and other components at design conditions. At the seminal CoMag plant in Concord, MA there has been no discernable wear on the plants sludge pumps or mixers after 5 years of operation.

Q. Does magnetite degrade at high temperatures (or low temperatures) or with changes in pH?

A. *Magnetite does not undergo any physical or chemical change in the temperature and pH ranges associated with almost all municipal and industrial wastewater treatment.*

Q. Does magnetite affect pH or the chemical characteristics of the effluent?

A. *No, magnetite is completely inert; has no effect on pH or the chemical characteristics of a system's effluent.*

Q. Does magnetite affect the oxygen content of wastewater?

A. *Since magnetite (Fe_3O_4) is fully oxidized, it does not consume dissolved oxygen in the wastewater.*

Q. How much magnetite is recovered on the magnetic drum and where does the remainder go?

A. *Evoqua has modified the design of conventional magnetic drums to optimize the capture and reuse of magnetite. In CoMag systems, the drums recover in excess of 99.8% of the magnetite in the sludge. Any magnetite not captured by the drum is carried away in the sludge where we have found no effect on downstream sludge management systems or processing.*

Q. What is the impact of magnetite on the effluent; TSS, turbidity, etc.

A. *Less than a half a percent of the magnetite used in CoMag escapes the system; hence, the direct effect on the effluent quality of either system is negligible. It is however, the use of magnetite in Evoqua's CoMag systems that enables both systems to achieve such high levels of contaminant removal. For example, the effluent turbidity from the Concord CoMag system can be easily reduced to levels less than that of bottled drinking water.*

Q. How does magnetite in the effluent effect the performance of a downstream UV disinfection system?

A. *Since very little of the magnetite escapes the system, the direct effect is not discernable. In fact, CoMag as a tertiary polishing system is a UV enabler. The fact that CoMag can perform well with alum coagulants and achieve very high levels of transmissivity, makes it possible to employ less UV treatment (and power)to achieve required levels of pathogen removal. Concord uses only 50% of one of its three banks of UV to meet its permit levels.*

2. QUESTIONS OFTEN ASKED ABOUT THE COMAG PROCESS AND PERFORMANCE:

Q. How does CoMag handle high flows and surges?

A. *CoMag uses automated controls to rapidly respond to flow variations. CoMag is also particularly effective in maintaining high removal levels during surges in solids loading. Unlike other ballasted sedimentation systems, the CoMag process recycles a significant fraction of settled solids from its clarifier back to its reaction tanks. The high mass and density of solids in* *the reaction tanks is many times greater than that of any surge in influent loading. The system is fully capable of managing surges in load with little degradation of performance. The result is superior solids removal, especially compared to those processes that don't incorporate an internal solids recycle.*

Q. Can CoMag equipment be serviced over the 20-year design period?

A. All the components of the CoMag process are readily available in the marketplace. The system employs standard pumps, mixers, piping, valves, clarifier systems, and instruments. The magnetic components have been used in the mining industry since the early 1970s. Spare parts are readily available from multiple sources.

Q. What is the cost to install CoMag including the cost of structures, equipment, connecting piping, peripheral support systems, associated power and instrumentation, etc?

A. The installation costs are low for a CoMag system because of its simplicity, small footprint, and readily available parts. In addition and unlike alternative solutions, CoMag may not need expensive post treatment filters to achieve the required treatment levels of current and expected future permits.

Q. What are the costs of chemicals, additives, power, equipment, and labor associated with the CoMag process.

A. Generally, the operational costs of CoMag are quite low.

Chemical consumption is likely to be less than competitive systems due to the ability of CoMag to achieve required treatment levels with less coagulant and flocculent.

The process provides for a nearly complete recovery and reuse of the magnetic ballast hence the cost is low.

Energy consumption is very low given the gravity flow of the system and the minimum required head. The ballast recovery drum employs permanent magnets and hence consumes no energy other than that required to turn the drum.

The system is fully automated; the need for operator attention is minimal.

The system does not use tube settlers, which require regular cleaning.

Q. Are there major parts that will require replacement?

A. There are no major parts that will require replacement other than the perhaps the pumps and sludge shear mixer, which are expected to have a useful life of 10 years or more. Their replacement is a simple process as they are easily accessible and readily available. None of the parts are hazardous or would require special disposal.

Q. Does CoMag enable the use of alternative chemicals with the same performance?

A. Yes. CoMag will produce nearly the same contaminant removal levels with alum, ferric chloride, or poly-aluminum chloride (PAC), and other conventional coagulants. The size of the CoMag system is the same for any coagulant, unlike other competitive systems. This gives the flexibility to meet limits with a coagulant chemical that best suits it's a plants needs.

Q. Are CoMag and its operation easily understood and operated?

A. Yes, CoMag is very operator friendly. The system readily responds to changing influent flows and loads, easily handling excess solids from the secondary clarifiers. It has few parts needing replacement and no inclined tubes that require regular cleaning to keep them from clogging. CoMag requires no sand filters, which can clog and must be backwashed.

Q. Can the process operate 24 hours with only being manned 8 hours a day?

A. Yes. The CoMag system has fully automated PLC controls.

Q. Are the process and its operation safe for operations and/or maintenance personnel?

A. Yes. CoMag equipment complies with industry standards for safety. It uses chemicals that can be safely handled without additional or specialized training.

