City of Beaverton – Sterling Park

Stormwater Artificial Recharge (AR) Limited License Application

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Abbreviations and Acronyms

AR	artificial recharge
ASR	aquifer storage and recovery
bgs	below ground surface
CGWA	Critical Groundwater Area
City	City of Beaverton
COC	chain-of-custody
CRBG	Columbia River Basalt Group
DEQ	Oregon Department of Environmental Quality
DO	dissolved oxygen
DOGAMI	Oregon Department of Geology and Mineral Industries
ft	feet
ft^2	square feet
GAC	granular activated carbon
gpm	gallons per minute
GSI	GSI Water Solutions, Inc.
JWC	Joint Water Commission
MCL	Maximum Contaminant Level
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
MGY	million gallons per year
OAR	Oregon Administrative Rules
ORP	oxidation reduction potential
OWRD	Oregon Water Resources Department
PCC	Portland Community College
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PLC	programmable logic controller
PPE	personal protective equipment
PTW	pump-to-waste
QA/QC	quality assurance and quality control
SMCL	Secondary Maximum Contaminant Level
SSPA	S.S. Papadopulos & Associates, Inc.

UIC	Underground Injection Control
USGS	U.S. Geological Survey
UTL	upper tolerance limit
UV	ultraviolet
VFD	variable frequency drive
WAB	Water Availability Basin
WQV	water quality vault
WY	water year

Executive Summary

The City of Beaverton, Oregon (City) is planning an artificial recharge (AR) project using treated stormwater as source water, with recovery of the stored water to be used for municipal non-potable distribution and streamflow enhancement. The overarching purpose for this AR project is to provide relief for summertime demand of potable water, which is roughly 60 percent greater than winter demand, primarily due to irrigation. Irrigation does not require treated drinking water, so an alternative non-potable source provided from this AR project would greatly alleviate both cost and strain on the City's existing potable water sources.

The proposed location for the AR project is adjacent to South Cooper Mountain, a rapidly developing area near the southwestern boundary of the City that was annexed in 2013. This area is also within the Cooper Mountain-Bull Mountain Critical Groundwater Area (CGWA). The CGWA designation prohibits new major withdrawals of groundwater from the Columbia River Basalt Group (CRBG) aquifer, thus imposing additional challenges for the City to obtain new water sources to meet increasing demands.

In the late 1990s and early 2000s, the City evaluated the area adjacent to South Cooper Mountain for possible expansion of their aquifer storage and recovery (ASR) program. An exploratory core hole and an ASR pilot well (referred to as ASR 3) were constructed in 2000 and 2001, respectively, at the AR site that also contained a stormwater detention facility for a developing residential area, referred to as Sterling Park. Initial testing data from ASR 3 indicated moderate ASR potential, and manganese and total dissolved solid levels above the federal Secondary Maximum Contaminant Level (SMCL). Based on this information, the City delayed development of ASR 3 as an ASR well, but has used the well for groundwater level monitoring as part of its ASR program under Oregon Water Resources Department (OWRD) ASR Limited License #002.

This AR project would use treated residential stormwater as source water for groundwater recharge at ASR 3. The conceptual plan is to capture stormwater at an existing stormwater detention basin at the Sterling Park site, treat it to meet water quality requirements for AR projects, and then use the treated stormwater as source water for recharge (injection)[1] into the local CRBG aquifer. Stored stormwater would be recovered during warmer and drier periods of the year for non-potable beneficial uses. Currently planned non-potable uses by the City include irrigation (nearby schools, residential right-of-way planting strips, etc.) and streamflow augmentation for nearby Summer Creek.

A series of feasibility studies were undertaken from 2015 to 2018 to characterize regional and site-specific stormwater quality, followed by stormwater treatment pilot testing in 2000 and 2021 to develop a treatment process to meet water quality objectives for recharge. Sterling Park stormwater quality is typical for residential areas with low-traffic streets. The results of treatment pilot testing indicates that filtration, synthetic removal with granular activated carbon (GAC), and ultraviolet (UV) disinfection is capable of meeting water quality requirements.

A key conclusion from pilot testing of the treatment system is that the optimal treatment rate is approximately 200 gallons per minute (gpm). Thus, it is anticipated that 200 gpm will be the typical injection rate, with lower and possibly higher rates of injection occurring during correspondingly smaller and larger precipitation events.

[1] The terms "recharge" and "injection" are used interchangeably in this report.

Data acquired from 2017 to 2019 indicate that potential annual recharge volumes might range from approximately 13 million gallons (MG) to more than 26 MG. Therefore, to accommodate higher runoff volumes that correspond to potentially higher precipitation years, the City anticipates being able to store up to 30 MG per year during AR pilot testing. Although retaining a significant volume of carryover storage on a year-to-year basis is not anticipated, the City is requesting a maximum storage volume of up to 50 MG.

Based on feasibility study work completed to date, the planned recharge rate and AR volumes for this AR application are summarized below; note that these values are somewhat greater than summarized above to provide the City with the flexibility to expand if the results from AR pilot testing support doing so:

- Instantaneous recharge rate: 300 gpm
- Annual recharge volume: 30 MG
- Maximum AR storage volume (including carryover): 50 MG

This AR Limited License Application meets or exceeds the requirements for AR applications in Oregon Administrative Rules (OAR) 690-350-0120. A pre-application conference with representatives from OWRD and the Oregon Department of Environmental Quality was held on August 31, 2021. This report includes a Hydrogeologic Feasibility Study and an AR Project Description Report, as well as other elements required for submittal of a Limited License application for AR Testing. Soon after the expected issuance of a Limited License for AR testing, the City plans to consult with OWRD to determine the best time to submit an application for a Limited License for AR recovery.

Plans are currently underway for constructing major facility improvements that will allow for the full-scale implementation of AR as described in this document. Final design and construction of the AR system is planned for 2022, with construction anticipated to start by mid-2022.

SECTION 1: **Introduction**

On behalf of the City of Beaverton, Oregon (City), GSI Water Solutions, Inc. (GSI) has prepared this report as the key component of a Limited License application for conducting artificial recharge (AR) at Sterling Park. This AR Limited License application meets or exceeds the requirements for AR applications in Oregon Administrative Rules (OAR) 690-350-0120.

The City of Beaverton, Oregon (City) is planning an AR project using treated stormwater as source water, with recovery of the stored water to be used for municipal non-potable distribution and streamflow enhancement. The overarching purpose for this AR project is to provide relief for summertime demand of potable water, which is roughly 60 percent greater than winter demand primarily due to irrigation. Irrigation does not require treated drinking water, so an alternative non-potable source provided from this AR project would greatly alleviate both cost and strain on the City's existing potable water sources.

The City's primary drinking water source is the Tualatin River through the Joint Water Commission (JWC) treatment plant located more than 20 miles from the City. Additionally, since the late 1990s the City has used aquifer storage and recovery (ASR) to store approximately 300 million gallons (MG) of treated drinking water annually. The City's overall summer water demands are currently met by a combination of water provided by the JWC (approximately 75 percent, up to 14 million gallons per day [mgd]) and from water recovered from its ASR wells (about 25 percent, up to 5 mgd).

In 2013, the City annexed approximately 544 acres of land near the far southwestern City boundary. This area, referred to as South Cooper Mountain, is currently under development to include approximately 3,500 new homes, several parks, a new high school, and a future elementary school. This new development has placed additional demands on the City's potable water supplies.

South Cooper Mountain is adjacent to a location that was previously evaluated for expansion of the City's ASR program. An exploratory core hole (Oregon Water Well Report WASH 55816) and an ASR pilot well (Oregon Water Well Report WASH 57952) were constructed in 2000 and 2001, respectively, at a site that also contained stormwater detention facility for a developing residential area referred to as Sterling Park (Figure 1). The ASR pilot well was originally referred to as the ASR 3 Pilot Well, and is hereafter referred to as ASR 3.

Initial testing data from ASR 3 indicated moderate ASR potential, but less favorable than ASR wells completed at the City's existing ASR facility located approximately three miles to the northeast. Additionally, water quality analysis indicated ASR 3 native groundwater quality has elevated concentrations of manganese and total dissolved solids, both of which are found in levels above their respective federal Secondary Maximum Contaminant Levels (SMCL). Based on this information, the City delayed development of ASR 3, but has used the well for groundwater level monitoring as part of its ASR program under Oregon Water Resources Department (OWRD) ASR Limited License #002.

Conceptual planning in 2014 and 2015 for residential and commercial development in the adjacent South Cooper Mountain area identified use of native groundwater[2] from ASR 3 as a source for non-potable[3] residential irrigation. This was considered a way to use this existing ASR well infrastructure while also providing a water source for irrigation, without impacting the City's peak drinking water supply.

[2] The City possesses a groundwater right (GR-343) to use this well.
[3] Direct potable use of groundwater from ASR 3 is not preferred because of aesthetic issues that would require additional treatment.

Collaboration between the City and Clean Water Services in 2015 identified use of wintertime stormwater as a potential source of aquifer recharge (injection) that could address stormwater management challenges in the South Cooper Mountain area, and serve as an additional source of non-potable irrigation water supply. This concept was further explored with a site-specific feasibility evaluation in 2017 to 2018 (GSI, 2018), funded in part by an OWRD Storage Feasibility Study Grant (GR-0117-17) that focused on characterization of stormwater quality and quantity. Based on positive feasibility, the City and Clean Water Services obtained an OWRD Water Project Grant and Loan (WPG-0022-18) that has included stormwater treatment pilot testing in 2020 to identify treatment components capable of treating stormwater to meet regulatory requirements for use as groundwater storage. Additional work under this grant includes design and construction of the stormwater treatment system that is described in this AR Limited License application.

Implementation of AR projects in Oregon are regulated by OWRD, the Oregon Health Authority (OHA), and the Oregon Department of Environmental Quality (DEQ). An initial permitting requirement for AR projects is the submission of a Limited License application to conduct AR recharge pilot testing. A second Limited License for AR recovery testing is required if the licensee wants to recover the stored water and put it to a beneficial use.

1.1 General Project Description

This section provides a general description of the Sterling Park stormwater AR project being planned by the City. Later sections of this report provide additional detailed discussion for each key component of the project.

Stormwater from the Sterling Park residential neighborhood currently discharges to detention ponds that are designed to provide stormwater quality treatment and are located at the intersection of SW Scholls Ferry Road and SW Loon Drive in Beaverton (site) (Figure 1). Stormwater that discharges to this location is collected primarily from residential roads, sidewalks, driveways, and roofs within the Sterling Park neighborhood and from a portion of SW Scholls Ferry Road (Figure 2).

The Sterling Park AR project would use treated residential stormwater as source water for AR. The conceptual plan is to divert stormwater at the Sterling Park stormwater quality treatment facility, treat it to meet Oregon water quality requirements for AR projects[4], and then use the treated stormwater as source water for recharge into the local Columbia River Basalt Group (CRBG) aquifer.

After the raw stormwater is treated it would be recharged, or injected, into the underlying aquifer via ASR 3. The City is planning on recovering stored water under a future AR recovery Limited License using both ASR 3 and ASR 3A (WASH 78442), the latter an additional larger-diameter water well completed by the City in 2019 located approximately 40 feet (ft) from the ASR 3.

Stormwater recharge into the local CRBG aquifer would be designed to protect the highest beneficial use of the receiving aquifer, which is drinking water. As discussed in this report, an evaluation of site-specific stormwater quality data as well as representative stormwater quality data from similar residential and municipal areas indicates that this residential stormwater runoff would meet all applicable water quality criteria with minimal treatment. During future pilot testing, stormwater quality and flow at the site would be monitored in accordance with applicable DEQ and OWRD regulatory requirements to ensure protection of the CRBG aquifer for its highest beneficial use.

[4] See OAR 690-350-110 to -130.

Stored stormwater would be recovered during warmer and drier periods of the year for non-potable beneficial uses. Currently planned uses by the City include irrigation (nearby schools, residential right-of-way planting strips, etc.) and streamflow augmentation for nearby Summer Creek.

1.1.1 Project Benefits

Some of the benefits of this proposed project are listed below. By extension, if the project is successful, these types of benefits could be realized at other locations in the region. Benefits will include:

- **Enhance groundwater supply:** providing direct recharge to the local basalt aquifer (CRBG) would enhance groundwater supply.
- **Reduce runoff:** injecting stormwater into the CRBG aquifer would more closely mimic the natural hydrologic cycle by reducing unnaturally large runoff volumes from impervious surfaces to surface water during periods of high flow, and mitigating the negative impacts to streams from rapid changes to stream flow (e.g., elevated solids concentrations and bank erosion).
- **Streamflow mitigation:** winter stormwater runoff that is captured and injected may be recovered in the summer and discharged to adjacent streams, such as Summer Creek, helping to maintain summer flows and reduce stream temperature.[5]
- **Reduce demands on groundwater and surface water:** recharged and banked stormwater may be used for other beneficial non-potable uses, such as irrigation in the local area, instead of the typical use as municipal drinking water, thereby reducing the demand on surface water and native groundwater sources.
- **Increase capacity of stormwater infrastructure:** injection of stormwater at Sterling Park may preclude the need to install, or increase the capacity of, piped stormwater infrastructure in this area.

1.2 Pilot Testing Objectives

The purpose for pilot testing will be to evaluate AR feasibility and capacity in the CRBG aquifer at Sterling Park, and to develop design criteria for a full-scale operational AR program under an AR Permit. The pilot testing will be conducted in stages and in a controlled manner designed to provide the data necessary to develop an initial AR operational plan. The objectives of the pilot testing will be to evaluate:

- Stormwater treatment facility operation
- Aquifer hydraulic response to AR
- Long-term performance of the AR wells
- Optimal rate of recharge and volume of storage
- Chemical compatibility of receiving aquifer water and source water (including an assessment of mixing, potential well clogging, and potential water quality changes)
- Quality of recovered water over time
- Frequency of redevelopment of the AR wells necessary to maintain an acceptable and sustainable degree of well efficiency during AR operations
- Potential impacts of AR including loss of stored water (e.g., seeps, surface streams), water quality degradation, and interference with surrounding wells as a result of recharge and recovery operations

[5] Winter stormwater temperatures are typically in the 6-8 degrees C (43-46 degrees F) range.

The pilot testing described in this AR Limited License Application is designed to meet the objectives listed above.

1.3 Pilot Testing Study Area

The pilot test will be conducted by recharging the CRBG aquifer at the Sterling Park site using the ASR 3 well. The pilot testing study area will comprise the Sterling Park stormwater detention basins and surrounding area as described previously and as shown on Figure 1.

1.4 Pilot Testing Schedule and Scope

This section provides a general introduction to the planned AR pilot testing schedule and scope; a more thorough discussion of planned AR pilot testing is provided in several later sections of this report.

1.4.1 Pilot Testing Schedule

The City plans to begin pilot testing immediately following issuance of an AR Limited License by OWRD, and plans to recharge the local CRBG aquifer each year from November through June. This planned recharge period is based on GSI's assumption that stormwater captured and treated at Sterling Park would be considered by OWRD to effectively be an unnamed tributary to Summer Creek (i.e., the "surface water" source). Summer Creek is a tributary to Fanno Creek. Review of the Fanno Creek Water Availability Basin (WAB) analysis at the 50 percent exceedance flow level indicates that water is available for storage from November through June.[6] Additional discussion related to water rights requirements is provided in Section 5.1.

1.4.2 Pilot Testing Scope

Treated stormwater collected at the Sterling Park detention basins will be used as the source water for AR. Prior to injection, the stormwater will be treated to levels that meet DEQ's water quality requirements for AR projects (i.e., compliance with the anti-degradation policy). Additional information related to the expected quality of the treated stormwater, including the results of extensive pilot testing and a description of the planned stormwater treatment system, are provided in Section 3.1.1.

The AR source water (treated stormwater) will be injected via ASR 3 (WASH 57952), located at the Sterling Park site. The maximum recharge rate is anticipated to range from approximately 200 to 300 gpm. While ASR 3 and the aquifer could accommodate a much higher injection rate without causing adverse conditions, and 200 gpm was found to be the optimal rate for the planned water treatment system, the City is requesting a somewhat greater rate (300 gpm) to provide operational flexibility. Recovery of stored water is planned to be primarily from ASR 3A, due to its much higher pumping capacity afforded by its relatively larger diameter borehole.

Current planning efforts are focused on treating, recharging and storing an *average* of approximately 22 MG of treated stormwater for each year of pilot testing; this volume is based on (1) the average annual stormwater runoff measurement made at Sterling Park between 2017 and 2019, and (2) an optimal treatment rate of 200 gpm.

However, using additional runoff data from the 2017–2019 period, potential recharge volumes might range from approximately 13 to 26 MG. Therefore, to accommodate higher runoff volumes that correspond to potentially higher precipitation years, the City anticipates being able to store up to 30 MG per year during AR

[6] Watershed ID #73543, Fanno Creek > Tualatin River – at mouth (50% exceedance level)

pilot testing. Although retaining a significant volume of carryover storage on a year-to-year basis is not anticipated, the City is requesting a maximum storage volume of up to 50 MG.

Based on feasibility study work completed to date, the planned recharge rate and AR volumes for this AR application are summarized below; note that these values are somewhat greater than summarized above to provide the City with the flexibility to expand if the results from AR pilot testing support doing so:

- Instantaneous recharge rate: 300 gpm
- Annual recharge volume: 30 MG
- Maximum AR storage volume (including carryover): 50 MG

The first year of AR pilot testing will consist of a shakedown test followed by a full recharge-storage-recovery cycle (with a recovery Limited License to be obtained separately). The shakedown test will assess the performance of piping, pumps, valves, and controls, and will last about one day. During this test, a relatively small volume of water will be recharged and recovered to evaluate initial system operations. The full AR cycle (i.e., Cycle 1) will more closely approximate an operational-scale AR cycle, and will be used to evaluate the aquifer response to AR.

1.5 Report Organization

This report, prepared by GSI on behalf of the City of Beaverton, is an AR Limited License application and includes all information required by OAR for AR applications, including the elements of the required AR Project Description Report and Hydrogeologic Feasibility Report.[7] Table 1 identifies where information required by the OAR for AR applications can be found in this document. The index was prepared to assist OWRD in reviewing the Sterling Park AR Limited License application.

Table 1. Oregon Administrative Rules Reference Index

Oregon Administrative Rules	Information Location in this Document
690-350-0120 (2) **Pre-Application Conference**	Conducted August 31, 2021
690-350-0120 (3) (a) **Minimum Perennial Stream Flow or Instream Water Right**	Not Applicable – Source water is not a stream
690-350-0120 (3)(b) **DEQ Water Quality Permit**	Not Applicable – Source water is not a wastewater
690-350-0120 (3)(c) **Purpose of Recharge**	Section 1 – Introduction AR Limited License Application Form (Appendix A)
690-350-0120 (3)(d) **Annual Storage**	Section 3 – AR Project Description AR Limited License Application Form (Appendix A)
690-350-0120 (3)(e) **Financial Capability**	Not Applicable – Recharge diversion is less than 5 cfs
690-350-0120 (3)(f) **Hydrogeologic Feasibility Report**	Section 2 – Hydrologic and Hydrogeologic Characterization Section 4 – Technical Feasibility Assessment

[7] Requirements for AR applications are set forth in OAR 690-350-0120, OAR 690-310-0040, and OAR 340-040. The required elements of the Project Description Report are listed in OAR 690-350-0120(3)(g), and the required elements of the Hydrogeologic Feasibility Report are listed in OAR 690-350-0120(3)(f).

Oregon Administrative Rules	Information Location in this Document
690-350-0120 (3)(g) **Project Description Report**	Section 2 - Hydrologic and Hydrogeologic Characterization Section 3 - AR Project Description Section 4 - Technical Feasibility Assessment Section 6 – AR Pilot Testing Work Plan
690-350-0120 (3)(h) **Additional Information**	Not Applicable - Not requested at this time
690-350-0120 (4) **Recharge Permit Processing**	Not Applicable – Not a required element of an AR Limited License application
690-350-0120 (5)(a) **Maximum Rate and Volume**	Section 3—AR Project Description
690-350-0120 (5)(b) **Meters**	Section 3 – AR Project Description Section 6 – AR Pilot Testing Work Plan
690-350-0120 (5)(c) **Recordkeeping**	Section 6 - AR Pilot Testing Work Plan Section 7 - Monitoring Procedures and QA/QC Plan
690-350-0120 (5)(d) **Estimated Data**	Not Applicable – Not a required element of an AR Limited License application
690-350-0120 (5)(e)(A) **Monitoring Program**	Section 3 - AR Testing Program Section 6 – AR Pilot Testing Work Plan Section 7 – Monitoring Procedures and QA/QC Plan
690-350-0120 (5)(e)(B) **Key Wells and Target Levels**	Section 6 – AR Pilot Testing Work Plan
690-350-0120 (5)(f) **Determination of Stored Recharge Water**	Section 6 - AR Pilot Testing Work Plan
690-350-0120 (5)(g) **Storage Account**	Not Applicable – Not a required element of an AR Limited License application
690-350-0120 (5)(h) **Annual Report**	Section 6 – AR Pilot Testing Work Plan
690-350-0120 (5)(i) **Allowable Use of Stored Recharge Water**	Section 5 – Permits and Authorizations
690-350-0120 (5)(j) through (5)(m) **Permit Assignment** **Condition Changes** **Technical Oversight** **Other Conditions**	Not Applicable – Not a required element of an AR Limited License application, or recharge diversion is less than 5 cfs
340-040 **Antidegradation Evaluation**	Section 4 – Technical Feasibility Assessment
690-310-0040(1)(a) **Application Form**	AR Limited License Application Form (Appendix A)

Oregon Administrative Rules	Information Location in this Document
690-310-0040(1)(b) **Additional Information Required for a Permit to Appropriate Groundwater**	Section 2 - Hydrologic and Hydrogeologic Characterization Section 3 – AR Project Description Section 4 – Technical Feasibility Assessment

Notes

cfs = cubic feet per second

QA/QC = quality assurance and quality control

Appendix A presents a completed OWRD AR Limited License application form, Land Use Compatibility Statement, and the accompanying Limited License map for the proposed AR project. The AR Limited License application was completed in a manner that allows operational flexibility during the pilot testing period.

SECTION 2: **Hydrologic and Hydrogeologic Characterization**

This section provides a summary of hydrologic and hydrogeologic characteristics in the Tualatin Basin where Sterling Park is located. This information is used to evaluate the feasibility of AR, and to develop the AR testing program under this Limited License application. This section is organized as follows:

- **Section 2.1:** Hydrology in the vicinity of Sterling Park (including stormwater)
- **Section 2.2:** Geology and hydrogeology in the vicinity of Sterling Park

2.1 Hydrology

2.1.1 Project Area Hydrology

Sterling Park is situated in the Tualatin River Basin, near Summer Creek which drains into Fanno Creek (a tributary of the Tualatin River). The Tualatin River has a drainage area of about 712 square miles, a total length of about 80 miles, and is an important source of water for those living in the Tualatin Basin (including the communities of Beaverton, Hillsboro, Tigard, Wilsonville, and Tualatin). The basin boundaries are the Coast Range to the west, Portland Hills to the east, and Chehalem Mountains to the south. The Tualatin River discharges into the Willamette River near West Linn.

2.1.2 Stormwater Flow

Stormwater runoff in the Beaverton area is derived primarily from residential roads, sidewalks, driveways, and roofs. Stormwater at the Sterling Park site is collected from two residential drainage areas, basin WS 1A (which drains Scholls Ferry Road and the surrounding neighborhood) and basin WS 1B (which drains Loon Drive and the surrounding neighborhood [Figure 2]). Outfalls at both basin WS 1A and WS 1B discharge stormwater to the upper stormwater detention basin (Pond B) at the Sterling Park site. Pond B drains into the lower detention basin (Pond A), which in turn discharges to Summer Creek. Pond B acts as an equalization basin for discharges from the WS 1A and WS 1B outfalls, increasing surge capacity during large storm events and providing limited water quality control as larger suspended solids settle in the pond.

The upper and lower detention basins are separated by a water quality vault (WQV) at the downstream end of Pond B, which is the desired point of diversion for stormwater treatment and subsequent aquifer recharge (Figure 3). The WQV structure is designed to limit maximum flow into the lower basin (Pond A) to prevent large erosional storm surges and to allow some suspended solids to settle on the upstream side of the vault, and is an ideal location for diverting stormwater.

2.2 Geology and Hydrogeology

The following discussion of the geologic and hydrogeologic setting at Sterling Park is based on studies conducted by the Oregon Department of Geology and Mineral Industries (Ma et al., 2012), the U.S. Geological Survey (USGS) (Wells et al., 2020), and past studies conducted by GSI (GSI, 2018, 2020).

2.2.1 Geologic Setting

The proposed project area is located in the Tualatin River Basin, a broad synclinal basin with extensive valley plains and several anticlinal hills, the most notable of which are Cooper Mountain and Bull Mountain. The Sterling Park site is located on the southwestern flanks of Cooper Mountain and is underlain by a thin veneer of sediments overlying the CRBG, a 1,000-ft-thick sequence of basalt. These geologic units are described in further detail below:

- **Sedimentary Deposits.** These deposits consist of alluvial sediments and catastrophic flood deposits, and are less than 25 ft thick at the project site (Figure 4). Alluvial deposits include unconsolidated Quaternary period landslide and stream deposits. Stream deposits consist of sand, gravel, and silt that are largely confined to channels and floodplains of local streams, rivers, and valley bottoms. Landslide deposits are found on steep slopes throughout the Cooper and Bull Mountain uplands. The catastrophic flood deposits consist of sediments deposited by catastrophic floods during the Pleistocene age. Locally, the catastrophic flood deposits consist of fine-grained material (predominantly silt-sized) deposited over large areas, with localized occurrences of coarser material ranging up to boulder size (channel deposits).
- **Columbia River Basalt Group.** The CRBG is unique to the Pacific Northwest and represents a thick (more than 10,000 ft thick near Pasco, Washington), aerially extensive series of extraordinarily large (63,321 square miles) lava flows that are Miocene-age (erupted 23 to 5.3 million years ago). Flows originated in eastern Oregon and Washington, and flowed through the Columbia River trans-arc lowland to inundate the Portland, Tualatin, and northern Willamette Basins. Uplifted CRBG are exposed at or near the surface along the Cooper Mountain and Bull Mountain anticlines, including the project area. Several flow members belonging to the Grand Ronde Basalt Formation of the CRBG have been identified in wells at the project site; including the Sentinel Bluffs, Winter Water, Ortley, Grouse Creek, and Wapshilla Ridge members.

2.2.2 Hydrogeologic Setting

The CRBG hosts extensive regional aquifer systems in eastern Washington, eastern Oregon, and western Oregon, inclusive of the proposed project area. The CRBG contain some of the most productive groundwater aquifers in the Pacific Northwest. Groundwater in the CRBG aquifer occurs within the permeable interflow zones between basalt flows and exists under confined conditions. Static water levels measured in fall 2019 at Sterling Park in the corehole, ASR 3, and ASR 3A ranged between 139 ft below ground surface (bgs) (at the corehole) and 147 ft bgs (at ASR 3).

Despite being generally very productive, this local CRBG aquifer and many other CRBG aquifers across the state have experienced declining groundwater levels, due largely to typically slow recharge and excessive pumping. Recharge of the CRBG aquifer primarily occurs via precipitation on surficially exposed sections of the CRBG in upland areas in and around the Tualatin River Basin; however, on a regional scale the amount of recharge that reaches the CRBG in the center of the Basin may be limited by aquifer compartmentalization.

The CRBG on Cooper Mountain is an anticline, and thus associated faulting and folding in the Cooper Mountain area may have partially compartmentalized the CRBG aquifer, disrupting regional flow paths and gradients in some areas. However, historic groundwater level data and flow profiling conducted over approximately the past 20 years has demonstrated that at the Sterling Park location the basalt aquifer interflow zones are hydraulically connected; this is the case for much of the Cooper Mountain-Bull Mountain Critical Groundwater Area (CGWA), and it is understood that consequently OWRD manages groundwater in the CGWA as a single aquifer system.

Table 2 summarizes hydraulic properties of the CRBG aquifer based on pumping tests conducted at the corehole, ASR 3, and ASR 3A.

Table 2. Properties of the CRBG Aquifer at Sterling Park

Well ID	Date	Transmissivity – Pumping (gpd/ft)	Transmissivity – Recovery (gpd/ft)	Specific Capacity (gpm/ft)
Corehole[1]	2001	N/A	6,600	N/A
ASR 3	2004	18,000	16,500	4.0
ASR 3A	October 2019	15,600	15,700	4.31

Notes

[1] Corehole transmissivity estimated from packer and recovery tests and is influenced by the small (1 inch) diameter of the completed hole.
gpd/ft = gallons per day per foot
gpm/ft = gallons per minute per foot of drawdown
N/A = not applicable

The planned Sterling Park AR project is consistent with existing ASR projects that seek to protect and optimize usage of the local groundwater and surface water resources. A primary driver in the development of ASR by local agencies, including the City of Beaverton, was persistent groundwater level declines and over-appropriation of the groundwater resources in this area from the 1950s to 1970s. These conditions led OWRD to designate the local CRBG aquifer as the Cooper Mountain-Bull Mountain CGWA in 1974.

The CGWA designation limits existing groundwater use to a maximum annual volume of 2,900 acre-feet (~945 MG) and prohibits any new groundwater withdrawals with the exception of domestic use on parcels larger than 10 acres. The historic declines in local groundwater availability have driven ASR development for surrounding water supply agencies, including the cities of Beaverton and Tigard and the Tualatin Valley Water District, which typically store 150 MG or more annually per well.

2.2.3 Water Quality

The water quality of both stormwater and native groundwater at Sterling Park has been extensively characterized. Stormwater sampling was conducted at the WS 1A and WS 1B basin outfalls in 2017, 2018, and 2019. Stormwater samples were also collected in 2020 and 2021 at the outfalls and WQV, and were used to establish a baseline for evaluating stormwater treatment methods. Native CRBG groundwater samples were collected at ASR 3 in 2001 and 2004, and at ASR 3A in 2019. Laboratory results for stormwater and groundwater samples are summarized in Appendix B. Water quality for each source is summarized below:

- **Raw Stormwater Quality:** Sterling Park stormwater quality is typical for residential areas with low-traffic streets. Several analytes exceeded their respective screening level value for AR (in other words, they were detected at a concentration higher than that of native groundwater). These include biological constituents (e.g., coliform bacteria and viruses), metals, synthetic compounds (including petroleum hydrocarbons, phthalates, per- and polyfluoroalkyl substances [PFAS], and pesticides), cations and anions (such as nitrate and sulfate), and suspended sediment and turbidity. As discussed in Section 4.4, the screening level exceedances will be addressed so that the AR project will be conducted in compliance with DEQ's groundwater protection rules (e.g., by treatment).

- **Native Groundwater:** Groundwater quality samples collected at ASR 3 and ASR 3A indicate that native groundwater is suitable for non-potable irrigation and streamflow enhancement. All parameters, with the exception of total coliform bacteria and turbidity, were within regulatory limits for drinking water. However, sodium was detected at concentrations above the recommended advisory level of 20 milligrams per liter (mg/L), and manganese was detected just above the SMCL of 0.05 mg/L.

More extensive discussions related to source water and native groundwater quality, specifically the results of mixing analyses and compliance with DEQ groundwater protection rules, are provided in Sections 4.3 and 4.4, respectively, of this report.

SECTION 3: **AR Project Description**

This section provides details related to the design and operation of the Sterling Park AR system, including the proposed stormwater treatment system and existing AR injection and recovery wells. This section is organized as follows:

- **Section 3.1:** The existing water supply infrastructure for use in an AR system.
- **Section 3.2:** Plans for full-scale AR system construction.

A work plan for years one through five of AR pilot testing is provided in Section 6:, with specific water quality and water level monitoring protocols presented in Section 7.

3.1 Pilot Test AR System Construction and Capacity

The design and operation of the Sterling Park AR system will follow the rules outlined in OAR 690 Division 350 (Artificial Groundwater Recharge) and Division 250 (Well Construction Standards). The following subsections provide an overview of the design and operation of AR infrastructure for the proposed AR system.

3.1.1 Source Water – Rates, Volumes, Treatment

As described previously in Section 1.4, the Sterling Park AR project proposes to use treated stormwater from a nearby detention basin (Pond B) as source water for recharge. The detention basin is located approximately 230 ft east and 1,500 ft south of the northwest corner of Township 2 South, Range 1 West, Section 5 (Figure 1).

3.1.1.1 Stormwater Flow Rates and Available Volume

From 2016 through 2019, stormwater flow rates, variability, and volume at the Sterling Park site were measured and analyzed. Understanding these parameters is necessary to: (1) optimally size various conveyance and treatment options for the proposed AR project, and (2) confirm that a sufficient volume of water is available on an annual basis to make AR viable for offsetting anticipated non-potable groundwater use by the City.

Stormwater flow from the two contributing stormwater drainage basins (Basin WS 1A and Basin WS 1B; Figure 2) has been monitored continuously since 2016 using Hach flow loggers (Model F1901) equipped with FLO-DAR (Model 4000) radar/ultrasonic sensors. The sensors were installed by Clean Water Services personnel in 2016 to measure stormwater flow rates at the Loon (WS 1B) and Scholls (WS 1A) outfalls.

In addition to stormwater flow, precipitation at the project site from 2016 to 2019 was estimated using data available from two rain gauges: Garden Home gauge #KORPORTL62 (approximately 4.4 miles from Sterling Park) and the Portland Community College (PCC) Sylvania Gauge (approximately 8.3 miles from Sterling Park).[8]

The average annual precipitation for the City of Beaverton is approximately 36 inches of rain per year (City of Beaverton, 2020). The 2016 to 2017 water year (WY) was a notably wet year with total annual precipitation measured at 42.2 inches at the Garden Home gauge and 54.6 inches at the PCC-Sylvania gauge. Precipitation measured for the 2017 to 2018 and 2018 to 2019 WYs was considerably lower (24.0 inches

[8] Both part of the HYDRA Rainfall Network, a collection of 39 rainfall gauges operated and maintained by the City of Portland's Bureau of Environmental Services.

and 26.0 inches, respectively, at the Garden Home gauge and 35.3 inches and 33.9 inches, respectively at PCC-Sylvania).

The volume of stormwater discharging to the upper stormwater detention pond (Pond B) correlates to the level of precipitation estimated for the site (Table 3). Stormwater flow data collected during the 2016 to 2017 WY, a wetter than average year, showed approximately 51.9 million gallons per year (MGY) of flow into Pond B. The drier 2017 to 2018 and 2018 to 2019 WYs experienced considerably less discharge, with 28.6 MGY and 23 MGY, respectively.

Table 3. Total Stormwater Volume and Annual Precipitation by Water Year (Oct. 1 – Sept. 30)

Water Year	Stormwater Volume into Basin (MGY)[1]	Total Annual Precipitation (inches)[2]	
		Garden Home Gauge	PCC Sylvania Gauge
2016–2017	51.9	42.2	54.6
2017–2018	28.6	24.0	35.3
2018–2019	23.0	26.0	33.9

Notes

[1] Due to some periods of missing data, flow totals were extrapolated using the average daily flows immediately preceding and following the missing period.

[2] Discrepancies in the data above may be due to geographical differences in the locations of data collection. The Garden Home gauge is approximately 4.4 miles away (by car) from the Sterling Park site; the PCC-Sylvania Gauge is approximately 8.3 miles away (by car) from the site.

MGY = million gallons per year

PCC = Portland Community College

During the 2016 to 2019 measurement period, stormwater flow into the two stormwater basins varied between several gpm and more than 1,000 gpm during peak periods of precipitation. Figure 5 is a summary of stormwater flow volume accumulated from a range of flow rates for the 2016 to 2017 precipitation period (although 2016 to 2017 was an exceptionally wet water year, the trends demonstrated during that period are generally scalable for other years). From the 2016 to 2017 data shown on Figure 5, the following can be concluded:

- Approximately 50 percent of the total volume from Basin WS 1A discharged at rates less than 175 gpm, which represents a volume of 19 MG.
- Approximately 50 percent of the total volume from Basin WS 1B discharged at rates less than 85 gpm, which represents a volume of 9.5 MG.
- Approximately 50 percent of the combined total volume from both basins discharged at a combined rate of approximately 260 gpm, which represents a volume of 28.5 MG.
  - The highest combined flow rates observed (>2,000 gpm) were relatively uncommon and accounted for less than 10 percent of the combined flow, and a total duration of less than 2 percent of the period of observed stormwater flow.

A stormwater treatment system for the proposed AR project has been designed with larger and more extensive treatment than is required for the design flow rate, which increases the likelihood of water quality treatment compliance. Figure 5 shows that, without any additional storage, a treatment system capable of accepting flow rates up to 200 gpm could have treated as much as 26 MG of stormwater over the monitoring period, whereas a system with a 400 gpm treatment capacity could have treated approximately

33.5 MG. These volumes do correspond to the relatively wet 2016 to 2017 period, and thus are likely about 25 to 30 percent greater than volumes that would be available during an average water year.

The stormwater flow and volume data collected from 2016 to 2019 at the Sterling Park site demonstrate that, regardless of whether it is an average or an exceptionally wet year, a large portion of the City's anticipated non-potable groundwater use could be offset with use of captured, treated, and injected stormwater on an annual basis. For context, the City is anticipating using approximately 52 MG of groundwater (based on an anticipated average 400 gpm pumping rate for a 90-day irrigation season) to meet non-potable demands on an annual basis. Therefore, capturing and treating stormwater at rates up to approximately 200 gpm has the potential to offset as much as half of the anticipated irrigation demand on an annual basis.

3.1.1.2 Stormwater Diversion, Conveyance and Treatment

In 2020 and 2021, extensive pilot testing of various treatment technologies was performed using raw stormwater collected from the Sterling Park site. A full-scale stormwater treatment plant is being designed based on the treatment pilot test results. Additional details on treatment pilot test configurations and results can be found in supplemental pilot testing evaluations written by GSI (2021) and Odell (2021), included in Appendix C.

While subject to slight modification as the pilot project progresses, the planned conveyance and collection of stormwater is presently as follows (Figure 3): water currently collected within the upper pond of the Sterling Park site would be pumped into a water treatment plant, gravity fed through the individual treatment components, then pumped into the AR injection well (Odell, 2021). The water treatment components are being designed to be constructed within the lower detention basin.

The stormwater treatment system will consist of the following components:

- **Slow-Sand/In-pond Filtration,** which acts as a pre-treatment step to reduce the turbidity and total suspended solids of raw stormwater.
- **Aquip® Enhanced Filtration System,** manufactured by StormwateRx (Portland, Oregon), contains a pretreatment buffering media and layered inert/organics sorptive enhanced filtration media. This treatment step will reduce concentrations of unwanted metals and organics.
- **Granular Activated Carbon (GAC) System** will act as a polishing step to completely remove unwanted organic compounds (such as PFAS/perfluorooctanoic acid [PFOA] and urban pesticides).
- **Ultraviolet (UV) Disinfection System** will treat water for bacteria and viruses, and provide disinfection without requiring chemical additives.

As shown on Table 4 and Table 5, pilot testing results using this system (slow sand/Package/GAC) demonstrated that concentrations of key contaminants, including bacteriological, metals, and nutrients, were reduced to acceptable levels (although not all to below background levels). Additional discussion related to the quality of treated stormwater/AR source water is presented in several later sections of this report.

A key element of the stormwater treatment system will be the inclusion of a continuous water-quality monitoring system. This system will be used to monitor key water quality constituents, and if a constituent exceeds a pre-established level, the system will be automatically shut down, including pumps that direct treated stormwater to the ASR 3 injection well. This safeguard will prevent the introduction of insufficiently treated stormwater to the aquifer system. Preliminary design sheets and specifications for the continuous water quality monitoring system are included in Appendix C.

Table 4. Efficacy of Selected Pilot Treatment System for Key Stormwater Contaminants (Bacteriological, General Chemistry, and Metals)

Analyte Class	Analyte	Units	Concentrations			
			Raw Stormwater Pilot Test 1	Raw Stormwater Pilot Test 2	Treated Stormwater SS/Package/GAC	Background Groundwater
Bacteriological	Fecal Coliform	MPN/100 mL	> 2,420	> 2,420	< 1	< 1
General Chemistry	Nitrate + Nitrite	mg/L	0.26	0.46	*0.28*	ND
	Sulfate	mg/L	3.9	2.3	59	1.6
Metals	Manganese	µg/L	170	29	15	48
	Iron	µg/L	460	530	*120*	110
	Aluminum	µg/L	140	430	*330*	ND
	Zinc	µg/L	690	130	ND	22

Notes

The table only shows analytes with concentrations in raw stormwater above background in native basalt groundwater.

ORANGE italicized = Treatment reduces analyte concentration, but not to below background.

> = greater than

< = less than

µg/L = micrograms per liter

GAC = granular activated carbon

mg/L = milligrams per liter

mL = milliliters

MPN = most probable number

ND = not detected

SS = slow sand

Table 5. Efficacy of Selected Pilot Treatment System for Key Stormwater Contaminants (Anthropogenic Compounds)

Analyte Class	Analyte	Units	Concentrations			
			Raw Stormwater Pilot Test 1	Raw Stormwater Pilot Test 2	Treated Stormwater SS/Package/GAC	Background Groundwater
PAHs	Di-n-octylphthalate	µg/L	0.85	ND	ND	ND
Pesticides	2,4-D	µg/L	2	1.7	ND	ND
	Paraquat	µg/L	2.6	ND	ND	ND
	MCPP-p	µg/L	0.11	0.6	ND	ND
	Diuron	µg/L	ND	0.08	ND	ND
	Triclopyr	µg/L	0.13	0.094	ND	ND
PFAS/PFOA	PFHxA	µg/L	0.0027	0.0046	ND	ND
	PFOA	µg/L	0.0051	0.0045	ND	ND
	Perfluorononanoic acid	µg/L	0.002	ND	ND	ND
	Perfluorodecanoic acid	µg/L	0.0024	ND	ND	ND
	PFOS	µg/L	0.0093	0.0044	ND	ND
Petroleum Hydro	Toluene	µg/L	0.88	ND	ND	ND

Notes

The table only shows analytes with concentrations in raw stormwater above background in native basalt groundwater.

µg/L = micrograms per liter
GAC = granular activated carbon
MCPP-p =mecoprop
ND = not detected
PAHs = polycyclic aromatic hydrocarbons
PFHxA = perflourohexanoic acid
PFAS = per- and polyfluoroalkyl substances
PFOA = perfluorooctanoic acid
PFOS = perfluorooctanesulfonic acid
SS = slow sand

Another key conclusion from pilot testing of the treatment system is that the optimal treatment rate is approximately 200 gpm. Thus, it is anticipated that 200 gpm will be the maximum injection rate, with lower rates of injection occurring during correspondingly smaller precipitation events.

3.1.1.3 Range of Potential Recharge Volumes

Using information obtained from monitoring stormwater flow characteristics at Sterling Park from 2016 through 2019, coupled with the optimal treatment rate (200 gpm) established from pilot testing, a range of anticipated recharge volumes for AR pilot test has been established.

Figure 6 summarizes the total volume of stormwater that arrived at the site between 2016 and 2019 at flow rates between 50 and 400 gpm. At the anticipated treatment rate of 200 gpm, the corresponding stormwater volumes ranged from approximately 13.3 MG to 26.2 MG.[9] Based on these values, it is estimated that for an *average* precipitation year, approximately 22 MG of stormwater will be available for treatment and storage at injection rates of about 200 gpm or less. The range of potential recharge volumes are summarized in Table 6.

Table 6. Range of Potential AR Recharge Volumes

Scenario	Recharge Rate (gpm)	Total Annual Recharge Duration (days)[1]	Annual Storage Volume (MG)
Average Recharge Volume	200	240	22.0
Maximum Recharge Volume	200	240	26.2
Minimum Recharge Volume	200	240	13.3

Note

[1]Refers to the number of days corresponding to the entire available recharge period (November through June); actual number of active recharge days will depend on source water availability, i.e., the occurrence of significant precipitation events.

gpm = gallons per minute

MG = million gallons

3.1.1.4 Summary of AR Testing Rates and Volumes

Based on feasibility study work completed to date, the planned recharge rate and AR volumes for this AR application are summarized below; note that these values are somewhat greater than summarized previously to provide the City with the flexibility to expand if the results from AR pilot testing support doing so:

- Instantaneous recharge rate: 300 gpm
- Annual recharge volume: 30 MG
- Maximum AR storage volume (including carryover): 50 MG

[9] This range of treatable stormwater volumes is constrained by the lack of stormwater storage at the site; implementation of storage prior to treatment could provide significantly greater volumes of stormwater to be available for treatment and recharge during high flow events.

3.1.2 AR Injection, Recovery, and Observation Wells

During AR pilot testing, ASR 3 will be used to inject treated stormwater. An exploratory corehole (WASH 55816) was also drilled at the site, and is located approximately 20 ft west of ASR 3; the corehole is completed to the same approximate depth as ASR 3 and ASR 3A, and will be used as an observation well during AR pilot testing. The locations of the wells and corehole are shown on Figure 3, and Figure 4 is a schematic showing the general completion details for all three wells.

The following subsections generally describe the construction of the wells and corehole. Estimated pumping and injection performance of the two wells is discussed in Section 4.1.

3.1.2.1 ASR 3 (WASH 57952) (Pilot Well)

ASR 3 is 1,000 ft deep and was originally drilled in 2001 as a pilot well to support an ASR feasibility study previously conducted at the Sterling Park site. A copy of the OWRD well log and an as-built diagram are included in Appendix D.

ASR 3 must meet current Oregon water well construction standards to be authorized by OWRD for AR recharge and recovery use. GSI reviewed the construction of the well (as reported on well log WASH 57952) to evaluate whether existing well construction meets OWRD requirements:

- **Borehole.** The borehole diameter telescopes as follows:
  - 12 inches from 0 to 147 ft bgs
  - 8 inches from 147 to 450 ft bgs
  - 6 inches from 450 to 1,000 ft bgs
- **Well Casing.** The well is cased with 8-inch diameter welded steel pipe from +2 to 147 ft bgs. These casing gauges meet the requirements of OAR 690-210-0190(3) for steel casing.
- **Well Screen.** No well screen (open borehole completion).
- **Well Seal.** The 12-inch diameter upper borehole is more than 4 inches in diameter greater than the 8-inch diameter permanent well casing, and is constructed at least 5 ft into bedrock. The annular space between the 8-inch casing and 12-inch borehole is filled with neat cement (from 0 to 147 ft bgs). This meets the requirements of OAR 690-210-150.
- **Well Liner Pipe.** A liner is not present.

3.1.2.2 ASR 3A (WASH 78442)

ASR 3A is 988 ft deep and was drilled in 2019 for use as a municipal irrigation well by the City. Construction specifications associated with the well (well log and as-built diagram) are included in Appendix D.

ASR 3A is anticipated to be used for AR recovery and must meet current Oregon well construction standards to be authorized by OWRD for AR use. GSI reviewed the construction of the well (as reported on well log WASH 57952) to evaluate whether existing well construction meets OAR requirements:

- **Borehole.** The borehole telescopes in diameter, as follows:
  - 24 inches from 0 to 20.5 ft bgs
  - 20 inches from 20.5 to 231 ft bgs
  - 16 inches from 231 to 605 ft bgs
  - 12 inches from 605 to 988 ft bgs

- **Well Casing.** The well is cased with 20-inch diameter 0.375 gauge steel casing from 0 to 20.5 ft bgs, and with 16-inch diameter 0.375 gauge welded steel casing from +3 to 231 ft bgs. These casing gauges meet the requirements of OAR 690-210-0190(3) for steel casing.
- **Well Screen.** A continuous wire-wrap screen with a slot size of 0.100-inch is present from 232 to 602 ft bgs. The well is open borehole from 605 to 988 ft bgs.
- **Well Seal.** The 24-inch and 20-inch diameter portions of the upper borehole are more than 4 inches in diameter greater than the respective 20-inch and 16-inch diameter permanent well casing, and are constructed at least 5 ft into bedrock. The annular space between the 20-inch casing and 24-inch borehole, and between the 16-inch casing and 20-inch borehole, is filled with neat cement (from 0 to 20.5 ft bgs and 0 to 231 ft bgs, respectively). This meets the requirements of OAR 690-210-150.
- **Well Liner Pipe.** A liner is not present.

In summary, ASR 3 (WASH 57952) and ASR 3A (WASH 78442) meet current OAR water well construction standards and are adequate for use as AR wells.

3.2 Plans for Full-Scale AR System Construction

Currently, the AR system at Sterling Park consists of the existing stormwater conveyance and storage system (i.e., detention basins, piping, and outfall structures) and the two wells and corehole as described previously in Section 3.1.1.4. The wells do not possess pumps or other wellhead appurtenances, and are currently completed simply with well casings extending to a few feet above ground surface.

Plans are being prepared to construct major facility improvements and components that will allow for the full-scale implementation of AR as described in this document (Murraysmith Associates, 2021). These improvements will include the following:

- Four new structures:
  - Mechanical building (1,050 square feet [ft^2])
  - In-pond gravity filter or preliminary filter structure (2,918 ft^2)
  - Proprietary stormwater treatment system (StormwaterRx Aquip®) enclosure (600 ft^2)
  - GAC enclosures (two 10-ft-tall tanks on the east side of the mechanical building).
- New pitless adaptors/covers for the ASR 3 and ASR 3A wells
- Underground piping connections to wells and structures
- Site grading, landscaping, and replacement of existing retaining walls
- An additional access driveway, paving of the wellhead area, and a gravel access road
- Security fencing and gates

The stormwater treatment system was previously described in Section 3.1.1.2, with more detailed information provided in Appendix C.

3.2.1 AR Well Improvements

The two wells will be developed with pitless adaptors and submersible pumps to reduce their footprints and allow more usable space on site for maintenance activities. Downhole flow control valves, designed specifically for each well's capacity, will be installed above each submersible pump to provide flow control for AR operations. The AR downhole flow control valves will be hydraulically actuated and controlled by a programmable logic controller (PLC). The PLC will monitor flow control and backpressure during storage operations as it receives water from the stormwater treatment system or the City's potable water supply.

Each well will include a hydraulically operated, piloted control valve housed within a concrete vault adjacent to each wellhead to provide pump-to-waste (PTW) capability and pressure relief. Discharge from the PTW or pressure relief valves will be directly to Sterling Park's lower pond. Recovery of AR stored water from the wells will be directed to the mechanical building for metering and delivery to the City's non-potable water purple pipe distribution system.

The ASR 3 submersible well pump will be designed to operate continuously during the summer season, thus affording the opportunity to provide in-stream flow augmentation to Summer Creek at rates up to 100 gpm. The well pump will be controlled by a variable frequency drive (VFD) to modulate flow for small irrigation demands up to 50 gpm in addition to providing instream flow benefits up to a maximum flow rate of approximately 150 gpm.

The ASR 3A submersible well pump will be designed to provide larger non-potable water system demands (e.g., irrigation) throughout the dry season between 50 and 900 gpm. ASR 3A will also be controlled by a VFD to modulate flow and to adjust for fluctuating drawdown conditions.

Both wells and the corehole will be instrumented with datalogging pressure transducers to provide high-resolution data to assess aquifer response to AR operations. Sampling ports will also be included at the discharge line for ASR 3 and ASR 3A to facilitate collection of water quality samples.

3.2.2 Next Steps

The capital cost estimate for construction of the full-scale AR site improvements described above is approximately $1.3 million for the stormwater treatment system. The Beaverton City Council has recently approved this expenditure and are proceeding with the next steps for the AR project, which will include remaining permitting, final design, and construction activities. It is anticipated that final design and construction of the AR system will occur in 2022, with a planned start of construction by mid-2022.

SECTION 4: **Technical Feasibility Assessment**

The following section discusses the technical feasibility of the proposed Sterling Park AR project, specifically: (1) assessing the recharge capacity of the proposed injection wells and the local CRBG aquifer system; (2) determining if recharging the local CRBG aquifer via the Sterling Park wells will adversely affect existing groundwater users; (3) determining if mixing between source water (treated stormwater) and native CRBG groundwater is expected to produce adverse effects; and (4) establishing that AR can be conducted in conformance with the DEQ's groundwater protection rules.

4.1 Aquifer Storage Capacity

Previous testing and analysis of ASR 3 determined that the CRBG aquifer at the Sterling Park site is less productive than at the City's existing ASR well locations, but is still potentially capable of accepting recharge at rates up to 500 gpm and storing up to 100 MG of water (GSI, 2004).

As part of this Limited License application, GSI has refined the previous estimate of aquifer storage capacity by using planned AR operational parameters, e.g., expected injection rate and duration. This analysis also includes the incorporation of information obtained during the installation and testing of ASR 3A in 2019, which has supplemented the previous understanding of the CRGB aquifer near this location.[10]

ASR 3 will be used for injection, and both ASR 3 and ASR 3A for recovery pumping. This operational scenario is being considered because ASR 3A is capable of sustainably pumping up to 700 gpm, versus approximately 150 gpm from the smaller-diameter ASR 3. The greater pumping capacity of ASR 3A will afford the City much more operational flexibility in meeting local demands for non-potable water.

As a proxy for estimating aquifer storage capacity, GSI used the following Cooper-Jacob approximation of the Theis equation to predict the maximum buildup of groundwater level, or head, at and near the location of the two wells:

$$s = \left(-528 * \frac{Q}{T}\right) * (\log(r) + (0.5 * \left(\log\left(\frac{S}{0.3} * T * t\right)\right))$$

Where:

s = buildup/drawdown (ft)
Q = pumping rate (gpm)
T = transmissivity (gallons per day per ft, gpd/ft)
t = time (days)
r = radial distance from well with a drawdown of s (ft)
S = storativity (dimensionless)

The following operational and aquifer parameters were applied to the above equation to estimate head buildup within and near the two wells:

- Injection rate (Q) (at ASR 3): 200 gpm
- Injection duration (t): 90 days
- T: 15,600 gpd/ft

[10] Aquifer parameters derived from the ASR 3A aquifer test are assumed to be applicable to ASR 3 as both are similarly completed wells located only about 40 ft apart.

- r: 0.25 to 40 ft (latter value is distance between ASR 3 and ASR 3A)
- S: 0.0005

The above calculation was used to provide estimates of maximum head buildup at the conclusion of a 90-day injection period. A continuous 90-day duration is conservatively long, because actual injection periods will be highly intermittent and much shorter, occurring only during precipitation events of sufficient magnitude to warrant operation of the stormwater treatment system. However, this duration was used to build additional conservatism into preliminary estimates of AR performance.

Table 7 provides a summary of the estimated maximum buildup in both ASR 3 and ASR 3A after continuously injecting in the former for 90 days at 200 gpm.

Table 7. Estimated Maximum and Residual Head Buildup after 90 Days of Continuous Injection at ASR 3

Head Buildup Estimates	ASR 3 (Injection)	ASR 3A (Idle)
Approximate static water level	138 ft bgs	146 ft bgs
Maximum buildup at 90 days injection	51 ft	19 ft
Maximum groundwater level	87 ft bgs	127 ft bgs
Total injection volume	25.9 MG	—

Notes

ft bgs = feet below ground surface

MG = million gallons

The results of the buildup analysis suggest that after injecting almost 26 MG of treated stormwater in ASR 3 (simulated very conservatively as continuously injecting over a 90-day period), the aquifer head would still remain far below ground surface at the Sterling Park site, with a maximum buildup to 87 ft bgs predicted in the injecting well ASR 3.

These results indicate that (1) localized buildup or mounding of stored water is unlikely to cause adverse impacts to surface or near-surface infrastructure located at both the Sterling Park site and nearby locations, and (2) the storage capacity of the local CRBG aquifer can readily accommodate the more than 26 MG of annual recharge volume (as previously indicated in Section 4.1, up to 100 MG of aquifer storage capacity was previously estimated for this location).

4.2 Potential Effects to Other Groundwater Users

GSI previously evaluated the potential effects that stored water may have on other nearby groundwater users as part of a 2017 Groundwater Recharge Feasibility Evaluation conducted for the Sterling Park site (included as Appendix E). To assess those potential effects, a 3-dimensional numerical groundwater flow model (GSI, 2011) was modified to predict flow paths of water recharged at ASR 3. The model uses the USGS MODFLOW-2000 finite-difference groundwater modeling software (Harbaugh et al., 2000), and the Groundwater Vistas graphical user interface (ESI, 2007) is used to manage the modeling process. The model is calibrated to historical data obtained from regional ASR programs. MODPATH particle tracking software with forward particle tracking to determine the advective transport of the recharged stormwater was used to delineate zones of influence from water recharged at Sterling Park.

For this AR Limited License application, the previous groundwater modeling evaluation was updated to include additional stormwater flow and volume data obtained since 2017, as well as more recent results from pilot testing of the stormwater treatment system (discussed in Section 3.1.1). The following revised AR operational parameters were simulated with the model:

- Annual recharge volume: 22 MG[11]
- Recharge rate: 200 gpm
- Recharge period: November through June.
- Predictive model scenario: assumes a total recharge volume of 22 MG of treated stormwater from November through June for one year *without any recovery pumping*.[12]

Table 8 lists the potential migration distances of stored water from Sterling Park that may occur at 500 days following recharge for the model scenario described above. Figure 7 depicts the same general information. A safety factor of 2x (1,000 days) and 3x (1,500 days) are included for comparison. Wells at a distance greater than approximately 675 ft from Sterling Park are not expected to be impacted, even with the conservative assumptions and safety factors considered for this scenario. It is important to note that the migration distances in Table 8 are for stormwater; constituents in stormwater would not migrate as far due to sorption on the aquifer matrix and degradation.

Table 8. Potential Stored Water Migration Distance from Sterling Park

Travel Time (days)	Migration Distance from Sterling Park (feet)
500	575
1,000 (2x safety factor)	615
1,500 (3x safety factor)	675

These model results and declining local groundwater usage suggest that it is highly unlikely that there are other groundwater users that could potentially be impacted by AR operations at Sterling Park. Over the past 20 years, nearly all parcels in surrounding areas have been converted from small farms and rural residences to dense residential and commercial developments. Because the new developments are served by public water supply systems, there are few, if any, existing groundwater users in the vicinity of Sterling Park.

For example, as development progressed in this area, numerous domestic wells were abandoned. According to OWRD records, the four sections encompassing and surrounding the site, which represents the area within approximately one mile, historically contained 72 wells. But since the early 1990s, records for that same area show that 67 wells were decommissioned. The nearest of the former wells was WASH 58861, with a recorded street address located about 1350 ft southwest of the Sterling Park site (Figure 7). WASH 58861 was a domestic use well installed in 2002, when aerial imagery indicates that that location was still a rural residential site. However, beginning around 2016, the land encompassing the WASH 58861 location was converted to a high-density residential subdivision, and WASH 58861 was abandoned in September

[11] Annual recharge volume of 22 MG is based on (1) optimum treatment rate of 200 gpm and (2) stormwater volume measured at Sterling Park for the average precipitation year as measured from 2016 to 2019 at the site.
[12] Simulating no recovery pumping for one year is a conservative assumption that could represent, for instance, a potential pump failure after recharge has occurred, thus precluding the ability to recover the stored water; this is a conservative scenario with respect to travel distance of the naturally attenuated surface water.