Q. Does the process have operational flexibility such as taking some units out of service on a seasonal basis to save on operational costs?

A. Yes. CoMag provides a high level of redundancy and the ability to modify operations to meet effluent requirements

The process design provided by Evoqua is redundant. The design of the CoMag system will hydraulically pass peak flows and meet the treatment requirements.

Inherent in the operation of CoMag is the ability to manage dosage levels to meet effluent contaminant requirements.

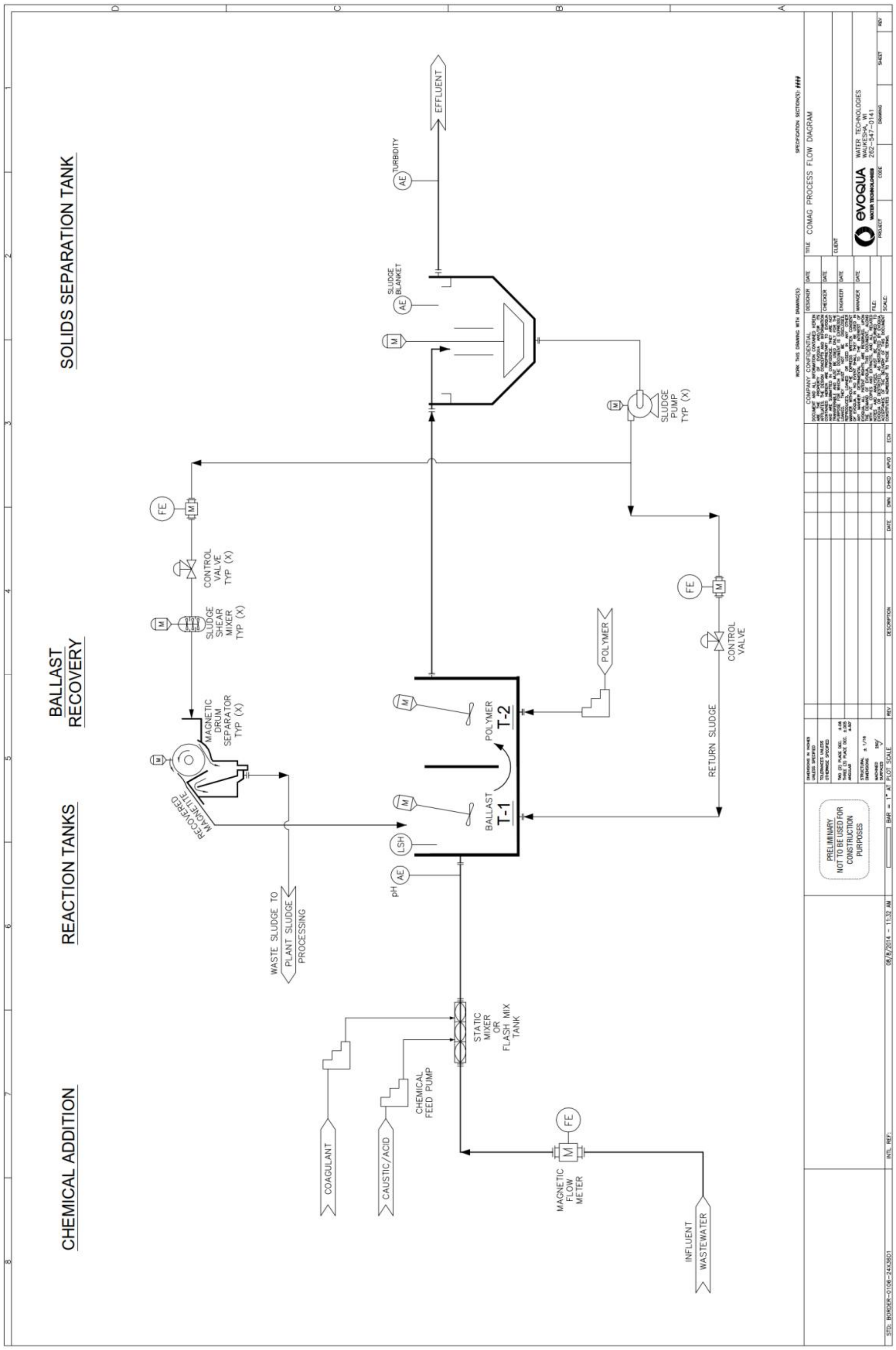
Q. Could the process have a negative effect on downstream unit operations, if needed for higher effluent quality in the future?

A. Implementation of CoMag will eliminate the need for downstream filters, thus eliminating the associated capital and O&M costs.

Q. Does the ballast rust or stick to steel pipe?

A. No, the ballast is a type of iron ore that is fully oxidized and does not rust. It is attracted to magnets, but it does not attach itself to steel pipe.