2016 (abandonment log WASH 75097). There are numerous other abandonment logs recorded in this same general area in 2015 and 2016, likely coinciding with the start of redevelopment.

There are several municipal water suppliers that use CRBG groundwater wells for ASR in the region. However, none of these ASR wells are closer than two miles from Sterling Park, which is well beyond the area of potential influence of treated stormwater proposed for recharge at this location.

To conclude, it is highly unlikely that there are any remaining water supply wells that are within the areas of potential influence of treated stormwater proposed for recharge at the Sterling Park location. Since 1974, OWRD's Critical Groundwater Area declaration has restricted existing groundwater use and prohibited issuance of new groundwater rights and construction of wells for irrigation or domestic use on properties of less than 10 acres in this area. This element of the CGWA rules has effectively limited the number of potential nearby wells that could capture recharged water from Sterling Park AR operations in the future.

4.3 Compatibility of Source Water and Native Groundwater (Mixing Analysis)

Mixing waters with different geochemical compositions has the potential to cause adverse effects on the aquifer (e.g., precipitation of minerals in the aquifer, which would reduce the permeability and storage capacity of the aquifer). If mixing source water and receiving water do not produce adverse effects, then the waters are "geochemically compatible"; conversely, if adverse effects occur as a result of mixing, then the waters are not geochemically compatible.

S.S. Papadopulos & Associates, Inc. (SSPA) evaluated whether source water and receiving water were geochemically compatible using the USGS geochemical mixing model PHREEQC (Parkhurst and Appelo, 1999) and the geochemical reactive transport model PHAST. A copy of the SSPA report is included in Appendix F.

- **PHREEQC.** PHREEQC calculates concentrations of dissolved constituents and saturation indices in groundwater-source water mixtures, with the objective of determining whether a mineral is likely to precipitate due to the mixing of the waters. Model input is stormwater quality data (specifically, a native basalt groundwater sample collected from ASR 3A in October 2019 and a treated stormwater sample from the pilot system). SSPA predicts that a mixture of source water and receiving water would be supersaturated in carbonate minerals (dolomite, witherite), sulfate minerals (barite), clay minerals, zeolites, manganese minerals (manganese oxides and oxyhydroxides), aluminum minerals (aluminum oxyhydroxides), and iron minerals (iron hydroxides and oxyhydroxides), meaning that these minerals may have a tendency to precipitate in the basalt aquifer.
- **PHAST.** PHAST is a geochemical reactive transport model that simulates multispecies reactive solute transport in groundwater in three dimensions. PHAST includes all the PHREEQC calculations, but also has the capability to simulate interactions between aquifer minerals and the water mixture, sorption, and dispersion. PHAST simulations were run for minerals that were predicted to precipitate based on the PHREEQC simulations and SSPA's professional judgement, because precipitation *may not* occur when interactions between aquifer minerals and the water mixture, sorption, and dispersion are considered. Input to PHAST includes aquifer dimensions, AR operational parameters (duration of recharge, storage, and recovery), groundwater and treated stormwater chemistry, aquifer mineralogy, and mineral dissolution/precipitation rates. Note that SSPA's PHAST simulations did not focus on sorption and dispersion processes. The PHAST simulations confirmed that precipitation amounts would be minor (i.e., there is no measurable change in porosity).

In summary, geochemical modeling using PHREEQC and PHAST predict that aquifer clogging due to mineral precipitation is not likely to occur when treated stormwater and basalt groundwater are mixed.

4.4 Conformance with DEQ Groundwater Protection Rules

Stormwater runoff from residential drainage basins and groundwater in the CRBG aquifer are characterized by different constituents. Some constituent differences occur because stormwater drains impervious surfaces and picks up synthetic constituents such as copper and zinc from brake pads, polycyclic aromatic hydrocarbons from vehicle exhaust, or low levels of pesticides from residential lawn drainage. Other differences are related to the presence of naturally occurring constituents; for example, stormwater may contain elevated levels of certain metals due to weathering of soils.

The AR rules require that AR projects conform to the DEQ groundwater protection rules, which require that "(a)ll groundwaters of the state shall be protected from pollution that could impair existing or potential beneficial uses." The groundwater protection rules further state that "domestic water supply is recognized as being the use that would usually require the highest level of water quality."[13] When applying the groundwater protection rules to an AR project, DEQ requires that the AR project meet background groundwater quality and selects the location where background groundwater quality must be met.[14]

This section presents a discussion of DEQ's groundwater protection rules and the Sterling Park AR project, including identification of constituents in raw stormwater that exceed background groundwater quality (Section 4.4.1) and documentation of an approach for confirming that the Sterling Park AR project will meet DEQ's groundwater protection rules (Section 4.4.2).

4.4.1 Stormwater Constituents that Exceed Background Groundwater Quality

Table 9 summarizes constituents that were detected in raw stormwater at concentrations that are greater than native groundwater based on stormwater quality sampling from 2017 to 2021. As discussed in Section 2.2.3, the types and concentrations of stormwater constituents are typical for stormwater draining low-traffic residential streets, and include both natural and synthetic compounds.

[13] See OAR 340-040-0020(3).
[14] See OAR 340-040-0030(2)(e).

Table 9. Groundwater Quality - Analytes with Concentrations Greater in Raw Stormwater than in Native Groundwater

Constituent	Units	Native Basalt Groundwater		Stormwater [1]			
		N	95% UTL	N	Minimum	Maximum	Geometric Mean [3]
Bacteriological							
Fecal Coliform	MPN/ 100 mL	1	ND	4	133	2,420	752.2
General Chemistry							
Nitrate + Nitrite	mg/L	5	ND	2	0.26	0.46	0.35
Sulfate	mg/L	5	7.8	2	2.3	3.9	3.0
Metals							
Manganese	µg/L	7	132.8	3	29	410	126.4
Iron	µg/L	8	214.8	4	460	1,800	806.3
Aluminum	µg/L	1	ND	4	48	743	215.3
Zinc	µg/L	1	22	4	130	690	322.3
PAHs							
Di-n-octyl phthalate	µg/L	1	ND	2	ND	0.85	0.21
Pesticides/Herbicides							
2,4-D	µg/L	1	ND	2	1.3	2.0	1.6
Paraquat	µg/L	1	ND	2	ND	2.6	1.6
MCPP-p	µg/L	1	ND	2	0.11	0.6	0.26
Diuron	µg/L	1	ND	2	ND	0.08	0.049
Triclopyr	µg/L	1	ND	2	0.94	0.13	0.111

Constituent	Units	Native Basalt Groundwater		Stormwater [1]			
		N	95% UTL	N	Minimum	Maximum	Geometric Mean [3]
Per- and Polyfluoroalkyl Substances (PFAS)							
Perfluorohexanoic acid (PFHxA)	µg/L	0	ND [2]	2	0.0027	0.0046	0.0035
Perfluorooctanoic acid (PFOA)	µg/L	0	ND [2]	2	0.0045	0.0051	0.0048
Perfluoronanoic acid	µg/L	0	ND [2]	2	ND	0.002	0.0014
Perfluorodecanoic acid	µg/L	0	ND [2]	2	ND	0.0024	0.0015
Perfluorooctanesulfonic acid (PFOS)	µg/L	0	ND [2]	2	0.0044	0.0093	0.0064
Petroleum Hydrocarbons							
Toluene	µg/L	1	ND	2	ND	0.88	0.47

Notes

[1] Stormwater samples were collected from the water quality vault, located downstream of the sedimentation basin, because the water quality vault will be the point of diversion into the treatment system. Stormwater quality samples collected only from the Scholls and Loon basins, which are upstream of a sedimentation basin, are not included in this table.

[2] Groundwater samples have not been analyzed for PFAS. Currently, the 95% UTL for PFAS is assumed to be "ND".

[3] When calculating the geometric mean, a value of ½ the detection limit was used for non-detect values.

µg/L = micrograms per liter
MCPP-p = mecoprop
mg/L = milligrams per liter
MPN/100 mL = Most Probable Number per 100 milliliters
ND = Non detect
UTL = upper tolerance limit

In Table 9, the constituent concentration in native basalt groundwater is calculated using a 95 percent upper tolerance limit (UTL) of basalt samples collected from ASR 3 and ASR 3A. Tolerance intervals estimate the range where a proportion of a population exists (Splinter et al., 2020); for example, the 95 percent tolerance interval of constituent concentrations in native basalt groundwater includes 95 percent of the concentrations. If the 95 percent UTL is exceeded, then the concentration *may* indicate a constituent concentration that is elevated above what is considered background in groundwater. As discussed in Section 6.2.2.1, at least one additional groundwater quality sample will be collected from ASR 3 or ASR 3A prior to recharge. The 95 percent UTL concentrations will be updated based on the additional sample(s).

4.4.2 Approach to Meeting Groundwater Protection Rules

The approach to meeting DEQ's groundwater protection rules is different for synthetic constituents and naturally occurring constituents based on the level where background groundwater quality must be met. For synthetic constituents[15], which are typically highly mobile, DEQ requires that background groundwater quality is met at the point of injection. For naturally occurring constituents[16], which are typically not mobile or not toxic (e.g., calcium), DEQ requires that the permittee demonstrate that background water quality will be preserved at vicinity water wells.

4.4.2.1 Synthetic Constituents

To meet background groundwater quality at the point of injection, stormwater will be treated to reduce concentrations of synthetic constituents to below detection using the treatment methods discussed in Section 3.1.1.2. Treatment effectiveness will be monitored during recharge by water quality sampling downstream of the treatment system (see Section 6.2 for the types of pollutants and frequency of sampling during recharge). If synthetic constituents are detected during recharge, then the City will take the contingency actions discussed in Section 4.4.2.3.

4.4.2.2 Naturally Occurring Constituents

Naturally occurring constituents include bacteriological (fecal coliform bacteria), general geochemistry (nitrate, sulfate), and metals (manganese, iron, aluminum, and zinc). For these constituents, DEQ requires that background groundwater quality be preserved at vicinity water wells.

AR projects typically demonstrate that groundwater quality is being preserved at vicinity water wells by installing monitoring wells around a recharge basin and collecting groundwater quality samples during recharge to delineate the extent of constituent migration. However, installing monitoring wells at Sterling Park to depths of about 1,000 ft below ground is not practicable[17], due to the high cost of well installation coupled with the low risk and/or low mobility of naturally-occurring constituents (as discussed in Section 4.2, it is unlikely that recharged stormwater would reach a water well). Therefore, the City will meet the groundwater protection rules using an empirical approach to confirm that naturally occurring constituents in the CRBG aquifer remain below background (Singh and Maichle, 2017). In addition, it should be noted that concentrations of naturally occurring constituents will be reduced to some extent by the treatment system.

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[15] Volatile organic compounds, semi-volatile organic compounds, polycyclic aromatic hydrocarbons, pesticides/herbicides, PFAS, and petroleum hydrocarbons.
[16] Metals and ions
[17] ASR 3 is 988 ft deep (see WASH 78442).

The City's approach to meeting DEQ's groundwater protection rules for naturally occurring constituents will involve collection of water quality samples during recovery[18] and comparison of the quality of the recovered water to background basalt groundwater quality (shown in Table 9 and discussed in Section 4.4.1). If concentrations of the Table 9 constituents in recovered water are below their respective 95 percent UTLs after 100 percent of recharged water has been recovered, then the City will have demonstrated that AR has met DEQ's groundwater protection rules. Alternatively, if concentrations of the Table 9 constituents in recovered water are above their respective UTLs after 100 percent of recharged water has been recovered, then the City will take the contingency actions discussed in Section 4.4.2.3.

4.4.2.3 Contingency Actions

If source water or recovered water do not meet DEQ's groundwater protection rules, the City will take the following contingency actions:

- **Detection of Synthetic Constituents in Source Water.** If synthetic constituents are detected in source water after treatment, the City will stop recharge and recover water from the AR well until concentrations of synthetic constituents return to below background levels. The recovered water will be conveyed to the Sterling Park detention ponds, which would restore the natural course of stormwater conveyance were the diversion to have not occurred. Recharge will not resume until the reason for detection of synthetic constituents is identified, and synthetic constituents are no longer detected in source water.
- **Constituent Concentrations in Recovered Water Exceeding Background.** If concentrations of Table 9 constituents in recovered water are above their respective UTLs after 100 percent of recharged water has been recovered, then the City will continue pumping the AR well under the water rights permit for the well (GR-343) for non-potable irrigation purposes. Pumping will continue until Table 9 constituents are below their respective UTLs based on groundwater samples. Note that the potential recovery rate at ASR 3A (700 to 1,000 gpm) is significantly greater than the planned maximum recharge range (300 gpm).

[18] See Table 9 (Cycle 1) and Table 10 (Cycle 2 to Cycle 5).

SECTION 5: **Permits and Authorizations**

This section identifies the permits and approvals necessary to conduct AR pilot testing and provides documentation that the necessary permits and approvals have either been obtained, requested, or will be obtained before AR pilot testing begins.

5.1 Groundwater Rights

This section provides an overview of the water right permits and Limited Licenses necessary for the Sterling Park AR project:

- **Limited License for AR Testing (Current).** The source water for AR injection will be treated stormwater collected from the Sterling Park stormwater drainage basins WS 1A (Scholls Ferry Road) and WS 1B Loon Drive). Stormwater from these basins is directed to detention Ponds A and B, which ultimately discharge to Summer Creek, a tributary to Fanno Creek. Therefore, it is assumed that OWRD will consider the AR stormwater source to effectively be an unnamed tributary to Summer Creek.

  OWRD has not designated a Water Availability Basin (WAB) for Summer Creek, and thus it is understood that OWRD will instead use water availability and storage statistics for the Fanno Creek WAB[19] when evaluating the Sterling Park AR project. For the Fanno Creek WAB, water is available for storage[20] from November through June of each year. Consequently, this project has planned for recharge to occur during those months.

- **Limited License for AR Recovery (Future).** A second Limited License will be required to recover the water stored in an AR project and put it to beneficial use (OAR 690-350-0130). Following are anticipated elements for the AR recovery Limited License:
  - Planned beneficial uses: non-potable municipal (e.g., irrigation) and streamflow augmentation to Summer Creek/Fanno Creek.
  - Anticipated period for beneficial uses: June through October.
  - Anticipated recovery rate: to be determined but anticipate up to 1,200 gpm from both ASR 3 and ASR 3A.
  - Anticipated volume: to be determined during early phases of AR pilot testing.

Soon after the expected issuance of a Limited License for AR testing, the City plans to consult with OWRD to determine the best time to submit an application for a Limited License for AR recovery.

5.2 Underground Injection Control (UIC) Registration

Because the City is proposing to conduct AR using a well to conduct recharge, operation and testing requires registration under a 1200-U General Permit from DEQ's Underground Injection Control (UIC) program. Appendix G contains the 1200-U UIC General Permit. The application will be submitted to DEQ for review and approval after this AR Limited License application is assigned a number by OWRD.

[19] OWRD Watershed ID 73543, Fanno Creek > Tualatin River – at mouth
[20] At the 50% exceedance flow level.

5.3 Land Use Approval

AR operation and testing requires evidence that land use and development approval from the local government is sought, obtained, or documented as being unnecessary. Appendix A contains a completed Land Use Information Form for the proposed AR project, including the locations of the extraction/injection wells and the Place of Use for recharged water.

SECTION 6: **AR Pilot Testing Work Plan**

This section presents a work plan for AR pilot testing. Pilot testing under the AR Limited License will be similar each year, except that Year 1 will include additional baseline testing and a shakedown test that are not part of Years 2 through 5. Therefore, the work plan for Year 1 is separated from the work plan for Years 2 through 5 in this section, which is organized as follows:

- **Section 6.1:** An overview of the AR pilot test objectives, wells, recharge rates and volumes, schedule, backflushing requirements, pump to waste requirements, and contingencies for water disposal.
- **Section 6.2:** Year 1 AR pilot testing (baseline testing, shakedown testing, and a full AR cycle).
- **Section 6.3:** Year 2 to Year 5 AR pilot testing (full AR cycles).

6.1 Pilot Testing Overview

Under a Limited License, AR systems are pilot tested to determine the ultimate size and scope of the AR project (e.g., storage volume, recharge rate, etc.). Results from the pilot testing are used to provide long-term operational characteristics for the project, and to inform the conditions of the AR permit.

6.1.1 Pilot Test Objectives

A cycle of AR consists of recharge, storage, and recovery. Data are collected during AR cycles to meet the following objectives:

- **Recharge.** Data collected during the recharge phase are used to assess the extent and magnitude of head (i.e., pressure) buildup in the CRBG aquifer, potential for loss of stored water from the current CRBG block, potential well efficiency changes as a result of recharge, effectiveness and reliability of the stormwater treatment system, and to verify that source water meets regulatory standards and DEQ's groundwater protection rules.
- **Storage.** Data collected during storage are used to evaluate the change in head over time after injection stops, and to assess any changes to stored water quality.
- **Recovery.** Data collected during recovery are used to determine if the AR project meets DEQ's groundwater protection rules, to evaluate any potential loss of stored water, and to identify changes in well performance over several cycles of recharge and recovery. Water quality, including temperature, of the stored water also will be evaluated relative to its intended beneficial uses (see Sections 6.1.3 and 6.1.4).

6.1.2 Pilot Testing Scope (Wells, Schedule, and Storage Volume)

The Sterling Park AR System includes the following wells, which were described previously in Section 3.1.1.4:

- ASR 3 / Pilot Well (WASH 57952)
- ASR 3A (WASH 78442)
- Observation Well / Core Hole (WASH 55816).

The following list summarizes the anticipated operational schedule and storage volumes of the AR system, which may change based on precipitation amounts, results from each year of AR pilot testing, and potential unforeseen factors (equipment failure, well maintenance, staffing needs, etc.):

- Recharge period: November 1 through June 30
- Recharge rate: up to 300 gpm
- Annual storage volume: up to 30 MG

The optimized flow rate for the planned stormwater treatment system is 200 gpm. However, actual injection rates will depend in large part on precipitation patterns during any given recharge period, and could thus be lower or higher than the optimum rate. Therefore, the City is requesting to inject up to 300 gpm to account for this current uncertainty. Similarly, the currently estimated range of annual storage volumes is based on measurements made at the site between 2016 and 2019, and could change as additional data become available in the future.

A central goal for AR pilot testing will be to determine specific recharge rates and volumes to be incorporated into future AR recharge and recovery permits for this project.

6.1.3 Recovery of AR Water

Depending on the hydraulic response of the CRBG aquifer to AR at the Sterling Park location, the City will apply to recover up to 85 percent of the recharged water during the first five years of AR. During subsequent years of recharge, the City may apply to recover more than 85 percent (if data support less potential for loss of stored water).[21] Based on evaluation of loss of stored water in existing regional ASR projects utilizing the CRBG aquifers of Cooper and Bull Mountains, very little, if any, loss of recharged water during storage at the Sterling Park site is anticipated.

The City plans to recover recharged water under an AR Recovery Limited License and will submit an application to OWRD after or near completion of recharge pilot testing, approximately one month before the proposed start date of recovery of AR water. Similar to language included in the City's ASR Limited License 002 Condition 12B, the City will likely seek the flexibility of recovering stored water at ASR 3 and ASR 3A under a recovery Limited License and/or their groundwater registration (GR-343), potentially simultaneously so long as the combined rate does not exceed the rate authorized by the recovery Limited License.

6.1.4 Monitoring (Water Quality, Water Level, Water Quantity)

The City will monitor water quality, water quantity, and groundwater levels during each AR Cycle. The specific AR monitoring program is described in Section 6.2 (Year 1) and Section 6.3 (Year 2 through Year 5).

6.1.5 Duration of Limited License

To implement the Sterling Park AR project, the City is requesting an AR Limited License with a duration of five years, with the option to extend the AR Limited License by five-year periods to allow for potential modifications of and continued operation of the AR system.

[21] See OAR 690-350-0130(3).

6.1.6 Backflushing

Periodic backflushing of recharge wells may be required to remove fine material (e.g., rust or fine silts/sands) that is potentially entrained in the recharge source water. Backflushing frequency typically depends on a number of well-specific factors. As a starting point, and based on experience with other nearby ASR wells operated by the City, the Sterling Park recharge well(s) will be backflushed every month during the initial recharge operations (i.e., Year 1). Backflushing frequency may be modified in the future based on changes in specific capacity over time during recharge.

Backflushing will consist of pumping the recharge well(s) at rates from about 130 to 150 percent of the recharge rate. The reason for pumping to waste at a rate that is higher than the recharge rate is to remove fine material from the basalt aquifer by imparting more energy on the well than occurs during recharge. Backflushing will consist of two cycles of pumping that last 20 minutes each, with a 20-minute rest in between each cycle. Backflush water will be discharged to the Sterling Park detention basin.

6.1.7 Pump to Waste Before Recharge

Prior to injecting any water into the recharge well(s), the well will first be pumped to waste via future improvements described briefly in Section 3.2. Pumping to waste before injection flushes particulate material from the conveyance piping. Water will be pumped to waste (Sterling Park detention basin) until it is visually clear, and then will be injected into the recharge well.

6.1.8 Water Disposal Contingency Plan

It is highly unlikely that the quality of the recharged water will become impaired during storage, based on the water quality analysis and geochemical mixing evaluation (Appendix F) and GSI's experience with AR and ASR systems in CRBG aquifers. However, in the unlikely event that the quality of the recharge water becomes impaired during storage, all the water recharged into the aquifer will be recovered and pumped to waste (discharged to the Sterling Park detention basin).

6.2 Year 1 AR Testing

The first year of AR testing will consist of baseline testing and a shakedown test (Section 6.2.1) in addition to performing one cycle of AR operations (Section 6.2.2).

6.2.1 Baseline AR Testing and Shakedown Testing

Baseline testing is performed to establish conditions in the aquifer and wells prior to AR, and to ensure proper functioning of the stormwater treatment system and wellhead equipment (i.e., valves, flow totalizers, etc.). Baseline testing and shakedown testing are discussed in the following sections.

6.2.1.1 Baseline Testing

Baseline testing will include water quality monitoring, water level monitoring, and well performance testing:

- **Baseline Water Quality.** As discussed previously in Section 2.2.3, native CRBG groundwater samples were collected at ASR 3 in 2001 and 2004, and at ASR 3A in 2019. To supplement this historic data with more contemporaneous information, prior to beginning initial recharge activities at least one additional set of groundwater quality samples will be collected from ASR 3 and ASR 3A; these baseline samples will be analyzed for the constituents listed in Table 9 of this report.

- **Baseline Water Level.** Baseline water level monitoring will be performed at ASR 3, ASR 3A, and the corehole at least one month prior to the beginning of recharge. Water levels will be recorded hourly with a pressure transducer and data logger, and will be measured manually when the pressure transducer is installed.
- **Baseline Well Performance.** As previously noted in Section 2.2, multiple pumping tests in the corehole and two ASR wells completed onsite have provided a very consistent set of CRBG aquifer and well performance parameters. The test results have indicated that aquifer and well conditions are favorable for the proposed AR pilot testing operations.

Based on extensive testing of the City's other ASR wells, the recharge specific capacity value is typically marginally lower than a respective well's pumping specific capacity value. Determination of actual recharge specific capacity values at ASR 3 will be determined soon after starting the initial shakedown recharge test described below.

6.2.1.2 Shakedown Test

Before initiating the first cycle of AR operations, a shakedown test will be performed that will consist of:

- **Recharge Test.** ASR 3 will be recharged with source water (treated stormwater) for about four hours to test and confirm proper functioning of pipes, valves, flow totalizers, and wells during recharge. Adjustments will be made as required.
- **Recovery Test.** After the recharge, ASR 3 and/or ASR 3A will be pumped to confirm proper functioning of pipes, valves, flow totalizers, and wells during recovery. All recharged water will be recovered. Recovered water from the shakedown test will be pumped-to-waste (Sterling Park detention basin).

The shakedown test is anticipated to last approximately two days.

A key focus during both the shakedown test and subsequent AR cycle testing will be to ensure the proper functioning of the facility's instrumentation and control systems, including water quality monitoring equipment.

6.2.2 Cycle 1 AR Testing

Following the completion of baseline monitoring and shakedown testing, the first cycle of AR operations will be performed (Cycle 1). The overall recharge duration for Cycle 1 is anticipated to encompass approximately 240 days from November 1 through June 30, dependent on the project construction schedule. However, the occurrence of specific recharge events during that period will depend primarily on precipitation patterns, i.e., recharge will occur only when sufficient rainfall is present. Determining the lowest viable treatment and recharge rate will be a key goal for early AR pilot testing.

The City plans to recover recharged water under an AR Recovery Limited License and will submit an application to OWRD after or near completion of recharge pilot testing, approximately one month before the proposed start date of recovery of AR water.

6.2.2.1 Cycle 1 AR Water Quality Testing

Water quality testing will involve collecting stormwater samples post-treatment, and groundwater samples at ASR 3 (ASR 3A will not be sampled because it is located about 40 ft from ASR 3 and is completed in the same aquifer, and thus water quality is anticipated to be very similar). The Cycle 1 water quality testing program consists of three analyte groups designated as Groups A through C, shown on Table 9A (included in Appendix H). Each analyte group provides information on a different aspect of AR as described below:

- **Group A.** A comprehensive list that includes most contaminants regulated under OAR 340-040 and OAR 333-061.
- **Group B.** A list of general geochemical parameters and metals to evaluate the response of the CRBG aquifer to recharge and ensure compliance with DEQ groundwater protection rules. Specifically, these parameters will help evaluate (1) potential changes in CRBG groundwater quality after it has been recharged with treated stormwater (e.g., silica and fluoride, which appear to be elevated in groundwater and low in stormwater), and (2) whether or not reactions are occurring in the CRBG aquifer system due to recharging with treated stormwater.
- **Group C.** A targeted list of constituents, found in Table 9 of this report, for which concentrations in raw stormwater exceed background concentrations in the CRBG aquifer. These constituents will be used to evaluate the effectiveness of stormwater treatment.
- **Group D.** A list of naturally occurring constituents that are not likely to be completely removed by stormwater treatment, and that are sampled with the objective of demonstrating that groundwater quality in the basalt aquifer has returned to background concentrations (and, therefore, that the groundwater protection rules have been met).

Table 10 shows the City's planned sampling program during recharge. The City will plan to collect samples every month during recharge; however, given the unpredictable nature of stormwater runoff events, this planned schedule may be modified based on staff availability and/or the timing of recharge events (i.e., whether recharge occurs during working hours).

At a minimum, the City will collect four samples during the recharge season (November to June). The sampling event indicated by the bold text in Table 10 (stormwater and ASR 3 for Group A) will always be the first sample that is collected (for example, if the sample cannot be collected in November, then the sample will be collected in December).

Table 10. Cycle 1 Water Quality Monitoring during Recharge

AR Stage	Time	Stormwater (Source Water)	ASR 3 (Recharge & Recovery Well)	ASR 3A (Recovery Well)
Recharge (Nov.-June)	***November***	***Group A***	***Group A***[1]	—
	December	Group B & C	—	—
	January	Group B & C	—	—
	February	Group B & C	—	—
	March	Group B & C	—	—
	April	Group B & C	—	—
	May	Group B & C	—	—
	June	Group B & C	—	—

Notes

[1] Collect sample before injection starts.

Bold italic text indicates that the sampling program (stormwater for Group A, the AR well for Group A, and the observation well for Group A) will be the first sample collected each year. For example, if this sampling group cannot be completed in November, then the sampling group will be completed in December.

Group A through C analyte suites are shown in Table 9A, which is included in Appendix H.

— = no samples to be collected

AR = artificial recharge

ASR = aquifer storage and recovery

Table 11 shows the City's sampling program during recovery. Unlike recharge, the recovery phase is predictable, and the City does not anticipate needing to modify the schedule below. During recovery, samples will be collected from ASR 3 *or* ASR 3A, as the water quality at these two wells is likely to be similar (the wells are located about 40 ft apart). Note that during recovery, the "100% +" sample will be collected only if Group D constituent concentrations exceed background levels (to ensure that the groundwater protection rules are being met).

Table 11. Cycle 1 Water Quality Monitoring during Recovery

AR Stage	Time	Stormwater (Source Water)	ASR 3 or ASR 3A (Recovery Well)
Recovery (July-Oct.)	Day 1	—	Group A
	50% of Recovery Volume	—	Groups B & D
	100% of Recovery Volume	—	Groups B & D
	100% +	—	Groups B & D [1]

Notes

[1] Recovery will continue, and Group D constituents will continue to be monitored as long as concentrations exceed background levels (see Section 2.2.3).

Group A through D analyte suites are shown in Table 9A, which is included in Appendix H.

— = no samples to be collected

AR = artificial recharge

ASR = aquifer storage and recovery

The frequency of water quality testing and suite of analyzed constituents may be altered if data indicate that changes to water quality testing are warranted. Prior to any change to the monitoring program, the City will propose the change to OWRD and/or DEQ, and will not make the change until authorized in writing by OWRD and/or DEQ.

6.2.2.2 Cycle 1 AR Water Level Monitoring

Groundwater level monitoring will be performed at ASR 3, ASR 3A, and the corehole. Water levels will be monitored hourly with a down-hole pressure transducer and data logger installed in each of the three wells.

In addition to transducer measurements, water levels will be measured manually multiple times each year to confirm that transducer measurements are accurate. Manual measurements will be taken prior to beginning initial Cycle 1 injection in November. During the recharge period from November through June, manual water level measurements will be made prior to, during, and at the conclusion of at least several individual recharge events. Similarly, additional manual measurements will be taken during the recovery period. As AR pilot testing progresses, the timing and frequency of manual measurements will be refined based on the actual occurrence of recharge and recovery events. To the extent possible, manual measurements and downloads from these wells will be coordinated with the City's ongoing and active ASR program.

6.2.2.3 Recovery Well (ASR 3A) Performance Test

A brief well performance test will be performed at ASR 3A at the start of the recovery phase. Results of the performance test will be compared to the 2019 aquifer test performed in ASR 3A to assess potential changes in well efficiency following the completion of one AR cycle. The performance test will consist of the following steps:

- Measure the static water level.
- Pump ASR 3A at the full recovery rate for two hours and measure the pumping water level.
- Turn off the pump.
- Calculate specific capacity (i.e., pumping rate divided by drawdown).

6.3 Cycle 2 through Cycle 5 AR Operations

The results of the Cycle 1 AR pilot testing will be evaluated and used to optimize and fine-tune AR operation for subsequent cycles. The objective of AR operations during Year 2 through Year 5 will be to develop larger storage volumes in support of stabilizing groundwater levels of the CRBG aquifer and improve the overall efficiency of the Sterling Park AR system. The anticipated AR operations plan for a subsequent year will be included with each AR annual report submitted to OWRD. Any modifications to the water level or water quality monitoring plan as outlined in this work plan will be submitted to OWRD for review and approval.

6.3.1 Cycle 2 to Cycle 5 Water Quality Testing

During Cycles 2 through 5, sampling will be conducted according to the same schedule as during Cycle 1, as was described in Section 6.2.2.1. Sampling during recharge is summarized in Table 10, and sampling during recovery is summarized in Table 11. If data collected during pilot testing indicate that changes to the water quality testing program in Table 10 and Table 11 are necessary, the City will communicate the changes to OWRD in the Annual Report that is submitted prior to the change taking effect (or by email, if notification is necessary prior to the Annual Report due date). The City will not implement any changes to the monitoring program until authorized in writing by OWRD and/or DEQ.

6.3.2 Cycle 2 to Cycle 5 Water Level Monitoring

Water level monitoring during Cycle 2 through Cycle 5 is planned to be identical to that of Cycle 1. If data collected during pilot testing indicate that changes to the water level monitoring program are necessary, the City will communicate the changes to OWRD in the Annual Report that is submitted prior to the change taking effect (or by email, if notification is necessary prior to the Annual Report due date). The City will not implement any changes to the monitoring program until authorized in writing by OWRD and/or DEQ.

6.4 Determination of Stored Water Available for Recovery

AR projects typically use water level changes in "key wells" to determine the amount of stored water that is available for recovery. Often, periodic measurements made in existing offsite wells (domestic, irrigation, municipal, etc.) can be used as the "key" monitoring wells for this purpose. However, few such wells still exist in areas near Sterling Park due to the transformation from a rural and agricultural area with independent wells, to residential and commercial properties that are now serviced by public water suppliers.

During AR pilot testing, the City proposes to use the three onsite wells (ASR 3, ASR 3A, and the corehole) to monitor CRBG aquifer responses to injection and recovery. Each well will be instrumented with a datalogging pressure transducer to obtain high-frequency water level measurements. Groundwater level data obtained during pilot testing will be used to evaluate the head buildup (mounding), and potential reduction of head, after stopping recharge.

If data collected during the recharge and storage phases indicate there is no significant loss of stored water, then the City anticipates that 85 percent of stored water will be available for recovery, in accordance with OAR 690-350-0120 (f5)(f). Additional analysis of potential loss of stored water will be evaluated throughout the pilot testing period, and a greater percentage of recovery may be requested for subsequent recharge permits if supported by the data. As noted previously, evaluation of loss of stored water in existing regional ASR projects utilizing the CRBG aquifers of Cooper and Bull Mountains, very little if any loss of recharged water during storage is anticipated.

6.5 Reporting

As required by OAR-690-350-0120 (5)(c), for the Sterling Park AR project the City will maintain records of metered quantities of water, water levels, water quality, and other pertinent information. Recordkeeping will conform to the standards and protocol of the quality assurance and quality control plan outlined in Section 7:

At the end of each year, the City will compile records and submit an annual report to OWRD and any other applicable regulatory agencies (i.e., DEQ) in fulfillment of OAR-690-350-0120(5)(h) that includes the following report structure and components, at a minimum:

- **Executive Summary**
- **Project Description**
  - Introduction
  - Existing Site Conditions
- **Pilot Test Results**
  - AR Recharge and Recovery Rates and Volumes (stored water and native groundwater)
  - AR Well Performance during Recharge and Recovery

- **Water Quality Monitoring**
  - Data Collection
  - Recharge Water Quality
  - Recovered Water Quality (All recovery-related data will also be provided as part of a secondary Limited License for use of artificially recharged waters, if one is submitted).
  - Chemical Reactions
- **Next AR Cycle and Future Considerations**

SECTION 7: **Monitoring Procedures and QA/QC Plan**

This section details the quality assurance and quality control (QA/QC) plan for monitoring that will be performed throughout the Sterling Park AR project. The objective of this QA/QC plan is to collect water level and water quality data that are valid representations of the conditions at each sampling location.

7.1 General

This section outlines QA/QC procedures that are required for all types of monitoring being performed (i.e., water level or water quality).

7.1.1 Personnel Qualifications

Only personnel that have prior water level/water quality sampling experience or site-specific training in the standards and procedures of this QA/QC plan shall collect monitoring data. GSI will review collected data for completeness and compliance with this plan.

7.1.2 Recordkeeping

The sampling technician will document field observations and measurements on the field form or a designated project field book. The following information will be recorded on the form for each sampling location:

- Name of person(s) performing monitoring activities
- Date and time of monitoring activities
- Location of monitoring activities
- Description of methodology for performing monitoring activities and any deviations from this QA/QC plan

The field form may be modified in the future to incorporate additional information, or to make the form more user-friendly.

7.2 Manual Water Level Monitoring

7.2.1 Manual Water Level Monitoring Equipment List

The following general list of equipment and materials is required for all monitoring activities, at a minimum:

- Field form
- Water level meter
- Personal protective equipment (PPE) (i.e., gloves)
- Chlorine bleach solution, spray bottle, and paper towels (to prevent cross-contamination between wells)

To prevent cross-contamination between wells, water level meters will be disinfected in between wells using a chlorine bleach solution.

7.2.2 Manual Water Level Monitoring Procedures

Procedures for water level monitoring at each location will proceed as follows:

1. Don nitrile gloves.
2. Record flow rate (instantaneous flow rate and totalizer reading) on the monitoring form.
3. Disinfect water level meter using chlorine bleach solution, spray bottle, and paper towels.
4. Lower the water level meter tape down the PVC access tube, and measure water level from the top of the tube to the nearest 0.1 ft. Record water level and measurement time on the monitoring form.
5. Copy the field forms and send to GSI.

7.3 Water Quality Monitoring

Water quality samples will be collected according to the schedule in Table 10 (recharge) and Table 11 (recovery).

7.3.1 Water Quality Monitoring Equipment List

The following general list of equipment and materials is required for all monitoring activities, at a minimum:

- Water sample containers, coolers, and chain-of-custody (COC) forms
- Field form
- Ice
- Meters for measuring temperature, conductivity, pH, dissolved oxygen (DO), oxidation reduction potential (ORP), and turbidity
- New tubing
- PPE (i.e., gloves)
- Distilled water in a spray bottle

To prevent cross-contamination between wells, only new tubing will be used during sampling. Gloves shall be replaced after handling equipment/samples from each location. Water quality meters will be cleaned with distilled water.

7.3.1.1 Water Quality Monitoring Procedure

The following procedure for water quality monitoring assumes that all sampling will occur in one day:

1. Order bottles from the lab and determine how many days after sampling that the lab needs the bottles (to meet U.S. Environmental Protection Agency holding times). Label the bottles before sampling (see Section 7.3.1.2).
2. Calibrate meters that will be used during the day's sampling.
3. Record flow rate (instantaneous rate and totalizer reading) on the monitoring form.
4. Purge three volumes of water from the sampling site. If ASR 3 or ASR 3A is being sampled, purge at least three well volumes from the well. If stormwater is being sampled, make sure that water has been flowing through the treatment system for at least 30 minutes. All purged water will be pumped to waste.
5. After the durations in Step 3, collect samples from each sampling point using the following methods:
    a. Record flow rate (instantaneous flow rate and totalizer reading) on the monitoring form.

b. Measure field parameters (temperature, conductivity, pH, dissolved oxygen [DO], ORP, and turbidity).
c. Don nitrile gloves.
d. Attach new tubing to the well sampling port and fill bottles. Transfer bottles to cooler after filling. Take care to ensure there are no bubbles larger than a pea in 40-milliliter vials.
e. Transfer ice into zip-top bags, ensuring that ice is double-bagged. Place ice in cooler.
f. Turn off well and dispose of tubing.

6. Complete the COC and send samples to analytical laboratory for analysis. Make sure the laboratory receives the samples by the required date.
7. Copy the field forms and send to GSI.

7.3.1.2 Sample Names

Samples will be assigned unique names to indicate where and when the sample was collected. The sample name will include the following information:

- **Location ID:** ID of the location being sampled:

Location	Sample ID
ASR 3 (WASH 57952)	ASR 3
ASR 3A (WASH 78442)	ASR 3A
Treated Stormwater	SW

- **Cycle ID:** The current cycle of the AR project:

Cycle	Cycle ID
1	C1
2	C2
3	C3
4	C4
5	C5

- **Monitoring Date:** The date of the monitoring (month, day, year).

For example, a sample collected from ASR 3A, during Cycle 1, on February 1, 2022, will be "ASR-3A-C1-02012022."

7.3.1.3 Laboratory QA/QC

Samples collected during the pilot testing program will be analyzed by an analytical laboratory certified by the Oregon Environmental Laboratory Accreditation Program.

With respect to water quality monitoring, no duplicate samples will be collected in the field. If laboratory testing results indicate that a parameter has an unexpectedly high concentration approaching applicable regulatory standards (i.e., federal Maximum Contaminant Level [MCL]), recharge or recovery will be stopped and the location will be resampled as soon as possible according to the procedures outlined above.

Analytical data will be assessed by GSI to ensure that the specified QA/QC objectives have been met, which includes a review of; COC documentation, holding times, and matrix spikes.

SECTION 8: **References**

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Figures

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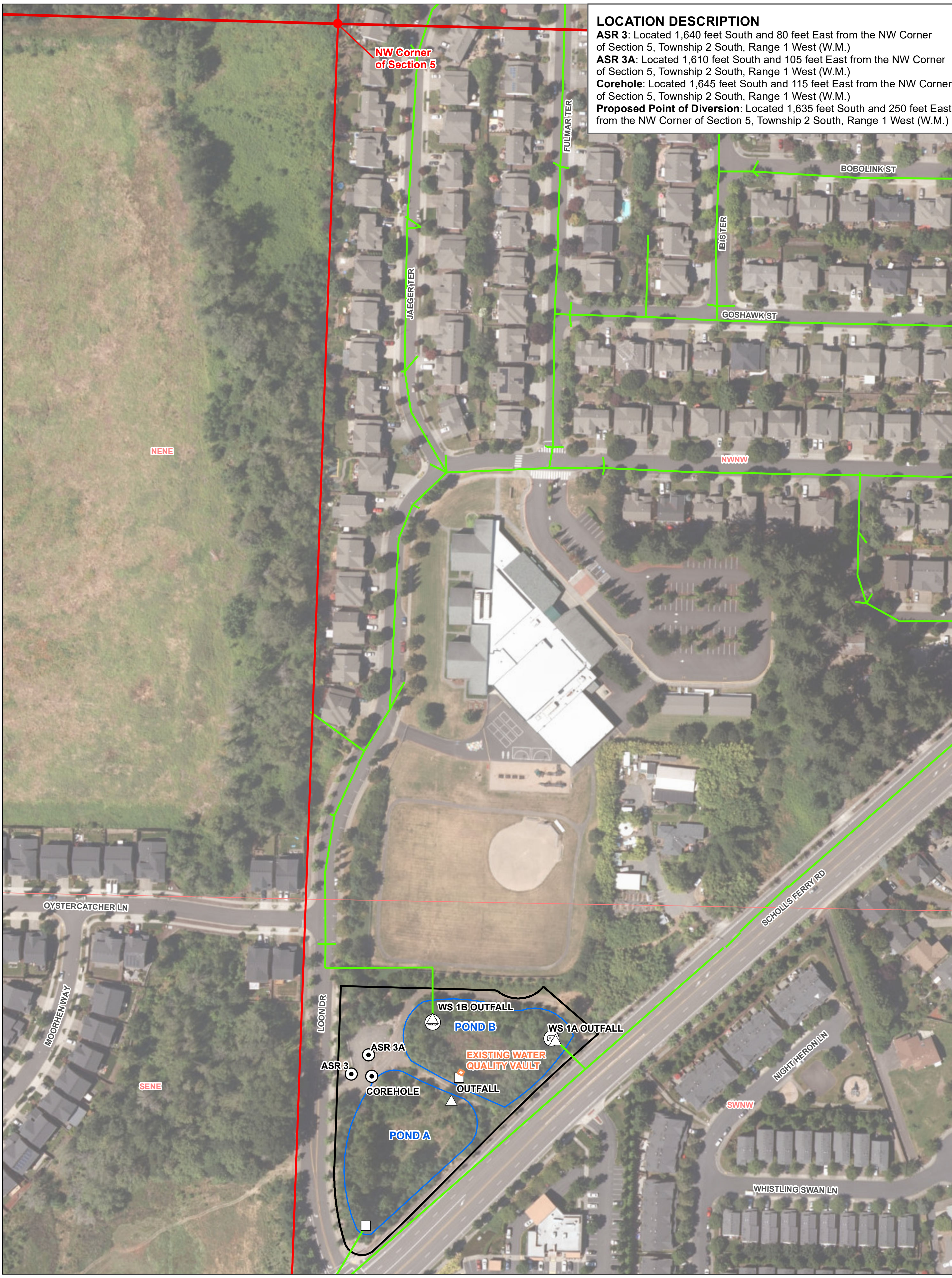

LEGEND

- Proposed Point of Diversion (POD)

All Other Features

- Well
- Outfall
- Inlet
- Stormwater Vault with Pump and Bypass System
- Stormwater Conveyance
- Stormwater Detention Basin
- Site

Date: October 13, 2021
Data Sources: METRO, USGS, COP imagery (2020)

FIGURE 1

Proposed Diversion Location

City of Beaverton
Sterling Park AR Limited License Application
Township 2 South, Range 1 West, Section 5 (W.M.)

N

0 75 150 225
Feet

GSI Water Solutions, Inc.

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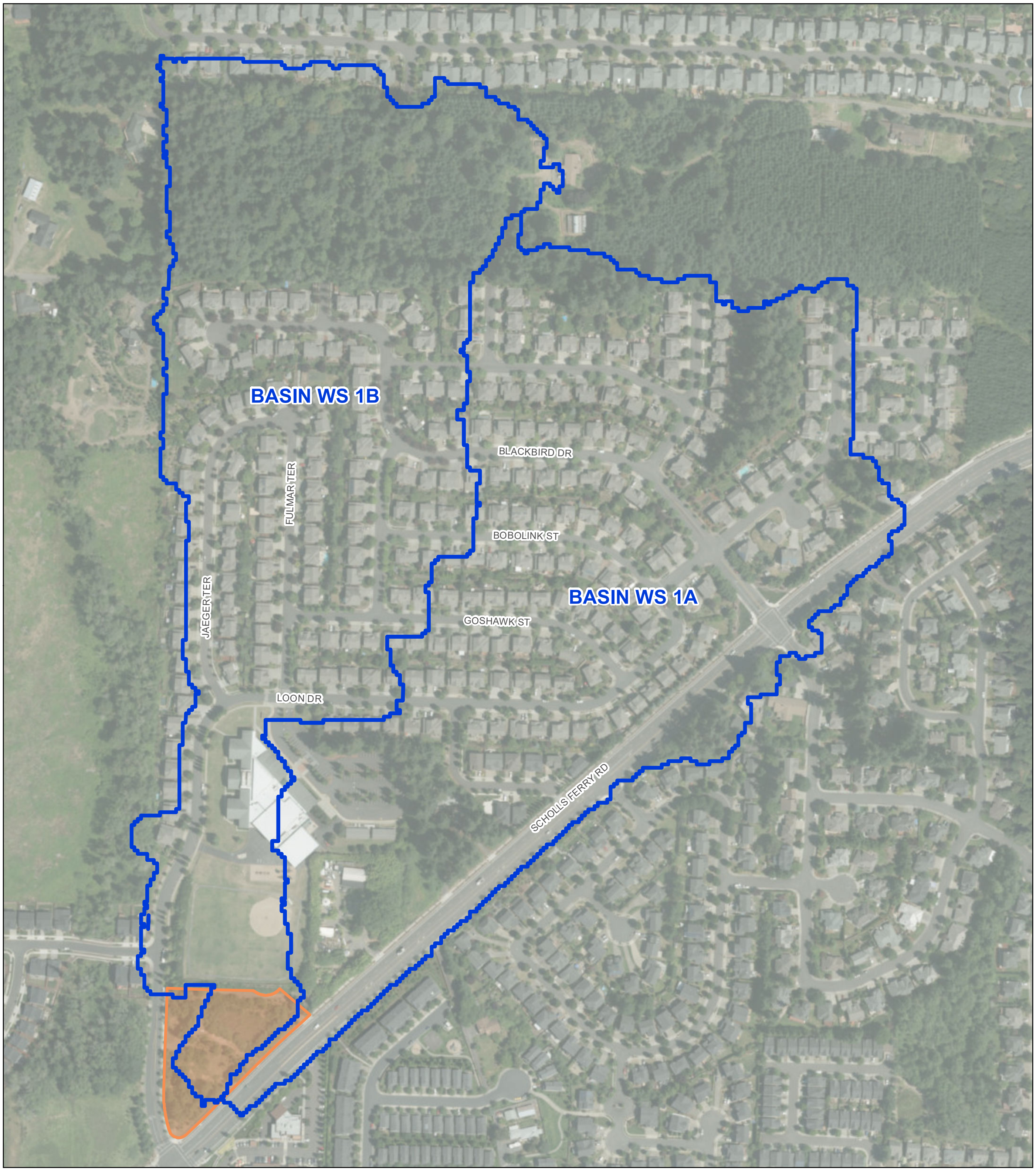


LEGEND

Site

Stormwater Drainage Basin Extent

FIGURE 2

Stormwater Drainage Basins

City of Beaverton

Sterling Park AR Limited License Application

N

0 200 400

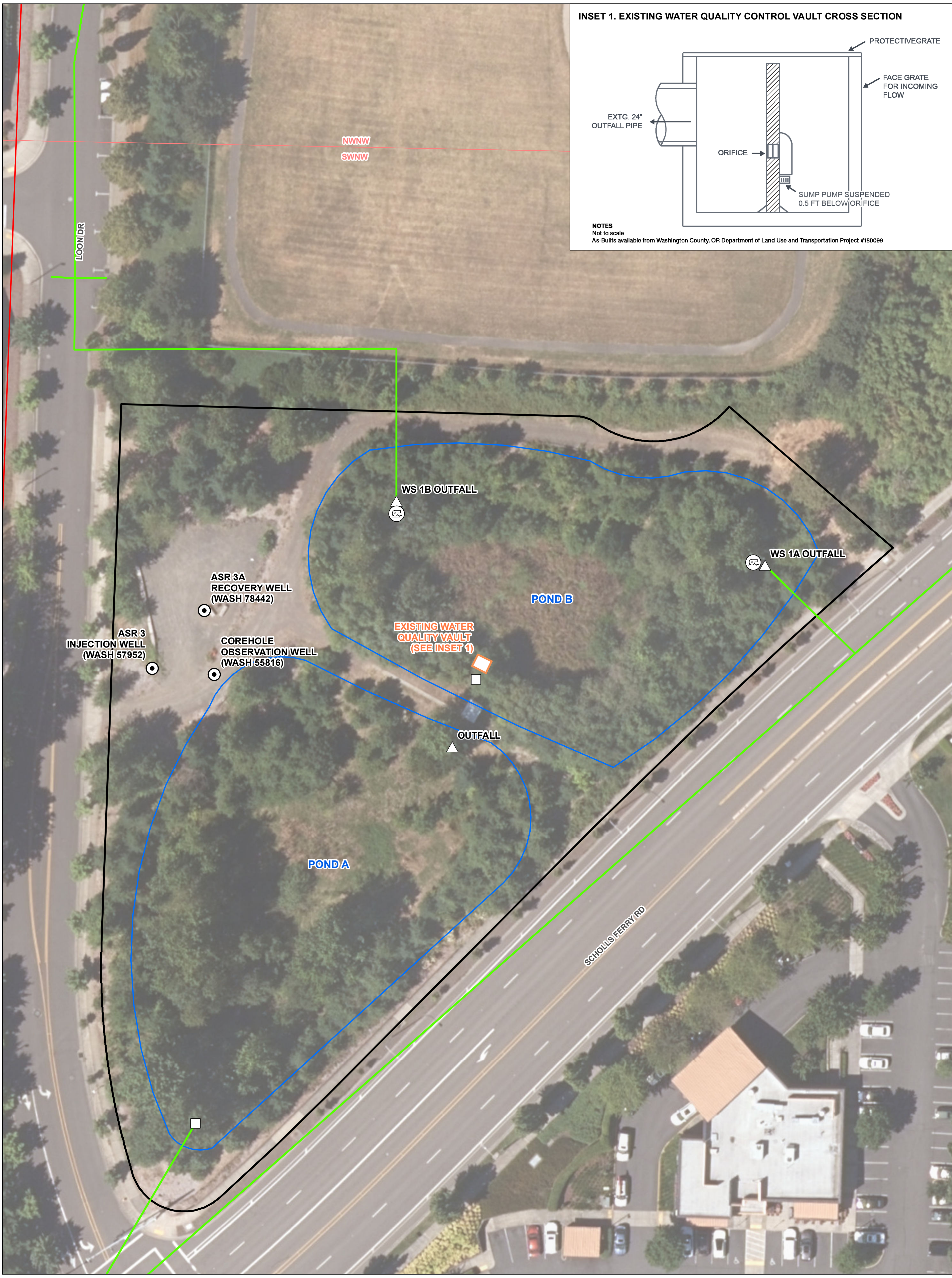
Feet

GSI Water Solutions, Inc.

Date: July 31, 2020

Data Sources: METRO, USGS, COP 2016

Document Path: Y:\0100_Beaverton\Source_Figures\101_Sterling_Park_SW_Recharge_Eval\SW_Treatment_Eval_Memo\Figure1_Project_Location.mxd



LEGEND

Proposed Point of Diversion (POD)

All Other Features

Well

Outfall

Inlet

Stormwater Vault with Pump and Bypass System

Stormwater Conveyance

Stormwater Detention Basin

Site

FIGURE 3

Proposed Diversion Location

City of Beaverton
Sterling Park AR Limited License Application
Township 2 South, Range 1 West, Section 5 (W.M.)

N

0 25 50 75
Feet

GSI Water Solutions, Inc.

Date: October 13, 2021
Data Sources: METRO, USGS, COP imagery (2020)

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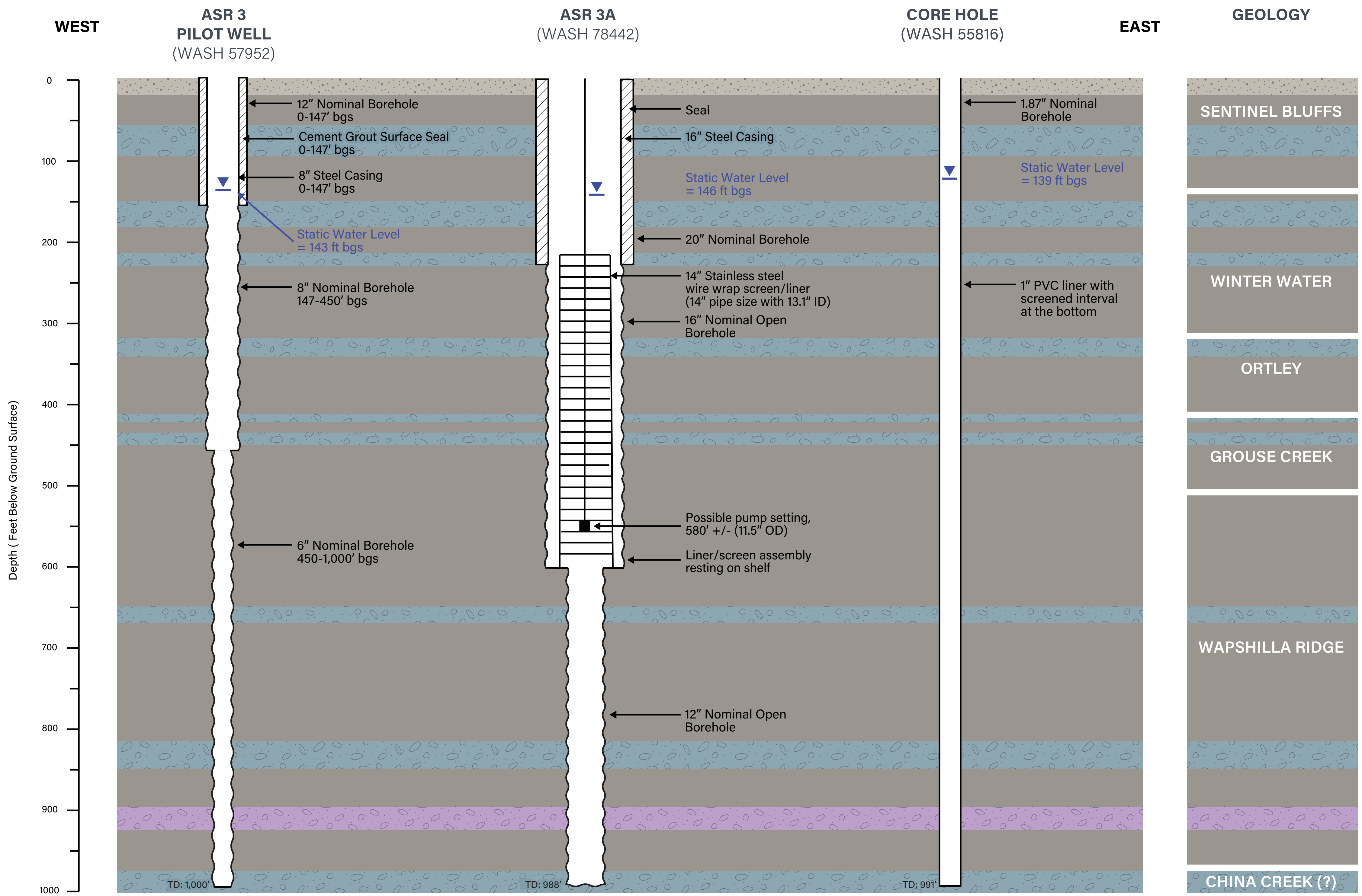


FIGURE 4

Schematic ASR Overview

City of Beaverton
Sterling Park AR
Limited License Application

LEGEND

- Clay, Silt, and Sand
- Massive to Jointed Flow Interior
- Interflow Zone
- Pillow Complex

NOTES

Horizontal axis not to scale.

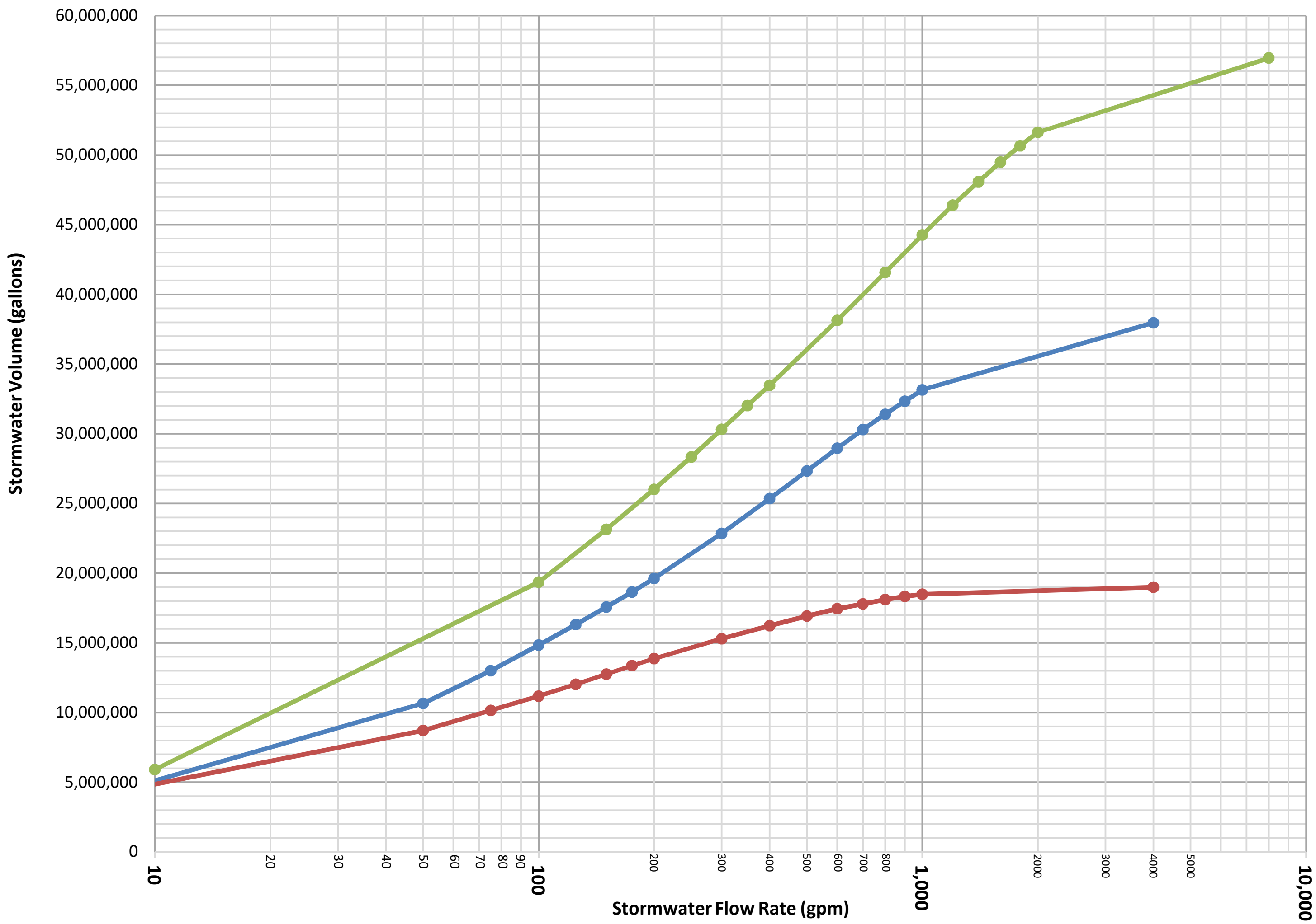
bgs: below ground surface
ID: inside diameter

GSI Water Solutions, Inc.

FIGURE 5

2016-2017 Stormwater Volume vs. Stormwater Flow Rate

City of Beaverton
Sterling Park AR
Limited License Application



LEGEND

- WS1A(Scholls)
- WS1B(Loon)
- Combined

NOTE

gpm: gallons per minute

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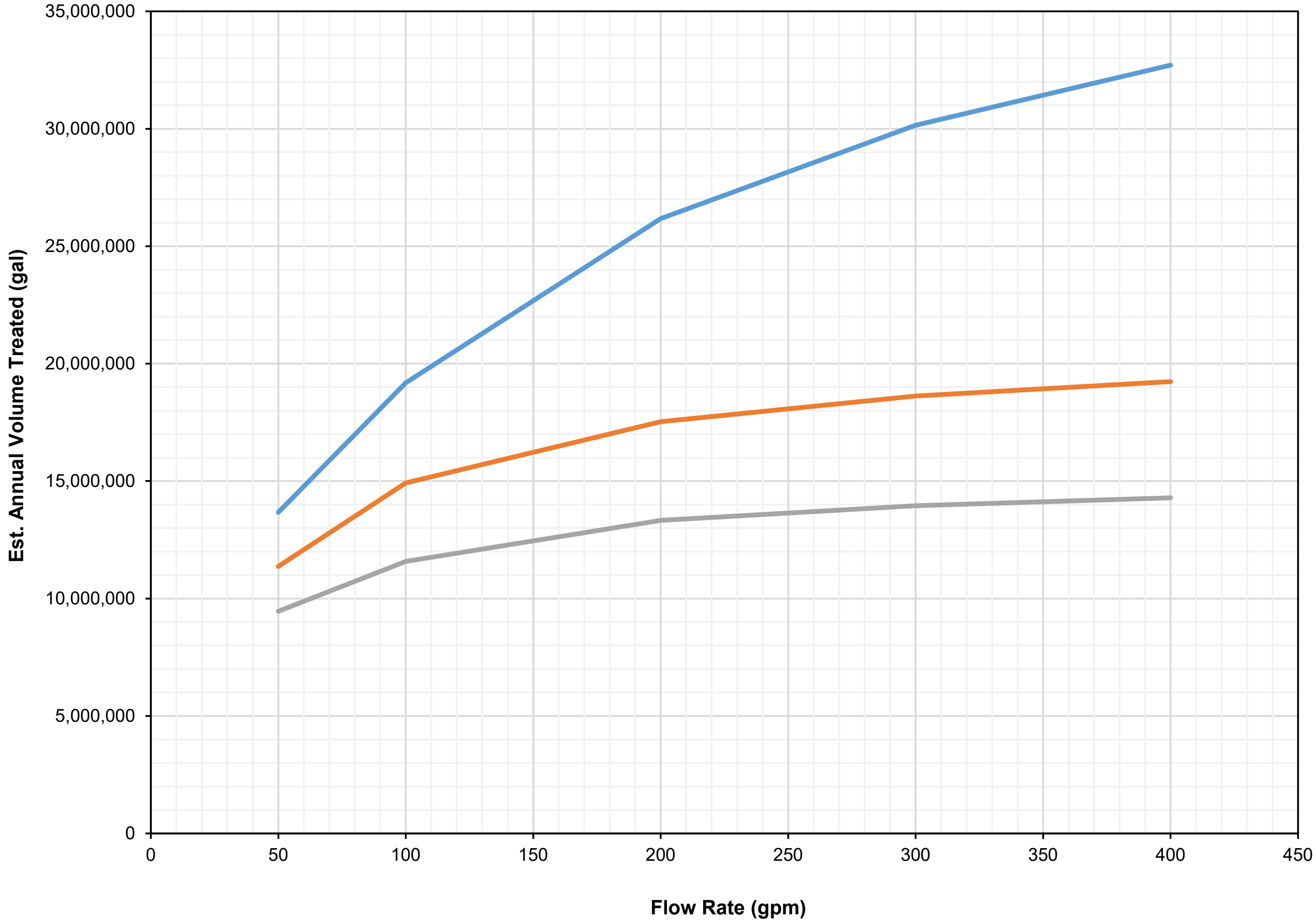

FIGURE 6

Estimated Annual Treated Stormwater Volumes at Varying Flow Rates

City of Beaverton

Sterling Park AR

Limited License Application

LEGEND

- 2016 - 2017
- 2017 - 2018
- 2018 - 2019

NOTE

gpm: gallons per minute

GSI Water Solutions, Inc.

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LEGEND

Potential/Stored Water Migration Extent

Scenario 1

- 500 Days
- 1000 Days (2X Safety Factor)
- 1500 Days (3X Safety Factor)

All Other Features

- Well
- ASR 3
- 3 Number of wells within Quarter Quarter
- Sterling Park Site

NOTE

*Number of wells within the Section, no QQ location available.

Date: November 8, 2021
Data Sources: 2017 Aerial, Google Earth

FIGURE 7

Potential/Stored Water Migration Extent

City of Beaverton
Sterling Park AR Limited License Application

N
0 325 650 975
Feet

GSI Water Solutions, Inc.

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APPENDIX A

AR Limited License Application Form
and Land Use Compatibility Statement

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Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem Oregon 97301-1271
(503) 986-0900
www.wrd.state.or.us

Application for Limited Water Use License

License No.:___________

Applicant Information

NAME City of Beaverton, Attn: Brian Diaz				PHONE (HM) N/A
PHONE (WK) 503-350-4094	CELL 971-288-8960			FAX N/A
ADDRESS 12725 SW Milikan Way				
CITY Beaverton	STATE OR	ZIP 97005	E-MAIL * bdiaz@beavertonoregon.gov	

Agent Information

NAME GSI Water Solutions, Inc. Attn:Jason Melady			PHONE 971-200-8526	FAX N/A
ADDRESS 55 SW Yamhill St, Suite 200				CELL 503-799-2198
CITY Portland	STATE OR	ZIP 97204	E-MAIL * jmelady@gsiws.com	

I (We) make application for a Limited License to use or store the following described surface waters or groundwater – not otherwise exempt, or to use stored water of for a use of a short-term or fixed-duration:

1. **SOURCE(S) OF WATER:** unnamed surface water a tributary of Summer Creek
2. **AMOUNT OF WATER** to be diverted;
   Maximum and instantaneous rate (cubic feet or gallons per minute): 300 gpm
   Total volume (gallons or acre-feet): 50,000,000 gallons. If water is to be used from more than one source, give the quantity from each:________
3. **INTENDED USE(S) OF WATER:** (check all that apply)
   - ☐ Road construction or maintenance
   - ☐ General construction
   - ☐ Forestland and rangeland management; or
   - ☒ Other: Artificial Recharge
4. **DESCRIPTION OF PROPOSED PROJECT:** Include a description of the place of use as shown on the accompanying site map, the method of water diversion, the type of equipment to be used (including pump horsepower, if applicable), length and dimensions of supply ditches and pipelines:

   See attached map and supplemental report describing project. Water will be diverted from an exiting water quality vault at rates up to 300 gpm, and will be conveyed through a treatment system to the ASR 3 (WASH 57952) well for storage. The final diversion and treatment system are still under design.

5. **PROJECT SCHEDULE:** (List day, month, and year)
   Date water use will begin: Date of LL issuance
   Date water use will be completed: 5 years from LL issuance
   Months of the year water would be diverted and used: November through June
   If for other than irrigation from stored water, how and where will water be discharged after use:
   N/A

Brian Diaz Digitally signed by Brian Diaz DN: C=US, E=bdiaz@beavertonoregon.gov, O=PW Eng, OU=City of Beaverton, CN=Brian Diaz Date: 2021.11.30 08:52:01-08'00'
Applicant Signature

Brian Diaz, Project Manager
Print Name *and title if applicable*

30 November 2021
Date

PLEASE READ CAREFULLY

NOTE: A completed water availability statement from the local watermaster, Land Use Information Form completed by the local Planning Department, fees and site map meeting the requirements of OAR 690-340-030 must accompany this request. The fee for this request is **$280** for the first point of diversion plus **$30** for each additional point of diversion. Please review the Department's fee schedule to view fees required to request a limited license for Aquifer Storage and Recovery testing purposes or for Artificial Groundwater Recharge testing purposes.

Failure to provide any of the required information will result in return of your application. The license, if granted, will not be issued or replaced by a new license for a period of more than five consecutive years. The license, if granted, will be subordinate to all other authorized uses that rely upon the same source, or water affected by the source, and may be revoked at any time it is determined the use causes injury to any other water right or minimum perennial streamflow.

If water source is well, well logs or adequate information for the Department to determine aquifer, well depth, well seal and open interval, etc. are required. The licensee shall indicate the intended aquifer. If for multiple wells, each map location shall be clearly tired to a well log.

If a limited license is approved, the licensee shall give notice to the Department (Watermaster) at least 15 days in advance of using the water under the Limited License and shall maintain a record of use. The record of use shall include, but need not be limited to, an estimate of the amount of water used, the period of use and the categories of beneficial use to which the water is applied. During the period of the Limited License, the record of use shall be available for review by the Department upon request.

**A summary of review criteria and procedures that are generally applicable to these applications is available at: http://www.oregon.gov/owrd/pages/pubs/forms.aspx*

Mapping Requirements (OAR 690-340-0030):

(1) A request for a limited license shall be submitted on a form provided by the Water Resources Department, and shall be accompanied by the following:

a. A site map of reproducible quality, drawn to a standard, even scale of not less than 2 inches = 1 mile, showing:

i. The locations of all proposed points of diversion referenced by coordinates or by bearing and distance to the nearest established or projected public land survey corner;

ii. The general course of the source for the proposed use, if applicable;

iii. Other topographical features such as roads, streams, railroads, etc., which may be helpful in locating the diversion points in the field.

REMARKS:

For WRD Use Only

This page to be completed by the local Watermaster.

WATER AVAILABILITY STATEMENT

Name of Applicant: City of Beaverton Limited License Number: ____________

1. To your knowledge, has the stream or basin that is the source for this application ever been regulated for prior rights?

☒ Yes ☐ No

If yes, please explain:

The Tualatin River Basin is regulated each year for senior water rights.

2. Based on your observations, would there be water available in the quantity and at the times needed to supply the use proposed by this application?

☒ Yes ☐ No

This conclusion is based on WAB analysis at 50% exceedence.

3. Do you observe this stream system during regular fieldwork?

☐ Yes ☒ No

If yes, what are your observations for the stream?

4. If the source is a well and if WRD were to determine that there is the potential for substantial interference with nearby surface water sources, would there still be ground water and surface water available during the time requested and in the amount requested without injury to existing water rights?

☐ Yes ☐ No ☒ N/A

What would you recommend for conditions on a limited license that may be issued approving this application?

5. Any other recommendations you would like to make?

Signature [signature] WM District #: 18 Date: 12/08/21

Land Use Information Form

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900
www.wrd.state.or.us

NOTE TO APPLICANTS

In order for your application to be processed by the Water Resources Department (WRD), this Land Use Information Form must be completed by a local government planning official in the jurisdiction(s) where your water right will be used and developed. The planning official may choose to complete the form while you wait, or return the receipt stub to you. Applications received by WRD without the Land Use Form or the receipt stub will be returned to you. Please be aware that your application will not be approved without land use approval.

This form is NOT required if:

1) Water is to be diverted, conveyed, and/or used only on federal lands; **OR**
2) The application is for a water right transfer, allocation of conserved water, exchange, permit amendment, or ground water registration modification, and **all** of the following apply:
   a) The existing and proposed water use is located entirely within lands zoned for exclusive farm-use or within an irrigation district;
   b) The application involves a change in place of use only;
   c) The change does not involve the placement or modification of structures, including but not limited to water diversion, impoundment, distribution facilities, water wells and well houses; and
   d) The application involves irrigation water uses only.

NOTE TO LOCAL GOVERNMENTS

The person presenting the attached Land Use Information Form is applying for or modifying a water right. The Water Resources Department (WRD) requires its applicants to obtain land-use information to be sure the water rights do not result in land uses that are incompatible with your comprehensive plan. Please complete the form or detach the receipt stub and return it to the applicant for inclusion in their water right application. You will receive notice once the applicant formally submits his or her request to the WRD. The notice will give more information about WRD's water rights process and provide additional comment opportunities. You will have 30 days from the date of the notice to complete the land-use form and return it to the WRD. If no land-use information is received from you within that 30-day period, the WRD may presume the land use associated with the proposed water right is compatible with your comprehensive plan. Your attention to this request for information is greatly appreciated by the Water Resources Department. If you have any questions concerning this form, please contact the WRD's Customer Service Group at 503-986-0801.

Land Use Information Form

Oregon Water Resources Department
725 Summer Street NE, Suite A
Salem, Oregon 97301-1266
(503) 986-0900
www.wrd.state.or.us

Applicant: City of Beaverton (First) ____ (Last)

Mailing Address: 12725 SW Millikan Way

Beaverton (City) OR (State) 97005 (Zip) Daytime Phone: 503-526-2269

A. Land and Location

Please include the following information for all tax lots where water will be diverted (taken from its source), conveyed (transported), and/or used or developed. Applicants for municipal use, or irrigation uses within irrigation districts may substitute existing and proposed service-area boundaries for the tax-lot information requested below.

Township	Range	Section	¼ ¼	Tax Lot #	Plan Designation (e.g., Rural Residential/RR-5)	Water to be:			Proposed Land Use:
2 south	1 west	5	sw nw	6500	R-5 residential	☐ Diverted	☒ Conveyed	☒ Used	artificial recharge
2 south	1 west	5	sw nw	5900	R-5 residential	☒ Diverted	☒ Conveyed	☐ Used	artificial recharge
2 south	1 west	5	sw nw	6400	R-5 residential	☐ Diverted	☒ Conveyed	☒ Used	artificial recharge
2 south	1 west	5	sw nw	6600	R-5 residential	☐ Diverted	☒ Conveyed	☒ Used	artificial recharge

List all counties and cities where water is proposed to be diverted, conveyed, and/or used or developed:

City of Beaverton, Washington County

B. Description of Proposed Use

Type of application to be filed with the Water Resources Department:

☐ Permit to Use or Store Water ☐ Water Right Transfer ☐ Permit Amendment or Ground Water Registration Modification
☒ Limited Water Use License ☐ Allocation of Conserved Water ☐ Exchange of Water

Source of water: ☐ Reservoir/Pond ☐ Ground Water ☒ Surface Water (name) unnamed tributary of Summer Creek

Estimated quantity of water needed: 300 ☐ cubic feet per second ☒ gallons per minute ☐ acre-feet

Intended use of water: ☐ Irrigation ☐ Commercial ☐ Industrial ☐ Domestic for ____ household(s)
☐ Municipal ☐ Quasi-Municipal ☐ Instream ☒ Other artificial recharge

Briefly describe:

See attached map and supplemental report describing project. Water will be diverted from an exiting water quality vault at rates up to 300 gpm, and will be conveyed through a treatment system to the ASR 3 (WASH 57952) well for storage. The final diversion and treatment system are still under design.

Note to applicant: If the Land Use Information Form cannot be completed while you wait, please have a local government representative sign the receipt at the bottom of the next page and include it with the application filed with the Water Resources Department.

See bottom of Page 3. →

For Local Government Use Only

The following section must be completed by a planning official from each county and city listed unless the project will be located entirely within the city limits. In that case, only the city planning agency must complete this form. This deals only with the local land-use plan. Do not include approval for activities such as building or grading permits.

Please check the appropriate box below and provide the requested information

☐ Land uses to be served by the proposed water uses (including proposed construction) are allowed outright or are not regulated by your comprehensive plan. Cite applicable ordinance section(s): ______________________.

☐ Land uses to be served by the proposed water uses (including proposed construction) involve discretionary land-use approvals as listed in the table below. (Please attach documentation of applicable land-use approvals which have already been obtained. Record of Action/land-use decision and accompanying findings are sufficient.) **If approvals have been obtained but all appeal periods have not ended, check "Being pursued."**

Type of Land-Use Approval Needed (e.g., plan amendments, rezones, conditional-use permits, etc.)	Cite Most Significant, Applicable Plan Policies & Ordinance Section References	Land-Use Approval:	
CU2021-0015	40.15.15.5.C	☐ Obtained ☐ Denied	☑ Being Pursued ☐ Not Being Pursued
DR2021-0101	40.20.15.3.C	☐ Obtained ☐ Denied	☑ Being Pursued ☐ Not Being Pursued
LD2021-0013	40.45.15.3.C	☐ Obtained ☐ Denied	☑ Being Pursued ☐ Not Being Pursued
PD2021-0004	40.55.15.1.C	☐ Obtained ☐ Denied	☑ Being Pursued ☐ Not Being Pursued
TP2021-0009	40.90.15.2.C	☐ Obtained ☐ Denied	☑ Being Pursued ☐ Not Being Pursued

Local governments are invited to express special land-use concerns or make recommendations to the Water Resources Department regarding this proposed use of water below, or on a separate sheet.

Applications listed above are currently under review. Initial hearing date is expected on January 12, 2022.

Name: Sambo Kirkman Sambo Kirkman Digitally signed by Sambo Kirkman DN: C=US, E=skirkman@beavertonoregon.gov, O=City of Beaverton, OU=CDD, CN=Sambo Kirkman Date: 2021.11.29 18:20:59-08'00' Title: Senior Planner

Signature: ______________________ Phone: 503-214-0843 Date: 11/29/21

Government Entity: City of Beaverton: Community Development Department

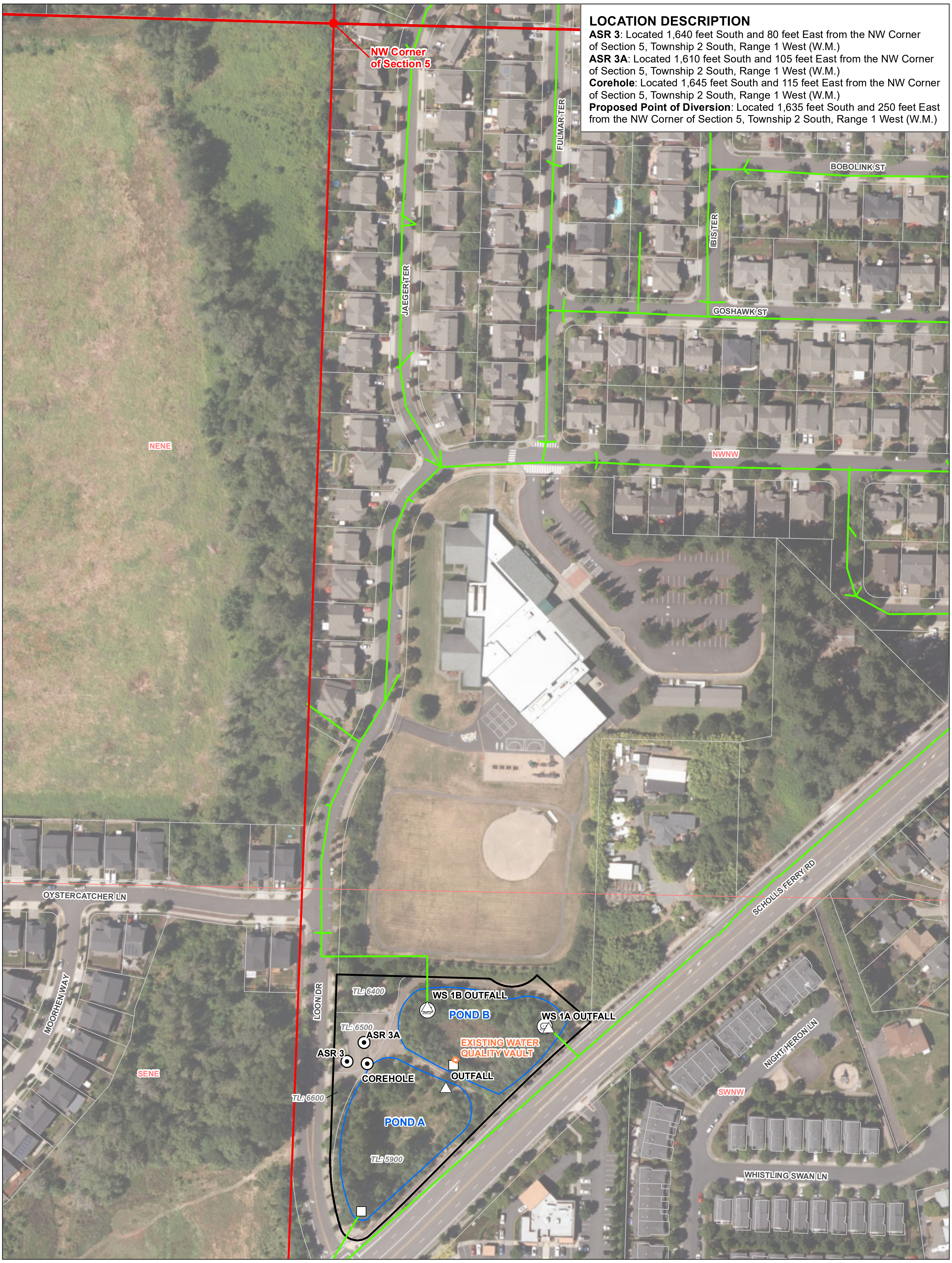
Note to local government representative: Please complete this form or sign the receipt below and return it to the applicant. If you sign the receipt, you will have 30 days from the Water Resources Department's notice date to return the completed Land Use Information Form or WRD may presume the land use associated with the proposed use of water is compatible with local comprehensive plans.

Receipt for Request for Land Use Information

Applicant name: ______________________

City or County: ______________________ Staff contact: ______________________

Signature: ______________________ Phone: ______________________ Date: ______________________



LEGEND

Proposed Point of Diversion (POD)

All Other Features

- Well
- Outfall
- Inlet
- Stormwater Vault with Pump and Bypass System
- Stormwater Conveyance
- Stormwater Detention Basin
- Site
- Tax Lot

FIGURE 1

Project Location

City of Beaverton
Sterling Park AR Limited License Application
Township 2 South, Range 1 West, Section 5 (W.M.)

N

0 75 150 225
Feet

GSI Water Solutions, Inc.

Date: November 11, 2021
Data Sources: METRO, USGS, COP imagery (2020)

Document Path: Y:\0100_Beaverton\Source_Figures\101_Sterling_Park_SW_Recharge_Eval\Artificial_Recharge_Permitting\Figure1_Proposed_Diversion_Loc_overview.mxd

APPENDIX B

Laboratory Analytical Results
(Raw Stormwater and Native Groundwater)

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Table B-1. ASR 3 and ASR 3A Native Groundwater Quality

ANALYTE	Drinking Water Quality Standard	Criteria	Units	ASR 3A Well SDWA	City of Beaverton ASR 3A Casing Sample	City of Beaverton ASR 3A Aquifer Sample	City of Beaverton Corehole ASR No. 3	City of Beaverton Corehole ASR No. 3	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 2	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 4	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 7	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 10	City of Beaverton ASR No. 3 Well
Date Sampled				**10/9/2019**	**10/7/2019**	**10/9/2019**	**9/5/2000**	**9/10/2001**	**3/10/2004**	**3/12/2004**	**3/15/2004**	**3/18/2004**	**9/18/2006**
Field Parameters (FP)†													
Specific Conductivity	--	--	uS/cm	544.1	--	544.1	756	746	798	848	880	902	437
Dissolved Oxygen	--	--	mg/L	0.76	--	0.76	--	6.3	8.6	--	--	6.3	1
ORP	--	--	mV	-14.2	--	--	--	-70	--	--	--	--	-37.4
pH	6.5 - 8.5	SMCL	su	7.48	--	7.48	8	6.78	6.79	6.79	6.79	6.78	7.54
Temperature	--	--	degC	15.1	--	15.1	14	16.1	16.2	16	16.1	15.7	14.6
Turbidity	5	MCL	NTU	**51.6^^**	--	--	--	--	--	--	--	--	--
General Chemistry (GC)													
Alkalinity, Total as CaCO3	--	--	mg/L	130	108	156	103	135	--	--	--	--	--
Bicarbonate	--	--	mg/L	160	108	156	125	165	--	--	--	--	193
Calcium, total	--	--	mg/L	40	20.82	36.84	47	51	53	54	56	58	35.8
Carbonate, as CaCO3	--	--	mg/L	ND	ND	ND	0.407	0.427	--	--	--	--	--
Chloride	250	SMCL	mg/L	94	44.4	106	177	170	170	190	200	210	46.7
Cyanide	0.2	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Fluoride	2	MCL/SMCL	mg/L	0.23	--	--	0.34	0.2	--	--	--	--	--
Hardness, as CaCO3	250	--	mg/L	180	92	164	82.2	226	235	238	247	**256**	164
Magnesium	--	--	mg/L	19	9.71	17.48	20	24	25	25	26	27	18.2
Nitrate + Nitrite	10	MCL	mg/L	ND	ND	ND	<0.2	ND	--	--	--	--	--
Nitrate as N	10	MCL	mg/L	ND	ND	ND	<0.2	ND	--	--	--	--	ND
Nitrite as N	1	MCL	mg/L	ND	--	--	<0.2	ND	--	--	--	--	--
Potassium	--	--	mg/L	5.9	3.4	5.6	10	6.9	7.3	7.5	7.7	7.9	4.82
Silica	--	--	mg/L	50	52.6	51.8	46	52	--	--	--	--	50.9
Sodium	--	--	mg/L	41	24.8	48.2	61	62	65	67	71	73	30.2
Sulfate	250	SMCL	mg/L	1.6	5	ND	4.24	ND	--	--	--	--	0.67
Total Dissolved Solids	500	SMCL	mg/L	340	182	426	480	480	**520**	**550**	**610**	**530**	214
Total Organic Carbon (total)	--	--	mg/L	2.2	0.5	0.1	<0.5	--	--	--	--	--	ND
Total Suspended Solids	--	--	mg/L	ND	--	--	--	ND	--	--	--	--	--
Metals (Total unless otherwise specified)													
Aluminum	0.05 - 0.2	SMCL	mg/L	ND	--	--	--	ND	--	--	--	--	ND
Antimony	0.006	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Arsenic	0.01	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Barium	1	MML	mg/L	0.023	--	--	--	--	--	--	--	--	--
Beryllium	0.004	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Cadmium	0.005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Chromium	0.05	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Copper	1	SMCL	mg/L	0.015	--	--	--	--	--	--	--	--	--
Iron	0.3	SMCL	mg/L	0.11	1.82	0.07	0.05	ND	0.14	0.13	0.12	0.12	--
Iron, Dissolved	0.3	SMCL	mg/L	ND	--	--	--	ND	--	--	--	--	ND
Lead	0.015	AL	mg/L	**0.00065**	--	--	--	--	--	--	--	--	--
Manganese	0.05	SMCL	mg/L	0.048	ND	ND	--	ND	**0.065**	**0.08**	**0.084**	**0.085**	--
Manganese, Dissolved	0.05	SMCL	mg/L	0.049	--	--	--	ND	--	--	--	--	0.0331
Mercury	0.002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Nickel	--	††	mg/L	ND	--	--	--	--	--	--	--	--	--
Selenium	0.01	MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Silver	0.05	MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Thallium	0.002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Zinc	5	SMCL	mg/L	0.022	--	--	--	--	--	--	--	--	--
Disinfection Byproducts (DBPs)													
Chloroform	--	--	mg/L	**0.0017**	--	--	--	--	--	--	--	--	ND
Bromoform	--	--	mg/L	ND	--	--	--	--	--	--	--	--	ND
Dibromochloromethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	ND
Bromodichloromethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	ND
Total Trihalomethanes (TTHM)	0.08	MCL	mg/L	**0.0017**	--	--	--	--	--	--	--	--	ND
Dibromoacetic Acid	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Dichloroacetic Acid	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Monobromoacetic Acid	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Monochloroacetic Acid	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Trichloroacetic Acid	--	--	mg/L	**0.0012**	--	--	--	--	--	--	--	--	--
Total Haloacetic Acids (HAA-5)	0.06	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Microbial													
Total Coliform Bacteria	<1	MML	MPN/100mL	**Positive**	--	--	--	--	--	--	--	--	--
Fecal Coliform	Absent	MCL	MPN/100mL	Absent	--	--	--	--	--	--	--	--	--
E. Coli	Absent	MCL	MPN/100mL	Absent	--	--	--	--	--	--	--	--	--
Miscellaneous (Misc)													
Color	15	SMCL	cu	ND	--	--	--	--	--	--	--	--	0
Corrosivity (Langlier Index)	noncorrosive	SMCL	none	0.15	--	--	--	--	--	--	--	--	--
Foaming Agents (MBAS, surfactants)	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Odor	3	SMCL	ton	2	--	--	--	1	3	--	--	2	0
SDWA Radionuclides (Rads)													
Gross Alpha	15	MML	pCi/L	ND	--	--	--	2.1	--	--	--	--	ND
Gross Beta ‡	50	MML	pCi/L	4.8	--	--	--	3.9	--	--	--	--	6
Radium 226	--	--	pCi/L	ND	--	--	--	--	--	--	--	--	ND
Radium 228	--	--	pCi/L	ND	--	--	--	--	--	--	--	--	ND
Radium 226/228	5	MML	pCi/L	ND	--	--	--	--	--	--	--	--	ND
Uranium	0.03	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Radon†††	--	--	pCi/L	**800**	--	--	--	**740**	--	--	--	**150**	**983**

Table B-1. ASR 3 and ASR 3A Native Groundwater Quality

ANALYTE	Drinking Water Quality Standard	Criteria	Units	ASR 3A Well SDWA	City of Beaverton ASR 3A Casing Sample	City of Beaverton ASR 3A Aquifer Sample	City of Beaverton Corehole ASR No. 3	City of Beaverton Corehole ASR No. 3	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 2	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 4	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 7	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 10	City of Beaverton ASR No. 3 Well
Date Sampled				**10/9/2019**	**10/7/2019**	**10/9/2019**	**9/5/2000**	**9/10/2001**	**3/10/2004**	**3/12/2004**	**3/15/2004**	**3/18/2004**	**9/18/2006**
Synthetic Organic Compounds (SOCs)													
2,4,5-TP (Silvex)	0.01	MML	mg/L	ND	--	--	--	--	--	--	--	--	--
2,4-D	0.07	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
2,4-DB	0.001	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
3,5-Dichlorobenzoic acid	0.0005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
2-Butanone (MEK)	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
3-Hydroxycarbofuran	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
4-Methyl-2Pentanone (MIBK)	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Acifluorfen	0.002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Aldicarb	0.0005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Aldicarb Sulfoxide	0.0005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Aldicarb Sulfone	0.0008	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Aldrin	0.0001	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Alachlor (Lasso)	0.002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Atrazine	0.003	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	0.0002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Carbofuran	0.04	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Chlordane	0.002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dalapon	0.2	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
DCPA (Acid metabolites)	0.0001	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Baygon	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Bentazon	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Bromobenzene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Bromoethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Bromomethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Carbaryl	0.002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dieldrin	0.0001	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dibromomethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Dichloromethane	0.005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dichlorodifluoromethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Di-isopropyl ether	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Di(2-Ethylhexyl) Adipate	0.4	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Di(2-Ethylhexyl) Phthalate	0.006	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dibromochloropropane (DBCP)	0.0002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dicamba	0.0002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dinoseb	0.007	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Dioxin(2,3,7,8-TCDD)	0.00000003	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Diquat	0.02	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Endothall	0.1	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Endrin	0.0002	MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Ethylene Dibromide (EDB)	0.00005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Glyphosate	0.7	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Heptachlor	0.0004	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Heptachlor Epoxide	0.0002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Hexachlorobenzene (HCB)	0.001	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Hexachlorocyclopentadiene	0.05	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Lindane (BHC-gamma)	0.0002	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Methomyl	0.004	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Methiocarb	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Methoxychlor	0.04	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Molintae	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Oxamyl (Vydate)	0.2	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
o-Chlorotoluene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Paraquat	0.0004	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Pentachlorophenol	0.001	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Picloram	0.5	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Polychlorinated Biphenyls (PCBs)	0.0005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
p-Isopropyltoluene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
sec-Butylbenzene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Simazine	0.004	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Tert-Butyl Ethyl Ether	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Toxaphene	0.003	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
trans-1.3-Dichloropropene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Trichlorofluoromethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Trichlorotifluoroethane (Freon 113)	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--

Table B-1. ASR 3 and ASR 3A Native Groundwater Quality

ANALYTE	Drinking Water Quality Standard	Criteria	Units	ASR 3A Well SDWA	City of Beaverton ASR 3A Casing Sample	City of Beaverton ASR 3A Aquifer Sample	City of Beaverton Corehole ASR No. 3	City of Beaverton Corehole ASR No. 3	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 2	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 4	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 7	City of Beaverton ASR No. 3 Pilot Well -- Start of Pump Test Day 10	City of Beaverton ASR No. 3 Well
Date Sampled				**10/9/2019**	**10/7/2019**	**10/9/2019**	**9/5/2000**	**9/10/2001**	**3/10/2004**	**3/12/2004**	**3/15/2004**	**3/18/2004**	**9/18/2006**
Volatile Organic Compounds (VOCs)													
2,4,5-TP (Silvex)	0.01	MML	mg/L	ND	--	--	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1,1,2-Tetrachloroethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	0.2	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1,2-Trichloroethane	0.005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1-Dichloroethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1,-Dichloroethylene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1,-Dichloropropene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,2,3-Trichlorobenzene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,2,4-Trichlorobenzene	0.07	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
1,2,4-Trimethylbenzene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,2,3-Trichloropropane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,2-Dichlorobenzene (o-dichlorobenzene)	0.6	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
1,2-Dichloroethane (EDC)	0.005	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
1,2-Dichloropropane	0.005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
1,4-Dichlorobenzene (p-dichlorobenzene)	0.075	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1,2,2,-Tetrachloroethane	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
1,1,2,2,-Tetrachloroethane	0.005	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Carbon Tetrachloride	0.005	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Chlorobenzene (Monochlorobenzene)	0.1	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
cis-1,2-Dichloroethene	0.07	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Ethylbenzene	0.7	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Hexachlorobutadiene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Methylene Chloride (Dichloromethane)	0.005	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Isopropylbenzene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Methyl-Tert-butyl ether	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Naphthalene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Styrene	0.1	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
tert-Butylbenzene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
tert-amyl Methyl Ether	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Toluene	1	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
trans-1,2-Dichloroethene	0.1	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--
Tetrachloroethylene (PCE)	0.005	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
trans-1,2-Dichloroethylene	--	--	mg/L	ND	--	--	--	--	--	--	--	--	--
Trichloroethene (TCE)	0.005	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Vinyl Chloride	0.002	MCL, MML	mg/L	ND	--	--	--	--	--	--	--	--	--
Xylenes, Total	10	MCL	mg/L	ND	--	--	--	--	--	--	--	--	--

Notes:
-- = Not analyzed or not available
Bold = parameter detected above regulatory limit
Red = Parameter concentration exceeds groundwater protection or drinking water quality standards,
or is greater than one-half the MCL for source water anticipated to be used for recharge
Italics = Laboratory detection level exceeded groundwater protection or drinking water quality standards
AL = Action Level
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
MML = Maximum Measureable Level
# MCLs for turbidity are applicable to all public water systems using surface water sources or groundwater sources under the direct influence of surface water in whole or in part. Compliance with MCLs shall be calculated pursuant to OAR 333-061-0036(5)
LHA = EPA's recommended lifetime health advisory level
* = LHA advisory number is the combine total of PFOA and PFOS results
† Measured using a YSI 556 MPS
†† MCL being re-evaluated by EPA
††† USEPA proposed standard is 300 to 4,000 pCi/L, depending on State primacy
‡ Gross beta MCL is 4 mrem/yr; however lab results presented in pCi/L so compared it to the MML standard.
^^turbidity measured on 10/1/19 at the end of pump development
Units:
mg/L = Milligram per liter (~ ppm)
ng/L = nanogram per liter (~ ppt)
MPN = most probable number
CU = color number
TON = threshold odor number
MFL = million fibers per liter
pCi/L = picocuries per liter
su = standard units
uS/cm = microsiemens per centimeter
mV = millivolts
degC = degrees Celsius

Data Flags:
* = Value exceeds Maximum Contaminant Level or is outside the acceptable range.

Table B-2. Summary of Raw and Treated Stormwater Quality Data

					Pilot Test 1		Supplemental Pilot Testing											
								2A - SLOW SAND + AQUIP						2B - COAGULANT + RAPID SAND				
Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Raw Stormwater 04/22/2020	Average Treated Stormwater Spring 2020	Raw Stormwater 11/13/20	Post-Slow Sand (A1)	Post-Aquip (B1)	Post-GAC (C1)	Post-GAC Dup	Post-UV (D1)	2A Final Treated Water	Post-Coagulant and Rapid Sand (A2, B2)	Post-GAC (C2)	Post-GAC Dup	Post-UV (D2)	2B Final Treated Water
Field Parameters																		
Temperature	--	--	C	9.41	--	--	8.6	8.7	8.8	9.5	--	--	9.5	9.4	10.1	10.1	10.2	10.2
Dissolved Oxygen	--	--	%	--	--	--	93	84.1	85.8	56.4	--	--	56.4	81.5	54.9	54.3	66	66
Dissolved Oxygen	--	--	mg/L	10.76	--	--	10.76	9.77	9.97	6.44	--	--	6.44	9.33	6.19	6.11	7.38	7.38
Specific Conductance (Conductivity)	--	--	us/cm	43.22	--	--	32.5	31.4	171	171.7	--	--	171.7	64.4	67.1	68.4	74.4	74.4
Oxidation/Reduction Potential	--	--	mV	150.2	--	--	150.2	144.5	121	38	--	--	38	184.4	118.3	107.9	142.2	142.2
pH	--	--	--	5.52	--	--	5.31	6.63	6.32	7.62	--	--	7.62	4.64	5.97	6.19	5.45	5.45
Turbidity	--	--	NTU	10.73	--	--	12	*9	*5	*3	--	--	*3	*26	*6	*6	*7	*7
Pathogens																		
Total Coliforms (including fecal coliform and *E. coli*)			MPN/100 mL	>2,420	>2,420	4.5	>2419.6	>2,420	>2419.6	--	--	<1	<1	>2419.6	--	--	<1	<1
Fecal Coliform			MPN/100 mL	752.2	>2,420	<1	>2419.6	>2,420	>2419.6	--	--	1	1	170	--	--	<1	<1
E. coli			MPN/100 mL	>2,420	>2,420	<1	>2419.6	>2,420	>2419.6	--	--	<1	<1	770	--	--	<1	<1
Heterotrophic plate count (HPC)	n/a	TT[3]	CFU/ml	>2,420	>2,420	19	1,600	3,349	2100	--	--	46	46	1000	--	--	43	43
Inorganics																		
Alkalinity in CaCO3 units	NA	NA	mg/L as CaCO3	12.59	22	11	7.2	9.4	6.9	25	--	--	25	ND	12	--	--	12
Bicarbonate Alkalinity	NA	NA	mg/L as HCO3 (calc)	ND	27	13	8.7	--	--	--	--	--	--	--	15	--	--	15
Phenolphthalein Alkalinity	NA	NA	mg/l	--	--	--	ND	--	--	ND	--	--	ND	--	--	--	--	--
Carbonate	NA	NA	mg/L	--	--	--	ND	--	--	ND	--	--	ND	--	--	--	--	--
Total Hardness	NA	250	mg/L as CaCO3	14.76	22	50	9.9	26	--	56	--	--	56	--	26	--	--	26
Non-Carbonate Hardness	NA	NA	mg/L	--	--	--	2.7	--	--	31	--	--	31	--	NA	--	--	NA
Apparent Color	NA	15 color units	ACU	52	45	20	45	20	ND	30	--	--	30	45	25	--	--	25
Odor at 60 degrees	3	threshold odor number	TON	5.83	17	2	2	--	2	ND	--	--	ND	2	2	--	--	2
Biochemical Oxygen Demand	NA	NA	mg/L	--	11	14	ND	ND	ND	ND	--	--	ND	ND	--	--	--	--
Chemical Oxygen Demand	NA	NA	mg/L	--	8	11	13	10	ND	ND	--	--	ND	13	ND	--	--	ND
Corrosivity (Langier Method)	NA	Non-corrosive	--	-2.7	-2.3	-2.7	-3.2	--	--	-1.2	--	--	-1.2	--	--	--	--	--
Cyanide (as free cyanide)	0.2	0.2	mg/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Hydrogen Ion (pH)	NA	6.5 to 8.5 pH Units	--	6.85	6.9	6.5	6.8	--	--	7.7	--	--	7.7	--	6.8	--	--	6.8
Silica	NA	NA	mg/L	--	--		3.6	--	--	1.8	--	--	1.8	--	8.1	--	--	8.1
Calcium	NA	NA	mg/L	4.5	6.7	14	3.0	--	--	14	--	--	14	--	7.5	--	--	7.5
Magnesium	NA	NA	mg/L	0.84	1.2	3.6	0.59	--	--	5.1	--	--	5.1	--	1.8	--	--	1.8
Potassium	NA	NA	mg/L	1.45	2.1	2.5	1	--	--	2.3	--	--	2.3	--	1.5	--	--	1.5
Sodium	NA	NA	mg/L	1.52	2.3	4.8	1	--	--	14	--	--	14	--	3.2	--	--	3.2
Major Cations (Ca, K, Mg, Na)	NA	NA	meq/L	0.59	0.59	1.3	--	--	--	1.8	--	--	1.8	--	0.71	--	--	0.71
Chloride	NA	250	mg/L	1.08	1.3	2.1	0.89	--	--	3.6	--	--	3.6	--	1.8	--	--	1.8
Sulfate – Method 300.0	NA	250	mg/L	2.99	3.9	48	2.3	--	--	59	--	--	59	--	19	--	--	19
Fluoride	4	4	mg/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Major Anions (Cl, CO3 HCO3, SO4)	NA	NA	meq/L	0.38	0.57	1.3	0.25	--	--	1.8	--	--	1.8	--	ND	--	--	ND
Nitrate (measured as Nitrogen)	10	10	mg/L	0.25	0.26	0.38	0.46	--	--	0.28	--	--	0.28	--	0.21	--	--	0.21
Nitrite (measured as Nitrogen)	1	1	mg/L	0.017	ND	ND	--	--	--	ND	--	--	ND	--	--	--	--	--
Ammonia	NA	NA	mg/L	0.15	0.3	0.46	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Orthophosphate as P	NA	NA	mg/L	0.05	0.026	0.2	0.12	--	--	0.026	--	--	0.026	--	0.037	--	--	0.037
Orthophosphate as Phosphate	NA	NA	mg/L	0.17	0.08	0.061	0.37	--	--	0.08	--	--	0.08	--	0.11	--	--	0.11
Total Phosphorus	NA	NA	mg/L	0.14	0.14	0.05	0.15	--	--	0.048	--	--	0.048	--	0.048	--	--	0.048
Specific Conductance (Conductivity)	NA	NA	umho/cm	44.89	62	150	30	--	--	200	--	--	200	--	80	--	--	80
Specific UV Absorbance, L/mg,	NA	NA	L/mg-m	2.53	2.2	0.69	2.9	--	--	--	--	--	--	--	1.4	--	--	1.4
Dissolved UV Abs. at 254 nm	NA	NA	cm-1	0.20	0.302	0.05325	0.144	--	--	ND	--	--	ND	0.029	0.019	--	--	0.019
Surfactants/Foaming Agents (MBAS)	NA	0.50	mg/L	0.23	0.23	ND	ND	--	--	ND	--	--	ND	--	--	--	--	--
Total Organic Carbon	NA	NA	mg/L	10.03	18	9.85	5.1	4.5	0.96	0.63	--	--	0.63	5.7	2	--	--	2
Dissolved Organic Carbon	NA	NA	mg/L	8.28	14	13	4.9	4.21	0.77	0.5	--	--	0.5	2.4	1.4	--	--	1.4
Total Dissolved Solids (TDS)	NA	500	mg/L	35.13	43	115	12	--	--	130	--	--	130	--	54	--	--	54
Total Suspended Solids (TSS)	NA	NA	mg/L	5.73	ND	2	6	2.8	2	1	--	--	1	30	8	--	--	8
Suspended Sediment Concentration (SSC)	NA	NA	mg/L	7.40	7.99	5.1	7.46	2.07	2.33	1.29	--	--	1.29	30.9	13	--	--	13
Grainsize (filtered stormwater solids)	NA	NA	--	--	See PDF	See PDF	see pdf	see pdf	see pdf	see pdf	--	--	see pdf	see pdf	see pdf	--	--	see pdf
Turbidity	NA	TT[3]	NTU	5.62	5.1	2.02	3.5	9.62	4.5	3.1	--	--	3.1	26	7.6	--	--	7.6
Metals																		
Aluminum		0.05 to 0.2	ug/L	215.26	140	110	430	--	--	330	--	--	330	--	1100	--	--	1100
Antimony	0.006	0.006	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Arsenic	0	0.01	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Barium	2	2	ug/L	10.71	14	4.2	8.2	--	--	63	--	--	63	--	56	--	--	56
Beryllium	0.004	0.004	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Cadmium	0.005	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Chromium (total)	0.1	0.1	ug/L	1.21	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Copper	1.3	TT[7]; Action Level=1.3	ug/L	5.14	10	8.9	2.6	--	--	ND	--	--	ND	--	ND	--	--	ND
Iron	NA	0.30	mg/L	0.81	0.46	0.25	0.53	--	--	0.12	--	--	0.12	--	0.18	--	--	0.18
Iron (dissolved)			mg/L	0.079	0.057	0.1	0.11	--	--	0.027	--	--	0.027	--	ND	--	--	ND
Lead	zero	TT[7]; Action Level=0.015	ug/L	0.66	ND	1.2	ND	--	--	0.68	--	--	0.68	--	ND	--	--	ND
Manganese		0.05	ug/L	126.44	170	79	29	--	--	15	--	--	15	--	41	--	--	41
Manganese (dissolved)			ug/L	--	--	--	ND	--	--	--	--	--	--	--	ND	--	--	ND
Mercury (inorganic)	0.002	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Nickel	NA		ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Selenium	0.05	0.05	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Silver	NA	0.10	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Thallium	0.0005	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Uranium	zero	30 ug/L	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Zinc	--	5.00	ug/L	322.33	690	29	130	--	--	ND	--	--	ND	--	130	--	--	130

Table B-2. Summary of Raw and Treated Stormwater Quality Data

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Pilot Test 1: Raw Stormwater 04/22/2020	Pilot Test 1: Average Treated Stormwater Spring 2020	Supplemental Pilot Testing: Raw Stormwater 11/13/20	2A - SLOW SAND + AQUIP: Post-Slow Sand (A1)	2A: Post-Aquip (B1)	2A: Post-GAC (C1)	2A: Post-GAC Dup	2A: Post-UV (D1)	2A Final Treated Water	2B - COAGULANT + RAPID SAND: Post-Coagulant and Rapid Sand (A2, B2)	2B: Post-GAC (C2)	2B: Post-GAC Dup	2B: Post-UV (D2)	2B Final Treated Water
Radionuclides																		
Alpha, Gross	zero	15 picocuries per Liter (pCi/L)	pCi/L	ND	ND	ND	ND			ND	--	--	ND		ND	--	--	ND
Alpha, Min Detectable Activity	--	--	pCi/L	2.45	2	ND	3	--	--	2	--	--	2	--	2	--	--	2
Alpha, Two Sigma Error	--	--	pCi/L	0.7	0.7	ND	0.71	--	--	0.66	--	--	0.66	--	0.73	--	--	0.73
Beta, Gross	zero	50 picocuries per Liter (pCi/L)	pCi/L	3	3.5	3.1	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Beta, Min Detectable Activity	--	--	pCi/L	2.65	2	ND	2	--	--	2	--	--	2	--	2	--	--	2
Beta, Two Sigma Error	--	--	pCi/L	1.13	0.68	ND	0.64	--	--	0.64	--	--	0.64	--	0.62	--	--	0.62
Radium 226	zero	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 226 Min Detect Activity	--	--	pCi/L	0.35	0.3	ND	0.4	--	--	0.3	--	--	0.3	--	0.4	--	--	0.4
Radium 226 Two Sigma Error	--	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 228	zero	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 228 Min Detect Activity	--	--	pCi/L	0.75	0.7	ND	0.8	--	--	0.8	--	--	0.8	--	0.8	--	--	0.8
Radium 228 Two Sigma Error	--	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 226 and Radium 228 (combined)	zero	5 pCi/L	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
PFAS/PFOA																		
Perfluorohexanoic acid (PFHxA)	NA	NA	ug/L	**0.0035**	**0.0027**	**0.0021**	**0.0046**	--	**0.0020**	ND	ND	--	ND	--	**0.0036**	**0.0035**	--	**0.00355**
Perfluoroheptanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorooctanoic acid (PFOA)	NA	NA	ug/L	**0.0048**	**0.0051**	**0.0031**	**0.0045**	--	**0.0020**	ND	ND	--	ND	--	**0.0039**	**0.0037**	--	**0.0038**
Perfluorononanoic acid	NA	NA	ug/L	**0.0010**	**0.002**	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorodecanoic acid	NA	NA	ug/L	**0.0012**	**0.0024**	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluoroundecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorododecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorotridecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorotetradecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorobutanesulfonic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorohexanesulfonic acid	NA	NA	ug/L	ND	ND	**ND**	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorooctanesulfonic acid (PFOS)	NA	NA	ug/L	**0.0064**	**0.0093**	**0.0044**	**0.0044**	--	**0.0021**	ND	ND	--	ND	--	**0.0045**	**0.0043**	--	**0.0044**
N-ethyl perfluorooctanesulfonamidoacetic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
N-methyl perfluorooctanesulfonamidoacetic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluoro-2-proxypropanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Dodecafluoro-3H-4,8-dioxanonanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
9-chlorohexadecafluoro-3-oxanonane-1 sulfonate	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
11-chloroeicosafluoro-3-oxanonane-1-sulfonate	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Polycyclic armatic hydrocarbons (PAHs) and phthalates																		
naphthalene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
acenaphthylene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
acenaphthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
fluorene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
phenanthrene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
anthracene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
fluoranthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
pyrene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benz[a]anthracene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
chrysene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[b]fluoranthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[k]fluoranthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[a]pyrene	zero	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
dibenz[a,h]anthracene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[g,h,i]perylene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
indeno[1,2,3-cd]pyrene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di-N-octylphthalate	NA	NA	ug/L	**0.85**	**0.85**	**0.14**	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Diethylphthalate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dimethoate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dimethylphthalate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di-n-Butylphthalate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1-Methylnapthalene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Acetochlor	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Aldrin	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Atrazine	0.003	0.003	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Carbofuran	0.04	0.04	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Carbon tetrachloride	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Chlordane	zero	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Chlorobenzene	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
2,4-D	0.07	0.07	ug/L	**1.32**	**2**	**0.63**	**0.87**	--	--	ND	--	--	ND	--	ND	--	--	ND
Dalapon	0.2	0.2	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
DDT	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
DDT Metabolite (DDE)	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
o-Dichlorobenzene	0.6	0.6	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
p-Dichlorobenzene	0.075	0.075	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2-Dichloroethane	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,1-Dichloroethylene	0.007	0.007	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
cis-1,2-Dichloroethylene	0.07	0.07	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
trans-1,2-Dichloroethylene	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND

Table B-2. Summary of Raw and Treated Stormwater Quality Data

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Pilot Test 1		Supplemental Pilot Testing											
								2A - SLOW SAND + AQUIP						2B - COAGULANT + RAPID SAND				
					Raw Stormwater 04/22/2020	Average Treated Stormwater Spring 2020	Raw Stormwater 11/13/20	Post-Slow Sand (A1)	Post-Aquip (B1)	Post-GAC (C1)	Post-GAC Dup	Post-UV (D1)	2A Final Treated Water	Post-Coagulant and Rapid Sand (A2, B2)	Post-GAC (C2)	Post-GAC Dup	Post-UV (D2)	2B Final Treated Water
Dichloromethane	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2-Dichloropropane	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di(2-ethylhexyl) adipate	0.4	0.4	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di(2-ethylhexyl) phthalate	zero	0.006	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dicamba	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dieldrin	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dinoseb	0.007	0.007	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Diquat	0.02	0.02	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Endothall	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Endrin	0.002	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Epichlorohydrin	zero	TT8	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Ethylene dibromide (EDB)	zero	0.00005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Glyphosate	0.7	0.7	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Heptachlor	zero	0.0004	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Heptachlor epoxide	zero	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Hexachlorobenzene	zero	0.001	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Hexachlorocyclopentadiene	0.05	0.05	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Lindane	0.0002	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Malathion	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Methomyl	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Methoxychlor	0.04	0.04	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Oxamyl (Vydate)	0.2	0.2	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Paraquat	NA	NA	ug/L	**2.6**	**2.6**	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Polychlorinated biphenyls (PCBs)	zero	0.0005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Pentachlorophenol	zero	0.001	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Picloram	0.5	0.5	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Simazine	0.004	0.004	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Styrene	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Tetrachloroethylene	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Toluene	1	1	ug/L	**0.88**	**0.88**	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Toxaphene	zero	0.003	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
2,4,5-TP (Silvex)	0.05	0.05	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2,4-Trichlorobenzene	0.07	0.07	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,1,1-Trichloroethane	0.2	0.2	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,1,2-Trichloroethane	0.003	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Trichloroethylene	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Vinyl chloride	zero	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Xylenes (total)	10	10	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Urban Detected Pesticides/MS4																		
2,4,5-T	70	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
2,4,5-TP (silvex)	50	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
2,4-D	70	MCL	ug/L	**1.8**	**1.9**	**1.2**	**1.7**	--	ND	ND	ND	--	ND	--	**0.14**	**0.14**	--	**0.14**
2,4-DB	200	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
2,6-dichlorobenzamide	29	Chronic or Lifetime (HHBPs)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
acifluorfen	90	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
aldrin	0.00092	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
alpha-HCH	0.006	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
atrazine	3	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
bentazon	200	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Bifenthrin	70	Acute or One Day HHBP	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
boscalid	1400	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
bromacil	700	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
carbaryl	40	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
chlorothalonil	100	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dacthal	20	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
diazinon	1	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dicamba	3000	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dichlobenil	60	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dichlorprop	300	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dimethoate	14	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dinoseb	7	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
diuron	2	Cancer HBSL (10-6 to 10-4)	ug/L	**0.08**	ND	ND	**0.08**	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
esfenvalerate	12	Acute or One Day & Chronic	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
ethofumesate	2000	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
ethoprop	1.14	Carcinogenic HHBP (E-6 to E	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
fenbuconazole	8.91	Carcinogenic HHBP (E-6 to E	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
fipronil	1	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
gamma-BHC (lindane)	0.043	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
glyphosate	700	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
heptachlor	0.0014	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
hexazinone	400	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
imazapyr	16000	Chronic or Lifetime (HHBPs)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
imidacloprid	360	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
iprodione	0.729	Carcinogenic HHBP (E-6 to E	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
kresoxim-methyl	11	Carcinogenic HHBP (E-6 to E	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
MCPA	7.4	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND

Table B-2. Summary of Raw and Treated Stormwater Quality Data

					Pilot Test 1		Supplemental Pilot Testing											
								2A - SLOW SAND + AQUIP						2B - COAGULANT + RAPID SAND				
Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Raw Stormwater 04/22/2020	Average Treated Stormwater Spring 2020	Raw Stormwater 11/13/20	Post-Slow Sand (A1)	Post-Aquip (B1)	Post-GAC (C1)	Post-GAC Dup	Post-UV (D1)	2A Final Treated Water	Post-Coagulant and Rapid Sand (A2, B2)	Post-GAC (C2)	Post-GAC Dup	Post-UV (D2)	2B Final Treated Water
mcpp-p	300	Chronic or Lifetime (HHBP)	ug/L	**0.26**	**0.11**	ND	**0.6**	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
methoxychlor	40	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
metolachlor	700	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
metribuzin	90	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
metsulfuron methyl	1600	Chronic or Lifetime (HHBPs)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
napropamide	770	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
p,p'-DDD	0.031	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
p,p'-DDE	0.046	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
pendimethalin	2000	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
pentachlorophenol	0.044	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
picloram	500	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
piperonyl butoxide	992	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
prometon	400	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
propiconazole	600	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
pyrimethanil	1100	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
siduron	960	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
simazine	4	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
sulfometuron-methyl	1760	Chronic or Lifetime (HHBPs)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
tebuthiuron	1000	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
terbacil	100	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
triclopyr	300	Chronic or Lifetime (HHBP)	ug/L	**0.11**	**0.13**	**0.087**	**0.094**	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
trifluralin	10	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND

Notes

* Turbidity measurements were obtained prior to sample collection. Additional turbidty removal optimization was completed for both treatment trains and are described in Murraysmith's March 5, 2021 Pilot Testing Results and Design Criteria Technical Memorandum.

Red = parameter detected above regulatory limit

[a] **Chloramines** (i.e., bound chlorine) is the product of the chemical reaction between chlorine and an amine compound. There is no direct chemical method for measuring chloramine. The amount of chloramine is calculated by subtracting free chlorine from the total chlorine. The concentration of chloramines will be conservatively estimated using the field measured total chlorine (residual) results. The chloramines concentration will be reported as "≤ Total Chlorine."

[b] **Chlorine (as Cl2)** (i.e., free chlorine). Free chlorine refers to both hypochlorous acid (HOCl) and the hypochlorite (OCl–) ion or bleach. Free chlorine is typically measured in drinking water disinfection systems to find whether the water system contains enough disinfectant to inactivate most of the bacteria and viruses. Free chlorine residual needs to analyzed immediately and is not anticipated to be present in stormwater samples. The concentration of chlorine will be conservatively estimated using the field measured total chlorine (residual) results. The chlorine concentration will be reported as "≤ Total Chlorine."