APPENDIX B – TYPICAL DRAWINGS



CESF Vendor Information

Remediation Solutions for the Real World™ – Stormwater, Groundwater, and Waste Water

Estimate of Probable Cost - August 7, 2014

SEATTLE PUBLIC UTILITIES: SOUTH PARK WATER TREATMENT FACILITY - CESF OPTION

BASED ON 6 CFS DESIGN FLOW RATE TREATMENT SYSTEM AND ANNUAL O&M FOR 232-257 ACRE DRAINAGE BASIN WITH AVERAGE RAINFALL IN SEATTLE, WA. WITH ANNUAL ESTIMATED TREATMENT VOLUME OF 10,100,000-13,700,000 CUBIC FEET

Task/Description		Quantity	UOM	Unit Price	Estimated Project Cost	Notes
Design & Engineering						
Design & Engineering Support	Initial Design, Pilot-Scale Testing, and 60-100% Design Support	As Req'd	HR	$ 95	$ -	Charge based on actual hours at specified rates.
	Software & Data Management Integration with SPU's current SCADA system			$ 80	$ -	
				Task Total	**$ -**	
Infrastructure Improvements						
Structure	Steel Structure	1	EA	$ 1,250,000	$ 1,250,000	Based on approximate build cost at $250/sq.ft. 10% Contingency Factor Recommended but NOT included.
				Task Total	**$ 1,250,000**	
6 CFS (2700 - 3375 GPM) Automated Stormwater Treatment System						
Fully Automated Control System, Water Quality Monitoring & Data Collection System & Dosing System	675-3375 GPM Variable Flow Rate: Remote Access PLC-Based System: Includes Pump Control, Pneumatic/Electric Filter Valve Control, Monitoring Instrumentation, Chemical Dosing System, Air Compressors, Fail-Safe Valving System, Data Collection, Alarm & Remote Telemetry System, and Heated Chemical Storage Tanks	1	EA	$ 439,992	$ 439,992	Fully Automated & Customized Control System
Sand Filter	54-24-4 Inline Yardney Sand Filters w/ PLC Based Backflush Controls and Pressure Regulated Valve Controls	5	EA	$ 42,946	$ 214,732	Drawings and Equipment Spec Sheets Available upon Request: System Power NOT Included. System Power Requirements = 480V, 3-Phase, 400 Amp Service
Filter Pumps	35 HP 6" Electric Pump, Vac Assist with Variable Frequency Drive (500-700 GPM @ 100' TDH)	5	EA	$ 16,923	$ 84,613	
Pretreat Pump	75 HP 8" Electric Pump, Vac Assist with Variable Frequency Drive (1000-3400 GPM @ 50' TDH)	1	EA	$ 42,813	$ 42,813	
Interconnected Plumbing	Schedule 80 4"-14" PVC w/ Flex Connectors, Pneumatic External Valve Control and Ultrasonic Vault Level Sensors	1	EA	$ 209,375	$ 209,375	
Mobilization and System Installation	Includes: Equipment Delivery, Initial Sand Filter Media Load, Plant Set-up, Start-up, Hydraulic Optimization, and Automation	1	LS	$ 294,174	294,174	Lump Sum: Based on previous experience with treatment system mobilization. Interconnecting plumbing lengths based on current system design.
				Task Total	**$ 1,285,698**	
Operations, Maintenance and Project Management						
Routine Maintenance	Regular maintenance and inspections	360	HR/YR	$ 70	$ 25,200	Estimate based on average rainfall for one year of system operations. Estimated hours based on automated operations, weekly inspections and monthly routine preventative maintenance. Charge based on actual hours at specified rates.
	Electrical & Programming Technician	96		$ 80	$ 7,680	
	Project Management and Reporting	72		$ 95	$ 6,840	
				Task Total	**$ 39,720**	
Consumables and Other Direct Costs						
Polymer	1% Chitosan Acetate: Treatment Volume =10,100,000 ft^3/yr.	13.6	TOTE/YR	$ 2,250	$ 30,600	Estimate based on average rainfall and estimated annual treatment volume of 10,100,000-13,700,000 cubic feet, estimated dose rate of 0.35-0.5 ppm and average treatability conditions for Seattle, WA. Chemical consumption rate is dependent on sediment and contamination loading. Charges based on actual consumption as specified rates.
	1% Chitosan Acetate: Treatment Volume =13,700,000 ft^3/yr.	18.1			$ 40,800	
Chemistry	pH Adjustment Chemistry and Misc. Lab Consumables	1	EA/YR	$ 7,492	$ 7,492	
Software Licensing	Use of PLC operations code, remote telemetry, and data logging	1	Year	$ 1,200	$ 1,200	CESF Specific PLC Auto-Code, Remote Alarm, Alert & Control Functions, Data Logging & Remote Storage.
Interconnected Plumbing	Replacement PVC Fittings and Pipe	As Req'd	EA/YR	Cost + 18%	$ -	Estimate: Charge based on replacement costs at 18% mark-up.
Media	Sand Filter Media Change-out	3	Filter/YR	$ 1,975	$ 5,924	Replacement of Sand Filter Media estimated at once per year for 3 of 5 filters. Charges based on actual costs + 18%.
Vac Truck Services	Vault Clean-out	1	EA/YR	$ 5,000	$ 5,000	
	Media Removal	3	EA/YR	$ 1,563	$ 4,688	
			Task Total	**$ 54,903**	**$ 65,103**	Range based on Treatment Volume

Infrastructure (Structure)	**$ 1,250,000**	10% Design Contingency NOT included.
Equipment & Set-up Sub-Total	**$ 1,285,698**	EXCLUDES: Power and applicable state/local taxes and fees
Annual O&M Estimate	**$ 94,623**	