[c] **Chlorine dioxide** is marketed for use as a disinfectant and is also the name for the neutral ClO2 molecule, while Chlorite is a –ClO2 anion of a molecule. For accurate results, chlorine dioxide needs to be analyzed immediately. Given the short holding time for chlorine dioxide, Eurofins will substitute Chlorite. However, for the purposes of this study the concentration of chlorine dioxide will be conservatively estimated by using the field measured total chlorine (residual) results and the concentration will be reported as "≤ Total Chlorine".

* Average stormwater concentrations are calculated by taking the geometric mean of detected concentrations (nondetects are excluded).

Table B-3. Comparison between treated stormwater and ASR 3A groundwater

ANALYTE	Drinking Water Quality Standard	Criteria	Units	Source Water Treated Stormwater Pilot 2A	Receiving water ASR 3A Well Groundwater 10/9/2019
Field Parameters (FP)†					
Specific Conductivity	--	--	uS/cm	171.7	544.1
ORP	--	--	mV	38	-14.2
Dissolved Oxygen	--	--	mg/L	6.44	0.76
Temperature	--	--	degC	9.5	15.1
Turbidity	5	MCL	NTU	*3	**51.6^^**
pH	6.5 - 8.5	SMCL	su	7.62	7.48
General Chemistry (GC)					
Nitrite as N	1	MCL	mg/L	ND	ND
Cyanide	0.2	MCL	mg/L	ND	ND
Total Suspended Solids	--	--	mg/L	1	ND
Asbestos	7	--	MFL	--	--
Biological Oxygen Demand (BOD5)	--	--	mg/L	ND	--
Bromide	--	--	mg/L	--	--
Carbonate, as CaCO3	--	--	mg/L	ND	ND
Ortho-phosphate as P	--	--	mg/L	0.026	--
Total Phosphorous	--	--	mg/L	0.048	--
Alkalinity, Total as CaCO3	--	--	mg/L	25	130
Bicarbonate	--	--	mg/L	--	160
Calcium, total	--	--	mg/L	14	40
Chloride	250	SMCL	mg/L	3.6	94
Silica	--	--	mg/L	1.8	50
Fluoride	2	MCL/SMCL	mg/L	ND	0.23
Hardness, as CaCO3	250	--	mg/L	56	180
Magnesium	--	--	mg/L	5.1	19
Potassium	--	--	mg/L	2.3	5.9
Sodium	--	--	mg/L	14	41
Total Dissolved Solids	500	SMCL	mg/L	130	340
Nitrate + Nitrite	10	MCL	mg/L	0.28	ND
Nitrate as N	10	MCL	mg/L	0.28	ND
Sulfate	250	SMCL	mg/L	59	1.6
Total Organic Carbon (total)	--	--	mg/L	0.63	2.20
Metals (Total unless otherwise specified)					
Antimony	0.006	MCL	mg/L	ND	ND
Arsenic	0.01	MCL	mg/L	ND	ND
Beryllium	0.004	MCL	mg/L	ND	ND
Cadmium	0.005	MCL	mg/L	ND	ND
Mercury	0.002	MCL	mg/L	ND	ND
Selenium	0.01	MML	mg/L	ND	ND
Silver	0.05	MML	mg/L	ND	ND
Nickel	--	††	mg/L	ND	ND
Thallium	0.002	MCL	mg/L	ND	ND
Barium	1	MML	mg/L	0.063	0.023
Chromium	0.05	MCL	mg/L	ND	ND
Copper	1	SMCL	mg/L	ND	0.015
Manganese, Dissolved	0.05	SMCL	mg/L	ND	0.049
Manganese	0.05	SMCL	mg/L	0.015	0.048
Iron, Dissolved	0.3	SMCL	mg/L	0.027	ND
Iron	0.3	SMCL	mg/L	0.12	0.11
Aluminum	0.05 - 0.2	SMCL	mg/L	0.33	ND
Lead	0.015	AL	mg/L	0.00068	0.00065
Zinc	5	SMCL	mg/L	ND	0.022
Disinfection Byproducts (DBPs)					
Dibromochloromethane	--	--	mg/L	--	ND
Bromodichloromethane	--	--	mg/L	--	ND
Dibromoacetic Acid	--	--	mg/L	--	ND
Dichloroacetic Acid	--	--	mg/L	--	ND
Monobromoacetic Acid	--	--	mg/L	--	ND
Monochloroacetic Acid	--	--	mg/L	--	ND
Total Haloacetic Acids (HAA-5)	0.06	MCL	mg/L	--	ND
Bromoform	--	--	mg/L	--	ND
Total Trihalomethanes (TTHM)	0.08	MCL	mg/L	--	0.0017
Chloroform	--	--	mg/L	--	0.0017
Trichloroacetic Acid	--	--	mg/L	--	0.0012
Microbiological					
Total Coliform Bacteria	<1	MML	MPN/100mL	Negative	Positive
Fecal Coliform	Absent	MCL	MPN/100mL	Absent	Absent
E. Coli	Absent	MCL	MPN/100mL	Absent	Absent
Miscellaneous (Misc)					
Foaming Agents (MBAS, surfactants)	--	--	mg/L	ND	ND
Odor	3	SMCL	ton	ND	2
Color	15	SMCL	cu	30	ND
Corrosivity (Langlier Index)	noncorrosive	SMCL	none	-1.2	0.15
SDWA Radionuclides (Rads)					
Radium 226	--	--	pCi/L	ND	ND
Radium 228	--	--	pCi/L	ND	ND
Radium 226/228	5	MML	pCi/L	1.1	ND
Uranium	0.03	MCL	mg/L	ND	ND
Gross Alpha	15	MML	pCi/L	ND	ND
Gross Beta ‡	50	MML	pCi/L	ND	4.8
Radon†††	--	--	pCi/L	--	800

Table B-3. Comparison between treated stormwater and ASR 3A groundwater

ANALYTE	Drinking Water Quality Standard	Criteria	Units	Source Water Treated Stormwater Pilot 2A	Receiving water ASR 3A Well Groundwater 10/9/2019
Synthetic Organic Compounds (SOCs)					
2,4,5-TP (Silvex)	0.01	MML	mg/L	ND	ND
2,4-DB	0.001	MCL	mg/L	ND	ND
3,5-Dichlorobenzoic acid	0.0005	MCL	mg/L	ND	ND
2-Butanone (MEK)	--	--	mg/L	ND	ND
3-Hydroxycarbofuran	--	--	mg/L	ND	ND
4-Methyl-2Pentanone (MIBK)	--	--	mg/L	ND	ND
Acifluorfen	0.002	MCL	mg/L	ND	ND
Aldicarb	0.0005	MCL	mg/L	ND	ND
Aldicarb Sulfoxide	0.0005	MCL	mg/L	ND	ND
Aldicarb Sulfone	0.0008	MCL	mg/L	ND	ND
Aldrin	0.0001	MCL	mg/L	ND	ND
Alachlor (Lasso)	0.002	MCL	mg/L	ND	ND
Atrazine	0.003	MCL	mg/L	ND	ND
Benzo(a)pyrene	0.0002	MCL	mg/L	ND	ND
Carbofuran	0.04	MCL	mg/L	ND	ND
Chlordane	0.002	MCL	mg/L	ND	ND
Dalapon	0.2	MCL	mg/L	ND	ND
DCPA (Acid metabolites)	0.0001	MCL	mg/L	ND	ND
Baygon	--	--	mg/L	ND	ND
Bentazon	--	--	mg/L	ND	ND
Bromobenzene	--	--	mg/L	ND	ND
Bromoethane	--	--	mg/L	ND	ND
Bromomethane	--	--	mg/L	ND	ND
Carbaryl	0.002	MCL	mg/L	ND	ND
Dieldrin	0.0001	MCL	mg/L	ND	ND
Dibromomethane	--	--	mg/L	ND	ND
Dichloromethane	0.005	MCL	mg/L	ND	ND
Dichlorodifluoromethane	--	--	mg/L	ND	ND
Di-isopropyl ether	--	--	mg/L	ND	ND
Di(2-Ethylhexyl) Adipate	0.4	MCL	mg/L	ND	ND
Dibromochloropropane (DBCP)	0.0002	MCL	mg/L	ND	ND
Dinoseb	0.007	MCL	mg/L	ND	ND
Dioxin(2,3,7,8-TCDD)	3.00E-08	MCL	mg/L	ND	ND
Diquat	0.02	MCL	mg/L	ND	ND
Endothall	0.1	MCL	mg/L	ND	ND
Endrin	0.0002	MML	mg/L	ND	ND
Ethylene Dibromide (EDB)	0.00005	MCL	mg/L	ND	ND
Glyphosate	0.7	MCL	mg/L	ND	ND
Heptachlor	0.0004	MCL	mg/L	ND	ND
Heptachlor Epoxide	0.0002	MCL	mg/L	ND	ND
Hexachlorobenzene (HCB)	0.001	MCL	mg/L	ND	ND
Hexachlorocyclopentadiene	0.05	MCL	mg/L	ND	ND
Lindane (BHC-gamma)	0.0002	MCL	mg/L	ND	ND
Methomyl	0.004	MCL	mg/L	ND	ND
Methiocarb	--	--	mg/L	ND	ND
Methoxychlor	0.04	MCL, MML	mg/L	ND	ND
Molintae	--	--	mg/L	ND	ND
Oxamyl (Vydate)	0.2	MCL	mg/L	ND	ND
o-Chlorotoluene	--	--	mg/L	ND	ND
Pentachlorophenol	0.001	MCL	mg/L	ND	ND
Picloram	0.5	MCL	mg/L	ND	ND
Polychlorinated Biphenyls (PCBs)	0.0005	MCL	mg/L	ND	ND
Propachlor	0.0001	MCL	mg/L	ND	--
Metribuzin	--	--	mg/L	ND	ND
p-Isopropyltoluene	--	--	mg/L	ND	ND
Bromacil	0.0002	MCL	mg/L	ND	ND
Fluorene	0.0002	MCL	mg/L	ND	ND
sec-Butylbenzene	--	--	mg/L	ND	ND
Simazine	0.004	MCL	mg/L	ND	ND
Tert-Butyl Ethyl Ether	--	--	mg/L	ND	ND
Toxaphene	0.003	MCL, MML	mg/L	ND	ND
trans-1.3-Dichloropropene	--	--	mg/L	ND	ND
Trichlorofluoromethane	--	--	mg/L	ND	ND
Trichlorotifluoroethane (Freon 113)	--	--	mg/L	ND	ND
Di(2-Ethylhexyl) Phthalate	0.006	MCL	mg/L	ND	ND
Dicamba	0.0002	MCL	mg/L	ND	ND
Metolachlor	--	--	mg/L	ND	ND
Butachlor	0.0004	MCL	mg/L	ND	--
Diuron	--	--	mg/L	ND	--
mcpp-p	--	--	mg/L	ND	--
Paraquat	0.0004	MCL	mg/L	ND	ND
Di-N-octylphthalate	--	--	mg/L	ND	--
Triclopyr	--	--	mg/L	ND	--
2,4-D	0.07	MCL	mg/L	ND	ND

Table B-3. Comparison between treated stormwater and ASR 3A groundwater

ANALYTE	Drinking Water Quality Standard	Criteria	Units	Source Water Treated Stormwater Pilot 2A	Receiving water ASR 3A Well Groundwater 10/9/2019
Volatile Organic Compounds (VOCs)					
2,4,5-TP (Silvex)	0.01	MML	mg/L	ND	ND
1,3,5-Trimethylbenzene	--	--	mg/L	ND	ND
1,1,1,2-Tetrachloroethane	--	--	mg/L	ND	ND
1,1,1-Trichloroethane	0.2	MCL, MML	mg/L	ND	ND
1,1,2-Trichloroethane	0.005	MCL	mg/L	ND	ND
1,1-Dichloroethane	--	--	mg/L	ND	ND
1,1,-Dichloroethylene	--	--	mg/L	ND	ND
1,1,-Dichloropropene	--	--	mg/L	ND	ND
1,2,3-Trichlorobenzene	--	--	mg/L	ND	ND
1,2,4-Trichlorobenzene	0.07	MCL	mg/L	ND	ND
1,2,4-Trimethylbenzene	--	--	mg/L	ND	ND
1,2,3-Trichloropropane	--	--	mg/L	ND	ND
1,2-Dichlorobenzene (o-dichlorobenzene)	0.6	MCL	mg/L	ND	ND
1,2-Dichloroethane (EDC)	0.005	MCL, MML	mg/L	ND	ND
1,2-Dichloropropane	0.005	MCL	mg/L	ND	ND
1,4-Dichlorobenzene (p-dichlorobenzene)	0.075	MCL, MML	mg/L	ND	ND
1,1,2,2,-Tetrachloroethane	--	--	mg/L	ND	ND
1,1,2,2,-Tetrachloroethane	0.005	MCL, MML	mg/L	ND	ND
Carbon Tetrachloride	0.005	MCL, MML	mg/L	ND	ND
Chlorobenzene (Monochlorobenzene)	0.1	MCL	mg/L	ND	ND
cis-1,2-Dichloroethene	0.07	MCL	mg/L	ND	ND
Ethylbenzene	0.7	MCL	mg/L	ND	ND
Hexachlorobutadiene	--	--	mg/L	ND	ND
Methylene Chloride (Dichloromethane)	0.005	MCL	mg/L	ND	ND
Isopropylbenzene	--	--	mg/L	ND	ND
Methyl-Tert-butyl ether	--	--	mg/L	ND	ND
Naphthalene	--	--	mg/L	ND	ND
trans-1,2-Dichloroethene	0.1	MCL	mg/L	ND	ND
Tetrachloroethylene (PCE)	0.005	MCL, MML	mg/L	ND	ND
trans-1,2-Dichloroethylene	--	--	mg/L	ND	ND
Trichloroethene (TCE)	0.005	MCL, MML	mg/L	ND	ND
Vinyl Chloride	0.002	MCL, MML	mg/L	ND	ND
Xylenes, Total	10	MCL	mg/L	ND	ND
Styrene	0.1	MCL	mg/L	ND	ND
tert-Butylbenzene	--	--	mg/L	ND	ND
tert-amyl Methyl Ether	--	--	mg/L	ND	ND
Toluene	1	MCL	mg/L	ND	ND
1,2-Dichloropropene	--	--	mg/L	--	--

Notes:
-- = Not analyzed or not available
Red = parameter detected above regulatory limit
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
MML = Maximum Measureable Level
* Turbidity measurements were obtained prior to sample collection. Additional turbidty removal optimization was completed for both treatment trains and are described in Murraysmith's March 5, 2021 Pilot Testing Results and Design Criteria Technical Memorandum.
[#] MCLs for turbidity are applicable to all public water systems using surface water sources or groundwater sources under the direct influence of surface water in whole or in part. Compliance with MCLs shall be calculated pursuant to OAR 333-061-0036(5)
† Measured using a YSI 556 MPS
†† MCL being re-evaluated by EPA
††† USEPA proposed standard is 300 to 4,000 pCi/L, depending on State primacy
‡ Gross beta MCL is 4 mrem/yr; however lab results presented in pCi/L so compared it to the MML standard.
^^turbidity measured on 10/1/19 at the end of pump development

Units:
mg/L = Milligram per liter (~ ppm)
ng/L = nanogram per liter (~ ppt)
MPN = most probable number
CU = color number
TON = threshold odor number
MFL = million fibers per liter
pCi/L = picocuries per liter
su = standard units
uS/cm = microsiemens per centimeter
mV = millivolts
degC = degrees Celsius

APPENDIX C

Stormwater Treatment Pilot Testing Reports

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TECHNICAL MEMORANDUM

Supplemental Stormwater Treatment Pilot Testing at Sterling Park, City of Beaverton

To:	Dave Winship, PE - City of Beaverton Sheila Sahu, PE - City of Beaverton
From:	Andrew Davidson, PE - GSI Water Solutions, Inc. (GSI) Jason Melady, RG, CWRE - GSI Ronan Igloria, PE, CWRE - GSI Ellen Svadlenak, GIT - GSI

Attachments	Attachment 1. Pilot Testing Results and Design Criteria Technical Memorandum (Murraysmith) Attachment 2. Supplemental Pilot Test Field Photos Attachment 3. Supplemental Pilot Test Field Notes
Date:	April 20, 2021

This technical memorandum summarizes the supplemental stormwater treatment pilot testing completed in November 2020 for the Sterling Park Stormwater Treatment Pilot Study. The purpose is to provide City staff data and findings from supplemental pilot testing completed in accordance with GSI's Phase II Stormwater Treatment Pilot Study Sampling and Analysis Plan (SAP [GSI, 2020a]) and to provide final recommendations for full-scale stormwater treatment system design.

1.0 Project Background

A detailed project background is provided in GSI's Preliminary Evaluation for City of Beaverton Sterling Park Stormwater Treatment Pilot Study Technical Memorandum (GSI, 2020b) and only relevant elements are included in this memorandum. Preliminary stormwater treatment pilot testing completed in April-June 2020 at Sterling Park indicated a small pilot system from StormwateRx, LLC (SRx) was reasonably effective at reducing many of the stormwater contaminants observed in influent stormwater. In addition, use of a coagulant in preliminary pilot testing proved effective at reducing concentrations of turbidity and color below target treatment goals. However, due to the concentrations of fine suspended solids, total organic carbon (TOC) and dissolved organic carbon (DOC), and several synthetic organic compounds, additional treatment components beyond those used in the preliminary pilot testing were necessary to make the final treatment train fully effective at achieving treatment goals and limiting frequent operations and maintenance (O&M) procedures.

Based on observations from preliminary pilot testing (GSI, 2020b), evaluation of two modified treatment trains was recommended to incorporate treatment elements with additional removal processes and technologies. The two treatment trains are described below and presented in Figure 1:

Treatment Train 1: In-pond biofiltration/slow sand filtration, SRx Aquip System, Granular Activated Carbon (GAC) contactors, ultraviolet (UV) disinfection

Treatment Train 2: Addition of a coagulant and coarse pre-filter, GAC contactors, UV disinfection

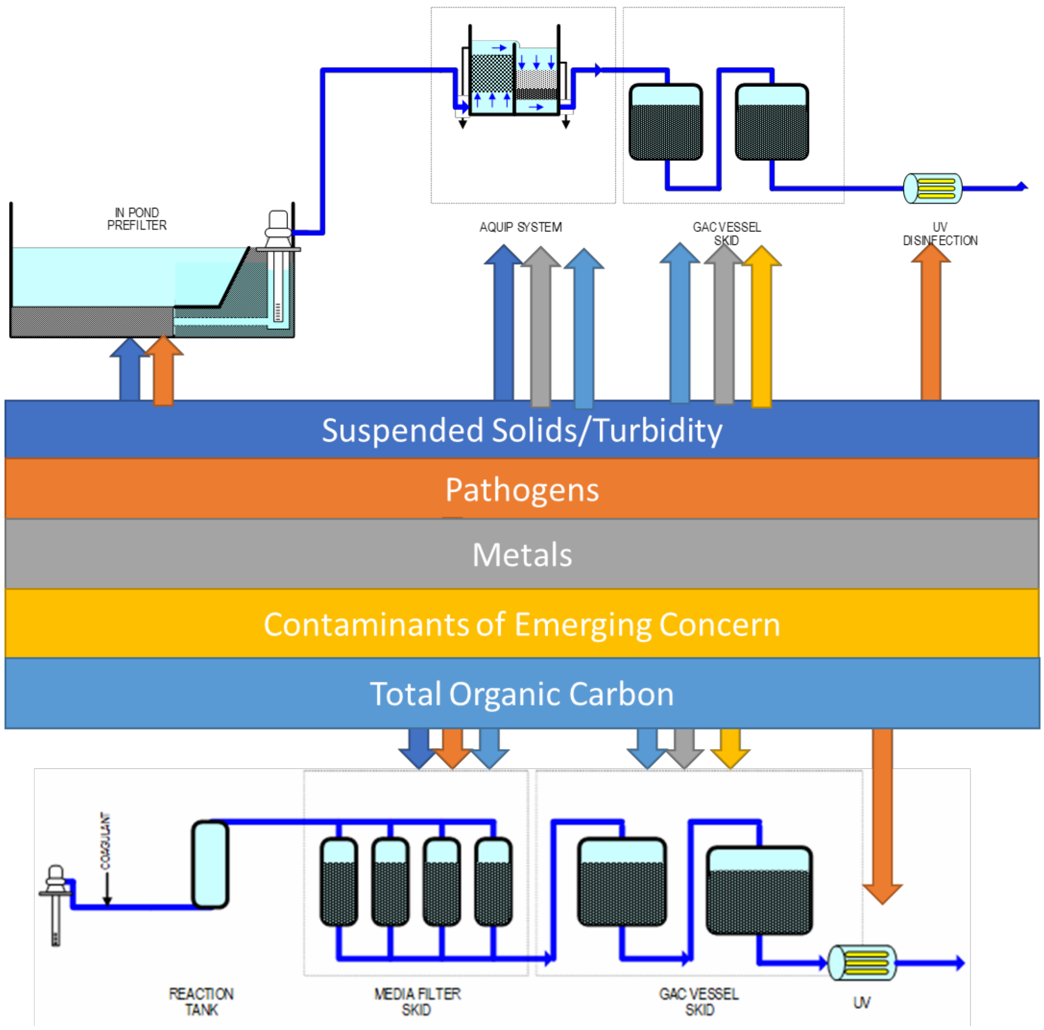

Figure 1: Recommended Modified Pilot Treatment Trains

Pilot scale versions of each treatment train were developed for supplemental pilot testing that was completed in November 2020 (GSI, 2020a). Details of each pilot system component and sampling event details are described in the following section.

2.0 Supplemental (Phase II) Pilot Testing Activities

Based on the proposed treatment modifications, two treatment trains were built and tested for the supplemental (Phase II) pilot study, as shown in Figure 2. Both treatment trains evaluated pre-filtration steps to target removal of suspended solids and turbidity prior to downstream components. The first treatment train used a slow sand filter pretreatment, meant to maximize the efficacy of the Aquip® enhanced filtration system tested during the Phase I pilot. The second treatment train added a coagulant to raw stormwater, then passed this water through a pressure vessel with backwashing capabilities. Both treatment trains then used GAC contactors and UV disinfection as a means to completely remove persistent organic compounds such as per- and polyfluoroalkyl substances (PFAS), pesticides, and herbicides.

Each treatment train consisted of a series of components which are equivalent to the full-scale models, but scaled to treat a much lower flow rate. The trains and components are described in further detail below.

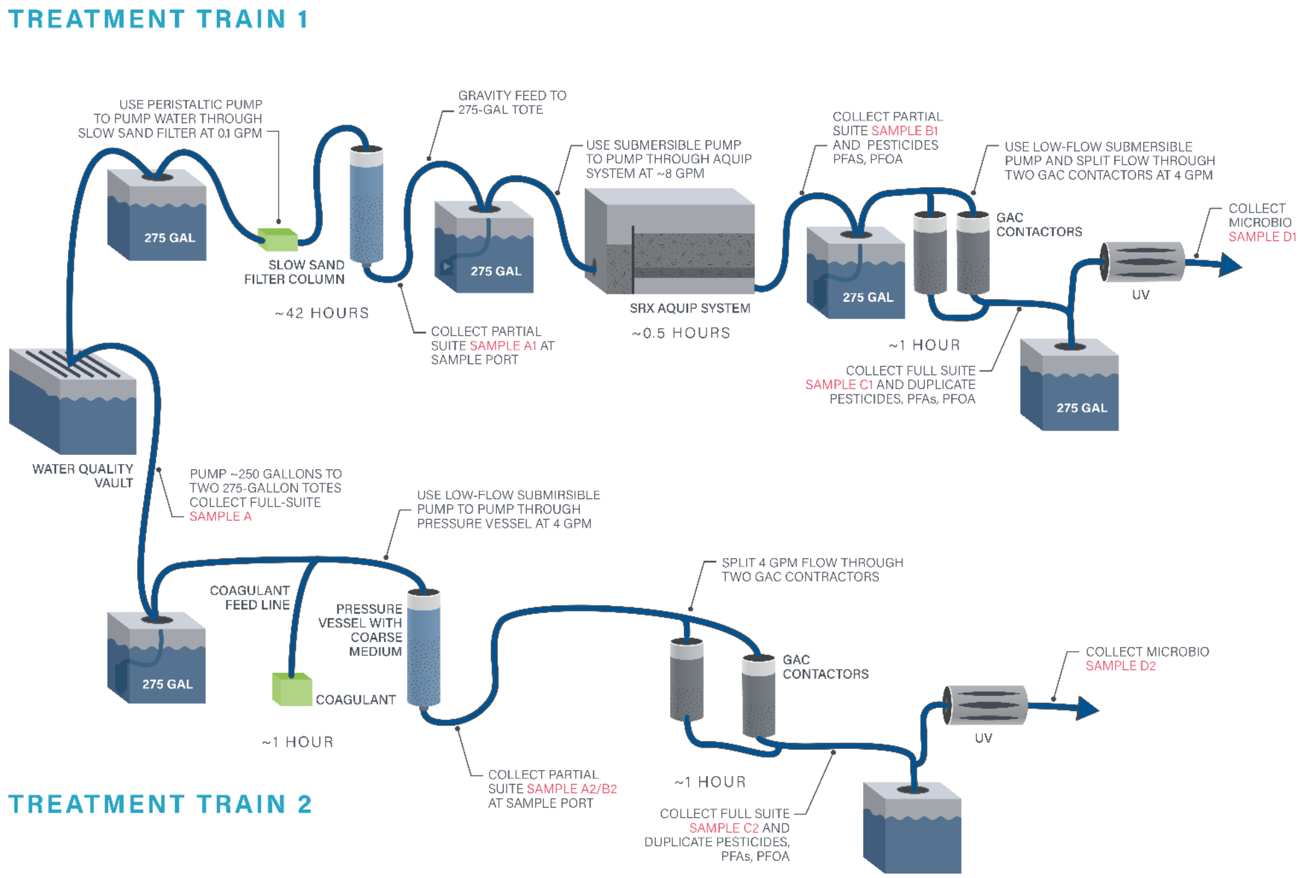

Figure 2: Supplemental Pilot Treatment Trains and Sample Points

Treatment Train 1

A1. Pilot-Scale Slow-Sand Filter, designed to mimic an “in-pond” filtration system at full scale. System is designed to operate at a loading rate of 0.04 and 0.08 gpm/ft^2 and was constructed of one 12”-diameter (0.79 ft^2) pilot columns containing 20” of graded support gravel (3” each of No. 14 - No. 6, No. 6 - No. 4, No. ¾”, and $^3/_8$” - ¾” grain atop 8” of ¾” – 1 ½” grain) overlain by 35” of silica sand (0.20-0.30 mm diameter, uniformity coefficient of ≤ 2.5) with a ≤ $^3/_8$” perforated polyvinyl chloride (PVC) underdrain pipe.

B1. Aquip® 8PBE Enhanced Filtration System, manufactured by StormwateRx out of Portland, OR. System operates at up to 8 gpm, contains a pretreatment buffering media and layered inert/organics sorptive enhanced filtration media, is contained in a watertight low density polyethylene (LDPE) structure, and features flow distribution piping, an underdrain manifold with cleanouts, an internal emergency overflow, an adjustable head controller for sediment loading compensation, a passive overflow level indicator, an inlet/inline totalizing flow meter, and flow control valve;

C1. Granular Activated Carbon (GAC) System, designed to operate at 2 gpm (3.6 gpm/ft^2) each and 30-75 psig for 8 to 24 hr/day, consisting of two 16” diameter vessels with 1.40 ft^2 each, approximately 5 ft^3 of media in each vessel at a depth of 42”, with a 5 minute backwash cycle every 24 hours with a backwash flow rate of 21 gpm and total backwash volume of 105 gal;

D1. Ultraviolet (UV) Disinfection System, manufactured by StormwateRx. The Purus® Bacteria Model 10V disinfection system contains 80W UV lamps, a standard 120V plug, and a 10-ft weatherproof cable.

Treatment Train 2

A2. B2. **Coagulant and Pressure Filter System**, designed to operate at 4 gpm (7.3 gpm/ft^2) and 30-75 psig for 8 to 24 hours/day, consisting of one 10" diameter vessel with 0.55 ft^2 surface area and 1.9 ft^3 of media at a depth of 42". The system included a 5 minute backwash cycle every 24 hours with a backwash flow rate of 8 gpm and total backwash volume of 40 gallons. Coagulant doses ranged 0.5 to just over 10 mg/L, with a maximum dose of 10.2 mg/L, to achieve a solution volume of 5 gal and strength of 50,000 mg/L with a pressure pump capacity of 3 gpd and storage of 15 days.

C2. **GAC Contactor System**, designed to operate at 2 gpm (3.6 gpm/ft^2) each and 30-75 psig for 8 to 24 hr/day, consisting of two 16" diameter vessels with 1.40 ft^2 surface area each, approximately 5 ft^3 of media in each vessel at a depth of 42", with a 5 minute backwash cycle every 24 hours with a backwash flow rate of 21 gpm and total backwash volume of 105 gal;

D2. **UV Disinfection System**, manufactured by StormwateRx. The Purus® Bacteria Model 10V disinfection system contains 80W UV lamps, a standard 120V plug, and a 10-ft weatherproof cable.

Test column components (slow sand filter, coagulant/pressure filter, and GAC system) were stored on-site, within an additional travel trailer adjacent to the 10' x 7' Conex box containing the StormwateRx treatment system (Aquip and UV disinfection system). Totes used to store raw stormwater and effluent water between treatment steps (See Figure 2), were placed between the travel trailer and Conex box.

3.1 Sampling and Analysis Plan for Supplemental Pilot

An updated SAP was completed in November 2020 (GSI, 2020a) prior to initiation of the pilot testing. The SAP specified a sampling protocol that would provide evaluation of each treatment regime and treatment component including evaluation of a comprehensive and partial list of stormwater contaminants consistent with that specified in the initial pilot testing SAP (GSI, 2020c). The list was refined based on detections during the 2017 Groundwater Recharge Feasibility Evaluation and December 2019 sampling events, but remained conservative to evaluate the suitability of treated stormwater injection into a drinking water aquifer by considering all existing pertinent regulatory criteria as well as various emerging contaminants. After conducting a review of contaminants found in regional (Portland metro area) stormwater and through discussions with external resources (staff from DEQ and Murraysmith) about the most relevant emerging contaminants, additional constituents were added based on consideration of the following:

- Clean Water Act (CWA; 33 USC Section 1251);
- National Pollutant Discharge Elimination System (NPDES) program (40 CFR 123);
- Underground Injection Control (UIC) Rules (Federal 40 CFR part 144-146; Oregon OAR 340-044);
- Oregon Department of Environmental Quality (DEQ) emerging pesticide monitoring or evaluation requirements under its Phase 1 Municipal Separate Storm Sewer System (MS4) permit or municipal UIC Water Pollution Control Facility (WPCF) permit;
- Emerging contaminants (PFAS, emerging pesticides), and cyanotoxins;
- General water chemistry (major anions and cations).

2.2 Phase II Pilot Testing Sampling

Stormwater samples were collected prior to treatment, and after treatment by each treatment train component, as depicted in Figure 2. Specifically, the influent water prior to treatment, effluent from the treatment components, and the final treated effluent for each full treatment train were sampled over the course of one storm event, as shown in Table 1.

Table 1. Summary of Supplemental Stormwater Pilot Testing Sampling and Analyses

<table>
<tr><th colspan="5">Sample Location</th></tr>
<tr><th>A. Influent</th><th>A1. Post-Slow Sand</th><th>B1. Post-Aquip</th><th>C1. Post-GAC[1]</th><th>D1. Post-UV (Effluent)</th></tr>
<tr><td rowspan="4">■</td><td>❍</td><td>❍●</td><td>■●</td><td>□</td></tr>
<tr><th colspan="2">A2, B2. Post-Coagulant/ pressure filter</th><th>C2. Post-GAC[1]</th><th>D2. Post-UV (Effluent)</th></tr>
<tr><td colspan="2">❍</td><td>■●</td><td>□</td></tr>
</table>

Notes

■	Comprehensive List (GSI, 2020a)
❍	Partial List (GSI, 2020a)
●	Pesticides, PFOS, PFOA
□	Total and Fecal Coliform, HPC
(1)	Duplicate samples of Post-GAC treated water from both treatment trains were collected and analyzed for Pesticides, PFAS, and PFOA

Influent stormwater was pumped to two 275 gallon totes before being routed into one of two treatment trains. A sample of the raw stormwater influent was collected and analyzed for the comprehensive set of constituents. Samples collected from the effluent of the treatment components (A1, B1, and A2) were analyzed for a subset of the comprehensive set of constituents reflective of more persistent stormwater contaminants requiring targeted treatment (see Notes of Table 1). Additionally, the effluent of treatment component B1 (i.e., StormwateRx Aquip® system) was analyzed for pesticides and PFAS/PFOA to better understand how the system used in the Phase I pilot test removed concentrations of synthetic organics when turbidity was lowered with a pre-filtering step. Field parameters (pH, temperature, dissolved oxygen, oxidation-reduction potential, conductivity, and turbidity) were also collected from both raw and treated stormwater during sampling events. Final treated effluent from both proposed treatment trains was sampled for the comprehensive list of contaminants. Additionally, duplicate samples were collected from the final effluent of both treatment systems and analyzed for PFAS/PFOA and pesticides. Sample locations and analyte list descriptions are shown in Figure 2 and Table 1, respectively.

Phase II Pilot Testing Results

Stormwater sampling for the Phase II pilot testing occurred on November 13, 2020. Based on precipitation measured at the Portland Community College (PCC) Sylvania[1] Campus, the selected storm produced 1.24 inches of precipitation and was preceded by a 37-hour period of no precipitation and 0.12 inches over the preceding 72 hours. Raw stormwater was pumped from the water quality vault located between the upper and lower detention ponds at the site into two 275 gallon water totes between 8:00 am and 11:45 am. Raw water samples were collected as the water totes were being filled. Treated water samples were collected as described in the SAP (GSI, 2020a) and as shown in Table 1. Field photos and field notes from the supplemental pilot testing are provided in Attachments 1 and 2.

Table 2 (attached) summarizes water quality data from initial pilot testing and supplemental pilot testing, including average raw stormwater concentrations from all sampling events, individual raw stormwater quality concentration for current and previous pilot testing events, and treated concentrations at various locations within the supplemental pilot treatment trains. Raw stormwater quality was generally consistent with previous sampling events with regard to turbidity, suspended sediment, most metals, and anthropogenic synthetic

[1] Sylvania PCC Rain Gage – SS Bldg – 12000 SW. 49th Ave. maintained as part of the City of Portland Hydra Network

compounds. The following sections describe treated stormwater quality across each pilot testing treatment train.

Treatment Train 1 – Slow sand/SRx Aquip/GAC/UV

Table 2 summarizes treated stormwater quality at locations within Treatment Train 1, illustrating changes to water quality induced by each treatment element. The following summarizes general observations based on water quality data:

- Raw stormwater turbidity was reduced by each treatment element, but initial reduction through the slow sand filter was less than anticipated, and target turbidity removal was not achieved. As described in the Technical Memorandum from Lee Odell, PE, at Murraysmith (See Attachment 1), the initial flow rate through the slow sand pilot was likely too high, and inadequate time was provided for the establishment of the biological “schmutzdecke” to optimize removal of turbidity and color. However, as the slow sand filter continued to operate, pre-treatment filtrate quality improved and target turbidity goals were eventually achieved. Engineers from Murraysmith are confident that a full-scale slow sand filtration system with established schmutzdecke would achieve pre-treatment goals.
- Apparent color, COD, TOC, and DOC were reduced by the slow sand filter and were either reduced to non-detect (ND) or near ND by the SRx Aquip. It should be noted that the GAC filter reintroduced some color compounds and would need to be optimized at full scale.
- Concentrations of metals including copper, iron, manganese, and zinc were reduced through Treatment Train 1 to non-detect levels or below associated target treatment goals. Aluminum which has an SMCL goal of 50 to 200 µg/L was reduced through the treatment train but still remained in the final treated effluent above the SMCL goal at 330 µg/L. Discussions with Oregon DEQ indicate compliance with artificial recharge anti-degradation standards can be achieved through recovery of stored water to background native groundwater concentrations, including background metals concentrations, thus additional treatment for aluminum is likely not necessary.
- Concentrations of synthetic organic compounds including the common pesticides/herbicides 2,4-D and triclopyr as well as several PFAS/PFOA compounds were detected in raw stormwater. Reduction of these compounds occurred through the Aquip system, and complete reduction of these compounds to non-detect levels occurred after the GAC polishing step.

Treatment Train 2 - Coagulant/Pressure Filter/GAC/UV

Table 2 also summarizes treated stormwater quality at locations within Treatment Train 2, illustrating changes to water quality induced by each treatment element. The following summarizes general observations based on water quality data:

- Raw stormwater turbidity was reduced by each treatment element, but initial reduction through the rapid sand filter after addition of coagulant did not meet target treatment goals. Additional testing at higher coagulant doses was conducted to optimize the filtration process. Target turbidity goals were eventually achieved at coagulant doses greater than 6.5 mg/L.
- Concentrations of COD, TOC, and DOC were reduced by treatment train 2 to ND or near ND levels. Apparent color was not reduced below the target treatment goal but may be a result of some color compounds introduced from the GAC filter. This process would be optimized at full-scale design.
- Concentrations of metals were not removed as effectively in Treatment Train 2 by the GAC filter alone. It is anticipated that a full-scale GAC filter with a longer empty bed contact time could reduce metals more effectively, but the combination of the GAC filter and Aquip system appears to provide a more effective multi-barrier approach for metals removal.
- Concentrations of synthetic organic compounds including the common pesticides/herbicides 2,4-D and triclopyr as well as several PFAS/PFOA compounds were detected in raw stormwater. Reduction of these compounds occurred through Treatment Train 2, but PFAS/PFOA compounds were still found to persist in the final treated effluent.

3.0 Conclusions and Next Steps

Although both treatment trains demonstrated excellent removal of most target stormwater constituents, the multi-barrier approach provided in Treatment Train 1 with the slow sand filter and Aquip system showed the greatest removal efficiencies for the full list of stormwater constituents, including removal of all synthetic organic constituents below ND levels. Table 3 provides a comparison of the final treated effluent concentrations with groundwater concentrations observed in the proposed receiving well, ASR 3A. With the exception of a couple of metals (i.e., iron and aluminum) and color compounds, final treated effluent from Treatment Train 1 was at or below background concentrations observed in groundwater from ASR 3A. In addition to treatment efficiency considerations and as described in more detail within Murraysmith's attached technical memorandum (Attachment 1), Treatment Train 1 is expected to require less operational and maintenance issues and costs compared with Treatment Train 2 where coagulant injection and waste streams would need to be optimized and managed. As capital costs for the two systems are cost comparable, it is both Murraysmith's and GSI's recommendation that the City consider Treatment Train 1 for full-scale implementation. The proposed system could effectively treat stormwater to target treatment goals for the given application. Preliminary cost estimate for full-scale treatment is provided in Attachment 3 and is estimated at $1,041,600 inclusive of design costs and a 20% cost contingency. Further detailed descriptions of design considerations, capital costs, and operation/maintenance costs are included in Attachment 1.

4.0 References

GSI, 2017, Sterling Park Stormwater Quality Facility, Groundwater Recharge Feasibility Evaluation, prepared for Clean Water Services for submittal to Oregon Water Resources Department in February 2018 as required for funding from Water Conservation, Reuse, and Storage Feasibility Grant.

GSI, 2020a. Phase II Stormwater Treatment Pilot Study Sampling and Analysis Plan, prepared for the City of Beaverton and submitted via email November 23, 2020.

GSI, 2020b. Preliminary Evaluation for City of Beaverton Sterling Park Stormwater Treatment Pilot Study Technical Memorandum, prepared for the City of Beaverton and submitted via email October 23, 2020.

GSI, 2020c. Stormwater Treatment Pilot Study Sampling and Analysis Plan, prepared for the City of Beaverton and submitted via email April 23, 2020.

Oregon Administrative Rules for Aquifer Storage and Recovery (ASR) and Artificial Groundwater Recharge (OAR Chapter 690 Division 350)

Oregon Administrative Rules for Drinking Water (OAR Chapter 333 Division 061)

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Additional Tables

Table 2. Summary of Raw and Treated Stormwater Quality Data

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Pilot Test 1		Supplemental Pilot Testing											
								2A - SLOW SAND + AQUIP						2B - COAGULANT + RAPID SAND				
					Raw Stormwater 04/22/2020	Average Treated Stormwater Spring 2020	Raw Stormwater 11/13/20	Post-Slow Sand (A1)	Post-Aquip (B1)	Post-GAC (C1)	Post-GAC Dup	Post-UV (D1)	2A Final Treated Water	Post-Coagulant and Rapid Sand (A2, B2)	Post-GAC (C2)	Post-GAC Dup	Post-UV (D2)	2B Final Treated Water
Field Parameters																		
Temperature	--	--	C	9.41	--	--	8.6	8.7	8.8	9.5	--	--	9.5	9.4	10.1	10.1	10.2	10.2
Dissolved Oxygen	--	--	%	--	--	--	93	84.1	85.8	56.4	--	--	56.4	81.5	54.9	54.3	66	66
Dissolved Oxygen	--	--	mg/L	10.76	--	--	10.76	9.77	9.97	6.44	--	--	6.44	9.33	6.19	6.11	7.38	7.38
Specific Conductance (Conductivity)	--	--	us/cm	43.22	--	--	32.5	31.4	171	171.7	--	--	171.7	64.4	67.1	68.4	74.4	74.4
Oxidation/Reduction Potential	--	--	mV	150.2	--	--	150.2	144.5	121	38	--	--	38	184.4	118.3	107.9	142.2	142.2
pH	--	--	--	5.52	--	--	5.31	6.63	6.32	7.62	--	--	7.62	4.64	5.97	6.19	5.45	5.45
Turbidity	--	--	NTU	10.73	--	--	12	*9	*5	*3	--	--	*3	*26	*6	*6	*7	*7
Pathogens																		
Total Coliforms (including fecal coliform and *E. coli*)			MPN/100 mL	>2,420	>2,420	4.5	>2419.6	>2,420	>2419.6	--	--	<1	<1	>2419.6	--	--	<1	<1
Fecal Coliform			MPN/100 mL	752.2	>2,420	<1	>2419.6	>2,420	>2419.6	--	--	1	1	170	--	--	<1	<1
E. coli			MPN/100 mL	>2,420	>2,420	<1	>2419.6	>2,420	>2419.6	--	--	<1	<1	770	--	--	<1	<1
Heterotrophic plate count (HPC)	n/a	TT[3]	CFU/ml	>2,420	>2,420	19	1,600	3,349	2100	--	--	46	46	1000	--	--	43	43
Inorganics																		
Alkalinity in CaCO3 units	NA	NA	mg/L as CaCO3	12.59	22	11	7.2	9.4	6.9	25	--	--	25	ND	12	--	--	12
Bicarbonate Alkalinity	NA	NA	mg/L as HCO3 (calc)	ND	27	13	8.7	--	--	--	--	--	--	--	15	--	--	15
Phenolphthalein Alkalinity	NA	NA	mg/l	--	--	--	ND	--	--	ND	--	--	ND	--	--	--	--	--
Carbonate	NA	NA	mg/L	--	--	--	ND	--	--	ND	--	--	ND	--	--	--	--	--
Total Hardness	NA	250	mg/L as CaCO3	14.76	22	50	9.9	26	--	56	--	--	56	--	26	--	--	26
Non-Carbonate Hardness	NA	NA	mg/L	--	--	--	2.7	--	--	31	--	--	31	--	NA	--	--	NA
Apparent Color	NA	15 color units	ACU	52	45	20	45	20	ND	30	--	--	30	45	25	--	--	25
Odor at 60 degrees	3	threshold odor number	TON	5.83	17	2	2	--	2	ND	--	--	ND	2	2	--	--	2
Biochemical Oxygen Demand	NA	NA	mg/L	--	11	14	ND	ND	ND	ND	--	--	ND	ND	--	--	--	--
Chemical Oxygen Demand	NA	NA	mg/L	--	8	11	13	10	ND	ND	--	--	ND	13	ND	--	--	ND
Corrosivity (Langier Method)	NA	Non-corrosive	--	-2.7	-2.3	-2.7	-3.2	--	--	-1.2	--	--	-1.2	--	--	--	--	--
Cyanide (as free cyanide)	0.2	0.2	mg/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Hydrogen Ion (pH)	NA	6.5 to 8.5 pH Units	--	6.85	6.9	6.5	6.8	--	--	7.7	--	--	7.7	--	6.8	--	--	6.8
Silica	NA	NA	mg/L	--	--		3.6	--	--	1.8	--	--	1.8	--	8.1	--	--	8.1
Calcium	NA	NA	mg/L	4.5	6.7	14	3.0	--	--	14	--	--	14	--	7.5	--	--	7.5
Magnesium	NA	NA	mg/L	0.84	1.2	3.6	0.59	--	--	5.1	--	--	5.1	--	1.8	--	--	1.8
Potassium	NA	NA	mg/L	1.45	2.1	2.5	1	--	--	2.3	--	--	2.3	--	1.5	--	--	1.5
Sodium	NA	NA	mg/L	1.52	2.3	4.8	1	--	--	14	--	--	14	--	3.2	--	--	3.2
Major Cations (Ca, K, Mg, Na)	NA	NA	meq/L	0.59	0.59	1.3	--	--	--	1.8	--	--	1.8	--	0.71	--	--	0.71
Chloride	NA	250	mg/L	1.08	1.3	2.1	0.89	--	--	3.6	--	--	3.6	--	1.8	--	--	1.8
Sulfate – Method 300.0	NA	250	mg/L	2.99	3.9	48	2.3	--	--	59	--	--	59	--	19	--	--	19
Fluoride	4	4	mg/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Major Anions (Cl, CO3 HCO3, SO4)	NA	NA	meq/L	0.38	0.57	1.3	0.25	--	--	1.8	--	--	1.8	--	ND	--	--	ND
Nitrate (measured as Nitrogen)	10	10	mg/L	0.25	0.26	0.38	0.46	--	--	0.28	--	--	0.28	--	0.21	--	--	0.21
Nitrite (measured as Nitrogen)	1	1	mg/L	0.017	ND	ND	--	--	--	ND	--	--	ND	--	--	--	--	--
Ammonia	NA	NA	mg/L	0.15	0.3	0.46	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Orthophosphate as P	NA	NA	mg/L	0.05	0.026	0.2	0.12	--	--	0.026	--	--	0.026	--	0.037	--	--	0.037
Orthophosphate as Phosphate	NA	NA	mg/L	0.17	0.08	0.061	0.37	--	--	0.08	--	--	0.08	--	0.11	--	--	0.11
Total Phosphorus	NA	NA	mg/L	0.14	0.14	0.05	0.15	--	--	0.048	--	--	0.048	--	0.048	--	--	0.048
Specific Conductance (Conductivity)	NA	NA	umho/cm	44.89	62	150	30	--	--	200	--	--	200	--	80	--	--	80
Specific UV Absorbance, L/mg,	NA	NA	L/mg-m	2.53	2.2	0.69	2.9	--	--	--	--	--	--	--	1.4	--	--	1.4
Dissolved UV Abs. at 254 nm	NA	NA	cm-1	0.20	0.302	0.05325	0.144	--	--	ND	--	--	ND	0.029	0.019	--	--	0.019
Surfactants/Foaming Agents (MBAS)	NA	0.50	mg/L	0.23	0.23	ND	ND	--	--	ND	--	--	ND	--	--	--	--	--
Total Organic Carbon	NA	NA	mg/L	10.03	18	9.85	5.1	4.5	0.96	0.63	--	--	0.63	5.7	2	--	--	2
Dissolved Organic Carbon	NA	NA	mg/L	8.28	14	13	4.9	4.21	0.77	0.5	--	--	0.5	2.4	1.4	--	--	1.4
Total Dissolved Solids (TDS)	NA	500	mg/L	35.13	43	115	12	--	--	130	--	--	130	--	54	--	--	54
Total Suspended Solids (TSS)	NA	NA	mg/L	5.73	ND	2	6	2.8	2	1	--	--	1	30	8	--	--	8
Suspended Sediment Concentration (SSC)	NA	NA	mg/L	7.40	7.99	5.1	7.46	2.07	2.33	1.29	--	--	1.29	30.9	13	--	--	13
Grainsize (filtered stormwater solids)	NA	NA	--	--	See PDF	See PDF	see pdf	see pdf	see pdf	see pdf	--	--	see pdf	see pdf	see pdf	--	--	see pdf
Turbidity	NA	TT[3]	NTU	5.62	5.1	2.02	3.5	9.62	4.5	3.1	--	--	3.1	26	7.6	--	--	7.6
Metals																		
Aluminum		0.05 to 0.2	ug/L	215.26	140	110	430	--	--	330	--	--	330	--	1100	--	--	1100
Antimony	0.006	0.006	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Arsenic	0	0.01	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Barium	2	2	ug/L	10.71	14	4.2	8.2	--	--	63	--	--	63	--	56	--	--	56
Beryllium	0.004	0.004	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Cadmium	0.005	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Chromium (total)	0.1	0.1	ug/L	1.21	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Copper	1.3	TT[7]; Action Level=1.3	ug/L	5.14	10	8.9	2.6	--	--	ND	--	--	ND	--	ND	--	--	ND
Iron	NA	0.30	mg/L	0.81	0.46	0.25	0.53	--	--	0.12	--	--	0.12	--	0.18	--	--	0.18
Iron (dissolved)			mg/L	0.079	0.057	0.1	0.11	--	--	0.027	--	--	0.027	--	ND	--	--	ND
Lead	zero	TT[7]; Action Level=0.015	ug/L	0.66	ND	1.2	ND	--	--	0.68	--	--	0.68	--	ND	--	--	ND
Manganese		0.05	ug/L	126.44	170	79	29	--	--	15	--	--	15	--	41	--	--	41

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Pilot Test 1		Supplemental Pilot Testing											
								2A - SLOW SAND + AQUIP						2B - COAGULANT + RAPID SAND				
					Raw Stormwater 04/22/2020	Average Treated Stormwater Spring 2020	Raw Stormwater 11/13/20	Post-Slow Sand (A1)	Post-Aquip (B1)	Post-GAC (C1)	Post-GAC Dup	Post-UV (D1)	2A Final Treated Water	Post-Coagulant and Rapid Sand (A2, B2)	Post-GAC (C2)	Post-GAC Dup	Post-UV (D2)	2B Final Treated Water
Manganese (dissolved)			ug/L	--	--	--	ND	--	--	--	--	--	--	--	ND	--	--	ND
Mercury (inorganic)	0.002	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Nickel	NA		ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Selenium	0.05	0.05	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Silver	NA	0.10	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Thallium	0.0005	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Uranium	zero	30 ug/L	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Zinc	--	5.00	ug/L	322.33	690	29	130	--	--	ND	--	--	ND	--	130	--	--	130
Radionuclides																		
Alpha, Gross	zero	15 picocuries per Liter (pCi/L)	pCi/L	ND	ND	ND	ND			ND	--	--	ND		ND	--	--	ND
Alpha, Min Detectable Activity	--	--	pCi/L	2.45	2	ND	3	--	--	2	--	--	2	--	2	--	--	2
Alpha, Two Sigma Error	--	--	pCi/L	0.7	0.7	ND	0.71	--	--	0.66	--	--	0.66	--	0.73	--	--	0.73
Beta, Gross	zero	50 picocuries per Liter (pCi/L)	pCi/L	3	3.5	3.1	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Beta, Min Detectable Activity	--	--	pCi/L	2.65	2	ND	2	--	--	2	--	--	2	--	2	--	--	2
Beta, Two Sigma Error	--	--	pCi/L	1.13	0.68	ND	0.64	--	--	0.64	--	--	0.64	--	0.62	--	--	0.62
Radium 226	zero	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 226 Min Detect Activity	--	--	pCi/L	0.35	0.3	ND	0.4	--	--	0.3	--	--	0.3	--	0.4	--	--	0.4
Radium 226 Two Sigma Error	--	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 228	zero	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 228 Min Detect Activity	--	--	pCi/L	0.75	0.7	ND	0.8	--	--	0.8	--	--	0.8	--	0.8	--	--	0.8
Radium 228 Two Sigma Error	--	--	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Radium 226 and Radium 228 (combined)	zero	5 pCi/L	pCi/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
PFAS/PFOA																		
Perfluorohexanoic acid (PFHxA)	NA	NA	ug/L	**0.0035**	**0.0027**	**0.0021**	**0.0046**	--	**0.0020**	ND	ND	--	ND	--	**0.0036**	**0.0035**	--	**0.00355**
Perfluoroheptanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorooctanoic acid (PFOA)	NA	NA	ug/L	**0.0048**	**0.0051**	**0.0031**	**0.0045**	--	**0.0020**	ND	ND	--	ND	--	**0.0039**	**0.0037**	--	**0.0038**
Perfluorononanoic acid	NA	NA	ug/L	**0.0010**	**0.002**	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorodecanoic acid	NA	NA	ug/L	**0.0012**	**0.0024**	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluoroundecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorododecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorotridecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorotetradecanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorobutanesulfonic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorohexanesulfonic acid	NA	NA	ug/L	ND	ND	**ND**	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluorooctanesulfonic acid (PFOS)	NA	NA	ug/L	**0.0064**	**0.0093**	**0.0044**	**0.0044**	--	**0.0021**	ND	ND	--	ND	--	**0.0045**	**0.0043**	--	**0.0044**
N-ethyl perfluorooctanesulfonamidoacetic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
N-methyl perfluorooctanesulfonamidoacetic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Perfluoro-2-proxypropanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Dodecafluoro-3H-4,8-dioxanonanoic acid	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
9-chlorohexadecafluoro-3-oxanonane-1 sulfonate	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
11-chloroeicosafluoro-3-oxanonane-1-sulfonate	NA	NA	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Polycyclic armatic hydrocarbons (PAHs) and phthalates																		
naphthalene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
acenaphthylene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
acenaphthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
fluorene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
phenanthrene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
anthracene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
fluoranthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
pyrene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benz[a]anthracene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
chrysene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[b]fluoranthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[k]fluoranthene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[a]pyrene	zero	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
dibenz[a,h]anthracene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
benzo[g,h,i]perylene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
indeno[1,2,3-cd]pyrene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di-N-octylphthalate	NA	NA	ug/L	**0.85**	**0.85**	**0.14**	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Diethylphthalate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dimethoate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dimethylphthalate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di-n-Butylphthalate	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1-Methylnapthalene	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Acetochlor	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Aldrin	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Atrazine	0.003	0.003	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND

					Pilot Test 1		Supplemental Pilot Testing											
								2A - SLOW SAND + AQUIP						2B - COAGULANT + RAPID SAND				
Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Raw Stormwater 04/22/2020	Average Treated Stormwater Spring 2020	Raw Stormwater 11/13/20	Post-Slow Sand (A1)	Post-Aquip (B1)	Post-GAC (C1)	Post-GAC Dup	Post-UV (D1)	2A Final Treated Water	Post-Coagulant and Rapid Sand (A2, B2)	Post-GAC (C2)	Post-GAC Dup	Post-UV (D2)	2B Final Treated Water
Carbofuran	0.04	0.04	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Carbon tetrachloride	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Chlordane	zero	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Chlorobenzene	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
2,4-D	0.07	0.07	ug/L	**1.32**	**2**	**0.63**	**0.87**	--	--	ND	--	--	ND	--	ND	--	--	ND
Dalapon	0.2	0.2	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
DDT	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
DDT Metabolite (DDE)	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
o-Dichlorobenzene	0.6	0.6	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
p-Dichlorobenzene	0.075	0.075	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2-Dichloroethane	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,1-Dichloroethylene	0.007	0.007	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
cis-1,2-Dichloroethylene	0.07	0.07	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
trans-1,2-Dichloroethylene	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dichloromethane	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2-Dichloropropane	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di(2-ethylhexyl) adipate	0.4	0.4	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Di(2-ethylhexyl) phthalate	zero	0.006	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dicamba	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dieldrin	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dinoseb	0.007	0.007	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Diquat	0.02	0.02	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Endothall	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Endrin	0.002	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Epichlorohydrin	zero	TT8	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Ethylene dibromide (EDB)	zero	0.00005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Glyphosate	0.7	0.7	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Heptachlor	zero	0.0004	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Heptachlor epoxide	zero	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Hexachlorobenzene	zero	0.001	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Hexachlorocyclopentadiene	0.05	0.05	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Lindane	0.0002	0.0002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Malathion	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Methomyl	NA	NA	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Methoxychlor	0.04	0.04	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Oxamyl (Vydate)	0.2	0.2	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Paraquat	NA	NA	ug/L	**2.6**	**2.6**	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Polychlorinated biphenyls (PCBs)	zero	0.0005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Pentachlorophenol	zero	0.001	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Picloram	0.5	0.5	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Simazine	0.004	0.004	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Styrene	0.1	0.1	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Tetrachloroethylene	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Toluene	1	1	ug/L	**0.88**	**0.88**	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Toxaphene	zero	0.003	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
2,4,5-TP (Silvex)	0.05	0.05	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,2,4-Trichlorobenzene	0.07	0.07	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,1,1-Trichloroethane	0.2	0.2	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
1,1,2-Trichloroethane	0.003	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Trichloroethylene	zero	0.005	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Vinyl chloride	zero	0.002	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Xylenes (total)	10	10	ug/L	ND	ND	ND	ND	--	--	ND	--	--	ND	--	ND	--	--	ND
Urban Detected Pesticides/MS4																		
2,4,5-T	70	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
2,4,5-TP (silvex)	50	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
2,4-D	70	MCL	ug/L	**1.8**	**1.9**	**1.2**	**1.7**	--	ND	ND	ND	--	ND	--	**0.14**	**0.14**	--	**0.14**
2,4-DB	200	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
2,6-dichlorobenzamide	29	Chronic or Lifetime (HHBPs	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
acifluorfen	90	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
aldrin	0.00092	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
alpha-HCH	0.006	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
atrazine	3	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
bentazon	200	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
Bifenthrin	70	Acute or One Day HHBP	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
boscalid	1400	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
bromacil	700	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
carbaryl	40	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND

					Pilot Test 1		Supplemental Pilot Testing	2A - SLOW SAND + AQUIP						2B - COAGULANT + RAPID SAND				
Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	UNITS	Average Stormwater* 2017-2020	Raw Stormwater 04/22/2020	Average Treated Stormwater Spring 2020	Raw Stormwater 11/13/20	Post-Slow Sand (A1)	Post-Aquip (B1)	Post-GAC (C1)	Post-GAC Dup	Post-UV (D1)	2A Final Treated Water	Post-Coagulant and Rapid Sand (A2, B2)	Post-GAC (C2)	Post-GAC Dup	Post-UV (D2)	2B Final Treated Water
chlorothalonil	100	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dacthal	20	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
diazinon	1	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dicamba	3000	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dichlobenil	60	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dichlorprop	300	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dimethoate	14	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
dinoseb	7	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
diuron	2	Cancer HBSL (10-6 to 10-4)	ug/L	**0.08**	ND	ND	**0.08**	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
esfenvalerate	12	Acute or One Day & Chroni	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
ethofumesate	2000	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
ethoprop	1.14	Carcinogenic HHBP (E-6 to	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
fenbuconazole	8.91	Carcinogenic HHBP (E-6 to	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
fipronil	1	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
gamma-BHC (lindane)	0.043	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
glyphosate	700	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
heptachlor	0.0014	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
hexazinone	400	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
imazapyr	16000	Chronic or Lifetime (HHBPs	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
imidacloprid	360	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
iprodione	0.729	Carcinogenic HHBP (E-6 to	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
kresoxim-methyl	11	Carcinogenic HHBP (E-6 to	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
MCPA	7.4	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
mcpp-p	300	Chronic or Lifetime (HHBP)	ug/L	**0.26**	**0.11**	ND	**0.6**	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
methoxychlor	40	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
metolachlor	700	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
metribuzin	90	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
metsulfuron methyl	1600	Chronic or Lifetime (HHBPs	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
napropamide	770	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
p,p'-DDD	0.031	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
p,p'-DDE	0.046	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
pendimethalin	2000	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
pentachlorophenol	0.044	Residential RBC	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
picloram	500	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
piperonyl butoxide	992	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
prometon	400	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
propiconazole	600	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
pyrimethanil	1100	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
siduron	960	Chronic or Lifetime (HHBP)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
simazine	4	MCL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
sulfometuron-methyl	1760	Chronic or Lifetime (HHBPs	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
tebuthiuron	1000	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
terbacil	100	Noncancer HBSL	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
triclopyr	300	Chronic or Lifetime (HHBP)	ug/L	**0.11**	**0.13**	**0.087**	**0.094**	--	ND	ND	ND	--	ND	--	ND	ND	--	ND
trifluralin	10	Cancer HBSL (10-6 to 10-4)	ug/L	ND	ND	ND	ND	--	ND	ND	ND	--	ND	--	ND	ND	--	ND

Notes

* Turbidity measurements were obtained prior to sample collection. Additional turbidty removal optimization was completed for both treatment trains and are described in Murraysmith's March 5, 2021 Pilot Testing Results and Design Criteria Technical Memorandum.

Red = parameter detected above regulatory limit

[a] **Chloramines** (i.e., bound chlorine) is the product of the chemical reaction between chlorine and an amine compound. There is no direct chemical method for measuring chloramine. The amount of chloramine is calculated by subtracting free chlorine from the total chlorine. The concentration of chloramines will be conservatively estimated using the field measured total chlorine (residual) results. The chloramines concentration will be reported as "≤ Total Chlorine."

[b] **Chlorine (as Cl2)** (i.e., free chlorine). Free chlorine refers to both hypochlorous acid (HOCl) and the hypochlorite (OCl–) ion or bleach. Free chlorine is typically measured in drinking water disinfection systems to find whether the water system contains enough disinfectant to inactivate most of the bacteria and viruses. Free chlorine residual needs to analyzed immediately and is not anticipated to be present in stormwater samples. The concentration of chlorine will be conservatively estimated using the field measured total chlorine (residual) results. The chlorine concentration will be reported as "≤ Total Chlorine."

[c] **Chlorine dioxide** is marketed for use as a disinfectant and is also the name for the neutral ClO2 molecule, while Chlorite is a –ClO2 anion of a molecule. For accurate results, chlorine dioxide needs to be analyzed immediately. Given the short holding time for chlorine dioxide, Eurofins will substitute Chlorite. However, for the purposes of this study the concentration of chlorine dioxide will be conservatively estimated by using the field measured total chlorine (residual) results and the concentration will be reported as "≤ Total Chlorine".

* Average stormwater concentrations are calculated by taking the geometric mean of detected concentrations (nondetects are excluded).

Table 3. Comparison between treated stormwaters and ASR 3A groundwater

ANALYTE	Drinking Water Quality Standard	Criteria	Units	Diverted Water Average Stormwater 2017 - 2020	Diverted Water Starting/Raw Stormwater 4/22/2020	Source Water Treated Stormwater Pilot 1	Diverted Water Starting/Raw Stormwater 11/13/2020	Source Water Treated Stormwater Pilot 2A	Source Water Treated Stormwater Pilot 2B	Receiving water ASR 3A Well Groundwater 10/9/2019
Field Parameters (FP)†										
Specific Conductivity	--	--	uS/cm	43.22	--	--	32.5	171.7	74.4	544.1
ORP	--	--	mV	150.2	--	--	150.2	38	142.2	-14.2
Dissolved Oxygen	--	--	mg/L	10.76	--	--	10.76	6.44	7.38	0.76
Temperature	--	--	degC	9.41	12.08	12.5	8.6	9.5	10.2	15.1
Turbidity	5	MCL	NTU	10.73	14	6	12	*3	*7	**51.6^^**
pH	6.5 - 8.5	SMCL	su	5.52	6.68	5.9	5.31	7.62	5.45	7.48
General Chemistry (GC)										
Nitrite as N	1	MCL	mg/L	0.017	ND	ND	ND	ND	ND	ND
Cyanide	0.2	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Total Suspended Solids	--	--	mg/L	5.73	ND	ND	6	1	8	ND
Asbestos	7	--	MFL	--	ND	ND	--	--	--	--
Biological Oxygen Demand (BOD5)	--	--	mg/L	--	11	14	ND	ND	ND	--
Bromide	--	--	mg/L	22	22	36	--	--	--	--
Carbonate, as CaCO3	--	--	mg/L	--	--	--	ND	ND	ND	ND
Ortho-phosphate as P	--	--	mg/L	0.05	0.026	0.2	0.12	0.026	0.037	--
Total Phosphorous	--	--	mg/L	0.17	0.14	0.05	0.15	0.048	0.048	--
Alkalinity, Total as CaCO3	--	--	mg/L	12.59	22	11	7.2	25	12	130
Bicarbonate	--	--	mg/L	ND	27	13	--	--	--	160
Calcium, total	--	--	mg/L	4.50	6.7	14	3	14	8	40
Chloride	250	SMCL	mg/L	1.08	1.3	2.1	0.89	3.6	1.8	94
Silica	--	--	mg/L	--	2.4	2.4	3.6	1.8	8.1	50
Fluoride	2	MCL/SMCL	mg/L	ND	ND	ND	ND	ND	ND	0.23
Hardness, as CaCO3	250	--	mg/L	14.76	22	50	9.9	56	26	180
Magnesium	--	--	mg/L	0.84	1.2	3.6	0.59	5.1	1.8	19
Potassium	--	--	mg/L	1.45	2.1	2.5	1	2.3	1.5	5.9
Sodium	--	--	mg/L	1.52	2.3	1.3	1	14	3.2	41
Total Dissolved Solids	500	SMCL	mg/L	35.13	43	100	12	130	54	340
Nitrate + Nitrite	10	MCL	mg/L	0.26	0.26	0.38	0.46	0.28	0.21	ND
Nitrate as N	10	MCL	mg/L	0.25	0.26	0.38	0.46	0.28	0.21	ND
Sulfate	250	SMCL	mg/L	2.99	3.9	48	2.3	59	19	1.6
Total Organic Carbon (total)	--	--	mg/L	10.03	18.00	14.00	5.10	0.63	2.00	2.20
Metals (Total unless otherwise specified)										
Antimony	0.006	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.01	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Beryllium	0.004	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Cadmium	0.005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Mercury	0.002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01	MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Silver	0.05	MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Nickel	--	††	mg/L	--	ND	ND	ND	ND	ND	ND
Thallium	0.002	MCL	mg/L	--	ND	ND	ND	ND	ND	ND
Barium	1	MML	mg/L	0.0107	0.014	0.0042	0.0082	0.063	0.056	0.023
Chromium	0.05	MCL	mg/L	0.00121	ND	ND	ND	ND	ND	ND
Copper	1	SMCL	mg/L	0.00514	0.01	0.0089	0.0026	ND	ND	0.015
Manganese, Dissolved	0.05	SMCL	mg/L	--	--	--	ND	ND	ND	0.049
Manganese	0.05	SMCL	mg/L	0.126	0.17	0.13	0.029	0.015	0.041	0.048
Iron, Dissolved	0.3	SMCL	mg/L	0.079	0.057	0.1	0.11	0.027	ND	ND
Iron	0.3	SMCL	mg/L	0.81	0.46	0.25	0.53	0.12	0.18	0.11
Aluminum	0.05 - 0.2	SMCL	mg/L	0.215	0.14	0.11	0.43	0.33	1.1	ND
Lead	0.015	AL	mg/L	0.00066	ND	0.0012	ND	0.00068	ND	0.00065
Zinc	5	SMCL	mg/L	0.322	0.69	0.029	0.13	ND	0.13	0.022
Disinfection Byproducts (DBPs)										
Dibromochloromethane	--	--	mg/L	ND	ND	ND	--	--	--	ND
Bromodichloromethane	--	--	mg/L	ND	ND	ND	--	--	--	ND
Dibromoacetic Acid	--	--	mg/L	ND	ND	ND	--	--	--	ND
Dichloroacetic Acid	--	--	mg/L	ND	ND	ND	--	--	--	ND
Monobromoacetic Acid	--	--	mg/L	ND	ND	ND	--	--	--	ND
Monochloroacetic Acid	--	--	mg/L	ND	ND	ND	--	--	--	ND
Total Haloacetic Acids (HAA-5)	0.06	MCL	mg/L	ND	ND	ND	--	--	--	ND
Bromoform	--	--	mg/L	ND	ND	ND	--	--	--	ND
Total Trihalomethanes (TTHM)	0.08	MCL	mg/L	ND	ND	ND	--	--	--	0.0017
Chloroform	--	--	mg/L	--	--	--	--	--	--	0.0017
Trichloroacetic Acid	--	--	mg/L	ND	ND	ND	--	--	--	0.0012
Microbiological										
Total Coliform Bacteria	<1	MML	MPN/100mL	Positive	Positive	Positive	Positive	Negative	Negative	Positive
Fecal Coliform	Absent	MCL	MPN/100mL	Present	Present	Absent	Present	Absent	Absent	Absent
E. Coli	Absent	MCL	MPN/100mL	Present	Present	Absent	Present	Absent	Absent	Absent
Miscellaneous (Misc)										
Foaming Agents (MBAS, surfactants)	--	--	mg/L	0.23	0.23	ND	ND	ND	--	ND
Odor	3	SMCL	ton	5.83	17	2	2	ND	2	2
Color	15	SMCL	cu	52	45	20	45	30	25	ND
Corrosivity (Langlier Index)	noncorrosive	SMCL	none	-2.7	-2.3	-2.7	-3.2	-1.2	--	0.15
SDWA Radionuclides (Rads)										
Radium 226	--	--	pCi/L	ND	ND	ND	ND	ND	ND	ND
Radium 228	--	--	pCi/L	ND	ND	ND	ND	ND	ND	ND
Radium 226/228	5	MML	pCi/L	ND	ND	ND	ND	1.1	1.2	ND
Uranium	0.03	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Gross Alpha	15	MML	pCi/L	ND	ND	ND	ND	ND	ND	ND
Gross Beta ‡	50	MML	pCi/L	ND	3.50	3.10	ND	ND	ND	4.8
Radon†††	--	--	pCi/L	--	--	--	--	--	--	800

ANALYTE	Drinking Water Quality Standard	Criteria	Units	Diverted Water Average Stormwater 2017 - 2020	Diverted Water Starting/Raw Stormwater 4/22/2020	Source Water Treated Stormwater Pilot 1	Diverted Water Starting/Raw Stormwater 11/13/2020	Source Water Treated Stormwater Pilot 2A	Source Water Treated Stormwater Pilot 2B	Receiving water ASR 3A Well Groundwater 10/9/2019
Synthetic Organic Compounds (SOCs)										
2,4,5-TP (Silvex)	0.01	MML	mg/L	ND	ND	ND	ND	ND	ND	ND
2,4-DB	0.001	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
3,5-Dichlorobenzoic acid	0.0005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
2-Butanone (MEK)	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
3-Hydroxycarbofuran	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2Pentanone (MIBK)	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Acifluorfen	0.002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Aldicarb	0.0005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Aldicarb Sulfoxide	0.0005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Aldicarb Sulfone	0.0008	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Aldrin	0.0001	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Alachlor (Lasso)	0.002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Atrazine	0.003	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	0.0002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Carbofuran	0.04	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Chlordane	0.002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dalapon	0.2	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
DCPA (Acid metabolites)	0.0001	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Baygon	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Bentazon	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Bromoethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Bromomethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Carbaryl	0.002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dieldrin	0.0001	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Dichloromethane	0.005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Di-isopropyl ether	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Di(2-Ethylhexyl) Adipate	0.4	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dibromochloropropane (DBCP)	0.0002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dinoseb	0.007	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dioxin(2,3,7,8-TCDD)	3.00E-08	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Diquat	0.02	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Endothall	0.1	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Endrin	0.0002	MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Ethylene Dibromide (EDB)	0.00005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Glyphosate	0.7	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Heptachlor	0.0004	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Heptachlor Epoxide	0.0002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene (HCB)	0.001	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Hexachlorocyclopentadiene	0.05	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Lindane (BHC-gamma)	0.0002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Methomyl	0.004	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Methiocarb	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Methoxychlor	0.04	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Molintae	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Oxamyl (Vydate)	0.2	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
o-Chlorotoluene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	0.001	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Picloram	0.5	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Polychlorinated Biphenyls (PCBs)	0.0005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Propachlor	0.0001	MCL	mg/L	ND	ND	ND	ND	ND	ND	--
Metribuzin	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Bromacil	0.0002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Fluorene	0.0002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Simazine	0.004	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Tert-Butyl Ethyl Ether	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Toxaphene	0.003	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
trans-1.3-Dichloropropene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Trichlorotifluoroethane (Freon 113)	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Di(2-Ethylhexyl) Phthalate	0.006	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Dicamba	0.0002	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Metolachlor	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Butachlor	0.0004	MCL	mg/L	ND	ND	ND	ND	ND	ND	--
Diuron	--	--	mg/L	0.00008	ND	ND	0.00008	ND	ND	--
mcpp-p	--	--	mg/L	0.00026	0.00011	ND	0.0006	ND	ND	--
Paraquat	0.0004	MCL	mg/L	0.0026	0.00011	ND	0.0006	ND	ND	ND
Di-N-octylphthalate	--	--	mg/L	0.00085	0.00085	0.00014	ND	ND	ND	--
Triclopyr	--	--	mg/L	0.00011	0.00013	0.000087	0.000094	ND	ND	--
2,4-D	0.07	MCL	mg/L	0.0018	0.0019	0.0012	0.0017	ND	ND	ND

ANALYTE	Drinking Water Quality Standard	Criteria	Units	Diverted Water Average Stormwater 2017 - 2020	Diverted Water Starting/Raw Stormwater 4/22/2020	Source Water Treated Stormwater Pilot 1	Diverted Water Starting/Raw Stormwater 11/13/2020	Source Water Treated Stormwater Pilot 2A	Source Water Treated Stormwater Pilot 2B	Receiving water ASR 3A Well Groundwater 10/9/2019
Volatile Organic Compounds (VOCs)										
2,4,5-TP (Silvex)	0.01	MML	mg/L	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.2	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1,-Dichloroethylene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1,-Dichloropropene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	0.07	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene (o-dichlorobenzene)	0.6	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane (EDC)	0.005	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	0.005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene (p-dichlorobenzene)	0.075	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1,2,2,-Tetrachloroethane	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
1,1,2,2,-Tetrachloroethane	0.005	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.005	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene (Monochlorobenzene)	0.1	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	0.07	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	0.7	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride (Dichloromethane)	0.005	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Methyl-Tert-butyl ether	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Naphthalene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	0.1	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene (PCE)	0.005	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethylene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Trichloroethene (TCE)	0.005	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	0.002	MCL, MML	mg/L	ND	ND	ND	ND	ND	ND	ND
Xylenes, Total	10	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
Styrene	0.1	MCL	mg/L	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
tert-amyl Methyl Ether	--	--	mg/L	ND	ND	ND	ND	ND	ND	ND
Toluene	1	MCL	mg/L	0.00088	0.00088	ND	ND	ND	ND	ND
1,2-Dichloropropene	--	--	mg/L	--	--	--	--	--	--	--

Notes:

-- = Not analyzed or not available

Red = parameter detected above regulatory limit

MCL = Maximum Contaminant Level

SMCL = Secondary Maximum Contaminant Level

MML = Maximum Measureable Level

* Turbidity measurements were obtained prior to sample collection. Additional turbidty removal optimization was completed for both treatment trains and are described in Murraysmith's March 5, 2021 Pilot Testing Results and Design Criteria Technical Memorandum.

MCLs for turbidity are applicable to all public water systems using surface water sources or groundwater sources under the direct influence of surface water in whole or in part. Compliance with MCLs shall be calculated pursuant to OAR 333-061-0036(5)

† Measured using a YSI 556 MPS

†† MCL being re-evaluated by EPA

††† USEPA proposed standard is 300 to 4,000 pCi/L, depending on State primacy

‡ Gross beta MCL is 4 mrem/yr; however lab results presented in pCi/L so compared it to the MML standard.

^^turbidity measured on 10/1/19 at the end of pump development

Units:

mg/L = Milligram per liter (~ ppm)

ng/L = nanogram per liter (~ ppt)

MPN = most probable number

CU = color number

TON = threshold odor number

MFL = million fibers per liter

pCi/L = picocuries per liter

su = standard units

uS/cm = microsiemens per centimeter

mV = millivolts

degC = degrees Celsius

Attachment 1 - Pilot Testing Results and Design Criteria TM (Murraysmith)

Technical Memorandum

Date: March 5 2021

Project: City of Beaverton Sterling Park ASR Testing

To: Ronan Igloria, GSI Water Solutions
Jason Melady, GSI Water Solutions
Andrew Davidson, GSI Water Solutions

From: Lee Odell, PE
Murraysmith

Re: Pilot Testing Results and Design Criteria

Introduction

In accordance with the recommendations of GSI Water Solutions, Inc.'s (GSI) October 2020 *Preliminary Evaluation for City of Beaverton Sterling Park Stormwater Treatment Pilot Study* (GSI, 2020a) and the November 2020 sampling and analysis plan (SAP) (GSI, 2020b), a supplemental pilot study was conducted in November 2020 at the Sterling Park stormwater facility to assess modifications to an existing pilot treatment system. As outlined in the SAP, two potential treatment trains were investigated to assess the optimal multiple barrier approach for removing stormwater contaminants below target treatment goals. The two treatment trains were:

1. An infiltration or "slow sand" filter, followed by a StormwaterRx (SRx) Aquip treatment unit, granular activated carbon (GAC) filtration, and UV disinfection.
2. Coagulant addition, followed by rapid sand filtration, GAC filtration, and UV disinfection.

The addition of pretreatment steps (i.e., slow sand filtration or coagulation-filtration) to the original pilot treatment train (i.e., Aquip and UV disinfection) were targeted at removing suspended solids and turbidity prior to downstream treatment components. The addition of GAC media prior to disinfection was targeted at removing a broad spectrum of dissolved contaminants including PFAS compounds, pesticides, and other organic contaminants.

Pilot Testing Objectives

Pilot testing was conducted to meet the following key objectives:

- Confirm the effectiveness of the two treatment train systems to consistently remove stormwater contaminants below target treatment goals in raw storm water collected from the Sterling Park facility.
- Determine pertinent design criteria necessary for full scale design.
- Determine scope and scale of operation and maintenance procedures necessary for a full-scale system.

Treatment Goals

As outlined in the SAP (GSI, 2020b), treatment goals for both pilot testing systems were established to provide a framework for evaluating treatment effectiveness of each treatment train and treatment component. Individual analyses for each system and system component are presented in the SAP, and tables of treatment results are provided in the accompanying GSI report (GSI, 2021). To meet all applicable or potentially applicable regulatory criteria for the intended application, including Aquifer Storage and Recovery (ASR) criteria and Oregon Department of Environmental Quality (DEQ) antidegradation policies, target treatment goals generally involved the following:

- Reduce contaminants to ½ of the National Primary Drinking Water Regulations (NPDWR) maximum contaminant levels (MCLs) and target treatment goals; or remove contaminants below the secondary maximum contaminant level (SMCL) for nuisance chemicals.
- Remove all concentrations of emerging synthetic organic contaminants including emerging pesticides, cyanotoxins, and polyfluoroalkyl substances (PFAS).

During the initial pilot studies, it was determined that additional pre-treatment and polishing steps would be needed to adequately treat raw stormwater below target treatment goals. While polishing steps are intended to achieve final target treatment goals for all but the biological parameters, pre-treatment steps are included to lower turbidity and other contaminants associated with suspended solids that inhibit adequate treatment in downstream treatment components. Accordingly, target treatment goals specific to pre-treatment components as presented in Table 1 were considered during the pilot studies.

Table 1: Treatment and Operational Goals for Pre-Treatment Components (i.e., Slow Sand Filter or Coagulant-Filtration)

Parameter	Treatment Objective
Effluent Turbidity	< 1 NTU
Effluent Total or Fecal Coliform	< 5 CFU/mL
Filter Run Length	> 30 days
Color	< 5 SCU
CFU/mL = colony forming units per milliliter; NTU = nephelometric turbidity units; SCU = standard color units.	

Configuration of Pilot Equipment

Pilot study testing was conducted for two treatment train systems as presented in the November 2020 SAP (GSI, 2020b). Figure 1 originally presented in Attachment 4 of the preliminary stormwater treatment evaluation memo (GSI, 2020a) presents the orientation and individual treatment components in each treatment train.

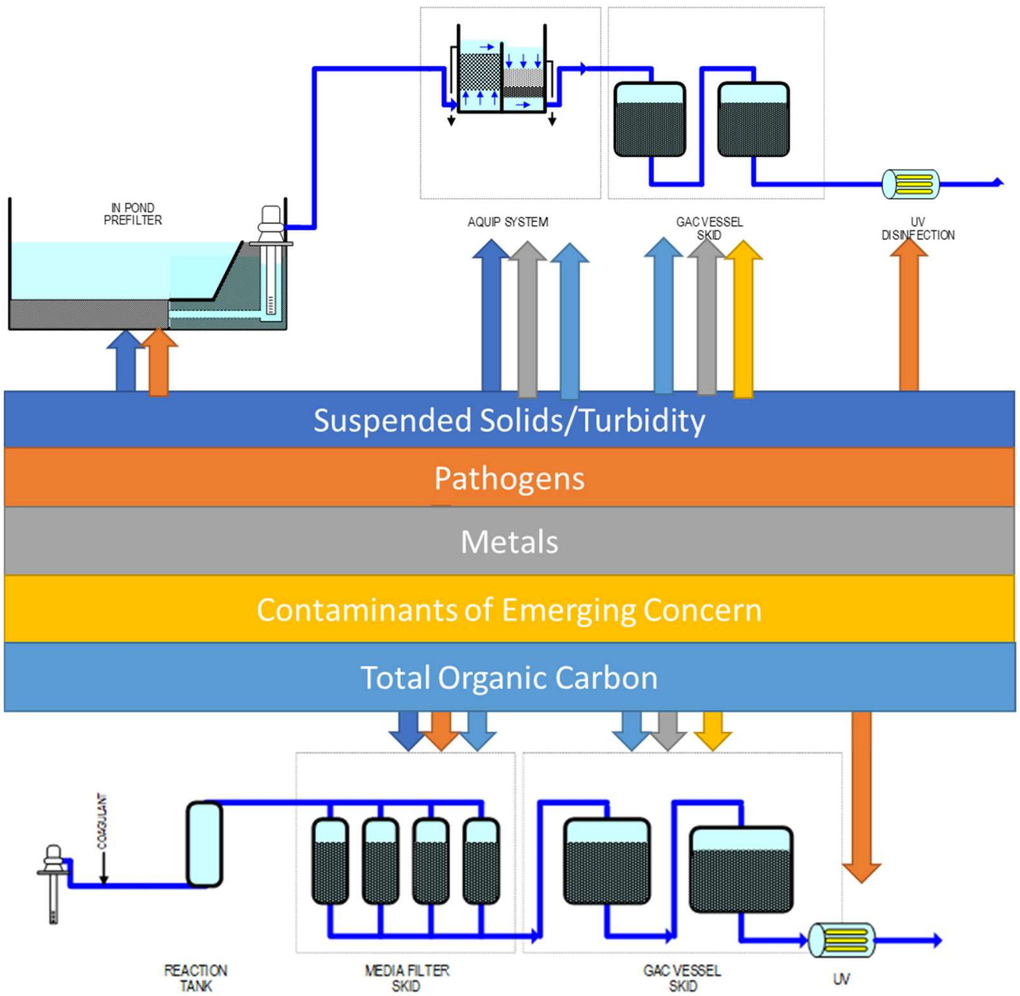

Figure 1: Treatment Barriers provide by Two Proposed Treatment Trains
(Train 1: In Pond Filter, Aquip, GAC and UV on top,
Train 2: Coagulation-filtration, GAC, and UV on bottom)

Treatment Train 1

A1. Pilot-Scale Slow-Sand Filter, designed to mimic an "in-pond" filtration system at full scale. System is designed to operate at a loading rate of 0.04 and 0.08 gpm/ft^2 and was constructed of one 12"-diameter (0.79 ft^2) pilot column containing 20" of graded support gravel (3" each of No. 14 - No. 6, No. 6 - No. 4, No. ¾", and 3/8" - ¾" grain atop 8" of ¾" – 1 ½" grain) overlain by 35" of silica sand (0.20-0.30 mm diameter, uniformity coefficient of ≤ 2.5) with a ≤ 3/8" perforated polyvinyl chloride (PVC) underdrain pipe. See Table 2 and Figure 2.

Table 2: In Pond Pre-Filter Support Gravel

Depth	Particle Size
3 inches	No. 14 - No. 6
3 inches	No. 6 - No. 4
3 inches	No. 4 - 3/8-inch
3 inches	3/8-inch – 3/4-inch
8 inches	3/4-inch - 1 ½-inch

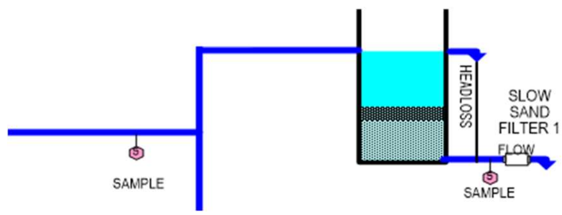

Figure 2: In Pond Filtration Pilot System Component Schematic

The sand was cleaned before installation to remove fines and other contaminants by backwashing in the pressure filter. Prior to treatment, the system was operated with recirculated raw stormwater in an attempt to begin forming the biologically-active "schmutzdecke" which optimizes treatment in a slow sand filter. Unlike conventional rapid granular media filters, in lieu of backwashing to remove solids, the top layer of the In-Pond Filter would be periodically scraped or harrowed. With scraping, the top ¼ to ½ inch of sand media is removed. Harrowing is a process by which the surface is raked to allow the built up schmutzdecke to be floated and skimmed. These operations require a fair amount of labor so long filter runs are a prerequisite for the successful application of the technology. Due to the time constraints needed to capture the target storm event for the supplemental pilot testing, full development of the schmutzdecke did not occur, and headloss rate calculations are not fully known for the given source water. The rate of headloss is expected to buildup very slowly in a slow sand filter and will require a multi-week test to better calculate expected maintenance schedules. This can occur as part of full-scale design.

B1. Aquip® 8PBE Enhanced Filtration System, manufactured by StormwateRx out of Portland, OR. System operates at up to 8 gpm, contains a pretreatment buffering media and layered inert/organics sorptive enhanced filtration media, is contained in a watertight LDPE (low density polyethylene) structure, and features flow distribution piping, an underdrain manifold with cleanouts, an internal emergency overflow, an adjustable head controller for sediment loading compensation, a passive overflow level indicator, an inlet/inline totalizing flow meter, and flow control valve.

C1. Granular Activated Carbon (GAC) System, designed to operate at 2 gpm (3.6 gpm/ft^2) and 30-75 psig for 8 to 24 hr/day, consisting of two 16" diameter vessels with 1.40 ft^2 each, approximately 5 ft^3 of media in each vessel at a depth of 42", with a 5 minute backwash cycle every 24 hours with a backwash flow rate of 21 gpm and total backwash volume of 105 gal as presented in Table 3 below.

Table 3: GAC Filter Specifications for Pilot Study

Operating Condition	GAC
Filter Capacity (gpm)	2
Operating Pressure, psig	30-75
Run Time (hours/day)	8 to 24
Filters	
Diameter of Vessels, in	16
Surface areas, per vessel, sq ft	1.40
Number of Vessels	2
Loading Rate, gpm/sq ft	1.43
Media Depth, in	42
Media, Cubic ft	10
Empty Bed Contact Time, min	37
Backwash	
Backwash Flow Rate, Each Vessel (gpm)	21
Backwash Frequency, Hrs	24
Backwash Duration (min)	5
Backwash Volume, Gal	105

D1. Ultraviolet (UV) Disinfection System manufactured by StormwateRx. The Purus® Bacteria Model 10V disinfection system contains 80W UV lamps, a standard 120V plug, and a 10-ft weatherproof cable.

In addition to removal of target contaminants, results of the pilot study together with engineering experience, were used to consider key full-scale design parameters. Table 4 lists key design criteria addressed in the pilot testing of Treatment Train 1.

Table 4: In Pond Pre-Filter (Treatment Train 1) Design Parameters

Design Criteria	Included in Pilot Test	Comment
Control Strategy	No	Developed as part of design
Filter Box Geometry	No	Engineer and industry experience and excepted design criteria was primary basis for filter design
Filter Media	Yes	Sand meeting the media specification was tested
Loading Rate	Yes	Loading rates of 0.04 and 0.08 gpm/ft2 were tested as this greatly impacts filter size (area) and cost
Piping Velocities	No	Developed as part of design
Underdrains	No	Underdrain design is based on Engineer's experience and accepted industry guidelines.
gpm/ft2 = gallons per minute per square foot.		

Treatment Train 2

A2, B2. Coagulant and Pressure Filter System, was designed to operate at 4 gpm (7.3 gpm/ft^2) and 30-75 psig for 8 to 24 hours/day, consisting of one 10" diameter vessel with 0.55 ft^2 surface area and 1.9 ft^3 of media at a depth of 42". The system included a 5 minute backwash cycle every 24 hours with a backwash flow rate of 8 gpm and total backwash volume of 40 gallons. Coagulant doses ranged from 0.5 to 10 mg/L, with a maximum dose of just over 10.2 mg/L, to achieve a solution volume of 5 gal and strength of 50,000 mg/L with a pressure pump capacity of 3 gpd and storage of 15 days. Pressure filter operation details are provided in Table 5 below.

Table 5. Coagulation/Rapid Filtration Operating Conditions

Operating Condition	Coagulation/ Filtration
Plant Capacity (gpm)	4
Operating Pressure, psig	30-75
Run Time (hours/day)	8 to 24
Filters	
Diameter of Vessels, in	10
Surface areas, per vessel, sq ft	0.55
Number of Vessels	1
Loading Rate, gpm/sq ft	7.3
Media Depth, in	42
Media, Cubic ft	1.9
Empty Bed Contact Time, min	3.6
Coagulant Dose	
Expected Dose, mg/L	0.5 to 10.2
Solution Strength, mg/L	50,000
Pump Capacity, gpd	3
Max Dose, mg/L	10.2
Solution Volume, gal	5
Backwash	
Backwash Flow Rate, gpm	8
Backwash Frequency, Hrs	24
Backwash Duration (min)	5
Backwash Volume, Gal	40

C2. GAC Contactor System, was the same as that used in Treatment Train 1 and presented in Table 3 above. It was designed to operate at 2 gpm (3.6 gpm/ft^2) and 30-75 psig for 8 to 24 hr/day, consisting of two 16" diameter with 1.40 ft^2 each, approximately 5 ft^3 of media in each vessel at a depth of 42", with a 5 minute backwash cycle every 24 hr with a backwash flow rate of 21 gpm and total backwash volume of 105 gallons.

D2. UV Disinfection System was the same as that used in Treatment Train 1 manufactured by StormwateRx. The Purus® Bacteria Model 10V disinfection system contains 80W UV lamps, a standard 120V plug, and a 10-ft weatherproof cable.

Pilot Testing Results

GSI's accompanying report (GSI, 2021) provides the full discussion of the pilot testing results for each treatment system as well as each treatment component. Routine operations during the pilot testing included record keeping, adjusting flow rates, sample collection and analysis of routine water quality parameters such as pH, alkalinity, turbidity, etc., and documenting rate of filter head loss development. This section of the report is limited to the operating conditions implemented and observed during the pilot testing of the two different treatment trains.

Figure 3 – Carboys used to hold water through each treatment step

Testing was conducted in two separate runs. Water was held in a series of carboys (See Figure 3) between each treatment step so that the flow rate could be controlled through each step. The first run was conducted on November 13, 2020 to evaluate Treatment Train 2 and included:

- Water pumped from the raw water carboy, injected with coagulant, and through the rapid sand filter.
- Filtered water was pumped through the GAC filters.
- GAC Filtered water was pumped through the UV system.

Subsequent rapid filtration tests were conducted on November 15, 2020 to optimize the dosage of coagulant needed to obtain target turbidity pre-treatment goals below 1 NTU. Results of the evaluation of rapid sand filtration at different dosages of coagulant are presented in Table 6 and are discussed in the accompanying data report (GSI, 2021).

Table 6: Beaverton Sterling Park Pilot Testing, Nov 13 and Nov 15 Evaluation of Treatment Train 2 with Rapid Sand Filter

		Slow Sand	Rapid Sand	Head	Nalco	Formazin	GAC	Head
	Sample	Flow	Flow	Loss	8150 Dose	Turbidity	Flow	Loss
Date	Number	Time	(gpm)	(psi)	(mg/L)	(FTU)	(gpm)	(psi)
11/13	Start		2.0	1	1.53	4		
	1		2.0	2	1.53	12		
	2		3.9	2	0.78	13		
	3		4.0	2	0.76	22		
	4		4.0	2	0.76	6		
	5						4.0	2
	6						4.0	2
	7						4.0	2
11/15	8		4.0	1	3.2	14		
	9		4.0	1	4.5	4		
	10		4.0	1	6.5	1		
	11		4.0	1	7.4	1		
	12		4.0	1	10.2	1		
	13		4.0	1				

The second test began November 14th to evaluate Treatment Train 1. The slow sand filter was run at a very low loading rate that required more than two days to fill the filtered water carboy, therefore, the second run was concluded on November 16, 2020 and included:

- Water pumped from the raw water carboy through the slow sand filter.
- Filtered water was pumped into a carboy and then through the Aquip unit.
- Aquip treated water was pumped directly through the GAC filters.
- GAC Filtered water was pumped through the UV system.

Operational conditions and resulting effluent turbidity for pre-treatment with the slow sand filter are presented in Table 7.

Table 7: Beaverton Sterling Park Pilot Testing, Nov 14-16, 2021 Evaluation of Treatment Train 1 with Slow Sand Filter

		Slow Sand	Head	Formazin	GAC	Head
	Sample	Flow	Loss	Turbidity	Flow	Loss
Date	Number	(gpm)	(psi)	(FTU)	(gpm)	(psi)
11/14	1	0.05	2	>9		
11/15	2	0.05	2			
11/16	3	0.05	2	1	4.0	2

Pilot Test Conclusions and Recommended Treatment Train

Initially, the results for the coagulation-filtration process did not meet the desired turbidity pre-treatment goals (Table 1) at lower doses of coagulant, so additional testing at higher coagulant doses was conducted to try to optimize the filtration process. Although desired turbidity removal was eventually achieved at higher doses of coagulant, it became apparent that the coagulation-rapid filtration process would likely require lengthier operator oversight to optimize turbidity removal and filter run-time. Target turbidity removal was initially not met with the slow sand filter due to a lack of adequate time needed to establish the schmutzdecke. However, as the slow sand filter continued to operate, pre-treatment filtrate quality improved and target turbidity goals were achieved. This is consistent with the results of other pilot test for slow sand filters. They often require a week or longer of continuous operation after initial construction before turbidity removal is optimized.

It is anticipated that the slow sand filter would be able to continuously meet pre-treatment goals once full establishment of the schmutzdecke has occurred. Both treatment trains performed very well at removing stormwater contaminants from raw influent and achieving target treatment goals in the final effluent. Treatment train 1 (which includes the slow sand filter) was able to achieve removal of all synthetic organic compounds including pesticides and PFAs and was able to achieve all other target treatment goals except for the metal aluminum for which an SMCL but not an MCL is available. Treatment train 2 (which includes the rapid sand filter and coagulant addition) was able to remove stormwater contaminants to target treatment goals except for aluminum and a few synthetic organic PFAs and pesticide compounds. Table 8 presents a high level comparison of the two treatment train alternatives at full scale.

Table 8: Comparison of Two Treatment Train Alternatives at Full-Scale

Key Evaluation Parameters	Treatment Train 1 In-pond filtration, Aquip, GAC, UV	Treatment Train 2 Coagulation, filtration, GAC, UV
Treatment Efficiency	Very effective, multi-barrier system capable of removing contaminants to target treatment goals without further modification.	Effective, multi-barrier system capable of removing most all contaminants to target treatment goals. GAC process may need to be further optimized to achieve consistent target removal of all synthetic organic compounds.
O&M Considerations	System is largely passive. Will require periodic harrowing of slow sand filter and Aquip system. Will require less frequent replacement of filter medias.	System will require more startup operation and maintenance time to optimize coagulant dose and filter run time. Backwashing will need to occur to maintain filter life.
Capital and O&M costs	Costs for pre-filter and polishing steps are provided in Attachment 4 of Preliminary Evaluation Report (GSI, 2020a). Costs are comparable between the two proposed systems.	Costs for pre-filter and polishing steps are provided in Attachment 4 of Preliminary Evaluation Report (GSI, 2020a). Costs are comparable between the two proposed systems.

Based on the both the treatment and operational results gleaned from the pilot studies as well as the comparable costs between the two treatment systems evaluated for full scale design, it is our professional judgment that treatment train 1 (which includes the slow sand pre-filter step) is the most viable system for full-scale design. The system will be able to consistently achieve target treatment goals, and its passive nature will require less operation and maintenance. As presented in the preliminary treatment evaluation report (GSI, 2020a), costs for the two treatment trains are comparable. However, long term cost savings may be achieved with treatment train 1 due to less frequent operation and maintenance requirements.

Full-Scale Design Criteria and Operational Considerations

A water treatment plant (WTP) consistent with pilot treatment train 1 is recommended for full-scale treatment of stormwater for the Sterling Park ASR injection as shown in Figure 4 below. Pre-treatment with a slow sand filter and polishing with GAC contactors would be added as additional treatment components to the originally planned Aquip unit and UV disinfection to provide multiple treatment barriers and address the full range of treatment challenges without chemical addition. Additionally, a number of safeguards would be added into the full-scale design to ensure all water pumped to the ASR well is of sufficient quality.

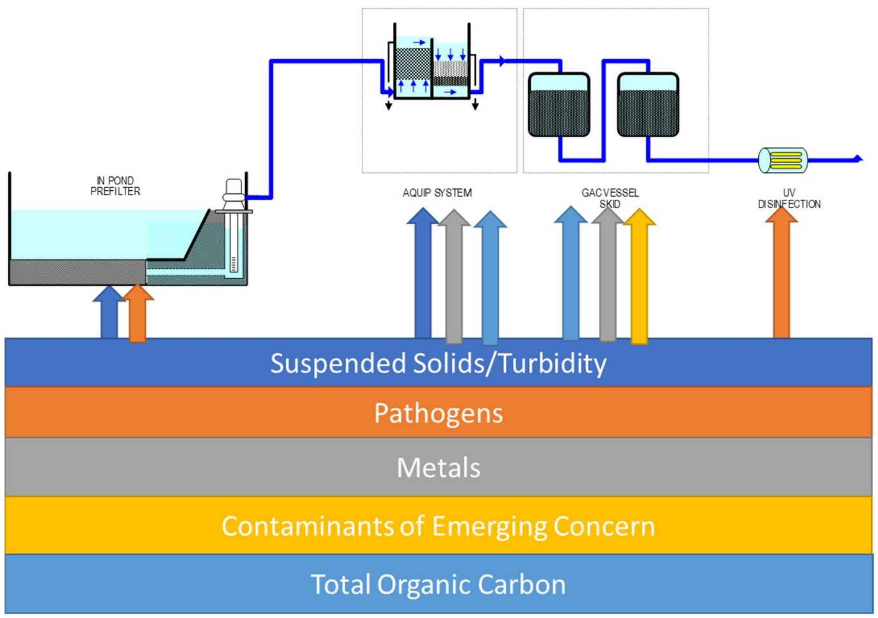

Figure 4 – Conceptual Full Scale Treatment Train

Water currently collected within the upper pond of the Sterling Park Stormwater facility would be pumped into the WTP and gravity fed through the individual treatment components until the final effluent is pumped into the ASR well.

A full-scale treatment facility is currently being considered to be built within the lower basin. The treatment facility will be designed and configured to accomplish the following:

- One or more In-Pond Filter cells
- Pretreatment using spread surface flow in the upper pond to reduce TSS and turbidity to the extent possible
- Bypass or feed piping control depending on the turbidity of the supply.
- Security fencing around the filter
- Manually controlled valves
- Incorporation of sustainable design, construction, and operational practices without adding cost
- Ability to operate with reduced operator oversight

Summary of Design Criteria

Conceptual design criteria are summarized in Table 9. The full-scale WTP should meet the following design criteria:

- Design flow rate: 200 gpm for full-scale operation
- Operating season: November 1 through May 1.
- Number of filter cells: one or two for full scale
- Type of construction: Membrane lined earthen embankment or ecology block embankment with high-density polyethylene liner; embankment slopes of 3:1 horizontal to vertical
- Filter loading rate: 0.08 gpm/ft^2
- Filter area each: 0.125 and 2,500 ft^2 based on horizontal area at a point 27 inches above the bottom of the filter cell
- Inlet and outlet piping: PVC
- Filter sand origin: to be determined; washed to 10 NTU or better
- Filter inlet shut-off: automatic if pre-treatment effluent or inlet turbidity exceeds pre-determined set-points
- Flow split automatic most-open valve
- Effluent hydraulic control structure with adjustable weir to prevent draining filter
- Total depth of filter from bottom of cell to top of berm: 11 feet (includes 2 feet of freeboard and 3 feet water depth above sand).

Table 9: Conceptual Design Criteria for Full Scale Treatment Facility at Sterling Park

Equipment Design Criteria Summary	Sterling Park
Freeboard/headloss, ft	5
Capacity, Gal/day	288,000
Plant Capacity (gpm)	200
Operating Pressure, psig	3
Run Time (hours/day)	24
Average Day Run Time (hours/day)	24
Stage 1 - In Pond Gravity Filter (Slow Sand Filter)	
Width of Filter, ft	100
Length of Filter, ft	30
Surface areas, per vessel, sq ft	3,000
Number of Vessels	1
Loading Rate, gal/sq ft/day	96
Sand Depth, in	36
Gravel Top Layer, in	9
Gravel Mid Layer, In	6
Gravel, Bottom layer, in	6
Media Depth, in	57
Media Volume Per Filter, Cubic ft	14,250
Media Weight, lbs	1,067,040
Stage 2 - Aquip Filter Model 210S	
Freeboard/Headloss, ft	3
Width of Filter, ft	10
Length of Filter, ft	35
Surface areas, per vessel, sq ft	350
Number of Filters	1
Loading Rate, gpm/sq ft	0.7
Media Depth, in	42
Overal Depth, Ft	7

Media Volume Per Filter, Cubic ft	2,100
Media Weight, lbs	88,000
Stage 3 - GAC Filters	
Freeboard/Headloss, ft	3
Width of Filter, ft	10
Length of Filter, ft	10
Surface areas, per vessel, sq ft	100
Number of Filters	1
Loading Rate, gpm/sq ft	2
Media Depth, in	72
Overal Depth, Ft	9
Media Voilume per Filter, Cubic ft	600
Media Weight, lbs	44,928
EBCT, min per filter	22
Stage 4 – UV Disinfection	
UV system to be selected from OHA-approved models to meet all disinfection goals Cryptosporidium and Giardia Inactivation	

Conceptual Schematics

A Hydraulic Schematic Diagram of the treatment components is shown in in Shown in Figure 5 with conceptual, relative elevations. Conceptual layouts of the components at the Sterling Park facility are shown in Figures 6 and 7.

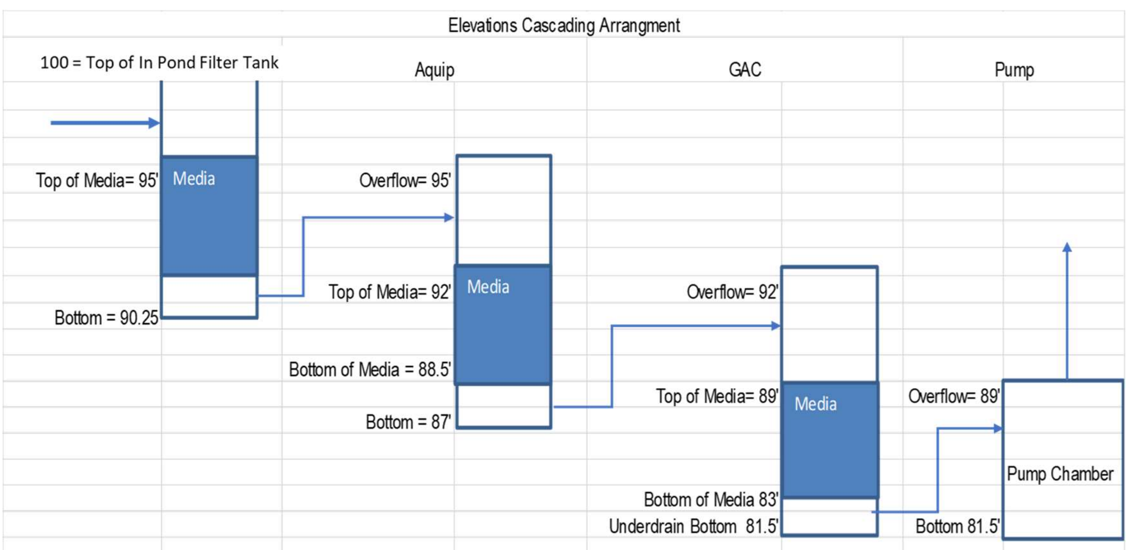

Figure 5. -Conceptual site layout of Full-Scale Basin

Figure 6 – Conceptual Layout of Treatment System

Figure 7 - Conceptual Layout of Treatment System

Preliminary Cost Estimate

Preliminary cost estimates for the full-scale operation of a WTP consistent with treatment train 1 is provided in Table 10. full-Scale cost estimate is $151,100 for the in-pond pre-filter. The GAC contactors are estimated at $522,000 for the full-scale system. These cost estimates assumed concrete ecology blocks would be used to construct the filter cells. There may be less expensive methods to construct the filter cells within the stormwater ponds.

Table 10: Preliminary Cost Estimates for Operation of Selected Full Scale Treatment Facility at Sterling Park

Element	In Pond Filter	A-Quip Unit	GAC Filter	UV	Pumps	Total
Excavation, Site Work	4,000	4,000	4,000			
Gabions/Ecology Blocks	60,000		60,000			
Liner	23,000		23,000			
Underdrains	4,000	included	4,000		3,000	
Underdrain Support Gravel	2,000	included	5,000			
Filter Media	31,000	172,500	13,000			
Fencing	3,000	3,000	3,000			
Shelter	12,000	12,000	12,000			
Pump station					15,000	
UV Disifnection				95,000		
Site Power				25,000	10,000	
Site Work	7,500	7,500	7,500	4,000	2,000	
Access Roads	4,000	4,000	4,000	4,000	4,000	
Subtotal	**150,500**	**203,000**	**135,500**	**128,000**	**34,000**	**651,000**
Contractor Markups						130,200
Contingency						130,200
Design						130,200
Total Capital Costs						**$1,041,600**
Media Replacement and Disposal	4,050	19,750	9,000			32,800
Energy Use				960	1800	2,760
Operations and Monitoring						30,000
Total O&M						**$65,560**

Recommendations and Next Steps

If the City decides to proceed forward with design of a full-scale WTP to use stormwater as a source of ASR at the Sterling Park facility, it is our professional recommendation that such a facility be designed consistent with pilot treatment train 1. Such a WTP could effectively treat stormwater to target treatment goals for the given application. Recommended next steps would include preliminary design including site investigations, and preliminary design for civil, mechanical, structural, electrical and architectural drawings for the facilities.

Attachment 2 - Field Photos

Phase II Supplementary Pilot Testing

Figure 1. Photo of site setup, with water totes on the right, and the trailer housing the sand filters and GAC vessels on the left.

Figure 2. Totes for storing water (left) and the connex box housing the StormwateRx Aquip and UV disinfection system

Figure 3. Sand filters

Figure 4. GAC vessels, treatment trains 1 and 2

Figure 5. StormwaterX Aquip

Attachment 3 - Field Notes

 11/9/20 Sterling Park

1600 ES & AO onsite w/ LO
combo lock #1 = 0131
combo lock #2 = 5911

Full samples post GAC, except
microbio
bacT samples post UV

Get fuel for generator
Ice
Shelter
Tables
YSI & turbidity meter
staff gage
coolers
perisaltic pump

11/10/20 Sterling Park

1638 upper basin outfall flowing
~79 gpm (5gal/3.8 sec)

1630 ES & GS onsite, set up
calibrate YSI
1635 JM onsite, get generator,
drain Raw water tote
bucket test @ 1638

(11/6 - AD & JM onsite,
bucket measurement was 150 gpm
weather was drizzling (~5gal/2 sec))

~~1648 flush to~~

1640 Flush tote w/ fresh SW
1648 begin filling tote #1

1700 Tote #1 Field Parameters
T = 10.2°C
DO = 71.4 %, ~~7.98 mg/L~~
SPC = 89.1 ms/cm
pH = 6.22
ORP = 209.7

1702 Tote #2 Field Parameters
T = ~~7.8°C~~ 10.2°C
DO = 68.4%, 7.64 mg/L
SPC = 87.1 us/cm
pH = 5.99
ORP = 185.8

1710 Turbidity = 13 NTU &
12 NTU

11/13/20

0600 ES, GS, AO, JM onsite w/ LO

0800 setup complete
out falls really flowing

0830 Begin sampling raw water

0855 Added more raw to totes in
middle of raw sampling

0950 Raw SW field parameters
T = 8.6 °C
DO = 93%, 10.76 mg/L
SPC = 32.5 µS/cm
ORP = 150.2 mV
pH = 5.31

1152 adding more raw SW to tote
rapid sand running @ 1gpm

~~1236 AZB2 Field parameters~~

 11/13/2020

12:23 Post rapid-sand Filter field parameters

T = 9.3°C
DO = 86.9%; 9.82 mg/L
SPC = 65.2 µS/cm
pH = 4.55
ORP = 172.8 mV

12:36 T = 9.4°C
~~DO = 83.2%; 9.38 mg/L~~
SPC = 64.4 µS/cm
pH = 4.64
ORP = 184.4 mV
DO = 81.5%, 9.33 mg/L

13:03 Post-GAC field parameters

T = 10.1°C
DO = 54.9%, 6.19 mg/L ↑
SPC = 67.1 µS/cm
pH = 5.97 ↑
ORP = ~~132.~~ 118.3 ↓

1308 post GAC
T = 10.1°C SPC = 68.4 µs/cm pH = 6.19 (stable)
ORP = 107.9 DO = 54.3 %, 6.11 mg/L

1315 post GAC Turbidity = 6 NTU
post rapid sand = 26 NTU

Post GAC duplicate. ID: SP11_C1C2

1506 Post UV FPS:
Turbidity = 7 NTU
T = 10.2°C
DO = 66.0%, 7.38 mg/L
pH = 5.45
SPC = 44.4 µs/cm
ORP = 142.2 mV

1515 Post SS
turbidity = 9 NTU

1530 T = 9.1°C
DO = 82.1 %, 9.43 mg/L ↓
SPC = 37.2 µs/cm
pH = 6.97 ↑
ORP = 173.0 mV ↓

 11/14/2020 Sterling Park

1300 AO onsite

1730 Refilled gas canister

1905 AO offsite, shut off generator

11/15/2020 Sterling Park

1015 AO on site

 11/16/2020 Sterling Park

0730 ES, GS, LO, AO onsite

0800 JM onsite

0830 Post slow-sand, pre AQUIP

T = 8.7°C
DO = 86.8% ; 10.12 mg/L
SPC = 41.6 μS/cm
pH = 6.74
ORP = 168.2 mV

0833 T = 8.7°C
DO = 84.1% ; 9.77 mg/L
SPC = 81.4 μS/cm
pH = 6.63
ORP = 144.5

0835 Turbidity = 9 NTU

0845 Post Aquip Field Par.
T = 8.7°C
DO = 96.1% , 11.17 mg/L
SPC = 247.0 μS/cm
pH = 6.46 ~~Turbidity =~~
ORP = 147.0 ↓ mV

0850 Post Aquip SS
Turbidity = 6 NTU

0900 Post Aquip (B1) field par #2
T = 8.8°C
DO = 89.9%, 10.38 mg/L ↓
SPC = 179.0 μS/cm
pH = 6.42
ORP = 139.6 mV ↓
Turb = 6 NTU

#3 T = 8.8°C
DO = 89.8%, 9.97 mg/L
SPC = 171.0 μS/cm
pH = 6.32
ORP = 121.0 mV
Turbidity = 5 NTU

1025 Post-GAC field par.
T = 9.5°C
DO = 56.4% ; 6.44 mg/L
SPC = 171.7 μS/cm
pH = 7.62
ORP = 38.0 mV ↓
Turbidity = 3 NTU
1130 Turbidity = 3 NTU

LOCATION	UNIT/MODEL	WATER QUALITY PARAMETER
Sample Point 1 Raw Water (Flow Control Structure)	**WQ Station 1 (Micro::Station)** Sensors pH::lyser Cond::lyser Spectro::lyser (5 mm) Controller con::cube V3	Spectro::lyser Turbidity BTX (Hydrocarbons) UV254 TOC pH::lyser pH Temperature Cond::lyser Conductivity
Sample Point 2 Finished Water (After Combined UV Treatment)	**WQ Station 2 (Micro::Station)** Sensors pH::lyser Cond::lyser Spectro::lyser (35 mm) Controller con::cube V3	
Sample Point 3 Non-Potable Finished Water (To Purple Pipe System)	**WQ Station 3** Analyzer HACH CL-17 Controller HACH SC200	Free Chlorine Residual

PLAN
SCALE: 1/8"=1'

\\ad.msa-ep.com\Portland\PDX_Projects\19\2519 - Beaverton Non-Potable Program\CAD\Sheets\Figures\19-2519-OR-FIG-2.dwg FIG 1 11/5/2021 8:13 AM JARED.CLOUD 23.0s (LMS Tech)

NO.	DATE	BY	REVISION

NOTICE
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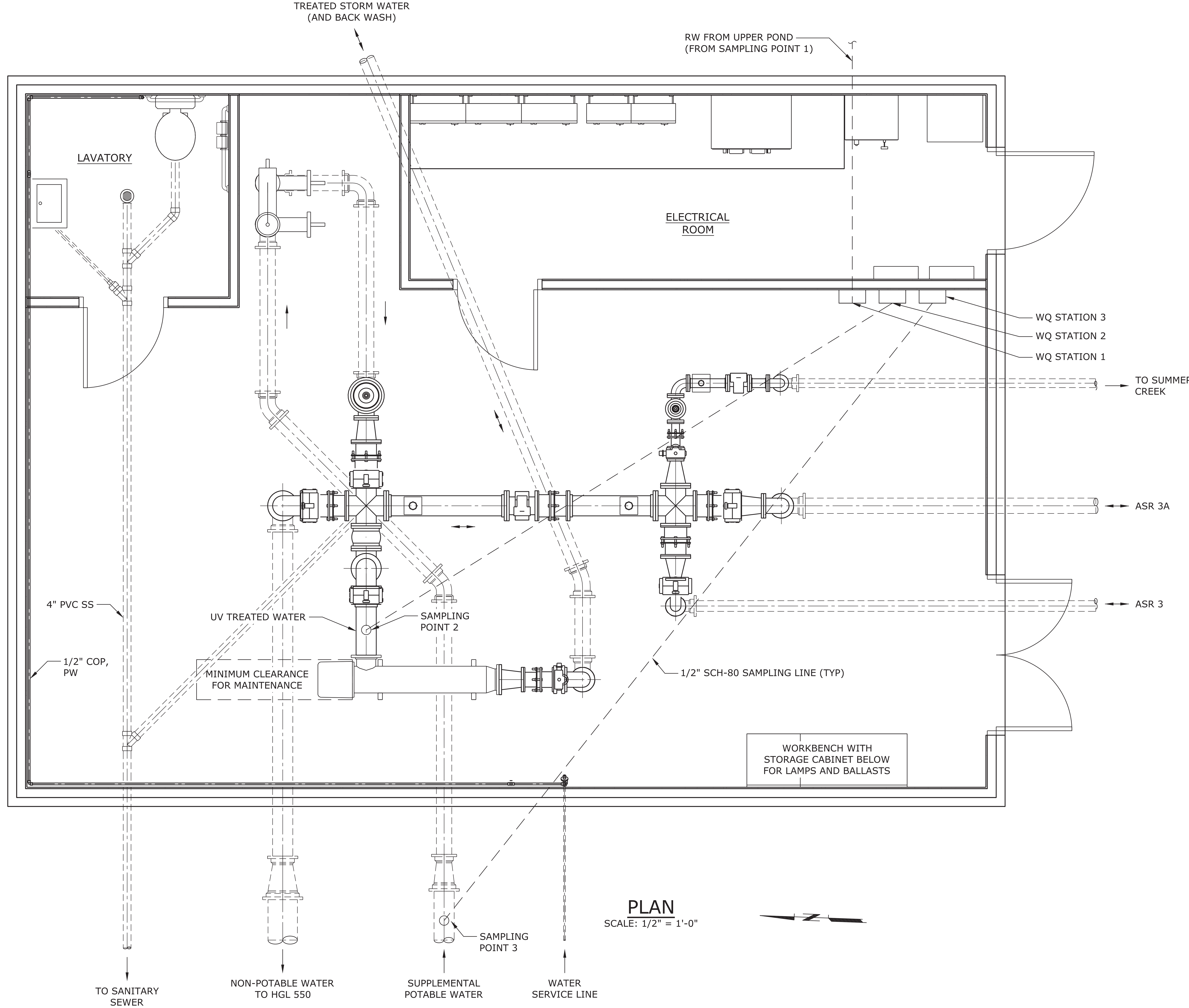
AQUIFER STORAGE AND RECOVERY (ASR) 3 FACILITY

WATER QUALITY SAMPLING PLAN

PROJECT NO.: 19-2519 | SCALE: AS SHOWN | DATE: NOVEMBER 2021

SHEET
FIG 1
X of X



\\ad.msa-ep.com\Portland\PDX_Projects\19\2519 - Beaverton Non-Potable Program\CAD\Sheets\Figures\19-2519-OR-FIG-2.dwg FIG 2 11/5/2021 8:13 AM JARED.CLOUD 23.0s (LMS Tech)

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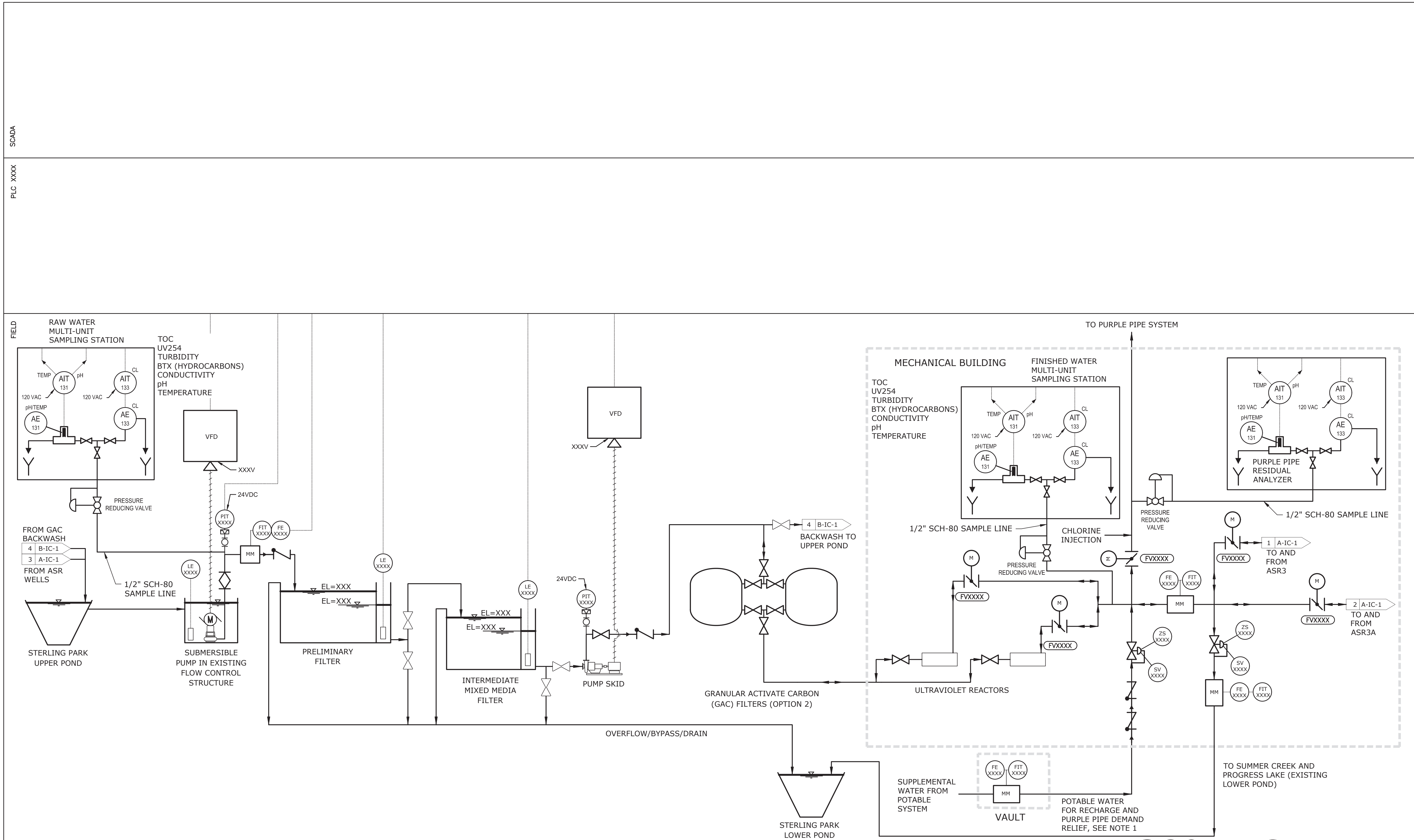
SHEET
FIG 2
X of X



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AQUIFER STORAGE AND RECOVERY (ASR) 3 FACILITY

SCHEDULE B
PROCESS & INSTRUMENTATION DIAGRAM
STORMWATER TREATMENT SYSTEM

PROJECT NO.: 19-2519 | SCALE: AS SHOWN | DATE: SEPTEMBER 2021

SHEET B-IC-1
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Multi-Unit Sampling Station:
- •TOC
- •UV254
- •Turbidity
- •BTX (Hydrocarbons)
- •Conductivity
- •pH
- •Temperature

micro::station

BTX
TOC
DOC
UV254
NO3
NO2
NH4
K+
TCl
FCl
F-
TSS
FTU/NTU
Color
pH
ORP
Conductivity
Temperature
O2
O3
H2S
AOC
Fingerprints
Alarms

The fully modular micro::station combines s::can instruments to a compact and versatile system. It presents a complete solution, as the user only has to connect water supply and -discharge ("plug & measure") in order to receive a previously unheard variety of immediately available information and parameters at no extra cost.