EC Vendor Information

WATERTECTONICS
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Tel: 425.349.4200 Fax: 425.349.4890 www.watertectonics.com

Seattle Public Utilities – South Park – Improvements – WaveIonics-DAF 2700gpm

Submitted to:
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Date: August 21, 2014
Document Version: 1.0

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Table of Contents

1. Submittal Contacts

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2. Statement of Qualifications

Executive Summary

Established in 1999, WaterTectonics designs, manufactures, deploys, and services integrated water treatment solutions for clients in industrial, construction, oil & gas, and mining applications worldwide. The company specializes in advanced technologies including electrocoagulation, electrochemical oxidation, dissolved air flotation, media filtration, ultrafiltration, and reverse osmosis. WaterTectonics focuses on delivering leading-edge technology that is easy to implement and effective with complex, high-volume waste streams.

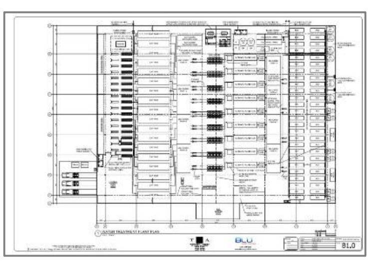
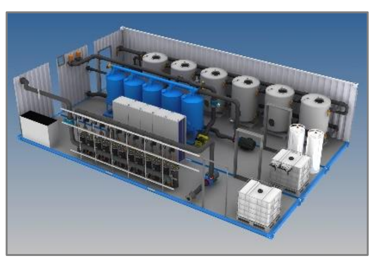
Technical Expertise

The strength of our solutions is rooted in the expertise of our technical leadership. The WaterTectonics team has a deep understanding of stormwater treatment in temporary and permanent applications. Our technologies are recognized and used by Fortune 500 companies around the world to treat complex waste stream in various applications. WaterTectonics has secured General Use Level Designation for its WaveIonics Electrocoagulation technology and has treated water on some of the most challenging sites throughout the Pacific Northwest over the past 15 years.



Product Manufacturing & Fulfillment

Superior manufacturing relies on precise engineering, defined processes, and skilled production personnel. The WaterTectonics team operates state-of-the-art manufacturing facilities which provide specialized manufacturing, assembly, and equipment staging and testing. Dimensional layout drawings, documented control logic, design specifications, wiring schematics, three-dimensional renderings, and other documents are used to ensure that every product meets the client's exact requirements. The WaterTectonics team has built equipment to some of the most stringent requirements in the world, including UL, CSA, Class 1 Div 1, Class 1 Div 2, DNV, and more.


Installation Support

Equipment delivery is accompanied by comprehensive operation & maintenance manuals, classroom and field equipment operations training, and client-tailored training videos (optional). The WaterTectonics field service team can provide turnkey field service and support after equipment delivery on an as-needed basis or through a defined maintenance program. WaterTectonics service technicians can dial in remotely to systems and help clients troubleshoot problems quicker and at lower cost than deploying a technician.

3. Project Information

This proposal is based on a collection of inputs from the client captured in discussions, emails, and documentation. For the purpose of this proposal, the following inputs are of material importance.

Site Location
This municipal stormwater outfall is located in Seattle, Washington on the Duwamish River. The outfall collects water from street runoff as well as sheet flow from various industrial facilities in a 234-acre heavy-use industrial area. A network of conveyance lines feed 3-4 primary trunk lines which feed a holding vault at the South Park location. Water flows by gravity from the vault through a 72" outfall via a tide-gate system.

System Sizing
The project engineer calculated the required treatment system flow rate at 2700gpm. Where appropriate, the client has requested N+1 redundancy in the treatment system design.

Water Quality Objectives
WaterTectonics conducted bench-scale treatability testing and field-scale pilot testing in 2011 and 2012. Multiple system configurations were tested during the pilot. During the 2012 pilot, simple clarification tanks were used for solids separation after the electrocoagulation process. In the current design, dissolved air flotation is proposed as the solids separation process, which should provide improved performance and reduced sludge management labor.

Table 1: WaveIonics 2012 Pilot Performance Data

PARAMETER	UNIT	INFLUENT	EFFLUENT	% REDUCTION	TARGET
TSS	mg/L	156	33.2	78%	80% Reduction
Turbidity	NTU	175	35	80%	< 5 NTU
Copper, Total	µg/L	42.6	10.1	76%	50% Reduction
Lead, Total	µg/L	28.5	5	82%	50% Reduction
*Zinc, Total	µg/L	163	41	74%	50% Reduction
Arsenic, Total	µg/L	Not Tested	Not Tested	N/A	50% Reduction

4. System Process Description

The objective of this multi-stage water treatment system is to provide a design that can accommodate varying water characteristics while meeting defined stormwater discharge benchmarks.

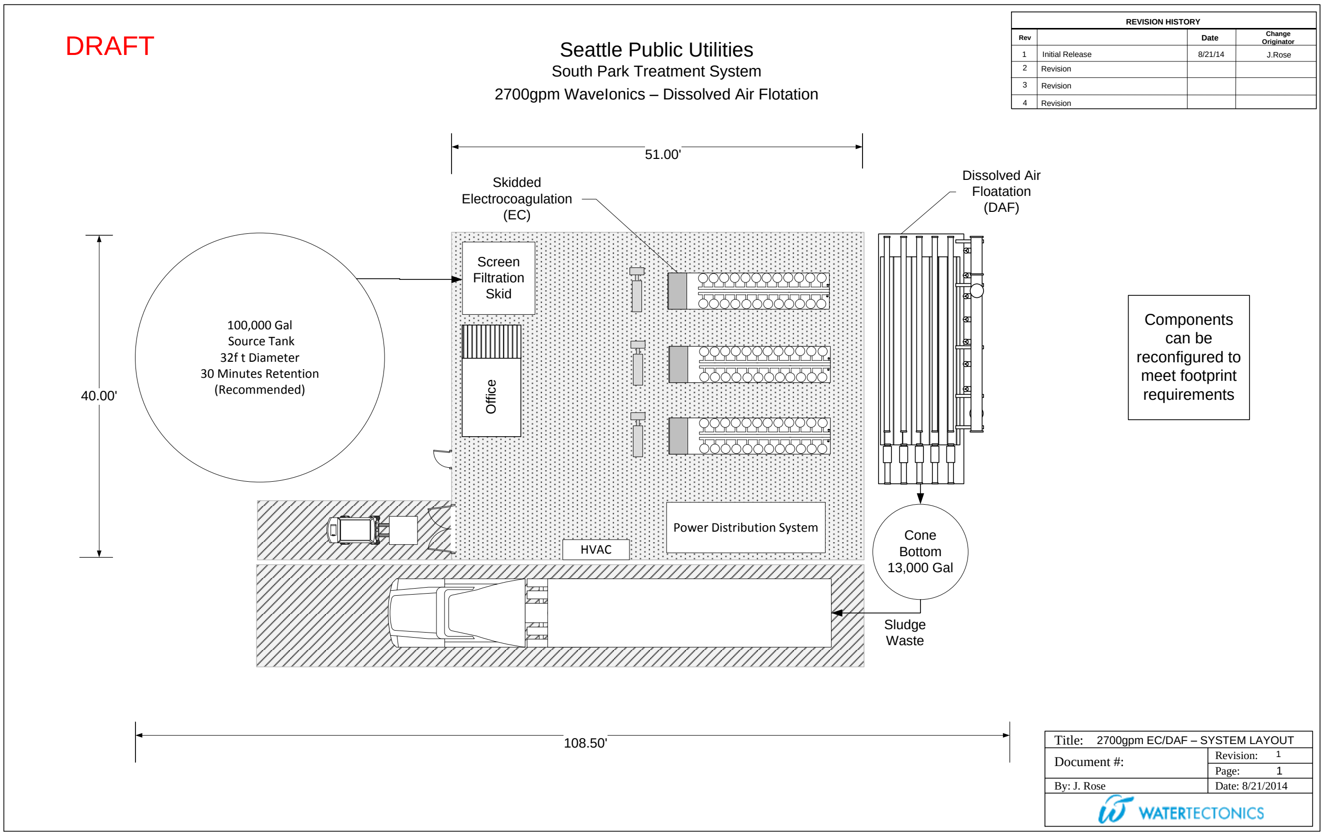
Process 1: WaveIonics Electrocoagulation Treatment
The WaveIonics electrocoagulation treatment system is the first treatment step and is also the core of the treatment process in the proposed design. Electrocoagulation is capable of coagulating fine particles, oxidizing metals, precipitating contaminants, and de-emulsifying emulsified oils for broad spectrum treatment. Water is conveyed from the final collection point to the WaveIonics treatment system where it is distributed through a series of electrocoagulation treatment cells.

Process 2: Dissolved Air Flotation
As water leaves the treatment cells, it enters into the dissolved air flotation system where non-settleable solids, fines, and heavy metal ions begin to coagulate due to cationic particle charges and electron surplus causing ionic/covalent bonding and agglomeration. The separation of these coagulated particles is encouraged by micro-bubbles introduced at the influent pipe and incline plates in the dissolved air flotation chamber. Sludge is removed via an automated scraper at the top of the tank and also through sumps at the bottom of the tank.

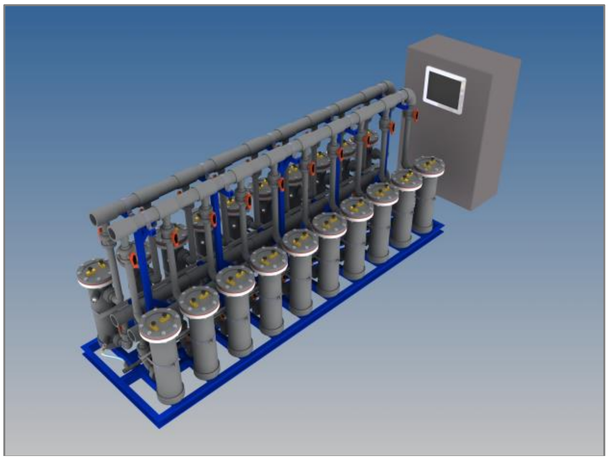
The WaveIonics Automated Operator System
Regardless of the configuration of treatment equipment shown above, all system processes will be controlled by the WaveIonics Automated Operator system. This system incorporates control and adjustment of all system processes to a single touch-screen user interface. This interface allows the operator to visualize system performance and operations and quickly see if there are any elements that require operator attention. In standard operation, the system is set to run automatically and send system alerts to operators via text or mobile phone.