The s::can micro::station is designed for OnLine monitoring of water quality parameters in clean media, such as drinking water. The required components - spectro::lyser, s::can probes and controller - are factory assembled with all required flow cells, mounting fittings and pipework on a compact panel.

micro::station - the s::can solution for water analysis - compact and easy like never before.

1 Terminal

con::cube terminal with moni::tool software for data acquisition, data display and station control

2 Spectrometer probe

All s::can spectrometer probes are multiparameter instruments that can measure a variety of water quality parameters

Possible parameters:
AOC, BOD, BTX, COD, color, DOC, FTU/NTU, H_2S, NO_2-N, NO_3-N, O_3, TOC, TSS, UV254, fingerprints and spectral alarms, temperature and pressure

3 Flow cell for spectrometer probe

Including auto brush cleaning device to provide cleaning of the optical measuring windows

4 System tubing

Included in panel assembly; Material PU, inside diameter 6 mm, outside diameter 8 mm

5 Flow detector

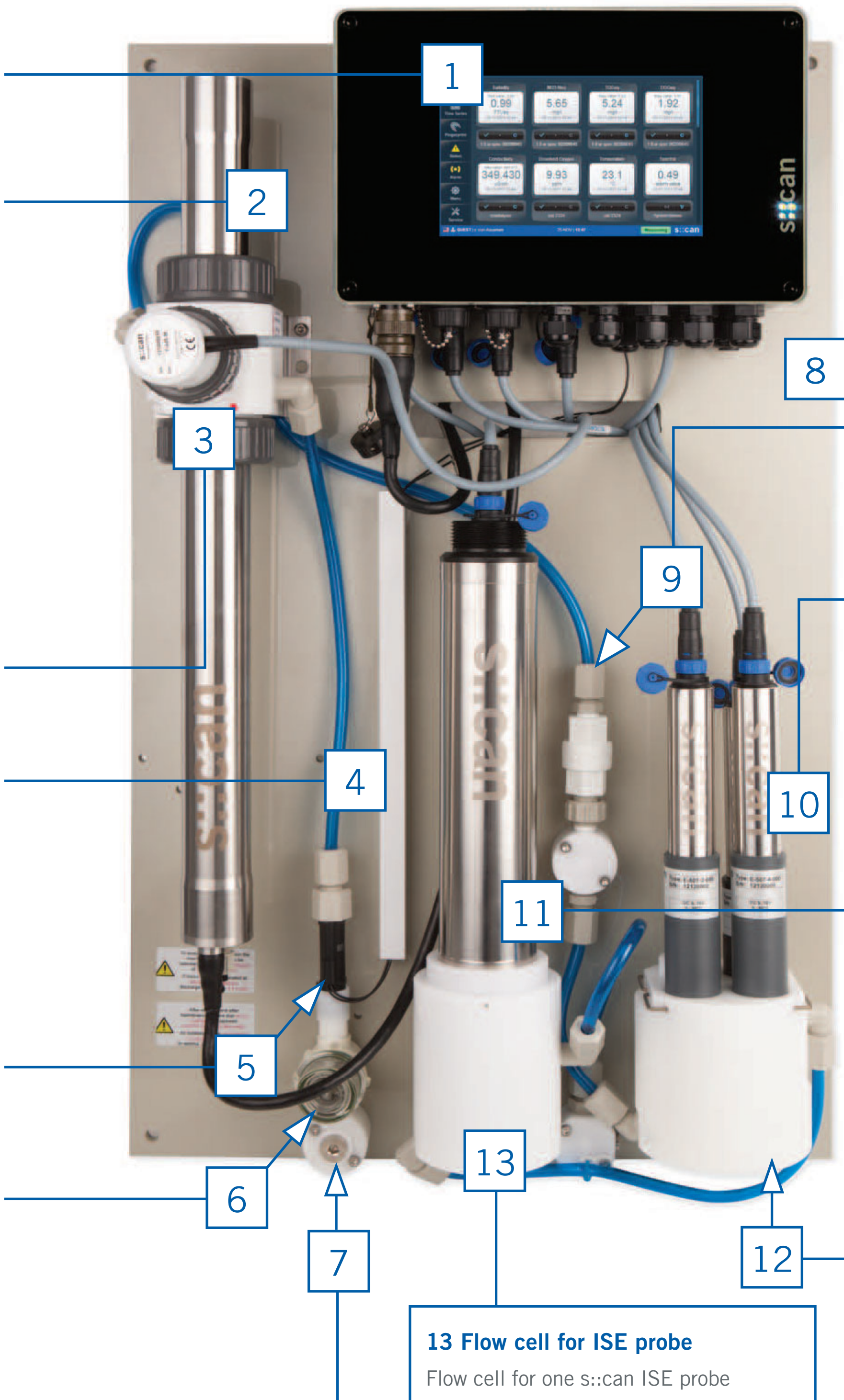
The flow detector is set to give an alarm if the flow rate decreases below a critical value

6 Inlet strainer

The inlet strainer ascertains that no coarse material enters the micro::station. With screw cap for sieve removal/cleaning

7 Pressure transmitter (optional)

Mounting position for pressure transmitter



8 Main panel

Material: PP
Weight of the station (fully equipped): 20 kg (+/- 1 kg)

9 Flow restrictor unit

For automatic flow restriction and back-flow prevention in by-pass

10 Physical probes

Up to four s::can physical probes can be installed in one flow cell

Possible parameters:
conductivity, FCl, pH, PSU, redox, TCl and temperature

11 Physical probe or ISE probe

Place for oxi::lyser, soli::lyser or s::can ISE probe (e.g. ammo::lyser)

Possible parameters:
F-, K+, NH_4-N, NO_3-N, O_2, pH and temperature

12 Flow cell for physical probes

Combined flow cell for up to four s::can physical probes. Provides quick connect/disconnect design by safety pins to reduce offline time during sensor maintenance

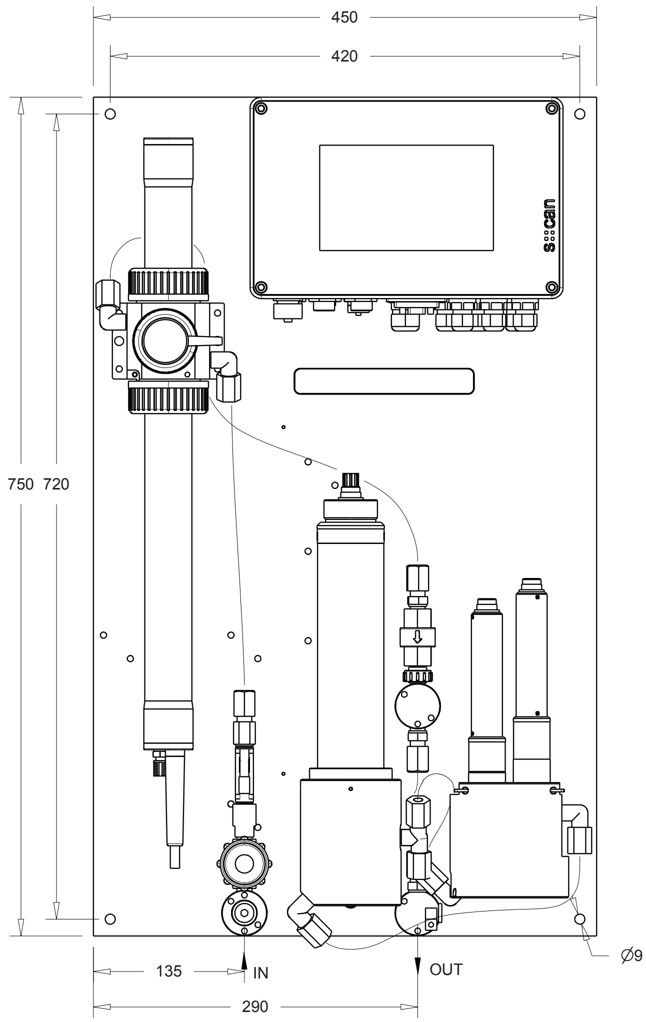
13 Flow cell for ISE probe

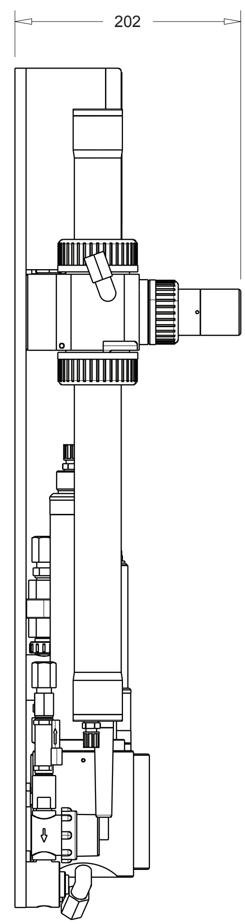
Flow cell for one s::can ISE probe

micro::station

Options for s::can micro::station

1 Terminal	con::cube con::lyte eco con::lyte pro
2 Spectrometer probe	spectro::lyser carbo::lyser color::lyser multi::lyser nitro::lyser ozo::lyser uv::lyser
3 Flow cell for spectrometer probe	flow-cell (by-pass fitting), POM-C (for pathlengths from 1 mm to 35 mm) flow-cell (by-pass fitting), POM-C (for pathlength 100 mm) flow-cell (by-pass fitting) autobrush, POM-C (for pathlength 35 mm) flow-cell (by-pass fitting) autobrush, POM-C (for pathlength 100 mm)
4 System tubing	inside diameter 6 mm, outside diameter 8 mm
5 Flow detector	flow detector
6 Inlet strainer	inlet strainer
7 Pressure transmitter	pressure transmitter for micro::station (optional)
8 Main panel	system panel micro::station US system panel micro::station EU system panel micro::station add-on module EU system panel micro::station add-on module US
9 Flow restrictor unit	automatic flow restrictor unit flow adjustment valve
10 Physical probes	pH::lyser redo::lyser condu::lyser chlori::lyser
11 Physical probe or ISE probe	ammo::lyser eco ammo::lyser pro fluor::lyser oxi::lyser soli::lyser
12 Flow cell for physical probes	flow-cell for up to 4 s::can physical probes, POM-C s::can physical probe flow-cell (by-pass setup), POM-C
13 Flow cell for ISE probe or physical probe	ammo::lyser flow-cell (by-pass setup), POM-C oxi::lyser flow-cell


450
420
750
720
s::can
135
IN
OUT
290
Ø9


202

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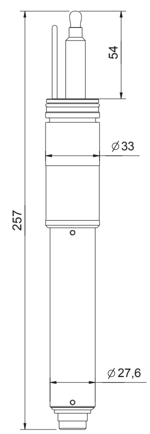
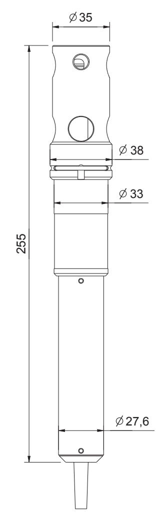
pH::lyser

pH::lyser eco monitors pH & temperature

pH::lyser pro: high temperature range

- s::can plug & measure
- measuring principle: unique, non-porous / non-leaking combined reference electrode for technically unrivalled and consistent pH performance
- multiparameter sensor
- ideal for surface water, ground water, drinking water and waste water
- long term stable and maintenance free in operation
- factory precalibrated
- mounting and measurement directly in the media (InSitu) or in a flow cell
- operation via s::can terminals & s::can software
- optional: automatic cleaning with compressed air
- plug connection or fixed cable





recommended accessories	
part number	**article name**
D-330-xxx	con::cube V3
D-320-xxx	con::lyte
C-1-010-sensor	1 m connection cable for s::can physical and ISE probes
F-12-sensor	carrier s::can physical probes
F-45-four	flow cell for four s::can physical probes
F-46-four-iscan	i::scan flow cell for up to 3 additional s::can probes
F-45-sensor	flow cell for s::can sensor
S-11-xx-moni	moni::tool Software

technical specification

measuring principle	potentiometric
measuring principle detail	combined, non-porous reference electrode
resolution	0.01 pH
accuracy (standard solution)	0.1 pH
automatic compensation instrument	temperature
response time (T90)	30 ... 0 sec.
integrated temperature sensor	0 ... 90 °C
integration via	con::cube con::lyte con::nect
power supply	9 … 18 VDC
power consumption (typical)	0.8 W
power consumption (max.)	1 W
interface to s::can terminals	sys plug (IP67), RS485
cable length	7.5 m fixed cable (-075) or plug connection (-000)
cable type	PU jacket

housing material	stainless steel 1.4404/1.4401, POM-C or stainless steel 1.4404/1.4401, PVC (E-514-4-075)
weight (min.)	400 g
dimensions (Ø x l)	33 x 257 mm
operating pressure	0 ... 10 bar
installation / mounting	submersed or in a flow cell
process connection	quick connect
flow velocity	3 m/s (max.) 0.01 m/s (min.)
automatic cleaning	media: compressed air permissible pressure: 3 ... 6 bar
storage temperature (electrode)	-5 ... 30 °C
storage temperature (sensor)	-10 ... 60 °C
conformity - EMC	EN 61326-1
conformity - safety	EN 61010-1
operating temperature (eco)	0 ... 70 °C
operating temperature (pro)	0 ... 90 °C
protection class (-000)	IP67
protection class (-075)	IP68

measuring range

		parameter		
		pH [pH]	temperature [°C]	part number
pH::lyser eco (pH, temp)	min.	2	0	E-514-2-000 / -075
	max.	12	70	
pH::lyser pro (pH, temp)	min.	0	0	E-514-3-000 / -075
	max.	14	90	

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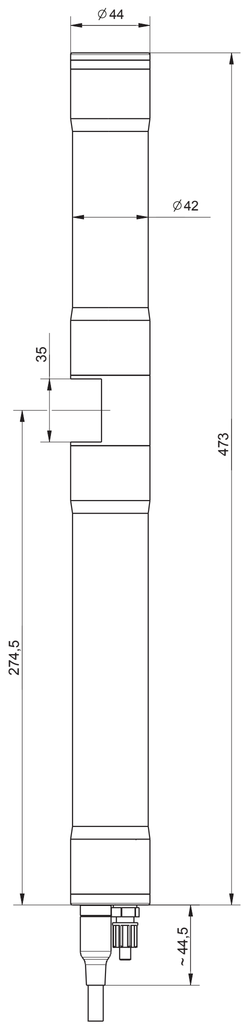
spectro::lyser V3

spectro::lyser® UV-Vis monitors depending on the application an individual selection of: TSS, TS, turbidity, color, TOC, DOC, BOD, COD, NO_3-N, NO_3, HS-, O_3, CLD, UV254, fingerprints, spectral alarms and temperature BTX

- measuring principle: UV-Vis spectrometry over the total range (190-750 nm)
- web server on board - IoT enabled, no user software is needed to configure the probe
- communicates directly with your mobile device via WLAN
- 8 GB onboard memory - capacity for logging data for many years
- improved optical performance - revolutionary precision
- fast measurement interval - every 10 seconds possible
- extremely power efficient - sleep mode for low energy consumption
- multiparameter probe with 1 mm, 5 mm or 35 mm optical path length, ideal for waste water, surface water and drinking water
- long term stable and maintenance free in operation
- factory precalibrated, local multi-point calibration possible
- automatic cleaning with compressed air or brush



recommended accessories

part number	article name
D-330-xxx	con::cube V3
B-33-012	con::nect V3
B-32-xxx	s::can compressor
B-44 B-44-2	cleaning valve
C-32-V3	Adapter cable to connect a V3 spectrometer (M12) to V2 Terminal (MIL Plug)
F-110-V3	carrier s::can spectrometer V3 & V2 probe, 45°
F-120-V3	carrier s::can spectrometer V3 & V2 probe, vertical attachment
F-446-V3	flow cell AutoBrush, POM-C (for spectrometer V3 & V2 pathlength 35 mm)
S-11-xx-moni	moni::tool Software

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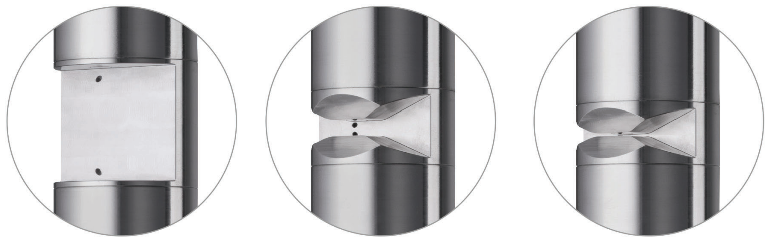
technical specification	
measuring principle	UV-Vis spectrometry 190 - 750 nm
measuring principle detail	xenon flash lamp, pixel array detector
measurement interval	10 sec (configurable, depending on application)
automatic compensation instrument	real dual beam measurement for compensation and detailed diagnostics
automatic compensation cross sensitivities	turbidity / solids / organic substances
precalibrated ex-works	all parameters
accuracy standard solution (>1 mg/l)	NO_3-N: +/- 2% +1/OPL[mg/l]* COD-KHP: +/-2% +10/OPL[mg/l]* (* OPL … optical pathlength in mm)
access to raw signals	access to spectral information
reference standard	distilled water
onboard memory	8 GB
integrated temperature sensor	0 … 45 °C
resolution temperature sensor	0.1 °C
integration via	con::cube V3 con::nect V3 con::lyte V5 (D-320-pro2) and adapter cable (C-32-V3)
power supply	10 … 18 VDC
power consumption (typical)	3 W
power consumption (sleep model)	60 mW
power consumption (max.)	20 W
interface to s::can terminals	M12 RSTS 8Y (IP67), RS485, Ethernet
interface to third party terminals	con::nect V3 incl. Modbus RTU, REST API, Modbus TCP/IP
digital interface (for cleaning devices)	1 digital in/out 1 digital out
network connection	100Base-T Ethernet, WLAN
status information	RGB LED ring
internal sensors	supply voltage sensor, tilt sensor, rotation sensor
cable length	1 m fixed cable (-010) or 7.5 m fixed cable (-075) or 15 m fixed cable (-150)
cable type	PU jacket
housing material	stainless steel 1.4404
window material	optical path length 5 and 1 mm: sapphire optical path length 35 mm: fused silica (UV-grade)
weight (min.)	3.4 kg (incl. cable)
dimensions (Ø x l)	optical path length 35 mm: 44 x 473 mm / 517.5 mm optical path length 5 mm: 44 x 457 mm / 501.5 mm optical path length 1 mm: 44 x 453 mm / 497.5 mm
operating temperature	0 … 45 °C
operating pressure	0 … 3 bar
high pressure specification (optional)	10 bar
installation / mounting	submersed or in a flow cell
flow velocity	3 m/s (max.)
mechanical stability	30 Nm
ingress protection class	IP68
automatic cleaning	media: compressed air or autobrush permissible pressure: 3 … 6 bar
storage temperature	-10 … 65 °C
conformity - environmental testing	EN 60721-3
conformity - EMC	EN 61326-1
conformity - RoHS 2	EN 50581
standard warranty	2 years
extended warranty (optional)	3 years

The perfect accuracy for every application

The spectro::lyser V3 is available with three different optical path lengths.



drinking water:	surface water:	waste water:
35 mm	5 mm	1 mm

Optical information ring

The color of the optical information ring signals the state of the sensor.

everything okay	sensor in service mode	parameter or device error

Wireless communication - Io::Tool

Intuitive web interface for data visualization and configuration of the spectro::lyser V3.

ground water

		parameter										
		turbidity [NTU/FTU]	color (app) [Hazen]	color (tru) [Hazen]	TOC [mg/l]	DOC [mg/l]	NO_3 [mg/l]	UV254 [Abs/m]	UV254 f [Abs/m]	BTX [mg/l]	H_2S [mg/l]	part number
spectro::lyser™ V3 (35 mm OPL, UV-Vis)	min.	0	0	0	0	0	0	0	0	0	0	SP3-1-35-NO-xxx
	max.	170	500	300	20	15	88	71	60	51	5	

surface water

		parameter																
		TSS [mg/l]	turbidity [NTU/FTU]	color (app) [Hazen]	color (tru) [Hazen]	TOC [mg/l]	DOC [mg/l]	BOD [mg/l]	COD [mg/l]	COD f [mg/l]	NO_3 [mg/l]	HS- [mg/l]	Chl-a [µg/l]	UV254 [Abs/m]	UV254 f [Abs/m]	BTX [mg/l]	part number
spectro::lyser™ V3 (35 mm OPL, UV-Vis)	min.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SP3-1-35-NO-xxx
	max.	170	200	500	300	30	25	42	71	42	66	5	100	71	60	51	
spectro::lyser™ V3 (5 mm OPL, UV-Vis)	min.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	SP3-1-05-NO-xxx
	max.	1200	1400	3500	2100	210	180	300	500	300	460	35	700	500	420	360	

drinking water

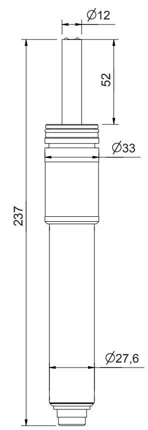
		parameter											
		turbidity [NTU/FTU]	color (app) [Hazen]	color (tru) [Hazen]	TOC [mg/l]	DOC [mg/l]	NO_3 [mg/l]	chloramine [mg/l]	O_3 [mg/l]	CLD [mg/l]	UV254 [Abs/m]	UV254 f [Abs/m]	part number
spectro::lyser™ V3 (35 mm OPL, UV-Vis)	min.	0	0	0	0	0	0	0	0	0	0	0	SP3-1-35-NO-xxx
	max.	170	500	300	22	17	88	42	25	22	71	60	

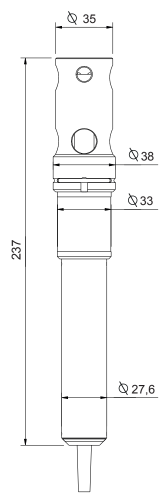
condu::lyser

condu::lyser monitors conductivity, temperature & salinity*

- s::can plug & measure
- measuring principle condu::lyser: 4-electrode, direct-contact measurement
- multiparameter sensor
- ideal for surface water, ground water, drinking water and waste water
- long term stable and maintenance free in operation
- factory precalibrated
- mounting and measurement directly in the media (InSitu) or in a flow cell
- operation via s::can terminals & s::can software
- plug connection or fixed cable

recommended accessories	
part number	**article name**
D-330-xxx	con::cube V3
D-320-xxx	con::lyte
C-1-010-sensor	1 m connection cable for s::can physical and ISE probes
F-12-sensor	carrier s::can physical probes
F-45-four	flow cell for four s::can physical probes
F-46-four-iscan	i::scan flow cell for up to 3 additional s::can probes
F-45-sensor	flow cell for s::can sensor
S-11-xx-moni	moni::tool Software





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technical specification

measuring principle	4-electrode, direct-contact
resolution	1 µS/cm
accuracy (standard solution)	1% of reading
automatic compensation instrument	temperature
integrated temperature sensor	-20 ... 130 °C
integration via	con::cube con::lyte con::nect
power supply	7 ... 30 VDC
power consumption (typical)	0.06 W
power consumption (max.)	0.15 W
interface to s::can terminals	sys plug (IP67), RS485
cable length	7.5 m fixed cable (-075) or plug connection (-000)
housing material	Stainless steel 1.4435, FDA-approved PEEK, POM-C
weight (min.)	240 g
dimensions (Ø x l)	33 x 237 mm
operating temperature	0 ... 70 °C
operating pressure	0 ... 20 bar
installation / mounting	submersed or in a flow cell
process connection	quick connect
flow velocity	0.01 m/s (min.) 3 m/s (max.)
automatic cleaning	media: compressed air permissible pressure: 2 ... 6 bar
storage temperature	0 ... 60 °C
conformity - EMC	EN 61326-1
protection class (-000)	IP67
protection class (-075)	IP68

measuring range

		parameter			
		conductivity [µS/cm]	temperature [°C]	salinity* [PSU]	part number
condu::lyser	min.	0	0	2	E-511-2-000 / -075
	max.	500000	70	42	

* Salinity measurement ist only possible in combination with con::cube terminal

HACH
Be Right™

CL17sc Colorimetric Chlorine Analyzer with Standpipe Installation Kit and Reagents for Free Chlorine

Product #: **8572700**

USD Price: $2,655.00
Ships within 6-8 weeks

Hazardous

Items with this mark may be considered hazardous under some shipping conditions.

If necessary, we will change your selected shipping method to accomodate these items.

The Next Standard in Chlorine Analysis

The CL17sc online chlorine analyzer extends Hach's decades-long legacy as the leader in online chlorine analysis. It uses EPA-approved colorimetric DPD analysis to deliver accurate and reliable measurements of free or total residual chlorine. Whether you use online chlorine measurements to optimize your process or report to regulatory agencies, the CL17sc is the analyzer you can trust.

Connection to Hach's SC controller platform gives you more flexibility to transfer, store, and interact with your chlorine measurement data, resulting in better understanding and control of your process, more cost-effective decision-making, and greater peace of mind that your data is always there no matter what happens.

A built-in flow meter, three-color status light, LED measurement cycle lights, and colorimeter window allow you to quickly and efficiently see that your CL17sc is functioning properly.

The CL17sc can also be used with Hach's Claros Water Intelligence System. With the innovative Claros Mobile Sensor Management, you can view measurements and instrument status anytime, anywhere, on any web-enabled device. Alerts for upcoming maintenance and issues requiring immediate attention are all in the palm of your hand. Detailed, step-by-step illustrated instructions for routine maintenance tasks also allow you to feel confident that you have performed routine maintenance correctly.

- Accurate, reliable online measurement of free or total residual chlorine

- Compliant with US EPA 40 CFR 141.74

- On-screen, guided workflows for routine maintenance tasks

- Comprehensive diagnostic features, including built-in flow meter, multi-color status light, and colorimeter window

- Available Claros Mobile Sensor Management for measurement data and instrument status anytime, anywhere

Maintenance made easy
The CL17sc reduces your routine maintenance touch time with programmable alerts, simplified tubing replacement, and step-by-step maintenance instructions.

Peace of mind through comprehensive diagnostics
With upgraded features like a flow meter, colorimeter window, multi-color status light, and predictive diagnostic software, you know your instrument is operating as intended.

Expanded connectivity. Increased flexibility.

By pairing the CL17sc with Hach's SC controller platform, your options increase significantly: internal data logging; external analog and digital communication alternatives; and multi-parameter instrument flexibility.

The CL17sc is compliant with US EPA regulation 40 CFR 141.74. Both Method 4500-CL G and Method 334.0 can be used for measuring residual chlorine in drinking water.

Specifications

Accuracy:	± 5% or ± 0.04 mg/L (whichever is greater) from 0 - 5 mg/L Cl_2 ± 10% from 5 - 10 mg/L Cl_2
Air Purge:	Optional with 3/8-inch quick-connect fitting and tubing; 0.003 m^3/min at 1.38 bar (20 psig) maximum
Alerts:	Low and high chlorine. Dirty cell. Low and high sample flow.
Certifications:	CE compliant with: EN 61326-1, CISPR 11, EN 50581 ACMA RCM South Korea KC Certificate North America: FCC Supplier's Declaration of Conformance, IEC/EN 60529, ICES-003
Controller Compatibility:	SC200, SC1000, SC1500, SC4200c
Cycle Time:	2.5 minutes
Dimensions (H x W x D):	342 mm x 329 mm x 177 mm
Drain:	½-inch ID flexible hose
Enclosure Rating:	IP66
Inlet:	¼-inch OD polyethylene tube, quick-disconnect fitting
Inlet Pressure:	0.3 - 5.2 bar (4.5 - 75 psig) supplied to Y-strainer 0.1 - 0.3 bar (1.5 - 5 psig) supplied to analyzer
Installation Kit:	Standpipe Installation Kit
Interferences:	Other oxidizing agents such as bromide, chlorine dioxide, permanganate, and ozone will cause a positive interference. Hardness must not exceed 1,000 mg/L $CaCO_3$.
Light Source:	LED, measurement at 510 nm, 1 cm light pathlength
Lower Limit of Detection (LOD):	0.03 mg/L
Mounting:	Wall mount
Operating Humidity:	0 - 90% relative humidity, non-condensing
Operating Temperature Range:	5 - 40 °C (41 - 104 °F)
Parameter:	Chlorine, free
Power Requirements (Voltage):	12 VDC, 400 mA maximum (supplied by the controller)
Range:	0 -10 mg/L Cl_2
Reagent Consumption:	0.5 L of buffer solution and 0.5 L of indicator solution in 31 days
Region:	US
Sample Flow Rate:	60 - 200 mL/min through the instrument
Sample Requirements:	Y-strainer filtration with 40-mesh screen or higher
Sample Temperature:	5 - 40 °C (41 - 104 °F)
Warranty:	12 months
Weight:	4.1 kg (9.0 lbs.)
What's included?:	CL17sc Chlorine Analyser with 1 Month Supply of Free Chlorine Reagents, Standpipe Installation Kit, and User Manual. User provides screws and/or anchors for mounting.

Hach SC controller is required for operation and is sold separately.

What's included?

CL17sc Chlorine Analyser with 1 Month Supply of Free Chlorine Reagents, Standpipe Installation Kit, and User Manual. User provides screws and/or anchors for mounting.Hach SC controller is required for operation and is sold separately.

Required Accessories

- SC1000 Probe Module for 4 Sensors, 4x 4-20 mA OUT, 4x mA/digital IN, 4x Relays, Modbus RS485, 100-240 VAC, Conduit, w/o power cord (Item LXV400.99.1B572)
- SC200 Universal Controller: 100-240 V AC with two digital sensor inputs and two 4-20 mA outputs (Item LXV404.99.00552)
- SC1500 Controller, 6 SENS 8mA OUT 110V/COND EXT MOD (Item LXV446.99.103N1)
- SC4200c Controller, North American Cellular Modem, mA out, 2 digital Sensors, w/o plug (Item LXV524.99.01120)

SC200™ UNIVERSAL CONTROLLER

Applications

- Drinking Water
- Wastewater
- Industrial Water
- Power

One Controller for the Broadest Range of Sensors.

Choose from 30 digital and analog sensor families for up to 17 different parameters.

Maximum Versatility

The SC200 controller allows the use of digital and analog sensors, either alone or in combination, to provide compatibility with Hach's broad range of sensors, eliminating the need for dedicated, parameter-specific controllers.

Ease of Use and Confidence in Results

Large, high-resolution, transreflective display provides optimal viewing resolution in any lighting condition. Guided calibration procedures in 19 languages minimize complexity and reduce operator error. Password-protected SD card reader offers a simple solution for data download and transfer. Visual warning system provides critical alerts.

Wide Variety of Communication Options

Utilize two to five analog outputs to transmit primary and secondary values for each sensor, or integrate Hach® sensors and analyzers into MODBUS RS232/RS485, Profibus® DP, and HART networks.

Password protected SD card reader offers a simple solution for data download and transfer, and SC200 and digital sensor configuration file duplication and backup.

HACH®
Be Right™

Controller Comparison

Features	Previous Models SC100™ Controller	 GLI53 Controller	SC200™ Controller	Benefits
Display	64 x 128 pixels 33 x 66 mm (1.3 x 2.6 in.)	64 x 128 pixels 33 x 66 mm (1.3 x 2.6 in.)	160 x 240 pixels 48 x 68 mm (1.89 x 2.67 in.) Transreflective	• Improved user interface—50% bigger • Easier to read in daylight and sunlight
Data Management	irDA Port/PDA Service Cable	N/A	SD Card Service Cable	• Simplifies data transfer • Standardized accessories/max compatibility
Sensor Inputs	2 Max Direct Digital Analog via External Gateway	2 Max Analog Depending on Parameter	2 Max Digital and/or Analog with Sensor Card	• Simplifies analog sensor connections • Works with analog and digital sensors
Analog Inputs	N/A	N/A	1 Analog Input Signal Analog 4-20mA Card	• Enables non-sc analyzer monitoring • Accepts mA signals from other analyzers for local display • Consolidates analog mA signals to a digital output
4-20 mA Outputs	2 Standard	2 Standard	2 Standard Optional 3 Additional	• Total of five (5) 4-20 mA outputs allows multiple mA outputs per sensor input
Digital Communication	MODBUS RS232/RS485 Profibus DP V1.0	HART	MODBUS RS232/RS485 Profibus DP V1.0 HART 7.2	• Unprecedented combination of sensor breadth and digital communication options

Choose from Hach's Broad Range of Digital and Analog Sensors

Parameter	Sensor	Digital or Analog
Ammonia	Amtax™ sc, NH4D sc, A-ISE sc, AN-ISE sc	●
Chlorine	CLF10sc, CLT10sc, 9184sc	●
Chlorine Dioxide	9187sc	●
Conductivity	GLI 3400 Contacting, GLI 3700 Inductive	△
Dissolved Oxygen	LDO® Model 2, 5740sc	●
Dissolved Oxygen	5500	△
Flow	U53, F53 Sensors	△
Nitrate	Nitratax™ sc, NO3D sc, N-ISE sc, AN-ISE sc	●
Oil in Water	FP360 sc	●
Organics	UVAS sc	●
Ozone	9185sc	●
pH/ORP	pHD	●
pH/ORP	pHD, pH Combination, LCP	△
Phosphate	Phosphax™ sc	●
Sludge Level	Sonatax™ sc	●
Suspended Solids	Solitax™ sc, TSS sc	●
Turbidity	1720E, FT660 sc, SS7 sc, Ultraturb sc, Solitax sc, TSS sc	●
Ultra Pure Conductivity	8310, 8311, 8312, 8315, 8316, 8317 Contacting	△
Ultra Pure pH/ORP	8362	△

● = Digital △ = Analog

Connect up to two of any of the sensors listed above, in any combination, to meet your application needs. The diagrams below demonstrate the potential configurations. Operation of analog sensors requires the controller to be equipped with the appropriate sensor module. Contact Hach Technical Support for help with selecting the appropriate module.

2 Channel Configurations

●	●
●	△
△	△

1 Channel Configurations

●
△

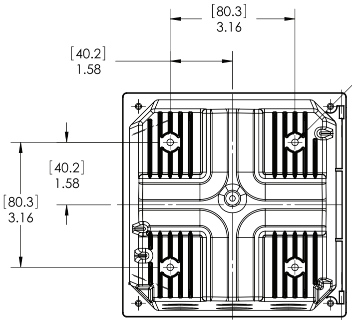
Specifications*

Dimensions (H x W x D)	5.7 in x 5.7 in x 7.1 in (144 mm x 144 mm x 181 mm)
Display	Graphic dot matrix LCD with LED backlighting, transreflective
Display Size	1.9 x 2.7 in. (48 mm x 68 mm)
Display Resolution	240 x 160 pixels
Weight	3.75 lbs. (1.70 kg)
Power Requirements (Voltage)	100 - 240 V AC, 24 V DC
Power Requirements (Hz)	50/60 Hz
Operating Temperature Range	-20 to 60 °C , 0 to 95% RH non-condensing
Analog Outputs	Two (Five with optional expansion module) to isolated current outputs, max 550 Ω , Accuracy: ± 0.1% of FS (20mA) at 25 °C, ± 0.5% of FS over -20 °C to 60 °C range Operational Mode: measurement or calculated value
Analog Output Functional Mode	Linear, Logarithmic, Bi-linear, PID
Security Levels	2 password-protected levels
Mounting Configurations	Wall, pole, and panel mounting
Enclosure Rating	NEMA 4X/IP66
Conduit Openings	1/2 in NPT Conduit
Relay: Operational Mode	Primary or secondary measurement, calculated value (dual channel only) or timer
Relay Functions	Scheduler (Timer), Alarm, Feeder Control, Event Control, Pulse Width Modulation, Frequency Control, and Warning
Relays	Four electromechanical SPDT (Form C) contacts, 1200 W, 5 A
Communication	Modbus RS232/RS485, Profibus DPV1, or HART 7.2 optional
Memory Backup	Flash memory
Electrical Certifications	EMC CE compliant for conducted and radiated emissions: - CISPR 11 (Class A limits) - EMC Immunity EN 61326-1 (Industrial limits) Safety cETLus safety mark for: - General Locations per ANSI/UL 61010-1 & CAN/CSA C22.2. No. 61010-1 - Hazardous Location Class I, Division 2, Groups A,B,C & D (Zone 2, Group IIC) per FM 3600 / FM 3611 & CSA C22.2 No. 213 M1987 with approved options and appropriately rated Class I, Division 2 or Zone 2 sensors cULus safety mark - General Locations per UL 61010-1 & CAN/CSA C22.2. No. 61010-1

**Subject to change without notice.*

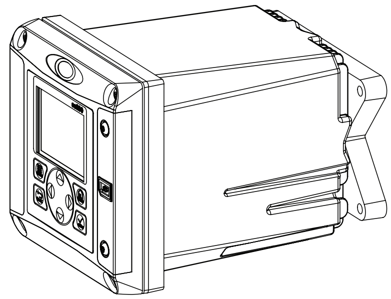
Dimensions

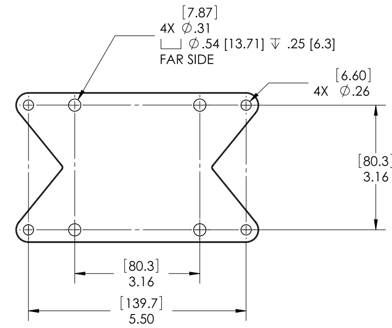
Surface Mounting Dimensions



Mounting Dimensions
(Rear View)

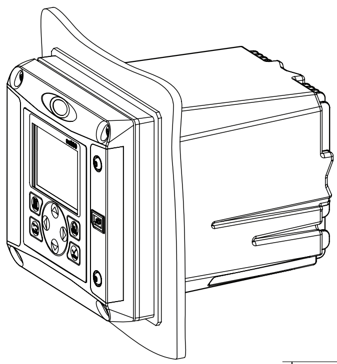
OR

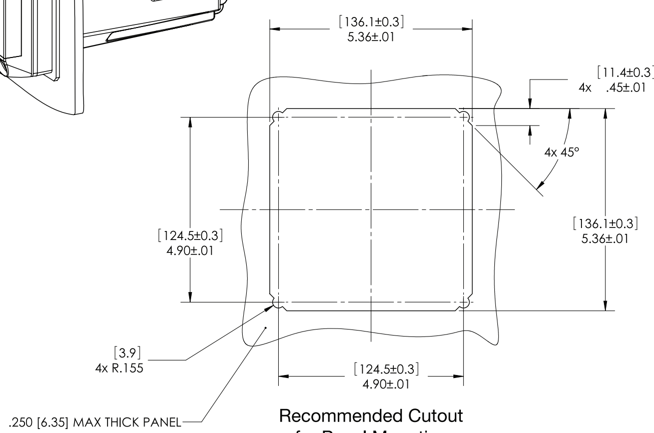




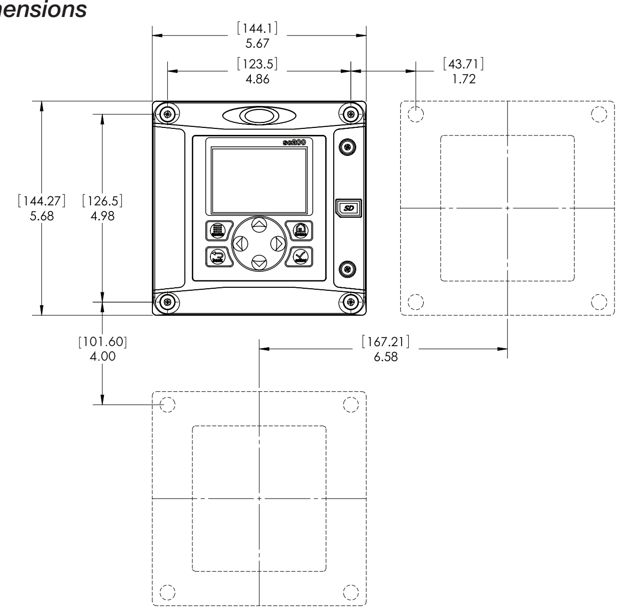
Bracket (supplied) for Surface Mounting
(Not compatible with Weather and Sun Shield
p/n 9220600 when surface mounting.)

Panel Mounting Dimensions



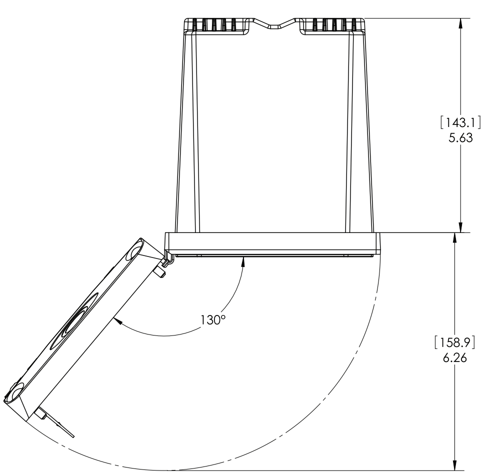


Recommended Cutout
for Panel Mounting

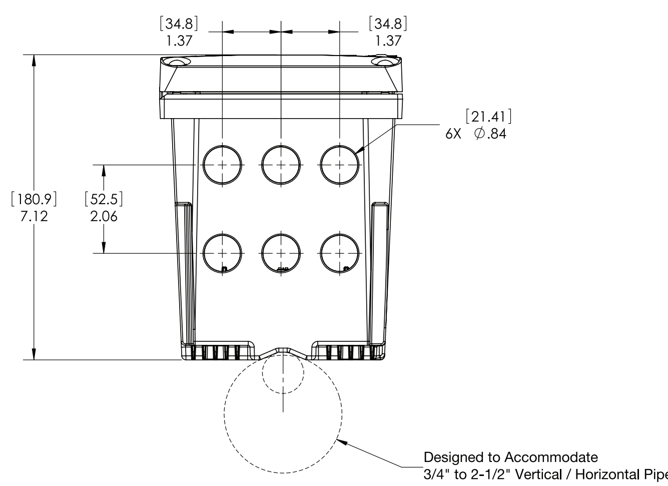


Minimum Spacing Dimensions
for Group Mounting

Top and Bottom Views



Door Opening Details



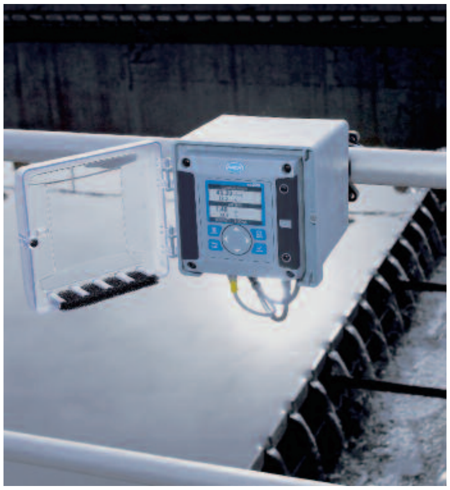
Ordering Information

SC200 for Hach Digital and Analog Sensors

LXV404.99.00552	SC200 controller, 2 channels, digital
LXV404.99.00502	SC200 controller, 1 channel, digital
LXV404.99.00102	SC200 controller, 1 channel, pH/DO
LXV404.99.00202	SC200 controller, 1 channel, Conductivity
LXV404.99.01552	SC200 controller, 2 channels, digital, Modbus RS232/RS485
LXV404.99.00112	SC200 controller, 2 channel, pH/DO

Note: Other Sensor combinations are available. Please contact Hach Technical Support or your Hach representative.

Note: Communication options (Modbus, Profibus DPV1, and HART) are available. Please contact Hach Technical Support or your Hach representative.



SC200 for Ultrapure Sensors

9500.99.00602	SC200 controller, 1 channel, ultrapure conductivity
9500.99.00702	SC200 controller, 1 channel, ultrapure pH
9500.99.00662	SC200 controller, 2 channel, ultrapure conductivity
9500.99.00772	SC200 controller, 2 channel, ultrapure pH

Sensor and Communication Modules

9012900	Analog pH/ORP and DO module for GLI Sensors
9013000	Analog Conductivity module for GLI Sensors
9012700	Flow module
9012800	4-20 mA Input Module
9525700	Analog pH/ORP Module for Polymetron Sensors
9525800	Analog Conductivity Module for Polymetron Sensors
9013200	Modbus 232/485 Module
9173900	Profibus DP Module
9328100	HART Module
9334600	4-20 mA Output Module (Provides 3 additional mA Outputs)

Accessories

9220600	SC200 Weather and Sun Shield with UV Protection Screen
8809200	SC200 UV Protection Screen
9218200	SD card reader (USB) for connection to PC
9218100	4 GB SD card

HACH COMPANY World Headquarters: Loveland, Colorado USA

United States: 800-227-4224 tel 970-669-2932 fax orders@hach.com
Outside United States: 970-669-3050 tel 970-461-3939 fax int@hach.com
hach.com

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APPENDIX D

OWRD Well Logs and As-Built Diagrams

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WASH 78442

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765 & OAR 690-205-0210)

WELL I.D. LABEL# L 128831
START CARD # 216481
ORIGINAL LOG #

WASH 78442

(1) LAND OWNER

Owner Well I.D.
First Name ____ Last Name ____
Company: City of Beaverton
Address: PO Box 4755
City: Beaverton State: OR Zip: 97076

(2) TYPE OF WORK

[x] New Well [ ] Deepening [ ] Conversion
[ ] Alteration (complete 2a & 10) [ ] Abandonment(complete 5a)

(2a) PRE-ALTERATION

Casing: Dia + From To Gauge Stl Plstc Wld Thrd

Seal: Material From To Amt sacks/lbs

(3) DRILL METHOD

[x] Rotary Air [ ] Rotary Mud [ ] Cable [ ] Auger [ ] Cable Mud
[x] Reverse Rotary [ ] Other

(4) PROPOSED USE

[ ] Domestic [x] Irrigation [ ] Community
[ ] Industrial/ Commericial [ ] Livestock [ ] Dewatering
[ ] Thermal [ ] Injection [x] Other ASR

(5) BORE HOLE CONSTRUCTION

Special Standard [ ] (Attach copy)

Depth of Completed Well 988 ft.

BORE HOLE Dia	From	To	SEAL Material	From	To	Amt	sacks/lbs
24*	0	20.5	cement	0	231	140	sks
20*	20.5	231			Calculated	102	
16*	231	605	cement	0	20.5	16	sks
12*	605	988			Calculated	11	

How was seal placed: Method [ ] A [ ] B [x] C [ ] D [ ] E
[ ] Other
Backfill placed from ____ ft. to ____ ft. Material ____
Filter pack from ____ ft. to ____ ft. Material ____ Size ____
Explosives used: [ ] Yes Type ____ Amount ____

(5a) ABANDONMENT USING UNHYDRATED BENTONITE

Proposed Amount ____ Actual Amount ____

(6) CASING/LINER

Casing	Liner	Dia	+	From	To	Gauge	Stl	Plstc	Wld	Thrd
●	○	20	[ ]	0	20.5	.375	●	○	[x]	[ ]
●	○	16	[x]	3	231	.375	●	○	[x]	[ ]
○	○						○	○		
○	○						○	○		
○	○						○	○		

Shoe [ ] Inside [ ] Outside [ ] Other Location of shoe(s) ____
Temp casing [ ] Yes Dia ____ From ____ To ____

(7) PERFORATIONS/SCREENS

Perforations Method ____
Screens Type V-wire wrap Material 304SS

Perf/ Screen	Casing/ Screen Liner	Dia	From	To	Scrn/slot width	Slot length	# of slots	Tele/ pipe size
SS riser		14	219	232	blank	n.a.	n.a.	PS
screen		14	232	602	.100	continuous	n.a.	PS
SS tail		14	602	605	blank	n.a.	n.a.	PS

(8) WELL TESTS: Minimum testing time is 1 hour

● Pump ○ Bailer ○ Air ○ Flowing Artesian

Yield gal/min	Drawdown	Drill stem/Pump depth	Duration (hr)
680	52		72

Temperature 60 °F Lab analysis [ ] Yes By ____
Water quality concerns? [ ] Yes (describe below) TDS amount 200

From	To	Description	Amount	Units

(9) LOCATION OF WELL (legal description)

County Washington Twp 2S N/S Range 1W E/W WM
Sec 5 SW 1/4 of the NW 1/4 Tax Lot 6500
Tax Map Number 2S 1 05BC Lot ____
Lat ____ ° ____ ' ____ " or ____ DMS or DD
Long ____ ° ____ ' ____ " or ____ DMS or DD
● Street address of well ○ Nearest address

16500 SW Loon Drive, Beaverton, OR 97007

(10) STATIC WATER LEVEL

	Date	SWL(psi)	+	SWL(ft)
Existing Well / Pre-Alteration			[ ]	
Completed Well	10/22/19		[ ]	146

Flowing Artesian? [ ] Dry Hole? [ ]

WATER BEARING ZONES Depth water was first found 209

SWL Date	From	To	Est Flow	SWL(psi)	+	SWL(ft)
6/21/19	209	213	1-2			143
10/22/19	305	981	see (8)			146

(11) WELL LOG

Ground Elevation ____

Material	From	To
See attached formation log		
*Bore hole diameters are nominal diameters.		
Top of 20" casing has steel plate welded between it and 16" csg.		
Top of SS screen riser has J receptor.		
Screen assembly is all 304SS. Blanks are from .375 wall pipe.		

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NOV 22 2019
OWRD

Date Started 6/12/19 Completed 11/5/19

(unbonded) Water Well Constructor Certification

I certify that the work I performed on the construction, deepening, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

License Number 649 Date 11/18/19

Signed [signature]

(bonded) Water Well Constructor Certification

I accept responsibility for the construction, deepening, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

License Number 649 Date 11/18/19

Signed [signature]

Contact Info (optional) ____

ORIGINAL - WATER RESOURCES DEPARTMENT
THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK Form Version: 0.95

City of Beaverton ASR 3
SC #216481 - Well Tag ID #L128831
Formation Log
by Schneider Water Services

FM	TO	DESCRIPTION
0	12	Clay, brown, silty
12	15	Basalt, broken, soft
15	20	Basalt, grey & brown, medium
20	37	Basalt, grey & brown, medium-hard, broken, fractured
37	59	Basalt, grey & brown, medium, broken, some vesicles
59	65	Basalt, grey, medium-hard, fractured
65	76	Basalt, grey & brown, medium-hard, fractured
76	83	Basalt, brown, broken, weathered, some vesicles
83	150	Basalt, grey & brown, medium, fractured
150	181	Basalt, brown & some grey, some vesicles & weathering
181	189	Basalt, brown, medium-soft, broken, weathered, vesicular, w/some sandstone, tan
189	197	Basalt, black, medium-hard, fractured
197	201	Basalt, grey & brown, medium-hard, fractured
201	207	Basalt, grey, hard, fractured
207	209	Basalt, grey w/brown, fractured
209	213	Basalt, brown, soft, broken, fractured
213	221	Basalt, grey w/brown, medium, fractured, broken
221	226	Basalt, grey, medium-hard, fractured
226	231	Basalt, dark grey, medium-hard, fractured
231	300	Basalt, dark grey, hard, fractured
300	305	Basalt, grey, hard
305	326	Basalt, brown, broken, fractured, weathered w/vesicles
326	338	sandy
338	340	Basalt, grey, medium-hard, fractured
340	354	Basalt, dark grey, hard, some fractures
354	356	Basalt, brown w/dark grey, broken
356	360	Basalt, dark grey w/some brown, fractured
360	366	Basalt, brown w/some grey, broken, fractured
366	377	Basalt, dark grey, fractured, hard
377	387	Basalt, dark grey, fractured, medium hard
387	390	Basalt, grey & brown, fractured, medium-hard
390	396	Basalt, dark grey, fractured, medium-hard
396	412	Basalt, grey, hard, fractured
412	423	Basalt, brown & grey, medium-soft, broken w/some vesicles & claystone, yellow
423	440	Basalt, grey and brown, medium, fractured, some vesicles
440	453	Basalt, grey, hard, fractured
453	457	Basalt, red, soft, broken, vesicleular
457	471	Basalt, brown & grey, medium, fractured, some vesicles

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NOV 22 2019
OWRD

City of Beaverton ASR 3
SC #216481 - Well Tag ID #L128831
Formation Log
by Schneider Water Services

FM	TO	DESCRIPTION
471	505	Basalt, grey, hard, fractured
505	509	Basalt, black, medium-soft, fractured w/vesicles & claystone, green
509	514	Basalt, black, medium soft, fractured, with claystone, black, vesicles
514	567	Basalt, dark grey, medium, fractured
567	575	Basalt, grey & red, medium, fractured
575	592	Basalt, dark grey, medium, fractured
592	598	Basalt, dark grey, medium-hard, some fractures
598	602	Basalt, grey, medium, fractured
602	656	Basalt, grey, hard, some fractures
656	660	Basalt, dark grey, medium-hard, fractured, some vesicles
660	666	Basalt, grey & brown, medium, fractured, vesicular w/claystone, grey
666	673	Basalt, dark grey, medium, fractured, some vesicles
673	679	Basalt, grey & some brown, fractured w/some vesicles & claystone, green
679	689	Basalt, grey, fractured some vesicles
689	710	Basalt, grey, medium-hard, some fractures
710	713	Basalt, grey, hard, some fractures
713	716	Basalt, grey, medium-hard, fractured, some vesicles
716	728	Basalt, grey, hard, some fractures
728	750	Basalt, grey, medium-hard, fractured
750	795	Basalt, grey, medium, fractured, some vesicles
795	816	Basalt, grey, hard, some fractures
816	819	Basalt, dark grey, medium-hard, fractured, some vesicles
819	829	Basalt, grey & brown, broken, vesicular, medium w/claystone, tan
829	844	Basalt, dark grey, medum-hard, fractured, some vesicles
844	873	Basalt, grey & brown, medium-hard, fractured w/some vesicles & claystone, tan
873	885	Basalt, grey, medium, fractured, vesicular w/some claystone, tan
885	925	Basalt, black & brown, soft, broken, vesicular w/some claystone, tan
925	943	Basalt, black, medium-hard, some fractures & vesicles
943	953	Basalt, dark grey & brown, medium hard, fractured, vesicular
953	970	Basalt, dark grey, medium, fractured, w/some vesicles & claystone, multicolored
970	981	Basalt, black, medium-soft, vesicular, some fractures w/claystone, multicolored
981	985	Claystone, grey
985	988	Claystone, blue-grey

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WASH 57952

RECEIVED NOV 29 2001 WATER RESOURCES DEPT SALEM, OREGON

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

WELL I.D. # L 51450
START CARD # 135195

(1) LAND OWNER Well Number TH 2B+?
Name City of Beaverton
Address 4755 SW Griffith DR
City Beaverton State OR Zip 97076

(2) TYPE OF WORK
☒ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☒ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☒ Other Test hole

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☒ No Depth of Completed Well 1000 ft.
Explosives used ☐ Yes ☒ No Type ____ Amount ____

HOLE Diameter	From	To	SEAL Material	From	To	Sacks or pounds
12	0	147	cement	0	147	60 sacks
8	147	450				
6	450	1,000				

How was seal placed: Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other
Backfill placed from ____ ft. to ____ ft. Material ____
Gravel placed from ____ ft. to ____ ft. Size of gravel ____

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	8"	+2	147		☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Drive Shoe used ☐ Inside ☐ Outside ☒ None
Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☐ Perforations Method
☐ Screens Type ____ Material ____

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☒ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
275	80		120 hr.