Water Quality Discharge Valve
Prior to final discharge, all effluent water will pass through a water quality discharge valve. This valve measures turbidity and pH in real-time and only allows discharge of effluent water that meets user-defined criteria. Non-compliant water is automatically returned for re-treatment via a programmable and system integrated auto-actuated re-circulation valve.

5. Equipment Layout



6. System Pictures


1000gpm WaveIonics Treatment Skid


Dissolved Air Flotation System


WaveIonics Treatment Cells


Source Tank


Water Quality Control Panel

Touch-Screen User Interface

7. System Summary Detail

WAVEIONICS SYSTEM SUMMARY

COMPONENT	DESCRIPTION
System Design	Includes dimensional layout drawings, documented control logic, design specifications, wiring schematics, and project-specific design requirements.
Electrocoagulation Treatment System	Includes containerized electrocoagulation treatment system with associated PLC control systems.
Managed Water Quality System	Includes automatic re-circulation setup interlocked with water quality readings. Monitors and logs turbidity and pH with real-time probes. Includes influent and effluent flow meters.
pH Management System	Includes equipment for monitoring and controlling influent and effluent water pH levels.
Conductivity Management System	Includes equipment for monitoring and controlling influent water conductivity levels.
System Pump	Includes influent system pump between the source tank and the WaveIonics electrocoagulation treatment system.

SOLIDS SEPARATION SYSTEM SUMMARY

COMPONENT	DESCRIPTION
Dissolved Air Flotation	Includes complete dissolved air flotation system manufactured with high-density plastic. Treatment elements include micro-bubble injection pump, incline plate separation, automated sludge skimmer, and sludge sumps and associated pumps.

INSTALLATION & COMMISSIONING SUMMARY

COMPONENT	DESCRIPTION
System Installation	Includes installation of intersystem hydraulic and electrical components and coordination of these activities with any client contractors as necessary. Piping to be Schedule 80 PVC and flex hose unless otherwise specified. Any and all below-grade work must be performed by others.
System Commissioning	Includes initial system startup and testing, calibration of all field instruments, and field-testing to ensure all components meet the design specification.
WaterTectonics Operator Training Program	Includes 40 hours of total on-site training time for up to four client operators. The training program includes 8 hours of classroom training, 24 hours of field training with staged troubleshooting and system diagnostics, and 8 hours of follow-up training after that first 60 days of operation to ensure operator success.
Operation & Maintenance Manuals	Includes design-specific operations & maintenance manuals for the system along with any third-party hardware manuals.
System Alerts & Notifications	Includes system status & performance alert notification to text or email of up to four system operators for one year after installation.

8. Cost Schedule

COST SUMMARY – 1000GPM SYSTEM

ITEM NO.	QUANTITY	ITEM	COST
1.1	1	WaveIonics 2700gpm	$1,215,000
1.2	1	Dissolved Air Flotation 2700gpm	$610,400
1.3	1	Installation & Commissioning	$154,600
1.4	1	100,000 Gallon Source Tank	$107,000
1.5	1	Delivery	$35,400
TOTAL			**$2,122,400**

PURCHASE TERMS

BILLING MILESTONE	ITEM	PERCENTAGE
1	Deposit	40%
2	Delivery	40%
3	Installation	10%
4	Commissioning	10%

ESTIMATED OPERATING COSTS

ITEM	ESTIMATED COST PER 1,000 GALLONS
WaveIonics Treatment Cells	$1.40
Sodium Hydroxide	$0.118
Carbon Dioxide	$0.055
Conductivity Solution	$0.075
Energy Consumption*	$0.17
Total	**$1.82**

** Energy consumption based on an estimated $0.07/KWH*
***Consumable pricing other than WaveIonics Treatment Cells are based on typical market rates*

Delivery
Based on standard design, the above treatment system can be delivered in 18 to 24 weeks from receipt of purchase order. Specific production/delivery timelines will be determine at the time of order.

9. Exclusions

Trenching
This proposal does not cover the cost of material or labor to place any hydraulic or electrical conduit below ground.

Equipment Loading/Offloading
This proposal does not cover the cost of equipment loading/off-loading that will be required for system components and materials.

Operational/Maintenance Consumables
This proposal does not include the consumables required with the operations and maintenance of the system including, but not limited to, the consumables described in the above proposal.

Laboratory Sampling Fees
This proposal does not include any costs for fees related to analytical sample analysis that may be conducted by a third party laboratory.

Permitting
This proposal does not include any costs for mechanical/electrical/other permitting and/or engineering drawings related to this effort.

Electrical Connection or Usage
This proposal does not include any costs to provide the necessary power requirement, nor does it cover any costs for the electrical usage consumed by the unit.

Code/Company Compliance
WaterTectonics provides a UL508 designation with its system. Additional company or local electrical code requirements are excluded from this proposal.

Environmental Containment
This proposal does not cover the cost to house/cover components external to the WaveIonics system.

Source Pumps
This proposal does not cover the cost to supply transfer pumps between the client's influent water source and the treatment system.

State & Local Sales Tax
State & local sales tax are not included in this proposal but will be charged as required by law.

10. Warranties

All components are covered for one (1) year beginning from the date of product commissioning. Labor to replace any components for one (1) year from the date of installation is covered under the product warranty. Acts of God, Negligence, operator error, lack of maintenance is not covered by warranty. Failure by operator to follow product operational requirements, guidelines and maintenance will void warranty. Environmental conditions outside of this range are not covered by this warranty (<35 degrees and/or >110 degrees).

Any modifications by the Client post installation are not covered by this warranty. Client shall not allow the presence of any hazardous waste in equipment. Client shall not use the Product in violation of any environmental law or regulation, or in violation of other laws or regulations. Should accidental contamination occur, Client shall completely indemnify and hold harmless Manufacturer from any and all financial, legal or any other such actions and waives all rights and claims as a result.

Attachment D: Project Cost Crosswalk Tables

Table D-1. Option 1: Ballasted Sedimentation Estimate Crosswalk

	Category	Item		Labor	Material	Subs	Equipment	Other	Net costs	Reference
Brown and Caldwell estimate	Line item pricing	Water treatment		$1,081,000	$1,811,000	$8,660,00	$130,000	$9,000	$3,897,000	Basis-of-Estimate report, vendor quotes, and Solids TM
		Solids facility		$328,000	$517,000	$277,000	$73,000	$8,000	$1,203,000	
		Line item subtotal		$1,409,000	$2,328,000	$1,143,000	$203,000	$17,000	$5,100,000	
	Contractor markups	Labor	10.0%	$141,000					$141,000	Basis-of-Estimate report
		Materials	8.0%		$186,000				$186,000	
		Equipment	8.0%				$16,000		$16,000	
		Subs	5.0%			$57,000			$57,000	
		Material shipping and handling	2.0%		$47,000				$47,000	
		Contractor markup subtotal		$141,000	$233,000	$57,000	$16,000	$0	$447,000	
	Gross cost markups	Line item plus contractor markups		$1,550,000	$2,561,000	$1,200,000	$219,000	$17,000	$5,547,000	
		Startup, training, and O&M	2.0%						$111,000	
		Subtotal							$5,658,000	
		Insurance	2.0%						$113,000	
		Subtotal							$5,771,000	
		Bonds	1.50%						$87,000	
		Line item plus markups							$5,878,000	
SPU cost estimate template	WQF unit price								$5,878,000	SPU cost estimating guidelines
	Allowance for indeterminates		0.0%						$0	
	Construction line item pricing								$5,878,000	
	Adjustment for market conditions		0.0%						$0	
	Construction bid amount								$5,878,000	
	Sales tax		9.5%						$556,000	
	Construction contract amount								$6,414,000	
	Crew construction costs		5.0%						$321,000	
	Miscellaneous hard costs		5.0%						$321,000	
	Construction cost total								$7,056,000	
	Soft costs		49.0%						$3,457,000	
	Property costs								$0	
	Base cost total								$10,513,000	
	Contingency reserve		35.0%						$3,680,000	
	Management reserve		20.0%						$2,103,000	
	Project reserves								$5,782,000	
	Total cost								$16,295,000	

Table D-2. Option 2: CESF Estimate Crosswalk										
	Category	Item		Labor	Material	Subs	Equipment	Other	Net costs	Reference
Brown and Caldwell estimate	Line item pricing	Water treatment		$1,294,000	$2,041,000	$1,094,000	$290,000	$32,000	$4,751,000	Basis-of-Estimate report, vendor quotes, and Solids TM
		Solids facility		$328,000	$517,000	$277,000	$73,000	$8,000	$1,203,000	
		Line item subtotal		$1,622,000	$2,558,000	$1,371,000	$363,000	$40,000	$5,954,000	
	Contractor markups	Labor	10.0%	$162,000					$162,000	Basis-of-Estimate report
		Materials	8.0%		$205,000				$205,000	
		Equipment	8.0%				$29,000		$29,000	
		Subs	5.0%			$69,000			$69,000	
		Material shipping and handling	2.0%		$51,000				$51,000	
		Contractor markup subtotal		$162,000	$256,000	$69,000	$29,000	$0	$516,000	
	Gross cost markups	Line item plus contractor markups		$1,784,000	$2,814,000	$1,440,000	$392,000	$40,000	$6,470,000	
		Startup, training, and O&M	2.0%						$129,000	
		Subtotal							$6,599,000	
		Insurance	2.0%						$132,000	
		Subtotal							$6,731,000	
		Bonds	1.50%						$101,000	
		Line item plus markups							$6,832,000	
SPU cost estimate template	WQF unit price								$6,832,000	SPU cost estimating guidelines
	Allowance for indeterminates		0.0%						$0	
	Construction line item pricing								$6,832,000	
	Adjustment for market conditions		0.0%						$0	
	Construction bid amount								$6,832,000	
	Sales tax		9.5%						$649,000	
	Construction contract amount								$7,481,000	
	Crew construction costs		5.0%						$374,000	
	Miscellaneous hard costs		5.0%						$374,000	
	Construction cost total								$8,229,000	
	Soft costs		49.0%						$4,032,000	
	Property costs								$0	
	Base cost total								$12,261,000	
	Contingency reserve		35.0%						$4,291,000	
	Management reserve		20.0%						$2,452,000	
	Project reserves								$6,740,000	
	Total cost								$19,005,000	