Temperature of water 57° Depth Artesian Flow Found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other
Depth of strata:

(9) LOCATION OF WELL by legal description:
County Washington Latitude ____ Longitude ____
Township 2S N or S Range 1 W E or W. WM.
Section 6 SE 1/4 NE 1/4
Tax Lot 00175 Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) NE Side of intersection of SW 100th Dr and SW Scholls Ferry Rd

(10) STATIC WATER LEVEL:
169 ft. below land surface. Date 8-28-01
Artesian pressure ____ lb. per square inch Date ____

(11) WATER BEARING ZONES:
Depth at which water was first found 200

From	To	Estimated Flow Rate	SWL
200	220	5	169
300	340	75	169
340	350	100	169
880			

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
Very fine Red/brown Silt	0	15	-
Weathered/Broken Basalt	15	16	-
Weathered Basalt grey	16	138	-
Basalt grey med	138	240	169
Basalt grey+Black med	240	300	169
Weathered Basalt Red	300	340	169
Weathered Basalt Grey/Red	340	350	169
Basalt Grey med	350	660	169
Weathered grey Basalt	660	662	169
with light Green clay			169
Black/Grey Basalt med	662	815	171
Basalt Grey med fractured	815	830	169
Basalt Grey/Black med	830	880	169
Weathered Basalt	880	940	169
Basalt med fractured	940	960	169
with Blue/Green clays			
Basalt grey med	960	1000	169

Date started 8-6-01 Completed 11-1-01

(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
WWC Number 1751
Signed [signature] Date 11/27/01

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
WWC Number 1764
Signed [signature] Date 11/27/01

ORIGINAL – WATER RESOURCES DEPARTMENT FIRST COPY – CONSTRUCTOR SECOND COPY – CUSTOMER

STATE OF OREGON
MONITORING WELL REPORT
(as required by ORS 537.765 & OAR 690-240-095)

WELL ID # L33782 WASH 55816

WASH 55816

Start Card # 127585

Instructions for completing this report are on the last page of this form.

(1) OWNER/PROJECT: WELL NO. ARS #3 core hole

Name City of Beaverton

Address P.O. Box 4755

City Beaverton State OR Zip 97076

(2) TYPE OF WORK:

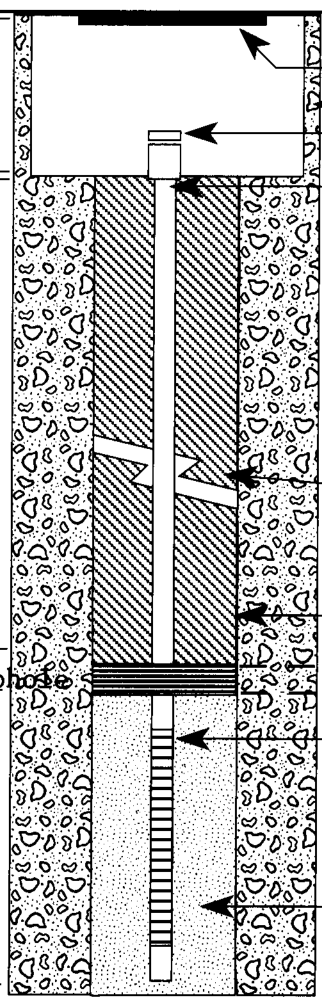
[X] New construction [ ] Alteration (Repair/Recondition)
[ ] Conversion [ ] Deepening [ ] Abandonment

(3) DRILLING METHOD

[ ] Rotary Air [ ] Rotary Mud [ ] Cable
[ ] Hollow Stem Auger [X] Other Core

(4) BORE HOLE CONSTRUCTION 1/12/00

Special Standards Yes [X] No [ ] Depth of completed well 992 ft.



Land surface

Vault 0 ft. TO 1 ft.

Water-tight cover

Surface flush vault

Locking cap

Casing diameter 1 in.

material Sched 80 PVC

Welded [ ] Threaded [X] Glued [ ]

Liner diameter ______ in.

material ______

Welded [ ] Threaded [ ] Glued [ ]

Seal 1 ft. TO 809 ft.

Well seal:

Material cement

Amount 30 sacks

Grout weight 15 #/gal

Borehole diameter NQ - 3 in.

N/A Piezohole

~~Bentonite plug at least 3 ft. thick~~

Screen

material Sch 80 PVC

interval(s):

From 820 To 992

From ______ To ______

Slot size .020 in.

Filter pack 809 ft. TO 992 ft.

Filter pack:

Material CSSI

Size 8 x 12 in.

(5) WELL TEST:

[ ] Pump [ ] Bailer [ ] Air [ ] Flowing Artesian

Permeability ______ Yield ______ GPM

Conductivity ______ PH ______

Temperature of water ~55 °F/C Depth artesian flow found ______ ft.

Was water analysis done? [ ] Yes [ ] No

By whom? ______

Depth of strata to be analyzed. From ______ ft. to ______ ft.

Remarks: ______

Name of supervising Geologist/Engineer CH2M Hill

(6) LOCATION OF WELL By legal description

Well Location: County Washington

Township 2S (N or S) Range 1W (E or W) Section 5

1. NW 1/4 of NW 1/4 of above section.

2. **Either** Street address of well location NYA - Loon Drive

or Tax lot number of well location 6500

3. ATTACH MAP WITH LOCATION IDENTIFIED. Map shall include approximate scale and north arrow.

(7) STATIC WATER LEVEL:

165 Ft. below land surface. Date 3/7/00

Artesian Pressure ______ lb/sq. in. Date ______

(8) WATER BEARING ZONES:

Depth at which water was first found 131

From	To	Est. Flow Rate	SWL
131	136	10+/-	127
147	184	10+/-	165
675	789	>10	165+/-
818	988	>100	see (7)

(9) WELL LOG: Ground elevation ~300

Material	From	To	SWL
see attached log			

RECEIVED MAY 02 2000 WATER RESOURCES DEPT. SALEM, OREGON

RECEIVED APR 05 2000 WATER RESOURCES DEPT. SALEM, OREGON

Date started 1/4/00 Completed 3/7/00

(unbonded) Monitor Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to the best knowledge and belief.

MWC Number 10191

Signed [signature] Date 3/28/00

(bonded) Monitor Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.

MWC Number 10115

Signed [signature] Date 3/28/00

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

2000-04

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APR 05 2000
WATER RESOURCES DEPT.
SALEM, OREGON

City of Beaverton

ASR No. 3 Piezometer Completed Core Hole

S.C. #127585 - Label #L33782 by Schneider Drilling Co. - 2000

RECEIVED
MAY 02 2000
WATER RESOURCES DEPT.
SALEM, OREGON

From	To	Description
0	3	Clay, brown, soft.
3	13	Claystone, brown & red, medium, some vesicles & fractures
13	29	Basalt, brown & red, med., fractured, vesicular
29	63	Basalt, grey, brown, medium, fracured, vesicular
63	71	Basalt, grey, hard, some fractures
71	72	Basalt, grey, hard.
72	74	Basalt, brown, medium, vesicular, fractured
74	75	Basalt, grey, hard, fractured
75	79	Basalt, grey, hard, fractured, some vesicules
79	107	Basalt, brown & grey, medium, fractured, vesicular, some claystone
107	130	Basalt, grey & brown, hard, fractured, some claystone
130	131	Clay, brown, soft
131	136	Basalt, grey & brown, medium, vesicular, fractured
136	140	Basalt, grey & brown, hard, some fractured
140	147	Basalt, grey, hard, fractured
147	184	Basalt, brown, medium, fractured, vesicular
184	204	Basalt, grey & brown, medium-hard, fractured
204	210	Basalt, brown & red, medium-soft, fractured, vesicular
210	236	Basalt, grey & brown, medium-hard, fractured, some vesicular
236	242	Basalt, brown & grey, medium, fractured, vesicular
242	273	Basalt, black, hard, fractured, some vesicular
273	304	Basalt, grey, hard, fractured
304	308	Basalt, brown, medium-soft, fractured, vesicular
308	323	Basalt, multi-color, medium-soft, fractured, vesicular
323	329	Basalt, grey, medium-hard, fractured
329	339	Basalt, multi-color, medium-soft, fractured, some vesicular
339	355	Basalt, black, medium-hard, fractured, vesicular
355	394	Basalt, Black, medium-hard, fractured
394	418	Basalt, grey, hard, fractured
418	433	Basalt, brown & grey, medium, fractured, vesicular, some clay seams
433	454	Basalt, grey, hard, fractured
454	455	Basalt, grey, hard, fractured, vesicular
455	464	Basalt, red & brown, medium-soft, vesicular, fractured
464	480	Basalt, grey, medium, fractured, vesicular
480	508	Basalt, grey, hard, fractured
508	511	Claystone, grey, medium

511	514	Claystone, green, medium
514	516	Claystone, black, medium
516	528	Basalt, black, medium, fractured, vesicular
528	530	Basalt, grey & brown, medium, fractured, vesicular, some claystone
530	557	Basalt, grey, medium-hard, fractured, vesicular
557	562	Basalt, grey & red, medium-hard, fractured
562	631	Basalt, grey, hard, fractured, some vesicular
631	659	Basalt, grey, hard, fractured, some vesicular
659	664	Basalt, brown & grey, medium, fractured, vesicular
664	670	Basalt, black, medium, fractured, vesicular
670	675	Basalt, grey, medium-hard, fractured, vesicular, some claystone
675	686	Basalt, grey, medium, fractured, vesicular
686	693	Basalt, black, medium, fractured, vesicular
693	704	Basalt, black, medium, fractured, some vesicular
704	727	Basalt, black, medium, fractured, some small vesicular
727	789	Basalt, black, medium-hard, fractured, some vesicular
789	818	Basalt, grey, hard, fractured
818	824	Basalt, brown, medium-soft, vesicular, broken
824	829	Basalt, brown, medium-soft, fractured, vesicular
829	844	Basalt, grey, medium-hard, fractured, vesicular
844	864	Basalt, black, medium, fractured, some vesicular
864	865	Basalt, black, medium, fractured
865	877	Basalt, grey, hard, fractured, some vesicular
877	885	Basalt, black, medium, fractured, vesicular
885	893	Basalt, black, soft, vesicular, claystone, blue
893	899	Basalt, dark grey, medium, fractured, some vesicular
899	900	Basalt, black, soft, vesicular, claystone, green
900	921	Basalt, black, soft, vesicular, broken, claystone, multi-colored
921	924	Basalt, grey, soft, fractured, vesicular
924	940	Basalt, grey, medium-soft, fractured, vesicular
940	950	Basalt, black, soft, vesicular, broken
950	963	Basalt, grey, medium, fractured, some vesicular
963	964	Basalt, black, medium-soft, fractured, vesicular
964	988	Basalt, black, medium-soft, fractured, vesicular, some claystone
988	992	Basalt, grey, medium, fractured, some vesicular

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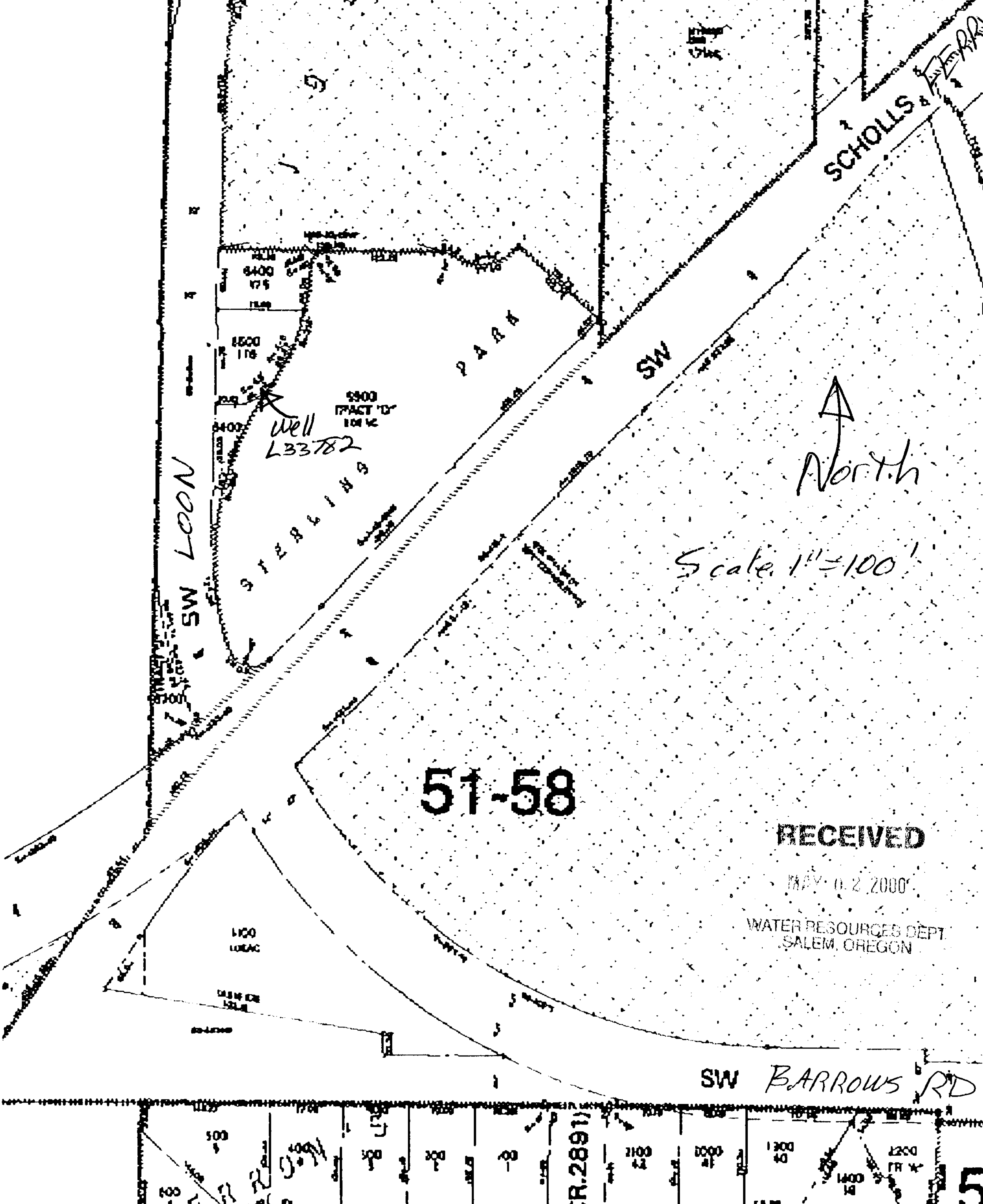

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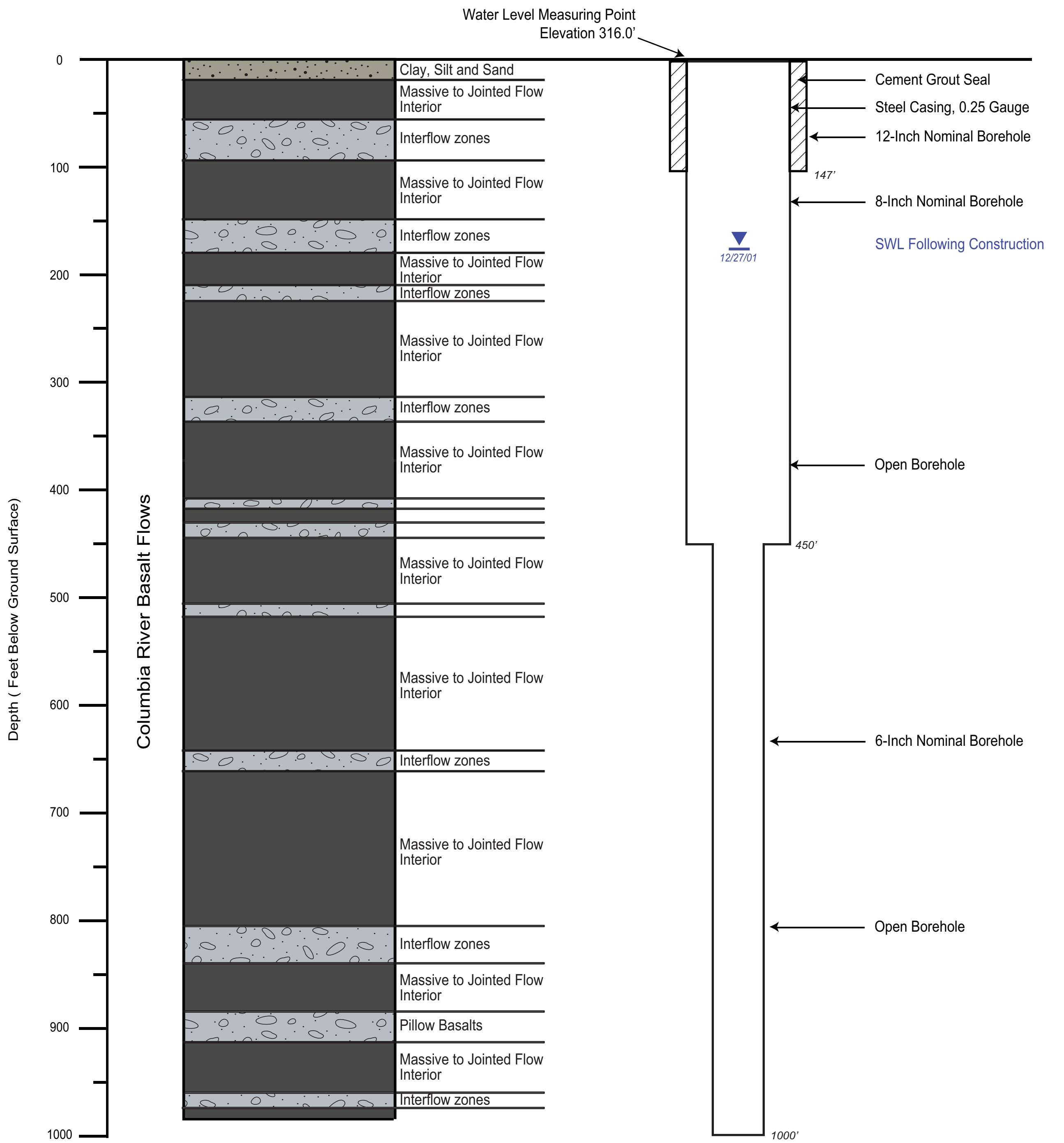

Notes:

Well drilled in 2001
Well Log ID = WASH 57952
Well located in Township 2 South, Range 1 West, Section 5

ASR 3, Pilot Well

City of Beaverton

GSI Water Solutions, Inc.

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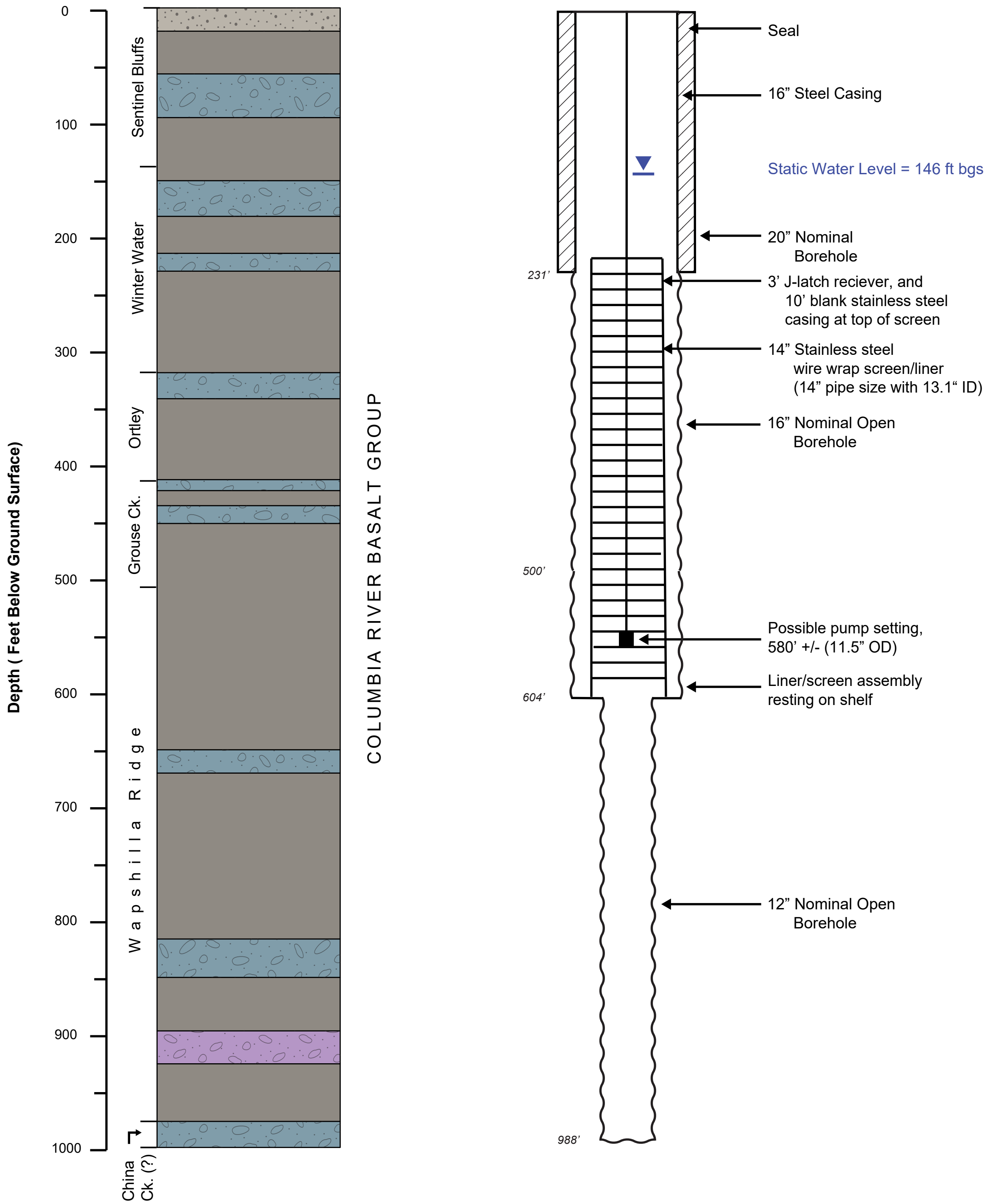

LEGEND

- Clay, Silt, and Sand
- Massive to Jointed Flow Interior
- Interflow Zone
- Pillow Complex

NOTES:

SC = Specific Capacity

gpm = gallons per minute

gpm/ft = gallons per minute / per foot of drawdown

ID = Inside Diameter

OD = Outside Diameter

As-Built
ASR 3A

Beaverton, Oregon

GSI Water Solutions, Inc.

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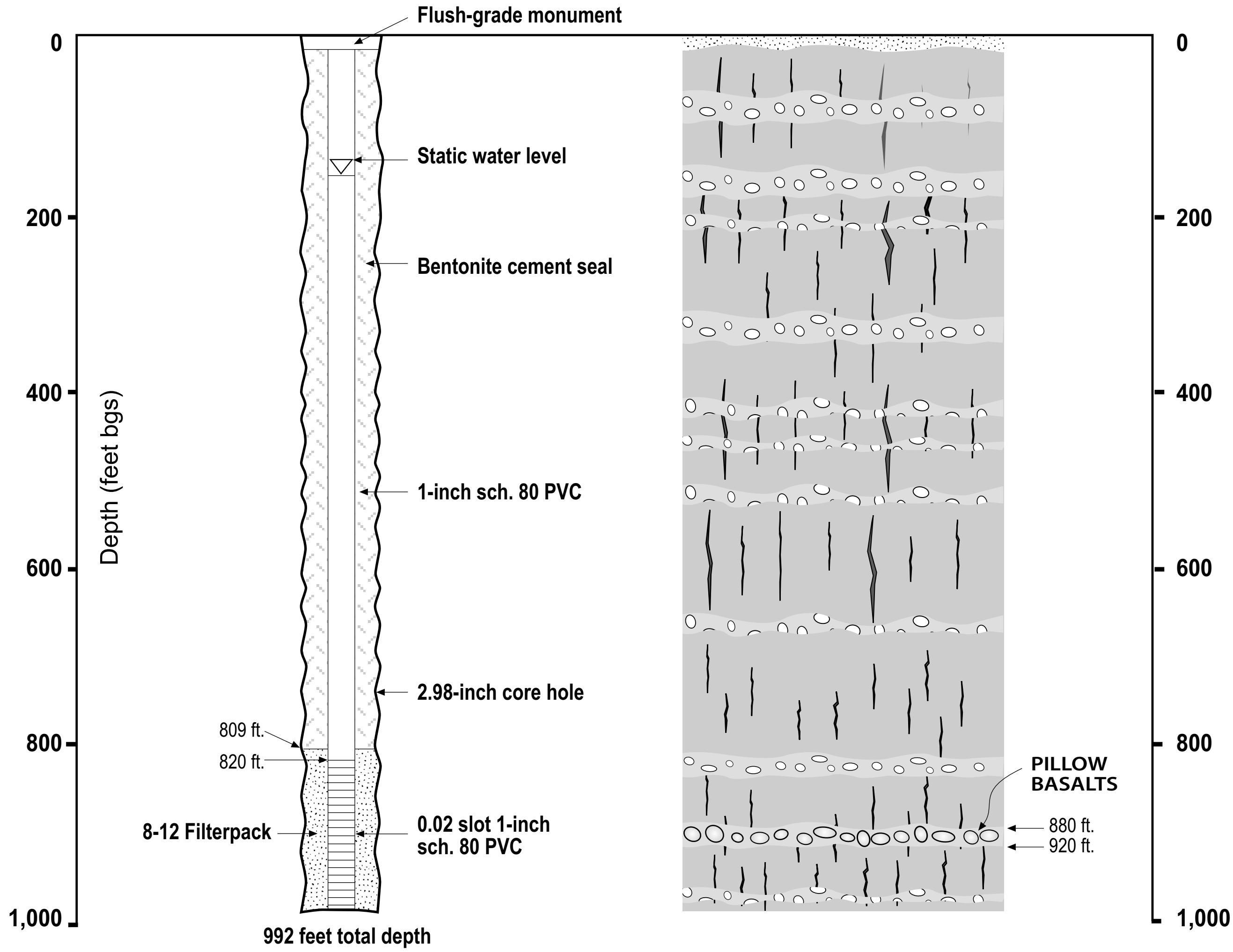

LEGEND

- Estimated Static Water Level
- Clay, Silt, and Sand
- Basalt:
  - – Water-producing interflow zones
  - – Massive to jointed flow interior

ASR No.3 Observation Well (Corehole) As-built

CITY OF BEAVERTON

APPENDIX E

2017 Groundwater Recharge Feasibility Evaluation

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Report

Sterling Park Stormwater Quality Facility

Groundwater Recharge Feasibility Evaluation

Prepared for

Clean Water Services

February 2018

Prepared by

GSI Water Solutions, Inc.

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Acronyms and Abbreviations

µg/L	microgram per liter
µm	micrometer
ASR	aquifer storage and recovery
BaP	benzo(a)pyrene
bgs	below ground surface
City	City of Portland
CRBG	Columbia River Basalt Group
CWS	Clean Water Services
DBP	disinfection by-product
DEHP	di(2-ethylhexyl)phthalate
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
gpm	gallons per minute
JWC	Joint Water Commission
MCL	maximum contaminant level
MG	million gallon
mg/L	milligram per liter
MRL	method reporting limit
MS4	Municipal Separate Storm Sewer System
mya	million years ago
NOM	natural organic matter
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
OAR	Oregon Administrative Rule
OHA	Oregon Health Authority
ORS	Oregon Revised Statute
OWRD	Oregon Water Resources Department
PCP	pentachlorophenol
PSD	particle size distribution
SDWA	Safe Drinking Water Act
Site	Sterling Park Stormwater Quality Facility
SMCL	secondary maximum contaminant level
TOC	total organic carbon

TSS	total suspended solids
TT	treatment technology
TVWD	Tualatin Valley Water District
UIC	underground injection control
USGS	U.S. Geological Survey
UV	ultraviolet
WPCF	Water Pollution Control Facilities

Acknowledgments

This project was funded in part by a Water Conservation, Reuse and Storage Feasibility Study Grant was awarded by the Oregon Water Resources Department. Additional funds and in-kind contribution was provided by Clean Water Services (CWS). Significant contribution was made by numerous staff at CWS, including Jadene Torrent Stensland, Bob Baumgartner, Steve Thompson, Doug Lager, Marta Frank, Doug Schuh, Scott Nys, Rachael Fast, and Marley Luke. Additionally, many staff at the City of Beaverton contributed greatly to this project including David Winship, Brion Barnett, Mark Boguslawski, and Geoff Hunsaker.

Executive Summary

The purpose of this study is to evaluate the feasibility of a proposed project to use treated stormwater as a source for Aquifer Storage and Recovery (ASR) at an existing City of Beaverton groundwater well for Summer Creek summertime base flow augmentation as well as for use for a non-potable irrigation supply. Based on the information obtained from site-specific data collected for this proposed project, combined with extensive regional stormwater quality data, the project appears feasible with reasonably minimal water quality treatment necessary to meet regulatory requirements. The following summarizes the key feasibility information:

- Regulatory feasibility for use of stormwater as a source for ASR is primarily dependent on compliance with Oregon underground injection control rules which generally require that drinking water quality standards (one-half of the primary drinking water standard for most constituents) be met prior to injection.
- Approximately 57 million gallons of stormwater were discharged to the Sterling Park Site between October 2016 and November 2017 as calculated from available stormwater flow data. Although more rain was observed over this period than in a typical calendar year (average annual rainfall in Beaverton, Oregon is approximately 40 inches), annual stormwater discharges into Sterling Park could offset a large portion of the groundwater that the City of Beaverton currently anticipates extracting for non-potable uses.
- Of the approximately 170 constituents analyzed over the course of four stormwater sampling events, only eight constituents including turbidity and microbiological components [coliform (total and fecal), Escherichia coli (E. coli), and enteric viruses] exceeded regulatory criteria. Approximately 75 additional regulated analytes were detected, but at concentrations below relevant regulatory criteria [i.e. one-half of the maximum contaminant level (MCL) or below one times the secondary maximum contaminant level (SMCL)].
- Temperature data indicate that wintertime stormwater used for recharge typically will range from 6.4 to 9.6 °C. This cool water could be recovered at similar temperatures during the summer and used to mitigate the temperature in Summer Creek and provide streamflow augmentation.
- Stormwater quality treatment will be needed to meet regulatory requirements for underground injection and is anticipated to consist of filtration, activated carbon/bio-char adsorption, and disinfection (e.g., chlorine or ultraviolet irradiation).
- Artificially recharged stormwater is anticipated to remain within 1,000 feet of the ASR 3 well even under conservative storage scenarios and should not impact other groundwater users.
- Following treatment, stormwater quality is anticipated to be similar in character to treated surface water used successfully on many ASR projects hosted in the Columbia River Basalt Group (CRBG) aquifer. As such, mixing of treated stormwater with native groundwater is not anticipated to result in adverse chemical reactions.
- Next steps for implementation of the proposed project include stormwater treatment pilot testing, regulatory permitting application, and final treatment design and construction.

Implementation is anticipated to require up to 3 years to complete and is estimated to cost approximately $785,000 to $1,025,000.

- Work completed in this feasibility assessment was funded in part by a Water Conservation, Reuse and Storage Feasibility Study Grant was awarded by the Oregon Water Resources Department (OWRD). Based on the positive feasibility, a Water Project Grant through OWRD is anticipated to be sought to provide funding for project implementation.

1. Introduction

This report was prepared for Clean Water Services (CWS) by GSI Water Solutions, Inc. (GSI), to meet the terms and conditions of a grant agreement between the Oregon Water Resources Department (OWRD) and CWS. A Water Conservation, Reuse and Storage Feasibility Study Grant was awarded by OWRD in May 2016 to CWS to evaluate the feasibility of using stormwater as a potential deep groundwater recharge source at an existing ASR test well in Beaverton Oregon. This report presents the findings of the feasibility evaluation.

Stormwater reuse is a relatively common practice across the southwestern United States, and ASR has been implemented by a number of Oregon municipalities for drinking water storage, but evaluating the use of treated stormwater as a source for ASR storage during the winter and use as non-potable water supply during the high demand summer season has not been assessed, and is the focus of this evaluation. Use of stormwater as a source for ASR, if feasible, would have the combined benefits of (1) enhancing groundwater supply with a source that does not require obtaining new water rights; (2) providing a means for managing urban stormwater runoff, which can negatively impact surface water hydrology and quality; and (3) allowing the water to be retrieved at times of the year when demands are greater and the retrieved water could potentially be used to supplement and benefit instream flows with cooler groundwater. Based on the feasibility assessment presented in this report, use of stormwater as a source for ASR appears to be feasible, and should be further evaluated through pilot testing.

The location for this stormwater ASR feasibility assessment is referred to as the Sterling Park Stormwater Quality Facility (Sterling Park Site; Site) and is owned and operated by the City of Beaverton, Oregon (City). The Site was selected for this proposed project because it has the basic elements that are needed for a detailed feasibility assessment, including the potential for a pilot study if the project is deemed feasible. The Site includes (1) a deep well that is not currently in use (and, therefore, is available as a possible location for stormwater recharge), (2) a nearby small-diameter monitoring well that could be used for data collection during a pilot study, and (3) an onsite stormwater quality treatment facility that receives runoff from residential neighborhoods and for which existing outfalls could easily be routed to the recharge well if pilot testing is pursued.

Capturing and storing stormwater to reduce the potential for excessive erosion and hydromodification is a primary driver for development of this feasibility assessment. Additionally, stored stormwater recovered during the summer for stream flow and temperature augmentation is also a significant benefit being explored by this project. Summer Creek, located near the Site and the discharge location for stormwater from the Sterling Park Site, is anticipated to be used as a discharge point of stored water to help mitigate summer-time stream temperatures. Additionally, the City intends to use the deep well in the near future as source for "purple pipe" irrigation in nearby developing residential neighborhoods and is working with CWS to evaluate using stormwater stored in the subsurface for non-potable irrigation purposes. The City's deep well is located in the Bull Mountain-Cooper Mountain Critical Groundwater Area, where offsetting groundwater usage would prove especially beneficial.

To assess the feasibility of using residential municipal stormwater as a source for ASR storage and non-potable use, the following tasks were completed as described in the OWRD grant application:

- **Collection of site-specific stormwater quantity and quality data.** For stormwater ASR to be feasible at the Site, sufficient stormwater volume must be available for recharge, the receiving well must be able to accommodate the rate of stormwater recharge, and the stormwater must meet applicable water quality standards. The following data were collected to confirm that these feasibility criteria will be met:
  - **Stormwater flow rate and volume.** Stormwater flow discharge rate was continuously measured from October 2016 to November 2017 in both stormwater systems discharging to the Sterling Park site. A summary of stormwater flow, stormwater volume estimates, and the correlation of precipitation and stormwater flows at the Site are provided in subsequent sections and figures.
  - **Water quality data.** Stormwater samples were collected from two stormwater drainage basins that discharge into the Site during four separate storm events in 2017. Samples were analyzed for a comprehensive suite of analytes including drinking water regulated constituents, emerging pesticides, suspended sediment, and microbiological parameters.

- **Groundwater fate and transport modeling was used to assess the potential for migration of recharged stormwater.** The modeling was conducted using existing hydrogeologic information available from an existing groundwater model (GSI, 2011) prepared in support of regional ASR evaluations.

- **A general geochemical comparative analysis using site-specific stormwater and native groundwater quality data previously obtained at ASR 3 was used to assess the risk of clogging the aquifer via introduction of sediments during injection or precipitation of solids during the mixing of the two waters.** The final quality of the treated stormwater will be determined during the pilot treatment evaluation. This report compares site-specific stormwater and native groundwater quality data to preliminarily evaluate the potential for excessive sediment loading, precipitation of unwanted solids, or other unintended chemical reactions.

- **An evaluation of stormwater treatment technologies to reduce concentrations of constituents detected in stormwater that have the potential to exceed drinking water standards or may clog the well during recharge was conducted after evaluating site-specific and local municipal stormwater data.** The evaluation includes an assessment of effectiveness, maintenance, and cost considerations.

- **Site-specific data were reviewed in the context of applicable Oregon Department of Environmental Quality (DEQ) water quality regulations and permits, and OWRD ASR regulations.** A preliminary review was completed to confirm that the existing regulatory framework provides a structure and process for permitting and operating a stormwater ASR system. Specifically, the proposed project is anticipated to require ASR-specific permitting and a state Water Pollution Control Facilities (WPCF) permit (i.e., underground injection control [UIC] permit. A more detailed feasibility evaluation is included in this report based on site-specific data, to confirm that the proposed project will meet all applicable criteria to receive and comply with state ASR and UIC permitting requirements.

- **This report includes a project implementation plan and a net present value (NPV) cost estimate.** The plan elements include a stormwater treatment pilot implementation and analytical assessment followed by full-scale stormwater treatment design and implementation, a general construction timeline, and a cost estimate for project implementation.

2. Project Description

This section describes the proposed ASR 3 stormwater recharge project (proposed project), which would use residential municipal stormwater as a source for ASR. Stormwater from a residential neighborhood in Beaverton, Oregon, that currently discharges to a stormwater quality treatment facility would be recharged into ASR 3 (Well ID: WASH 57952). ASR 3 is owned by the City and located adjacent to the stormwater water quality facility; the area is referred to as the Sterling Park Water Quality Basin. The Site is shown in Figure 1.

ASR 3 extends to a total depth of approximately 1,000 feet below ground surface (bgs). The well is 8 inches in diameter from the surface to 450 feet bgs and 6 inches in diameter for its remaining depth. ASR 3 is hosted in the Columbia River Basalt Group (CRBG) aquifer, which is host to several successful municipal ASR projects, including one operated by the City. The CRBG aquifer has been shown to store millions of gallons of recharged water and recover the same stored water. Also located at the Site is a 992-foot-deep, 2-inch-diameter well (referred to as "ASR 3 Corehole" – Well ID: WASH 55816), initially drilled to evaluate the CRBG section in this area; the well has a screen interval between approximately 809 and 992 feet bgs. While ASR 3 Corehole may be too small to be used for recharge of meaningful quantities of water, it could be used for water quality or water level monitoring purposes during ASR operation at the Site. The locations of these wells are shown in Figure 1.

Stormwater recharge into ASR 3 would be designed to protect the highest beneficial uses of the receiving aquifer, which is drinking water. Stored stormwater would be recovered from ASR 3 for beneficial, non-potable uses; potential identified uses include streamflow augmentation and mitigation into nearby Summer Creek and irrigation (nearby schools, residential parking strips, and ponds).

The conceptual plan is to capture stormwater before discharging into the Sterling Park Water Quality Basin between approximately November and April for recharge into ASR 3. Stormwater in the area is derived primarily from residential roads, sidewalks, driveways, and roofs. As discussed in subsequent sections, an evaluation of site-specific stormwater quality data as well as representative stormwater quality data from similar residential and municipal areas indicates that this residential stormwater runoff would meet all applicable water quality criteria with minimal treatment. During any future pilot testing, stormwater quality and flow at the Site would be monitored in accordance with applicable DEQ and OWRD permit requirements to ensure protection of the CRBG aquifer for its highest beneficial use: drinking water.

Some of the potential benefits of this proposed project are listed below. By extension, if the proposed project is successful, these types of benefits could be realized at other locations in the region. Benefits include:

- Providing direct recharge to the local basalt aquifer (CRBG) would enhance groundwater supply with a source that does not require obtaining new water rights.
- Infiltrating stormwater into the CRBG via ASR 3 would more closely mimic the natural hydrologic cycle by reducing unnaturally large runoff volumes from impervious surfaces to surface water during periods of high flow, and mitigating the negative impacts to streams from rapid changes to stream flow (e.g. elevated solids concentrations and bank erosion).
- Winter stormwater runoff that is captured and infiltrated may be recovered in the summer and discharged to adjacent streams helping to maintain summer flows and reduce stream temperature, such as in Summer Creek, near ASR 3.
- Recharged and banked stormwater may be used for other beneficial non-potable uses, such as irrigation in the local area, instead of the typical use as municipal drinking water, and thereby reduce the demand on surface water and native groundwater.
- By developing the area around ASR 3, infiltration of stormwater may preclude the need to install, or increase the capacity of piped stormwater infrastructure in this area.

3. Conceptual Hydrogeology and Potential for ASR Storage

The proposed project area is located in the Tualatin River Basin, a broad synclinal basin with extensive valley plains and several anticlinal hills (which consist of an arch of layered basalt rock in which the layers bend downward in opposite direction from the crest), the most notable of which is the Cooper Mountain-Bull Mountain area. The Sterling Park Site is located on the southwestern flanks of Cooper Mountain and is underlain by a thin veneer of sediments overlying the CRBG, a 1,000-foot thick sequence of basalt. The CRBG is unique to the Pacific Northwest and represents a thick (more than 10,000 feet thick near Pasco, Washington), aerially extensive series of extraordinarily large (63,321 square miles) lava flows that are Miocene-age (23 to 5.3 million years ago [mya]). The CRBG hosts extensive regional aquifer systems in eastern Washington, eastern Oregon, and western Oregon, inclusive of the proposed project area. The CRBG basalts contain some of the most productive groundwater aquifers in the Pacific Northwest. In the Tualatin River Basin, the CRBG comprises the target aquifers for ASR development for surrounding water supply agencies including, the Cities of Beaverton and Tigard, and the Tualatin Valley Water District (TVWD), typically storing 150 million gallons (MG) or more annually per well.

Although productive, the regional CRBG aquifer and CRBG aquifers across the state have had declining groundwater levels, in many cases resulting from overappropriation caused by limited natural groundwater recharge pathways. A primary driver in the development of ASR by these agencies was groundwater level declines and overappropriation of the groundwater resources in this area from the 1950s to 1970s. Groundwater level declines led OWRD to designate the local CRBG aquifer as a Critical Groundwater Area (Cooper Mountain-Bull Mountain Critical

Groundwater Area) in 1974, limiting existing groundwater use to a maximum annual volume of 2,900 acre-feet (~945 MG) and prohibiting any new groundwater withdrawals with the exception of domestic use on parcels larger than 10 acres.

ASR is a technique used to store water and, therefore, does not result in the appropriation of native groundwater; it is allowed within the Critical Groundwater Area and has been beneficial to a continued reduction in native groundwater usage in the region.

The Sterling Park Site is located in the Cooper Mountain-Bull Mountain Critical Groundwater Area and, as described previously, is the location of ASR 3, which was constructed by the City in 2001. Preliminary testing at the Site determined the CRBG aquifer in this location was less productive than the City's existing ASR wells, but was potentially capable of accepting recharge at rates **up to 500 gallons per minute (gpm)** and storing **up to 100 MG** of water (GSI, 2004). Although the Site is feasible for municipal drinking water ASR, the City opted to delay development because greater production rates and storage volumes could be obtained at other locations more cost effectively. ASR development did not occur and ASR 3 has remained unused. The area surrounding the Sterling Park Site has experienced significant development within 544 acres of recently annexed parcels at the southwestern extent of the City. Currently, the City is designing a non-potable irrigation system for installation with public utility infrastructure within residential neighborhood developments and plans to use ASR 3 as a non-potable supply source for residential irrigation in this area. Use of treated stormwater as an ASR recharge source at ASR 3 is of interest to the City because it will offset groundwater use and reduce the City's impact on regional groundwater supply within the Cooper Mountain-Bull Mountain Critical Groundwater Area.

4. Stormwater Flow and Volume

This section provides a summary of stormwater flow information obtained at the Sterling Park Site to evaluate stormwater flow rates, variability, and annual volume. Understanding these elements is necessary to (1) size various conveyance and treatment options for the proposed project and (2) confirm that a sufficient volume of stormwater is available on an annual basis to make ASR viable to offset anticipated non-potable groundwater use.

Stormwater flow from the two contributing stormwater drainage basins (Basin WS 1B and Basin WS 1A; see Figure 1) was monitored continuously from October 2016 to November 2017 with Hach® flow loggers (model F1901) equipped with a FLO-DAR, model 4000, radar/ultrasonic sensor. The flow loggers were monitored monthly by CWS personnel and were inspected at the start of each stormwater sampling event to ensure the logger was functioning properly. In addition to stormwater flow, precipitation data during this same period was reviewed from the nearest City of Portland HYDRA Rainfall Network[1] at the Sylvania Portland Community College (PCC) rain gauge (approximately 7 miles from the Site). As shown in Figure 2, precipitation data generally correlated to stormwater flow data from the two flow loggers[2]. Based on the precipitation data, a total of approximately 100 discrete storm events[3] were observed during the monitoring period. Total flow volumes measured during this period were

[1] The HYDRA Rainfall Network is a collection of 39 gauges operated and maintained by the City of Portland's Bureau of Environmental Services.

[2] Precipitation intensity was not identical between the rain gauge location and the Site (e.g., rain and subsequent flow through the two basin conveyance systems were observed at times when precipitation was absent at the Sylvania PCC gauge location.).

[3] Discrete storm events are defined by rainfall lasting at least 1 hour and separated by at least 12 hours with no precipitation.

approximately 38 MG at the Basin WS 1A monitoring location and approximately 19 MG at the Basin WS 1B monitoring location, with a combined volume between the two basins of approximately 57 MG.

Stormwater flow varied at the two stormwater basins between several gpm and more than 1,000 gpm during peak periods of precipitation. A summary of stormwater flow volume accumulated from flow rates ranging from 10 to more than 1,000 gpm is shown in Figure 3. Based on the flow rates observed:

- Approximately 50 percent of the total volume from Basin WS 1A discharged at rates less than 175 gpm, which represents a volume of 19 MG.
- Approximately 50 percent of the total volume from Basin WS 1B discharged at rates less than 85 gpm, which represents a volume of 9.5 MG.
- Approximately 50 percent of the combined total volume from both basins discharged at a combined rate of approximately 260 gpm, which represents a volume of 28.5 MG. The highest flow rates observed (>2,000 gpm) were relatively uncommon and accounted for less than 10 percent of the combined flow and a total duration of less than 2 percent of the period of observed stormwater flow.

Stormwater treatment anticipated for the proposed project typically is sized with a design flow rate, with larger and more expensive treatment required at higher flow rates. The summary of volume and flows shown in Figure 3 indicates that access to greater volumes of stormwater would be possible if some stormwater detention were included prior to treatment to store excess volume of stormwater during periods of higher flows. Without any additional storage, a treatment system capable of accepting flow rates up to 200 gpm could have treated 26 MG of stormwater over the flow monitoring period, and a system capable of accepting flow rates up to 400 gpm could have treated up to 33.5 MG of stormwater from October 2016 to November 2017.

Approximately 64 inches of rain were observed over the flow monitoring period which is atypically wetter than average stormwater years. The average annual rainfall in the City of Beaverton is 40 inches per year. Despite the unusually wet monitoring period, the discharge volumes from both basins indicate that a large portion of the City's anticipated non-potable groundwater use could be offset with captured, treated, and injected stormwater on an annual basis. For context, the City is anticipated to use approximately 52 MG of groundwater (based on a 400 gpm design pumping rate for a 90-day irrigation season) to meet non-potable demands on an annual basis. Capturing and treating stormwater with flow rates less than 400 gpm has the potential to offset as much as half of the anticipated groundwater usage on an annual basis. Additional volumes of stormwater could be captured and treated if stormwater detention or storage is built into the conveyance system prior to treatment. Excess stormwater volume due to flow rates exceeding treatment capacity rates would be stored in available detention as design treatment flow rates are metered into the treatment system. Maximizing stormwater capture and treatment will be a key aspect of the final design phase.

5. Regulatory Feasibility

Identifying applicable regulations and standards that need to be met is an important step in evaluating the feasibility of stormwater ASR in general and for this proposed project specifically. Toward this end, preliminary discussions with state regulators were completed to assess potential regulatory concerns related to using stormwater as a source of water for an ASR project. The proposed project would fall under the following general sets of regulations, as discussed below: ASR, UIC, and municipal separate stormwater system permitting. If the stored stormwater is withdrawn and discharged to Summer Creek to supplement streamflow or to mitigate stream temperatures, this discharge will be done in accordance with all applicable water quality criteria.

5.1. ASR Regulatory Requirements

ASR in Oregon is administered by OWRD in consultation with DEQ and Oregon Health Authority (OHA). OWRD's rules governing ASR are described in Oregon Administrative Rules (OAR) 690-350. General requirements include authorization of recharge source water, typically through a water right; recharge source water quality requirements; and hydrogeologic assessments necessary to evaluate the viability of a proposed project and the potential for injury to other groundwater users.

Authorization of recharge source water for this proposed project would be different from most ASR projects because OWRD does not require a water right for use of stormwater, which is defined as "precipitation collected from an artificial impervious surface" under Oregon Revised Statute (ORS) 537.141 (h). Water quality requirements for source water for ASR projects are based on drinking water quality standards that reference U.S. Environmental Protection Agency (EPA) maximum contaminant levels (MCLs) and secondary MCLs (SMCLs). Specifically, allowable concentrations are limited to one-half the MCL for most constituents, with the exception of analytes with an SMCL and disinfection by-products (DBP), which allow recharge water with concentrations up to the SMCL (OAR 690-350-0020(5)(i)). Microbiological constituents in recharge source water also are regulated on the basis of drinking water requirements of 4-log inactivation (discussed in more detail in Section 6).

Federal and state rules prohibit the construction, operation, maintenance, conversion, plugging, or abandonment of any type of injection system or activity that would allow the direct or indirect movement of contaminated fluids into groundwater if the presence of the contamination may cause a violation of the Safe Drinking Water Act (SDWA) MCLs. In addition, the injection system must comply with DEQ's Groundwater Quality Protection Rules in OAR 340-040, which require that discharges meet existing background water quality at a compliance point that DEQ chooses (usually the property boundary).

5.2. UIC Regulatory Requirements

The proposed recharge system would also fall under DEQ's UIC rules. DEQ regulates the UIC Program under OAR Chapter 340, Division 44; these rules regulate all groundwater as a potential source of drinking water. According to the UIC rules, the burden of proof is on the owner/operator of the system, not DEQ, to prove that an injection activity does not have the potential to cause a violation of the primary drinking water standards or adversely impact groundwater quality, human health, or the environment. Before operating the proposed system, DEQ would require the owner/operators of the injection system to register the injection system and gain written DEQ approval to operate by either of the following:

- Qualifying as a rule-authorized UIC.
- Receiving a WPCF permit (i.e., UIC permit).

Under current regulations, the proposed system would not qualify as a rule-authorized UIC, given that the proposed system is deeper than 30.5 meters (100 feet) and discharges to groundwater. Therefore, DEQ is expected to require a WPCF permit to manage the use of stormwater for aquifer recharge.

DEQ has developed two types of UIC WPCF permits:

- **General UIC Permit.** CWS would register for coverage under the existing General UIC Permit for stormwater UICs, which was issued by DEQ in 2015 with the objective of authorizing UICs that do not meet the conditions for authorization by rule. DEQ is required by rule to conduct a preliminary review of CWS' registration application within 45 days, and typically issues coverage under the permit a few weeks after the preliminary review (usually 3 months total). The General UIC Permit would not require that CWS conduct stormwater sampling (because the UIC drains stormwater from low-traffic residential streets); however, DEQ likely would require sampling for all SDWA pollutants and require stormwater to meet MCLs when it assigns coverage under the permit to CWS[4]. If CWS cannot meet MCLs, then CWS would be required to demonstrate, using a groundwater modeling approach, that injection in excess of MCLs would not adversely affect water wells.
- **Individual UIC Permit.** CWS would apply for an Individual UIC Permit that is customized to the injection project. DEQ typically requires 3 months to issue an individual permit; however, DEQ currently has a backlog of nine Individual UIC Permits, and plans to issue only three permits in federal fiscal year 2018. Because DEQ tailors the permit to the injection project, the permit likely would require sampling for all SDWA pollutants and require that CWS meet MCLs.

Table 1 summarizes the key elements of the two types of permits. A General UIC Permit would be ideal for regulatory approval from the UIC Program, based on cost and issuance timeline considerations. CWS should propose testing procedures that ensure protection of the groundwater resource (e.g., procedures to ensure removal of all injected water). If implementability testing is favorable to ASR, then CWS should apply for an ASR Limited License for long-term system operation CWS should meet with DEQ to propose this permitting strategy, propose sampling requirements, propose pre-treatment, and discuss other aspects of the proposed project.

Table 1. Key Requirements of General and Individual UIC Permits

	General UIC Permit	Individual UIC Permit
Fees	$859 (application fee) $674 (annual fee)	$12,449 (application fee) $2,635 (annual fee)
Issuance Timeline	3 Months	Uncertain
Public Comment Period	No (the permit has already had public comment and been issued, CWS would be	Yes

4 DEQ has this authority under Schedule A, condition 6 of the permit.

	seeking coverage under the permit	
Regulatory Standard at Point of Injection	MCLs [1]	MCLs [1]
Pre-Treatment Required	Yes	Yes

Notes:
[1] CWS may inject above MCLs if it can demonstrate, using a modeling approach, that stormwater pollutants will not reach a water well.
MCL= maximum contaminant level
UIC = underground injection control

5.3. Regulatory Feasibility Summary

In summary, the existing regulatory framework provides a structure and process for permitting and operating a stormwater ASR system. Section 6 evaluates factors pertaining to the specific criteria that the proposed project would need to meet to receive and comply with a WPCF permit.

6. Stormwater Quality

A key component of this feasibility evaluation was to assess whether the general quality of stormwater that would be recharged into ASR 3 is suitable for injection. Specifically, because the beneficial use of the target CRBG aquifer is for drinking water, any stormwater considered for ASR injection must be of a quality that would protect the native groundwater as a drinking water source. GSI collected site-specific stormwater quality data and reviewed it along with stormwater quality data collected from similar regional municipal and residential area studies. Data were compared to screening values to identify stormwater chemicals/analytes of interest (COIs) that may be present at concentrations that could adversely impact the native groundwater and thus require treatment or removal before ASR injection. Consistent with the regulatory requirements discussed above, stormwater COIs were screened against one-half their respective MCL, with the exception of analytes with an SMCL, which were screened at the full SMCL value.

6.1 Evaluation of Stormwater Discharging to the Sterling Park Water Quality Basin

6.1.1 Stormwater Sampling and Analysis

Four stormwater sampling events were conducted in 2017 within drainage basins WS 1A and WS 1B. Samples were collected from two stormwater manholes just upstream of the respective conveyance system outfalls to the Sterling Park Water Quality Basin. Locations of the two sampling points within basins WS 1A and WS 1B are depicted in Figure 1. Minimum storm event criteria[5] were targeted, but samples were collected for a range of seasonal and storm conditions, including “first flush[6]” conditions, to determine the range of COI concentrations that

[5] OAR 340-044-0018 storm event criteria that were targeted included (1) antecedent dry period of at least 72 hours with less than 0.1 inch rain, (2) minimum predicted rainfall volume greater than 0.1 inch per event, and (3) expected duration of storm event of at least 3 hours.

[6] “First flush” is defined in OAR 340-044-0018 and DEQ’s *Guidance for Evaluating Stormwater Pathways at Upland Sites* (DEQ, 2009, Updated 2010) to mean within the first 30 minturesminutes of stormwater discharge.

may be present in stormwater discharging to the Sterling Park Water Quality Basin. Time series grab samples were collected at both locations during two storm events (Events 1 and 3) to assess COI concentrations and concentration trends for the course of the storm events, and single grab samples were collected from both locations during the other two events (Events 2 and 4). Figure 4 depicts hydrographs for each storm sampling event based on flow logger data and local precipitation data[7]. The timing at which samples were collected during the storm event are displayed shown in Figure 4, including samples that targeted "first flush" conditions.

Samples were collected in accordance with a Sampling and Analysis Plan (SAP – See Appendix A) and analyzed for either (1) a comprehensive "full" suite of COIs including all chemicals for which an MCL, SMCL, or treatment technology (TT) is available as well as additional emerging contaminants (e.g., new pesticides), and a variety of viral, bacterial, and protozoan pathogens; or (2) a shorter list of indicator analytes deemed to be representative of common COIs that could be encountered in the Sterling Park development or similar residential land use areas. Table 2 provides a summary of the stormwater sampling events and associated analyses.

Table 2. Summary of Stormwater Sampling and Analyses

Sampling Event	Date	Time Series	Stormwater Drainage Basin	
			WS-1A (Scholl's)	WS-1B (Loon)
1	2/15/2017	Sample 1*	♦	♦
		Sample 2	●	●
		Sample 3	●	●
2	6/8/2017	Sample 1	●	●
3	10/11/2017	Sample 1*	●	♦
		Sample 2	●	●
		Sample 3	●	●
4	11/8/2017	Sample 1	●	●

Notes:
* Targeted first flush
♦ Indicates sample was analyzed for comprehensive list of COIs identified in the SAP (CWS and GSI, November 2016).
● Indicates sample was analyzed for list of indicator COIs identified in the SAP.
COI = chemical of interest
SAP = sampling and analysis plan

6.1.2 Stormwater Data Screening

The full set of stormwater data collected during the four stormwater sampling events is presented in Table 3 including data for pathogens, pesticides, disinfectants and DBPs, metals, radionuclides, organics, inorganics, and other constituents. In general, many of the COIs that were analyzed as part of the sampling events were not detected above method reporting limits (MRLs), and concentrations of COIs that were detected in stormwater samples were generally below screening criteria limits of one-half the MCL or one times the SMCL. Table 4 lists the COIs detected above MRLs in one or more sample(s), the frequency of those COI detections and

[7] Precipitation data were evaluated from the Sylvania PCC rain gauge (https://or.water.usgs.gov/non-usgs/bes/pcc_sylvania.html), which is located approximately 7 miles from the siteSite. Although precipitation data generally correlate with flow data observed by the two flow loggers, precipitation intensity was not always similar between the rain gauge location and siteSite. Flow data are used within the hydrographs as they more accurately describe the conditions at the Sterling Park facility during the sampling events.

any screening level exceedances, the range of concentrations or values detected for that specific COI, and the geometric mean concentration of the COI for the full sample set. Table 5 presents a list of the COIs that exceeded the screening level criterion of one-half the MCL or one times the SMCL in one or more stormwater samples and the percentage of samples that exceeded the screening criteria for that particular analyte.