Table D-3. Option 3: EC Estimate Crosswalk

	Category	Item		Labor	Material	Subs	Equipment	Other	Net costs	Reference
Brown and Caldwell estimate	Line item pricing	Water treatment		$1,554,000	$2,891,000	$1,128,000	$212,000	$29,000	$5,814,000	Basis-of-Estimate report, vendor quotes, and Solids TM
		Solids facility		$328,000	$517,000	$277,000	$73,000	$8,000	$1,203,000	
		Line item subtotal		$1,882,000	$3,408,000	$1,405,000	$285,000	$37,000	$7,017,000	
	Contractor Markups	Labor	10.0%	$188,200					$187,200	Basis-of-Estimate report
		Materials	8.0%		$272,640				$272,640	
		Equipment	8.0%				$22,800		$22,800	
		Subs	5.0%			$70,250			$70,250	
		Material shipping and handling	2.0%		$68,160				$68,160	
		Contractor markup subtotal		$188,200	$340,800	$70,250	$22,800	$0	$621,050	
	Gross cost markups	Line item plus contractor markups		$2,070,200	$3,748,800	$1,475,250	$307,800	$37,000	$7,639,050	
		Startup, training, and O&M	2.0%						$152,781	
		Subtotal							$7,791,831	
		Insurance	2.0%						$155,837	
		Subtotal							$7,947,668	
		Bonds	1.50%						$119,215	
		Line item plus markups							$8,066,883	
SPU cost estimate template	WQF unit price								$8,066,883	SPU cost estimating guidelines
	Allowance for indeterminates		0.0%						$0	
	Construction line item pricing								$8,066,883	
	Adjustment for market conditions		0.0%						$0	
	Construction bid amount								$8,066,883	
	Sales tax		9.5%						$766,354	
	Construction contract amount								$8,833,236	
	Crew construction costs		5.0%						$441,662	
	Miscellaneous hard costs		5.0%						$441,662	
	Construction cost total								$9,716,560	
	Soft costs		49.0%						$4,761,114	
	Property costs								$0	
	Base cost total								$14,477,675	
	Contingency reserve		35.0%						$5,067,186	
	Management reserve		20.0%						$2,896,535	
	Project reserves								$7,962,721	
	Total cost								$22,440,396	

Attachment E: Estimate Summary

Construction Contract Amount Spreadsheet - Before Stage Gate 2 Approval

Project Name: South Park WQF
Project ID:
Project Phase: <<Enter project phase>>
Cost Estimator(s):
Date:

Assumptions for all options and each major item are documented in the Basis of Estimate document

#	Cost Item Description	Unit	Unit Price	Option 1 Ballasted Sedimentation Quantity	Option 2: Enhanced Filtration Quantity	Option 3: Electro-coagulation Quantity	Option 1 Ballasted Sedimentation Estimated Cost	Option 2: Enhanced Filtration Estimated Cost	Option 3: Electro-coagulation Estimated Cost
1	Ballasted Sedimentation	LS	$ 5,858,000	1	-	-	$ 5,858,000	$ -	$ -
2	Enhanced Filtration	LS	$ 6,832,000	-	1	-	$ -	$ 6,832,000	$ -
3	Electrocoagulation	LS	$ 8,067,000	-	-	1	$ -	$ -	$ 8,067,000
8	0% AFI for Standalone WQF / Joint project	%	0%	1	1	1	$ -	$ -	$ -
						Construction Line Item Pricing	**$ 5,858,000**	**$ 6,832,000**	**$ 8,067,000**
						Adjustment for Market Conditions	0%	0%	0%
						Construction Bid Amount	**$ 5,858,000**	**$ 6,832,000**	**$ 8,067,000**
						Sales Tax %	9.50%	9.50%	9.50%
						Construction Contract Amount	**$ 6,414,510**	**$ 7,481,040**	**$ 8,833,365**
						Crew Construction Costs	$ 320,726	$ 374,052	$ 441,668
						Miscellaneous Hard Costs	$ 320,726	$ 374,052	$ 441,668
						Construction Cost Total	**$ 7,055,961**	**$ 8,229,144**	**$ 9,716,702**
						Soft Cost %	49%	49%	49%
						Soft Cost	$ 3,457,421	$ 4,032,281	$ 4,761,184
						Property Acquisition Costs	$ -	$ -	$ -
						Base Cost Total	**$ 10,513,382**	**$ 12,261,425**	**$ 14,477,885**
						Contingency Reserve %	35%	35%	35%
						Contingency Reserve	$ 3,679,684	$ 4,291,499	$ 5,067,260
						Management Reserve %	20%	20%	20%
						Management Reserve	$ 2,102,676	$ 2,452,285	$ 2,895,577
						Project Reserves	$ 5,782,360	$ 6,743,784	$ 7,962,837
						Total Cost	**$ 16,295,742**	**$ 19,005,208**	**$ 22,440,722**
						Total Cost Projection	**NA**	**NA**	**NA**