Of the approximately 170 COIs analyzed in the comprehensive or "full" suite, eight COIs exceeded their respective screening level value in one or more sample:

- Turbidity
- Apparent color
- Total aluminum
- Total iron
- Fecal coliform
- Total coliform
- E. Coli
- Culturable enteric viruses

Three of these analytes (apparent color, total aluminum, and total iron) do not have MCLs, but instead have non-mandatory SMCLs, which are developed for aesthetic considerations such as taste, color, and odor. The remaining COIs, including turbidity and the microbiological parameters (coliform bacteria and enteric viruses), are ubiquitous in residential stormwater runoff. Concentrations of many COIs are expected to increase with increasing concentrations of suspended solids and particulates entrained in the stormwater runoff. Accordingly, it is expected that many of these COI concentrations could be greatly reduced with an effective solids removal process. Figure 5 illustrates the generally positive correlations between select COIs and suspended solids concentrations. In general, many of the constituents that exceeded screening criteria have a positive correlation with increasing suspended solids concentrations. However, coliform data appear to have less association with suspended solids concentrations than with increasing temperatures.

Microbiological constituents are an important consideration in drinking water quality standards, but typically are of less interest in stormwater management because of the end use of routing stormwater to existing source waters[8]. Preliminary discussions with regulators and recent work completed in support of various municipal UIC programs indicates that microbiological constituents present in stormwater attenuate after injection and may not require treatment before recharge. However, this evaluation includes analysis of potential impacts to the aquifer from microbiological constituents resulting from stormwater ASR. Potential survival of pathogens, particularly viruses, is a concern, particularly for a period of time long enough to impact the beneficial use of groundwater as a drinking water resource (e.g., potential impact to a hypothetical nearby private or municipal well by the stored water). For these reasons, disinfection or other effective antimicrobial treatment processes will be considered before ASR injection.

It is worth noting that while concentrations of zinc never exceeded the SMCL of 5,000 micrograms per liter (µg/L), zinc and other metals may need to be further reduced to meet requirements of CWS's basin wide individual permit for discharge into the Tualatin Basin. As described in the regulatory requirements, stormwater may be used to augment and cool adjacent

[8] The current NPDES benchmark for E. coli at active landfills and sewage treatment plants is 406 counts/100ml.

streams during summer months and would thus be subject to these requirements. If stream augmentation is a desired use for stormwater recovery, metals removal processes (e.g., via adsorptive media) should be considered.

6.2 Review of Municipal Urban Stormwater Data

In addition to collecting site-specific stormwater data, GSI reviewed municipal urban stormwater data in Oregon as a further evaluation of anticipated water quality in stormwater that would be used for ASR. The urban stormwater data were obtained from two sources:

- Kennedy/Jenks (2009), a compilation of stormwater data from 15 public agencies in Oregon
- DEQ (2015), a municipal UIC database that includes the Cities of Portland, Gresham, Redmond, Bend, and Keizer

DEQ's UIC permits require stormwater monitoring at the point of discharge into the UIC to demonstrate that stormwater quality meets permit limits and is protective of groundwater as a drinking water resource. The above-referenced studies focus on approximately 40 permit-defined COIs. Table 6 presents a summary of the COIs that were identified in those two studies as being detected in stormwater at concentrations exceeding EPA's MCLs. As indicated, 10 permit-required COIs were detected at concentrations greater than their respective MCLs. Of those, five COIs were detected at concentrations that exceeded MCLs in approximately 1 percent or more of the samples: benzo(a)pyrene (BaP), total chromium, di(2-ethylhexyl)phthalate (DEHP), total lead, and pentachlorophenol (PCP). Concentrations of PCP and total lead were observed to exceed their respective MCL values most frequently with 10 to 15 percent of the samples exceeding MCLs. The other constituents listed in Table 1 exceeded the MCLs in less than 1 percent of the samples included in the studies.

Table 6. Analytes Detected in Oregon Municipal Stormwater Above MCLs

Analyte	EPA MCL (mg/L)	Previous Regional Studies: Total Number of Samples: Kennedy/ Jenks Study (2009)	Previous Regional Studies: Total Number of Samples: DEQ Municipal Database (2015)[a]	Previous Regional Studies: Percent of Total Samples Exceeding the MCL: Kennedy / Jenks (2009)	Previous Regional Studies: Percent of Total Samples Exceeding the MCL: DEQ Municipal Database (2015)[a]	This Study: Total Number of Samples	This Study: Percentage exceeding the MCL
Antimony	0.006	347	277	0.3	0.0	16	0.0
Arsenic (total)	0.01	846	1,183	0.2	0.08	16	0.0
Benzo(a)pyrene	0.0002	740	1,284	0.3	0.93[b]	16	0.0
Cadmium	0.005	1,609	1,183	0.5	0.0	16	0.0
Chromium	0.1	1,226	1,183	0.8	0.0	16	0.0
DEHP	0.006	641	1,284	4.7	5.5	16	0.0
Lead (total)	0.015 ("Action level")	1,782	1,284	12.7	13.3	16	0.0
Nitrate-Nitrogen	10	633	1,136	0.3	0.0	14	0.0
PCP	0.001	675	1,279	11.7	14.5	3	0.0
Zinc (total)	5[c]	1,661	1,284	0.1	0.0	16	0.0

Notes:
[a] Results represent stormwater quality in municipal urban rights-of-way as measured at the point of discharge into UICs.
[b] Shading indicates analytes detected at concentrations greater than the MCL in approximately 1 percent or more of the samples.
[c] No MCL exists for total zinc. The SMCL and UIC permit limit of 5 milligrams per liter (mg/L) was used for calculations.
DEHP = di(2-ethylhexyl)phthalate
DEQ = Oregon Department of Environmental Quality
EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level PCP = pentachlorophenol
PCP = pentachlorophenol

6.3 Evaluation of Portland Metropolitan Area Residential Stormwater Data

GSI reviewed 9 years of the City's UIC Program stormwater data collected from locations with single-family residential land use similar to that in the Sterling Park residential development area. UIC stormwater samples from these areas were collected at the point of discharge into individual UIC facilities in public rights-of-way, and reported to DEQ in compliance with the City's municipal WPCF permit (i.e., UIC permit). The City's UIC permit required that any analyte detected at any concentration be reported (i.e., ancillary pollutants). Of the 100+ permit-required and ancillary COIs analyzed during the 9-year period, the following constituents were detected at concentrations greater than one-half the MCL in at least one sample:

- Antimony (total)
- Arsenic (total)
- Benzene
- Benzo(a)pyrene
- Cadmium (total)
- Chromium (total)
- DEHP
- Lead (total)
- PCP

This list of COIs exceeding screening values is similar to COIs observed in the two municipal stormwater studies. Five of the nine COIs listed above (antimony, arsenic, benzene, cadmium, and chromium) were detected in less than 1 percent of the samples. The four remaining COIs—benzo(a)pyrene, DEHP, total lead, and PCP—were detected at concentrations greater than one-half of the MCL in more than 1 percent of the samples. The frequency of these exceedances ranged between 6 and 33 percent of the samples. However, geometric mean concentrations for these four COIs during the 9-year period did not exceed one-half of their respective MCL (see Table 7).

Table 7. Geometric Mean Concentrations of Stormwater Analytes in Residential Use UICs (Portland, Oregon)

Analysis	1/2 EPA MCL (µg/L)	Geometric Mean Concentration (µg/L)								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Benzo(a)pyrene	0.1	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02
DEHP	3	1.3	1.5	1.5	1.3	1.2	1.1	1.01	0.8	1.3
Lead (total)	7.5	2.3	3.6	3	2.8	1.8	2.3	3	2.7	2.7
PCP	0.5	0.1	0.3	0.2	0.2	0.2	0.09	0.2	0.2	0.1

Notes:
µg/L = microgram per liter
N = 897 samples
DEHP = di(2-ethylhexyl)phthalate EPA = U.S. Environmental Protection Agency
MCL = maximum contaminant level
PCP = pentachlorophenol
UIC = underground injection control

6.4 Stormwater Quality Evaluation Summary: Suitability for Recharge

The concentrations of stormwater COIs observed in site-specific stormwater samples and those evaluated from applicable local and regional stormwater datasets indicate that (1) local municipal residential stormwater generally meets screening criteria and (2) recharge of this water into the aquifer would not be expected to adversely impact the beneficial use of the aquifer if coupled with minimal treatment. The COIs exceeding screening criteria in site-specific stormwater samples, as well as those in Tables 6 and 7, are ubiquitous in the environment (BES, 2008; DEQ, 2015). A large fraction of the COI concentrations likely is associated with stormwater particulates that could be removed via an effective suspended solids removal process, and the remaining dissolved fractions could be removed through treatment steps, such as activated carbon adsorption. Concentrations of particulates and COIs that do migrate to the aquifer would have limited mobility in the subsurface and would be expected to be further reduced through the processes of mechanical filtration, degradation, dispersion, and adsorption.

Microbiological data (bacteria, protozoa, and viruses) were not analyzed in the Portland UIC data. However, these constituents are known to be ubiquitous in the environment and were observed in site-specific samples. Disinfection or other anti-microbial treatment processes (e.g., ultraviolet [UV] irradiation) would need to be employed before ASR injection to meet primary drinking water standard treatment technology requirements and safeguard the aquifer's beneficial use.

6.5 Temperature

Water temperature is an important physical property of water and of interest for the proposed project because the recovered stormwater may be considered for streamflow mitigation during the summer months. Maintaining cool stream temperatures in the summer is important for supporting aquatic ecosystems. Cool stormwater, stored in the aquifer, can be pumped from the subsurface, and discharged to mix with surface water, thereby potentially reducing the overall thermal load to a stream.

Temperature data collected during the site-specific stormwater sampling and from Portland's UIC data were evaluated to estimate typical temperatures of the stormwater proposed for recharge. Site-specific temperature data ranged from 6.96 to 9.09 degrees Celsius (ºC). During the 9-year period of UIC data that GSI reviewed, stormwater temperatures ranged from 6.4 (in January) to 14.4ºC (in October) (see Table 8).

Table 8. Geometric Mean Stormwater Temperature in UICs (residential land use, Portland, Oregon)

Month	Number of Samples	Temperature (ºC)
October	75	14.4
November	90	9.6
December	62	7.6
January	79	6.4
February	83	6.9
March	110	8.4
April	63	10.5
May	15	13.4

Notes:
Blue highlight = likely months of stormwater recharge
ºC = degrees Celsius
UIC = underground injection control

The site-specific and UIC temperature data indicate that the temperature of banked stormwater used to recharge ASR 3—particularly runoff generated during cooler months (highlighted in blue)—could be used to cool streamflow (i.e., streamflow mitigation) in nearby Summer Creek. Summer Creek streamflow temperature data are not available, but temperature data from Fanno Creek downstream from its confluence with Summer Creek indicates an average summertime (June-September) streamflow temperature of approximately 19°C (USGS, 2015). Observation from other regional ASR projects indicate that stored water quality characteristics, including temperature, are generally maintained during ASR storage. Given the temperature differential between wintertime stormwater and summertime streamflow temperatures, a significant thermal benefit is anticipated from the project.

7. Stormwater Treatment Prior to Recharge

Based on a review of the preliminary data collected from the Sterling Park Water Quality Basin and a review of local municipal residential stormwater data, the majority of COIs present in stormwater discharging to Sterling Park are likely to be at concentrations below ASR regulatory criteria. However, several groups of constituents, including metals, turbidity and nuisance parameters (e.g., odor, color), pathogens, pesticides, and PAHs and phthalates, may be present in stormwater discharges above the regulatory requirement of less than one-half the MCL or one times the SMCL during some storm events. A substantial fraction of these constituents likely is associated with suspended stormwater particulates that could be reduced through an effective solids removal process before recharge. For the dissolved fraction of COIs, adsorptive materials, such as biochar or activated carbon, may be required to reduce COI concentrations to less than regulatory levels. Table 9 presents COIs detected at levels exceeding the screening criteria in the site-specific, local, and regional stormwater quality studies along with several potential treatment options that could be employed for COI removal.

Table 9. Stormwater COIs Potentially Requiring Treatment at Sterling Park Water Quality Facility

Data Source			Treatment Options
Sterling Park Site-Specific Stormwater Data (2017)	**Oregon Municipal Stormwater Studies (Kennedy/Jenks, 2009; DEQ Municipal Database, 2015)**	**DEQ Municipal Database (2015)**	
Solids, Nuisance, Odor			
Turbidity, Apparent Color, Odor	Not analyzed	Not analyzed	Turbidity may be removed with flocculants/coagulants, filtration, sedimentation, adsorption, or some combination of all of these processes. Water quality issues associated with color and odor may be greatly reduced after suspended solids removal processes.
Metals			
Zinc (total), Aluminum (total), Iron (total)	Antimony, Arsenic (total), Cadmium (total), Chromium (total), Lead (total), Zinc (total)	Antimony, Arsenic (total), Cadmium (total), Chromium (total), Lead (total)	Particulate portion of the total metals can be reduced through filtration processes (e.g., sand filter). Concentrations of dissolved metals may be removed through activated carbon/biochar adsorption, ion exchange processes, ultra or membrane filtration, precipitation, electrodialysis, or distillation.
PAHs, Phthalates, and Other Organics			
No COIs above screening levels	Benzo(a)pyrene, DEHP	Benzo(a)pyrene, DEHP, Benzene	Activated carbon is particularly effective in removing concentrations of dissolved organics such as PAHs, phthalates, and benzene.
Nitrate-Nitrogen			
No COIs above screening levels	Nitrate-Nitrogen	No COIs exceeding the screening level	Likely would require ion exchange units, reverse osmosis, or distillation. Some nitrate-nitrogen may be removed through filtration and adsorptive treatment steps or biological processes
Pesticides			
No COIs above screening levels	PCP	PCP	Activated carbon and other adsorptive media, such as organoclay, are often effective in removing pesticides such as PCP.
Potential Pathogens			
Fecal Coliform, Total Coliform, E. Coli, Culturable Enteric Viruses	Not Analyzed	Not Analyzed	Various effective means of disinfection are readily available including chlorine, chloramines, ozonation, ultraviolet irradiation, etc.

Notes:
COI = chemical of interest
DEHP = di(2-ethylhexyl)phthalate
DEQ = Oregon Department of Environmental Quality
PAH = polycyclic aromatic hydrocarbon
PCP = pentachlorophenol

7.1 Solids, Turbidity, and Nuisance Parameter Removal

A large fraction of the COIs, including turbidity, heavy metals, and organics detected in the Site stormwater, likely are associated with suspended particulates (Muthukrishnan, 2005; Sansalone, 2003). Turbidity has a close relationship with the total suspended solids (TSS) concentration (See Figure 5).[9] TSS concentrations in Site stormwater ranged from non-detect values up to 80 mg/L with geometric mean concentrations of 6.5 and 4.1 mg/L at the WS 1A and WS 1B sampling locations, respectively. An effective suspended solids removal process is expected to reduce TSS concentrations by 60 to over 90 percent and potentially reduce large fractions of many of the detected COI concentrations.

To effectively design a suspended solids removal process that is capable of achieving COI reduction goals, it is important to understand the particle size distribution (PSD) of influent suspended solids. Removal of clays and colloids (< 3.9 µm) can be difficult with conventional means such as sand filtration, and additional filtration or polishing steps may be required to effectively reduce these particles. PSD analyses were conducted on sample from the Sterling Park data set. In general, 80 to 90 percent of suspended solids observed in samples were larger than 3.9 micrometers (µm) with the majority of these solids in the silt particle range between 3.9 and 62.5 µm. In samples with more than 10 mg/L of TSS, fewer than 20 percent of the particles were clays or colloids. Accordingly, it is expected that conventional filtration methods will provide sufficient reduction in turbidity and many other COIs.

Color is often a result of dissolved material (iron, copper, natural organic matter, manganese) and suspended solids concentrations and is expected to be reduced with many of the treatment processes that eliminate these underlying constituents including suspended solids removal and adsorption of dissolved organics. Similarly, odor is often a result of concentrations of iron, sulfur, or microbiological constituents and largely will resolve with treatment processes that eliminate these root constituents.

7.2 Metals Removal

A large fraction of total metals often is associated with coarser particulates (James, 2003) that can be removed through conventional solids removal processes (e.g., sand filter). The dissolved fraction of metals may be readily removed through activated carbon/biochar adsorption, ion exchange processes, ultra or membrane filtration, precipitation, electrodialysis, and distillation. However, not all processes are equally effective in removing specific metals. For example, activated carbon varies in its effectiveness for removing lead, aluminum, iron, and chromium depending upon pH and influent concentrations. Concentrations of metals in site-specific stormwater data indicate that both total and dissolved metals could be easily reduced below screening values, but treatability studies may need to be conducted to determine the ideal mix and quantity of filter media or dissolved metal treatment substrate.

7.3 PAHs and Phthalates Removal

PAHs and phthalates are common municipal stormwater pollutants,[10] but were not detected above screening level values in site-specific stormwater. However, activated carbon is

[9] While TSS is a measurement of solid material per volume of water, turbidity is a measure of the light scattered by suspended solids as well as by dissolved colored organic matter.

[10] DEHP often is associated with water pipes.

particularly effective in removing concentrations of dissolved organics such as PAHs, phthalates, and benzene and easily could be employed as a preventive measure.

7.4 Nitrate-Nitrogen Removal

Nitrates are difficult to remove from water sources with passive physical treatment options such as conventional filtration and generally require ion exchange units, reverse osmosis, or distillation processes to effectively remove it. Nitrate concentrations detected in site-specific stormwater data (0.27 and 0.25 mg/L in drainage basins WS 1A and WS 1B, respectively) were well below one-half the MCL value of 10 mg/L and are not expected to be of concern. Additionally, some nitrate-nitrogen may be removed through filtration and adsorptive treatment steps. Additional stormwater data should be collected over time to determine if nitrate concentrations increase as the Sterling Park residential area is further developed.

7.5 Pesticides Removal

PCP was not detected in any of the site-specific stormwater samples, but it is a common residential stormwater pollutant often associated with treated power polls. Activated carbon and other adsorptive media, such as organoclay, are often effective in removing pesticides such as PCP. At lower concentrations, PCP is readily degraded in the environment.

7.6 Potential Pathogens

As would be expected in residential stormwater, bacterial indicator organisms (total and fecal coliform, E .coli, heterotrophic plate count) and culturable viruses were detected in site-specific samples. Potential survival of pathogens, particularly viruses, for a period of time long enough to impact the beneficial use of groundwater is a concern. Accordingly, an effective means of disinfection (e.g., chlorine, chloramines, ozonation, UV irradiation, etc.) should be employed before ASR injection.

Although disinfection is an anticipated component of the stormwater treatment that will be used in pilot testing for the proposed project, the feasibility assessment conservatively included evaluation of the potential risk of migration of stored water potentially containing viruses past the disinfection step. For this evaluation, information related to virus survival time in groundwater was reviewed to evaluate time-of-travel for stored groundwater before it is brought to the surface for use. The fate of viruses in groundwater is controlled by temperature and adsorption to clay surfaces (Yates et al., 1985). Studies thus far indicate that the removal of viruses by adsorption would be limited in highly permeable aquifer materials and presumably this would apply to basalt interflow zones typical of the CRBG aquifer. Inactivation rates, however, tend to be higher in highly permeable aquifers (e.g., the inactivation rate of hepatitis A varies from 0.03/day in clay to 0.08/day in gravel; ViralT, 1994). A brief survey of the data provided by Yates et al. (1985) and ViralT (1994) indicates that the inactivation rate, as a function of environmental conditions, varies from 0.02/day to 0.676/day.

Survival time of viruses in groundwater, together with the calculated time-of-travel of groundwater in the aquifer, provide the basis for estimating that the horizontal separation distance between the recharge site and the nearest groundwater user, and is required to provide sufficient inactivation to be considered safe for consumption (i.e., “safe distance”). For treated drinking water, OAR rules (OAR 333-061-0032) require a 4-Log (99.99 percent) removal for viruses. This is generally accomplished through a specified contact time with chlorine and is temperature dependent. Chlorine disinfection is not being considered in this report, but the 4-Log requirement provides a target to determine the "safe distance."

Knowing the inactivation rate for a given virus, the half-life ($T_{1/2}$) of that virus can be calculated. The half-life is defined as the time it takes for 50 percent of the virus population at a given time to become inactivated. Assuming a first-order decay equation, the half-life can be calculated from the inactivation rate (λ) as follows:

$$T_{1/2} = 0.693/\lambda$$

Given the variation in inactivation rates noted above, the half-life of viruses may range from approximately 1 to 35 days. Beginning with a hypothetical concentration of 1,000, 4-Log removal would reduce the concentration to 0.1, and it would take between 13 and 14 half-lives to achieve that concentration. Assuming the most conservative half-life (35 days), a time-of-travel for groundwater of 455 to 490 days would be required to ensure adequate inactivation.

7.7 Preliminary Treatment Scheme and Layout

Based on a review of the required treatment processes needed to eliminate concentrations of COIs potentially exceeding regulatory criteria, a conceptual preliminary treatment train was generated (Figure 6) for a gravity-fed system that incorporates the key components of effective treatment for the observed flows and water quality: settling, filtration, adsorption/treatment, and disinfection.

The preliminary treatment train was used to explore treatment options including construction of a custom stormwater treatment system for the Sterling Park Water Quality Facility and installing pre-fabricated stormwater treatment systems. Key criteria used to evaluate these options included capital costs, operation and maintenance (O&M) costs, expected lifetime of the system, flow capacity, reliability of the system, and access to installation and operation support. In addition to constructing a site-specific treatment system, pre-fabricated stormwater treatment systems from Contech Engineered Solutions, Crystal Stream Technologies, Lakeside Equipment Corporation, and StormwaterRX were evaluated.

Although more detailed treatment design options will be assessed and fine-tuned during a pilot treatment system, a StormwaterRX Treatment system is evaluated in this feasibility analysis because it was found to be cost-effective and particularly applicable based upon the options that were researched in this study. Specifically, StormwaterRX is a local company and has cost-competitive stormwater treatment equipment that can (1) handle flow rates up to 400 gpm and (2) reduce a host of COIs, including TSS, heavy metals, PAHs, nitrate, and pathogens, to target concentration goals. Additionally, StormwaterRX offers a pilot test program to customize the design and treatability of the system. The pilot test program will allow for a more cost-effective evaluation of full scale implementation options.

For feasibility costing and treatment purposes, the following treatment components were assumed:

- An Aquip® Model 400SBE filtration system, enhanced stormwater filtration system designed for a treatment flow rate of 400 gpm with an aboveground system footprint of 13 x 48 feet. Includes pre-treatment chamber and integrated oil skimmer, and down-flow filtration chamber with layered inert and adsorptive biofiltration media for particulates, organics, and dissolved pollutants.

- A standard treatment pump and bypass system for a 400SBE system including 1.5 horsepower (208 volt/1Ph/15A) pumps operating at 400 gpm with less than 28 feet of total dynamic head, float switches, and check valves.
- A Purus® Bacteria Model 400-volt UV disinfection and polishing system designed to disinfect flows up to 400 gpm with an aboveground foot print of 1.5 x 12 feet. Includes 32 UV lamps with a total system continuous power requirement of 2,800 watts.

An initial layout of this system at the Site with planned ASR operation buildings is provided in Figure 7. Costing and implementation assumptions are provided in Section 10 and a five-year Net Present Value (NPV) cost estimate is provided in Appendix D.

8. Stored Water Movement during ASR Storage

This section evaluates the potential migration of treated stormwater during ASR storage and assesses the potential for stored water to interact with other groundwater users. To evaluate groundwater flow, a previously developed 3-dimensional numerical groundwater flow model (GSI, 2011) was modified to predict flow paths of water recharged at ASR 3. The model uses the U.S. Geological Survey (USGS) MODFLOW-2000 finite-difference groundwater modeling software (Harbaugh et al., 2000), and the Groundwater Vistas graphical user interface (ESI, 2007) is used to manage the modeling process. The model is calibrated to historical data from regional ASR programs. MODPATH particle tracking software with forward particle tracking to determine the advective transport of the recharged stormwater was used to delineate zones of influence from water recharged at ASR 3 based on the following assumptions:

- Based on stormwater flow data from basins WS-1A and WS-1B in 2017, 49 MG of treated stormwater were conservatively assumed as an annual recharge volume. Recharge would occur between October and May at rates up to 400 gpm.
- Two predictive model scenarios were selected to predict the most conservative conditions with respect to travel distance of the naturally attenuated surface water:
    - Scenario 1: Assumes a total recharge volume of 49 MG of treated stormwater from October through May for 1 year without any recovery pumping. No recovery pumping for 1 year is conservative and represents a potential pump failure after the recharge has occurred.
    - Scenario 2: Assumes a total injection volume of 49 MG of treated stormwater from October through May for 4 consecutive years (total volume of 196 MG in 4 years) without any recovery pumping. No recovery pumping represents a conservative scenario and unlikely potential pump failure for multiple years following each of the annual recharge periods.
- Stormwater treatment is anticipated to include UV treatment for microbiological inactivation. In the event inactivation is incomplete during the treatment process, based on natural microbiological attenuation within the aquifer as described previously, 4-log attenuation is expected for the most conservative viral inactivation rate within 500 days of entering the groundwater system.

Based on these assumptions, Table 10 summarizes potential migration distances of stored water from ASR 3 may occur at 500 days following recharge for the two scenarios. A safety factor of 2x (1,000 days) and 3x (1,500 days) are included for comparison.

Table 10. Potential Stored Water Migration Distance from ASR 3

Travel Time	Migration Distance from ASR 3 (feet)	
	Scenario 1	Scenario 2
500-day	830	1,070
1,000-day (2x Safety Factor)	880	1,510
1,500-day (3x Safety Factor)	930	1,800

Notes:
ASR = aquifer storage and recovery

Figure 7 shows the extent of each of these potential stored water migration zones including the safety factor. Figure 7 also shows the general distribution of water well locations based on review of OWRD's well construction records. The location of two wells (WASH 9179 and WASH 11456) constructed in 1971 are shown in Figure 7, approximately 750 feet south of ASR 3, based on tax lot information from OWRD. Given the conversion of nearly all parcels in this area from small farms to dense residential development since these wells were constructed, it is likely that these wells are no longer in use and have been abandoned. OWRD well records indicate that 25 water wells have been abandoned in Township 2 South, Range 1 West, Section 5. Specifically, two abandonment logs (WASH 51194 and WASH 51200) appear to be associated with the decommissioning of these two wells based on the address, tax lot, and well construction information. No other wells were identified in a search of OWRD's water well records within the extent of potential stored water migration predicted within 1,500 days of storage.

Similarly, in the surrounding sections (see Figure 7) high density residential development is underway and most wells that previously were constructed in this area for domestic use are no longer in use and have been abandoned. Based on OWRD records, the four sections encompassing and surrounding the Sterling Park Site, which represents the area within approximately 1 mile of the Site, historically has contained 72 wells (at least 2 of which appear to be mislocated) and 67 wells have been decommissioned since the early 1990s. Based on the dense residential development that has occurred and is being initiated in the vicinity, former domestic water supply wells likely are no longer in use and have been decommissioned. Beyond the area within 1 mile of the Sterling Park Site, several municipal water supply agencies used groundwater wells for ASR in the region; none of these are closer than 2 miles from the Sterling Park Site, which is well beyond the area of potential influence of treated stormwater proposed for recharge at this location.

As previously stated, OWRD's Critical Groundwater Area declaration has restricted existing groundwater use and prohibited issuance of new groundwater rights and construction of wells for irrigation or domestic use on properties of less than 10 acres in this area since 1971. Ultimately, the Critical Groundwater Area limits the number of potential nearby wells that could capture recharged water from ASR 3 in the future.

9. Groundwater Mixing

Mixing stormwater runoff with native groundwater has the potential to result in precipitation of constituents that could result in clogging of the well. Table 11 summarizes water quality data for select analytes from stormwater collected at the Sterling Park Site for the proposed project, drinking water quality used as source water for the City's other ASR wells, and native groundwater quality from sampling at ASR 3 during testing in 2000, 2001, and 2004. In general, with the exception of iron, manganese, total organic carbon (TOC), and TSS, stormwater quality is fairly consistent with drinking water used by the City as source water for its ASR wells (Table 11); this water is provided through the Joint Water Commission (JWC) system. It is anticipated that the proposed stormwater treatment would significantly reduce concentrations of metals, TOC, and TSS, likely to concentrations similar to or lower than the JWC water quality characteristics. Since the City initiated ASR in 1999, more than 4 billion gallons of JWC water have been recharged at the City's ASR wells without observation of precipitation or clogging, indicating chemical compatibility between the JWC source water and native groundwater.

Because stormwater quality will be altered by the anticipated treatment process, comparison of raw stormwater quality data collected in this assessment with native groundwater does not provide a basis for a full groundwater mixing analysis. With that being said, based on similarities between the Sterling Park Site stormwater quality data and the JWC water quality data, and similarities between the ASR 3 native groundwater quality and native groundwater quality at the City's ASR wells, compatibility issues are not anticipated. Additional water quality analysis is anticipated to be completed during initial pilot testing of stormwater quality treatment, and compatibility of treated stormwater quality and native groundwater should be confirmed.

10. Project Implementation Plan and Cost Estimate

This section provides a summary of the steps necessary to begin development of an ASR system with use of treated stormwater at the Sterling Park Site and the estimated time schedule for implementation. The overall objective for this section is to serve as a plan for implementation of ASR through preliminary design testing to full-scale construction of the stormwater treatment system and conveyance to provide a recharge source for storage at ASR 3. Additionally, preliminary cost estimates are provided for the implementation phase, as well as O&M during pilot testing.

10.1 Preliminary Design Pilot Testing

Before full-scale construction, initial pilot testing should be completed to confirm the efficacy of the proposed treatment technique and to confirm water quality elements during aquifer storage. The following is a general description of anticipated tasks and schedule during this phase of implementation:

- Stormwater treatment design pilot testing:
    - The stormwater treatment pilot system would consist of a scaled treatment system (anticipated to be approximately 5 to 10 percent of full-scale design capacity) with filtration and UV disinfection capabilities.

    - Water quality analysis of pre- and post-treated stormwater at the Sterling Park Site would be completed to confirm the level of treatment and to develop full-scale design parameters.

- Recharge pilot testing:
    - A scaled recharge cycle at ASR 3 would be completed with treated stormwater anticipated to be approximately 24 hours of recharge, a 24-hour storage period, and a 24-hour recovery period.
    - Water quality analysis of native groundwater at ASR 3, treated stormwater, stored water, and recovered water would be completed to evaluate water quality changes during artificial recharge.
    - Aquifer parameters would be evaluated during recharge testing to confirm the ability to recharge at projected rates and volumes.

Schedule: Anticipated to be completed within 1 year dependent upon timing of project initiation relative to stormwater season.

Cost Estimate: $230,000

10.2 Full-Scale Treatment System Design, Construction, and Implementation

Based on information obtained during initial pilot testing, the next steps would be: develop project regulatory permitting documents, complete design, and construct full-scale treatment and conveyance infrastructure from the existing stormwater system to the ASR 3 wellhead. The following is a general description of anticipated tasks and schedule during this phase of implementation:

- Regulatory permitting: ASR limited license and UIC permit.
- Stormwater treatment and conveyance system design and construction.
- Initiate ASR testing including detailed evaluation of treated stormwater water quality at full scale, baseline native groundwater quality, and recovered water quality. Groundwater level monitoring and assessment of aquifer response to recharge and recovery.

Schedule: Anticipated to be completed within 2 years

Cost Estimate: $555,000 to $795,000

10.3 Operation and Maintenance

Full-scale system O&M is anticipated to consist of water quality analysis, groundwater-level monitoring, treatment system and filter media maintenance, electrical costs, and annual regulatory reporting.

Schedule: Ongoing

Cost Estimate: Annually $75,000

Table 12 summarizes anticipated O&M costs for this project as compared to other regional water supply and mitigation costs for context. In general, project O&M costs are anticipated to be significantly less than retail drinking water costs and less than CWS treated wastewater costs for land application near CWS wastewater treatment facilities. Project O&M as compared to raw water storage in Hagg Lake is significantly more costly, but provides many other benefits as described in the benefit matrix shown in Table 12.

In summary, two phases of project implementation are anticipated to require approximately 3 years to complete and cost approximately $785,000 to $1,025,000. Ongoing O&M for the proposed project is anticipated to cost approximately $75,000 per year. Estimated five-year NPV costs presented in Appendix D range from $900,000 to $1,135,000 (depending upon the treatment system flow capacity) at a discount rate of 1.5 percent.

11. Conclusions

This section provides a summary of findings related to the use of stormwater as a source water for ASR at the Sterling Park Site. Based on the evaluation of the applicable regulations and the assessment of the physical and chemical parameters, stormwater recharge at the Sterling Park Site appears feasible, with minimal treatment, to meet regulatory requirements. Specifically:

- Regulatory feasibility for use of stormwater as a source for ASR is primarily dependent on compliance with drinking water quality standards (one-half of the primary drinking water standard for most constituents).
- Analysis of continuous stormwater flow data collected between October 2016 to November 2017 indicate a volume of nearly 57 MG of stormwater was discharged to the Sterling Park Site.
- Stormwater sampling conducted for this study indicates drinking water standard exceedances for a small number of constituents including turbidity, apparent color, aluminum, iron and microbiological components (coliform, fecal, E. coli, and enteric viruses). Several other regulated analytes were detected, but at concentrations below one-half of respective drinking water standards.
- Temperature data indicate that wintertime stormwater used for recharge typically range from 6.4 to 9.6°C. This cool water could be recovered during the summer and used to mitigate the temperature in Summer Creek and provide streamflow enhancement. Summer Creek streamflow temperature data are not available, but it discharges to Fanno Creek which has an average summertime streamflow temperature of approximately 19°C (USGS, 2015).
- Stormwater quality treatment would be needed to meet regulatory requirements and is anticipated to consist of filtration, activated carbon/biochar adsorption, and disinfection (e.g., chlorine or UV irradiation).
- Artificially recharged stormwater is anticipated to remain within 1,000 feet of ASR 3 even under conservative storage scenarios and would not impact other groundwater users.
- Following treatment, stormwater quality is anticipated to be similar in character to treated surface water used successfully on many ASR projects hosted in the CRBG aquifer. As such, mixing of treated stormwater with native groundwater is not anticipated to result in adverse chemical reactions.

- Next steps for implementation of the proposed project include stormwater treatment pilot testing, regulatory permitting application, and final treatment design and construction. Implementation is anticipated to require up to 3 years to complete and is estimated to cost approximately $785,000 to $1,025,000. The NPV of a 400 gpm system implemented with a pilot test program over a five year period was estimated at $1,135,000 using a discount factor of 1.5 percent.

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Tables

SM 9223B	Total Coliform *(Colilert 18)*	P or A	--	--	Present		Present		Present		Present	NC	Present		Present		Present		Present		Present		Present		Present		Present	NC	Present		Present		Present		Present	
SM 9223B	E. coli *(Colilert 18)*	P or A	--	--	Present		Present		Present		Present	NC	Present		Present		Present		Present		Present		Present		Present		Present	NC	Present		Present		Present		Present	
SM 9215B	Heterotrophic Plate Count (HPC) †	CFU/mL	1	--	360																230								>5700							
SM 9223B	Fecal Coliform	MPN/100 mL	1	0	64		66		111		2420		1553		1300		816		1300		15		18		1203		1553		326		866		488		172	
EPA 1623.1	Cryptosporidium spp. Enumeration , Primary Value †	C.O./100 L	4.4/2.0	0	1	ND															1	ND	1	ND					1	U, J1, ND						
EPA 1623.1	Cryptosporidium spp. Enumeration , Secondary Value †	P.V.O./100 L	4.4/2.0	0	1	ND															1	ND	1	ND												
EPA 1623.1	Giardia spp. Enumeration, Primary Value †	G.C./100 L	4.4/2.0	0	1	ND															1	ND	1	ND					1	U, J1, ND						
EPA 1623.1	Giardia spp. Enumeration, Secondary Value †	P.V.C./100 L	4.4/2.0	0	1	ND															1	ND	1	ND												
SM 9260J	Legionella spp †	L.S./1000 ml	1	0	1	ND															1	ND	1	ND					1	U, ND						
EPA 600	Culturable Cytopathic Enteric Viruses, Primary Value †	IU MPN	1	0	1.1																		1.1						1	ND						
EPA 600	Culturable Cytopathic Enteric Viruses, Secondary Value †	IU MPN	1	0	0.6																		1.8													
EPA 1615	Norovirus RTPCR, Primary Value	P or A	0	0	1	ND															1	ND	1	ND					0							
EPA 1615	Enterovirus RTPCR, Primary Value	P or A	0	0	1	ND															1	ND	1	ND					0							
EPA 300.0	Nitrate (measured as Nitrogen)	mg/L	0.1	10	0.937		0.468		0.131		0.5		0.127		0.182		0.175		0.1		0.591		0.216		0.371		0.5		0.203		0.101		0.141		0.112	
EPA 300.0	Nitrite (measured as Nitrogen)	mg/L	0.01	1	0.011		0.005	ND	0.005	ND	0.02		0.0739		0.0423		0.0344		0.01		0.005	ND	0.0676		0.005	ND	0.01		0.0415		0.0318		0.0128		0.0108	
Calculate	Total Nitrate + Nitrite (as N)	mg/L	0.01	10	0.948		0.468		0.136		0.52		0.2009		0.2243		0.2094		0.11		0.596		0.2836		0.376		0.51		0.2445		0.1328		0.1538		0.1228	
EPA 180.1	Turbidity	NTU	0.1	0.3 - 5 (Goal)	4.5		6.4		16		13		9		3.5		16		15		9.5		4.5		8.6		4.5		6.4		3.5		33		3	
SM 2150B	Odor at 60 degrees	TON	1	3 Threshold Odor Number	0.5	ND															0.5	ND							1							
EPA 300.0	Orthophosphate as Phosphate (PO4)	mg/L	0.1	--	0.05																0.17															
EPA 300.0	Orthophosphate as P	mg/L	0.1	--	0.05	ND															0.05	ND							0.1	ND						
SM 5910B	UV Absorbance at 254 nm	1/cm	0.005	--	0.179																0.228								0.223							
SM 2120B	Apparent Color	CU	5	15 Color Units	15																23								30							
EPA 425.1	Surfactants (MBAs, Foaming agents)	mg/L	0.05	0.5	0.025	ND															0.025	ND														
EPA 100.2	Asbestos (Subbed)	MFL	0.18	7 MFL1	0.09	ND															0.09	ND														
SM4500CN-F	Cyanide	mg/L	0.025	0.2	0.0125	ND															0.0125	ND							0.0125	ND						
SM 4500F-C	Fluoride	mg/L	0.05	4	0.025	ND															0.051								0.025	ND						
EPA 300.0	Chloride	mg/L	1	250	3.8																4.7								0.5	ND						
SM 4500-HB	pH (before sample collection)	Std. Units	0.1	6.5 to 8.5 pH Units	5.54		6.09		6.34				6.65						6.86		5.46		5.32		5.74										7.34	
SM 4500-HB	pH (after sample collection)	Std. Units	0.1	6.5 to 8.5 pH Units	6.29		6.23		6.22								6.96		6.85		5.75		5.68		5.86								7.34		6.97	
EPA 300.0	Sulfate	mg/L	0.5	250	5.5																6.6								2.6							
E160.1/SM2540C	Total Dissolved Solids (TDS)	mg/L	10	500	64		45		26		45		36		51		52		44		53		34		27		41		30		37		57		34	
SM 2340B	Total Hardness as CaCO3 by ICP	mg/L	3	250	38																28								15							
EPA 300.0	Bromide	ug/L	5	--	23																41								2.5	ND						
SM2510B	Specific Conductance, 25 C	umho/cm	2	--	100		70		38		58		51		61		59		52		110		51		42		47		41		41		65		42	
SM 5310C	Dissolved Organic Carbon	mg/L	0.3	--	2.3																3.4								8.4							
SM5310C/E 415.3	Total Organic Carbon	mg/L	0.3	--	2.1		2.4		2.1		13		6.8		6.3		7.8		13		3		1.7		1.9		14		7.9		7.2		14		12	

SM4500-PE/EPA 365.1	Total phosphorus as P	mg/L	0.02	--	0.043																0.042								0.085							
EPA 300.0	Chlorate by IC	ug/L	10	--	5	ND															5	ND							5	ND						
SM 1030E	Cation Sum	meq/L	0.001	--	0.97																0.75								0.35							
SM 1030E	Anion Sum	meq/L	0.001	--	0.0005	ND															0.0005	ND							0.0005	ND						
SM 2320B	Alkalinity in CaCO3 units	mg/L	2	--	36																37								13							
ASTM D3977	Suspended Sediment Concentration	ppm	1	--	1.9		5.1		27		8		6.2		6		9.9		22.7		2.4		3.1		7.6		1.3		0.5	ND	2.1		71.1		19.4	
SM 2540D	Total Suspended Solids (TSS)	mg/L	10	--	5	ND	5	ND	20		14		5	ND	5	ND	5	ND	18		5	ND	5	ND	5	ND	5	ND	5	ND	5	ND	80		5	ND
SM 4500-Cl G	Chlorine (Total Residual)	mg/L	0.01	4.0 (as Cl_2)	0.19		0.14		0.2												0		0		0											
SM 4500-Cl G	Chloramines	mg/L	0.01	0.8 (as ClO_2)	≤ 0.19[1]	ND	≤ 0.14[1]	ND	≤ 0.20[1]	ND											<0.01	ND	≤ 0.20[1]	ND	≤ 0.20[1]	ND										
SM 4500 CLO2-D	Chlorine dioxide	mg/L	0.01	0.8 (as ClO_2)	≤ 0.95[2]	ND	≤ 0.70[2]	ND	≤ 1.0[2]	ND											<0.05	ND	≤ 1.0[2]	ND	≤ 1.0[2]	ND										
SM 6251B	Total Haloacetic Acids (five)(HAA5)	ug/L	2	60	1	ND															ND								1	ND					1	ND
EPA 524.2	Total THM (Total Trihalomethanes)	ug/L	0.5	80	0.5		0.25	ND	0.25	ND	0.77		0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.51		0.25	ND	0.51		0.51		0.25	ND
EPA 300.0	Chlorite	mg/L	0.01	1	0.005	ND															ND								0.0025	ND						
EPA 317	Bromate	ug/L	1	10	0.5	ND															ND								0.25	ND						
EPA 8151A	Bifenthrin	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Chlorothalonil	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Cypermethrin	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Dithiopyr	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Fipronil	ug/L	0.12	--	0.06	ND															0.06	ND							0.06	ND						
EPA 8151A	Metolachlor	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Myclobutanil	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Pendrimethalin	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Permethrin	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Propiconazole	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Trifluralin	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Triclopyr	ug/L	0.08	--	0.04	ND															0.04	ND							0.04	ND						
EPA 8151A	Carbaryl	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	DCPMU	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Diuron	ug/L	0.06	--	0.03	ND															0.03	ND							0.41							
EPA 8151A	Imidacloprid	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 8151A	Malathion	ug/L	0.06	--	0.03	ND															0.03	ND							0.03	ND						
EPA 200.8	Antimony, Total	ug/L	1	6	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND
EPA 200.8	Arsenic, Total	ug/L	1	10	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND
EPA 200.8	Barium, Total	ug/L	2	2000	11																19								7.3							
EPA 200.8	Beryllium, Total	ug/L	1	4	0.5	ND															0.5	ND							0.5	ND						
EPA 200.8	Cadmium, Total	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 200.8	Chromium, Total	ug/L	1	100	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	1.1		1.4		0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	2.5		0.5	ND
EPA 200.8	Copper, Total	ug/L	2	1300	2		2.5		4.6		8.8		4.1		1	ND	6.5		7.7		1	ND	1	ND	1	ND	2.9		4.5		2.4		7.8		3.0	
EPA 200.8	Lead, Total	ug/L	0.5	15	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	2.6		0.25	ND
EPA 245.1	Mercury, Total	ug/L	0.2	2	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 200.8	Selenium,Total	ug/L	5	50	2.5	ND															2.5	ND							2.5	ND						
EPA 200.8	Thallium, Total	ug/L	1	2	0.5	ND															0.5	ND							0.5	ND						
EPA 200.8	Zinc, Total	ug/L	20	5000	54		67		68		620		1200		10	ND	1000		2700		190		130		83		150		1300		1200		1300		160	
EPA 200.8	Aluminum, Total	ug/L	20	200	320																460								87							
EPA 200.8	Manganese, Total	ug/L	2	50	18																11								13							
EPA 200.8	Silver, Total	ug/L	0.5	100	0.25	ND															0.25	ND							0.25	ND						
EPA 200.7	Iron, Total	mg/L	0.02	0.3	0.43																0.49								0.11							
EPA 505	Alachlor (Alanex)	ug/L	0.1	--	0.05	ND															0.05	ND							0.025	ND						
EPA 505	Chlordane	ug/L	0.1	2	0.05	ND															0.05	ND							0.025	ND						
EPA 505	Endrin	ug/L	0.01	2	0.005	ND															0.005	ND							0.0025	ND						
EPA 505	Heptachlor	ug/L	0.01	--	0.005	ND															0.005	ND							0.0025	ND						
EPA 505	Heptachlor Epoxide	ug/L	0.01	0.2	0.005	ND															0.005	ND							0.0025	ND						
EPA 505	Methoxychlor	ug/L	0.05	40	0.025	ND															0.025	ND							0.0125	ND						
EPA 505	Toxaphene	ug/L	0.5	3	0.25	ND															0.25	ND							0.125	ND						
EPA 625	Dibenz(a,h)anthracene	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 505	Dieldrin	ug/L	0.01	--	0.005	ND															0.005	ND							0.0025	ND						
EPA 515.4	2,4-D	ug/L	0.1	70	0.19																0.05	ND							1.4							
EPA 515.4	Dalapon	ug/L	1	200	0.5	ND															0.5	ND							0.25	ND						
EPA 515.4	Dicamba	ug/L	0.1	--	0.05	ND															0.05	ND							0.22							
EPA 515.4	Dinoseb	ug/L	0.2	7	0.1	ND															0.1	ND							0.05	ND						
EPA 515.4	Pentachlorophenol	ug/L	0.04	1	0.02	ND															0.02	ND							0.01	ND						
EPA 515.4	Picloram	ug/L	0.1	500	0.05	ND															0.05	ND							0.025	ND						

EPA 515.4	2,4,5-TP (Silvex)	ug/L	0.2	50	0.1	ND															0.1	ND							0.05	ND						
EPA 524.2	Benzene	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Naphthalene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Carbon Tetrachloride	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chlorobenzene	ug/L	0.5	100	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	o-Dichlorobenzene (1,2-DCB)	ug/L	0.5	600	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	p-Dichlorobenzene (1,4-DCB)	ug/L	0.5	75	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2-Dichloroethane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1-Dichloroethylene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	cis-1,2-Dichloroethylene	ug/L	0.5	70	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	trans-1,2-Dichloroethylene	ug/L	0.5	100	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Epichlorohydrin	ug/L	0.4	--	0.2	ND															0.2	ND							0.1	ND						
EPA 524.2	Ethyl benzene	ug/L	0.5	700	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Styrene	ug/L	0.5	100	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Tetrachloroethylene (PCE)	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Toluene	ug/L	0.5	1000	0.25	ND	0.25	ND	0.25	ND	0.59		0.54		0.25	ND	0.25	ND	0.57		0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,4-Trichlorobenzene	ug/L	0.5	70	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND, LE	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Trichloroethylene (TCE)	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Vinyl chloride (VC)	ug/L	0.3	2	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.075	ND	0.15	ND	0.15	ND	0.15	ND
EPA 524.2	Total xylenes	ug/L	0.5	10000	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.125	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Alachlor	ug/L	0.05	2	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Atrazine	ug/L	0.05	3	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Acenaphthene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.025	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Acenaphthylene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.025	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Naphthalene	ug/L	0.3	--	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.075	ND	0.15	ND	0.15	ND	0.15	ND
EPA 525.2	Fluorene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Phenanthrene	ug/L	0.04	--	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND
EPA 525.2	Anthracene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.005	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Fluoranthene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.025	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Pyrene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Benz(a)Anthracene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Chrysene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.005	ND	0.01	ND	0.073		0.01	ND
EPA 525.2	Benzo(a)pyrene	ug/L	0.02	0.2	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.005	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Benzo(b)Fluoranthene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.005	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Benzo(g,h,i)Perylene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Benzo(k)Fluoranthene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.005	ND	0.01	ND	0.072		0.01	ND
EPA 525.2	Indeno(1,2,3,c,d)Pyrene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Di-(2-Ethylhexyl)adipate	ug/L	0.6	400	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.3	LE,N	0.3	E,ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.15	ND	0.3	ND	0.3	ND	0.3	ND
EPA 525.2	Di(2-Ethylhexyl)phthalate	ug/L	0.6	6	0.3	ND	0.3	ND	0.92		0.72	B1, L3, LE	0.3	ND	0.3	ND	0.97		0.93		0.3	ND	0.3	ND	0.3	ND	0.3	BA,LE,LK,ND	0.15	ND	0.97		0.3	ND	0.3	ND
EPA 525.2	Endrin	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND	0.1	LE,ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	LE, ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	Heptachlor	ug/L	0.03	0.4	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.0075	ND	0.015	ND	0.015	ND	0.015	ND
EPA 525.2	Hexachlorobenzene	ug/L	0.05	1	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Hexachlorocyclopentadiene	ug/L	0.05	50	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Lindane	ug/L	0.04	0.2	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND
EPA 525.2	Methoxychlor	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.025	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Pentachlorophenol	ug/L	1	--	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.25	ND	0.5	ND	0.5	ND	0.5	ND
EPA 525.2	Simazine	ug/L	0.05	4	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.0125	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Dieldrin	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.05	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	4,4-DDE	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.025	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	4,4-DDT	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.025	ND	0.05	ND	0.05	ND	0.05	ND
EPA 531.2	Carbofuran (Furadan)	ug/L	0.5	40	0.25	ND															0.25	ND							0.125	ND						
EPA 531.2	Oxamyl (Vydate)	ug/L	0.5	200	0.25	ND															0.25	ND							0.125	ND						
EPA 547	Glyphosate	ug/L	6	700	3	ND															3	ND							1.5	ND						
EPA 548.1	Endothall	ug/L	5	100	2.5	ND															2.5	ND							1.25	ND						
EPA 549.2	Diquat	ug/L	0.4	20	0.2	ND															0.2	ND							0.1	ND						
EPA 551.1	Ethylene Dibromide (EDB)	ug/L	0.01	0.05	0.005	ND															0.005	ND							0.0025	ND						
EPA 625	Acenaphthene	ug/L	5	--	2.5	ND							1.25	ND											2.5	ND							1.25	ND	1.25	ND						
EPA 625	Acenaphthylene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Naphthalene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Fluorene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Phenanthrene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Anthracene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Fluoranthene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Pyrene	ug/L	5	--	2.5	ND							1.25	ND									2.5	ND							1.25	ND						
EPA 625	Chrysene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Benzo(a)anthracene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Benzo(a)pyrene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Benzo(b)fluoranthene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Benzo(g,h,i)perylene	ug/L	10	--	5	ND															5	ND							2.5	ND						
EPA 625	Benzo(k)fluoranthene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Indeno(1,2,3-c,d)pyrene	ug/L	10	--	5	ND															5	ND							2.5	ND						
EPA 625	Di(2-Ethylhexyl)phthalate	ug/L	4	6	2	ND															2	ND							1	ND						

EPA 625	Hexachlorobenzene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
EPA 625	Hexachlorocyclopentadiene	ug/L	10	--	5	ND															5	ND							2.5	ND						
EPA 625	Pentachlorophenol	ug/L	20	--	10	ND															10	ND							5	ND						
EPA 625	1,2,4-Trichlorobenzene	ug/L	5	--	2.5	ND															2.5	ND							1.25	ND						
MWH/LCMS MS	Acrylamide	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 900.0	Alpha, Gross	pCi/L	3	15	1.5	ND															1.5	ND							1.5	ND						
EPA 900.0	Alpha, Min Detectable Activity	pCi/L	--	15	1.8																1.9								2.4							
EPA 900.0	Alpha, Two Sigma Error	pCi/L	--	15	0.47																0.45								0.52							
EPA 900.0	Beta, Gross (Beta/Photon emitters)	pCi/L	3	4 mrem/yr	1.5	ND															1.5	ND							1.5	ND						
EPA 900.0	Beta, Min Detectable Activity	pCi/L	--	--																									1.8							
EPA 900.0	Beta, Two Sigma Error	pCi/L	--	--																									0.54							
EPA 900.0	Gross Alpha + adjusted error	pCi/L	3	15	1.5	ND															1.5	ND							1.5	ND						
Ra-226 GA	Radium 226	pCi/L	1	5	0.5	ND															0.5	ND							0.5	ND						
Ra-226 GA	Radium 226 Min Detect Activity	pCi/L	--	--																									0.45							
Ra-226 GA	Radium 226 Two Sigma Error	pCi/L	1	--																									0.5	ND						
RA-228 GA	Radium 228	pCi/L	1	5	0.5	ND															0.5	ND							0.5	ND						
Ra-226 GA	Radium 286 Min Detect Activity	pCi/L	--	--																									0.71							
Ra-226 GA	Radium 228 Two Sigma Error	pCi/L	1	--																									0.5	ND						
Calculated	Combined Radium 226 and Radium 228	pCi/L	2	5	1	ND															1	ND							1	ND						
EPA 200.8	Uranium	ug/L	1	30	0.5	ND															0.5	ND							0.5	ND						
EPA 1613B	2,3,7,8-TCDD (Dioxin)	pg/L	1.96	30 pg/L	0.98	ND															0.98	ND							0.98	ND						
EPA 200.7	Calcium Total ICAP	mg/L	1	--	11																8								5.2							
EPA 200.7	Magnesium Total ICAP	mg/L	0.1	--	2.6																2								0.44							
EPA 200.7	Potassium Total ICAP	mg/L	1	--	0.5	ND															0.5	ND							0.5	ND						
EPA 200.7	Sodium Total ICAP	mg/L	1	--	5																4.1								1.2	ND						
EPA 505	Aldrin	ug/L	0.01	--	0.005	ND															0.005	ND							0.005	ND						
EPA 505	Lindane (gamma-BHC)	ug/L	0.01	--	0.005	ND															0.005	ND							0.005	ND						
EPA 505	PCB 1016 Aroclor	ug/L	0.08	--	0.04	ND															0.04	ND							0.04	ND						
EPA 505	PCB 1221 Aroclor	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 505	PCB 1232 Aroclor	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 505	PCB 1242 Aroclor	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 505	PCB 1248 Aroclor	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 505	PCB 1254 Aroclor	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 505	PCB 1260 Aroclor	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 505	Total PCBs (Polychlorinated Biphenyls)	ug/L	0.1	0.5	0.05	ND															0.05	ND							0.05	ND						
EPA 515.4	2,4,5-T	ug/L	0.2	--	0.1	ND															0.1	ND							0.1	ND						
EPA 515.4	2,4-DB	ug/L	2	--	1	ND															1	ND							1	ND						
EPA 515.4	3,5-Dichlorobenzoic acid	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 515.4	Acifluorfen	ug/L	0.2	--	0.1	ND															0.1	ND							0.1	ND						
EPA 515.4	Bentazon	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 515.4	Dichlorprop	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 515.4	Tot DCPA Mono&Diacid Degradate	ug/L	0.1	--	0.05	ND															0.05	ND							0.05	ND						
EPA 524.2	1,1,1,2-Tetrachloroethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1,1-Trichloroethane	ug/L	0.5	200	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1,2,2-Tetrachloroethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1,2-Trichloroethane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1-Dichloroethane	ug/L	0.5	7	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,3-Trichlorobenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,3-Trichloropropane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,4-Trimethylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2-Dichloropropane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,3,5-Trimethylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,3-Dichloropropane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	2,2-Dichloropropane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	2-Butanone (MEK)	ug/L	5	--	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND			2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND
EPA 524.2	4-Methyl-2-Pentanone (MIBK)	ug/L	5	--	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND			2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND
EPA 524.2	Bromobenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.3	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromochloromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromodichloromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromoethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	LK, ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	LK, ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromoform	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.51		0.25	ND	0.25	ND	0.25	ND	0.25	ND

EPA 524.2	Bromomethane (Methyl Bromide)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Carbon disulfide	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	VC, ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	VC, ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chlorodibromomethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chloroethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chloroform (Trichloromethane)	ug/L	0.5	--	0.5		0.25	ND	0.25	ND	0.77		0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chloromethane(Methyl Chloride)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	cis-1,3-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Dibromomethane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Dichlorodifluoromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Dichloromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Di-isopropyl ether	ug/L	3	--	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND			1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND
EPA 524.2	Hexachlorobutadiene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Isopropylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	m,p-Xylenes	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	m-Dichlorobenzene (1,3-DCB)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Methyl Tert-butyl ether (MTBE)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	n-Butylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	n-Propylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	o-Chlorotoluene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	o-Xylene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	p-Chlorotoluene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	p-Isopropyltoluene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	sec-Butylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	tert-amyl Methyl Ether	ug/L	3	--	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND			1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND
EPA 524.2	tert-Butyl Ethyl Ether	ug/L	3	--	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND			1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND
EPA 524.2	tert-Butylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Total 1,3-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	trans-1,3-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Trichlorofluoromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Trichlorotrifluoroethane(Freon 113)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	2,4-Dinitrotoluene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	2,6-Dinitrotoluene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	4,4-DDD	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Acetochlor	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Aldrin	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Alpha-BHC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	alpha-Chlordane	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Beta-BHC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Bromacil	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND			0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	Butachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Butylbenzylphthalate	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Caffeine by method 525mod	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.16				0.025	ND	0.025	ND	0.057		0.05		0.025	ND	0.4		0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Chlorobenzilate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Chloroneb	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Chlorothalonil(Draconil,Bravo)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Chlorpyrifos (Dursban)	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Delta-BHC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Diazinon (Qualitative)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Dibenz(a,h)Anthracene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Dichlorvos (DDVP)	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	LE, ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Diethylphthalate	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Dimethoate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Dimethylphthalate	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Di-n-Butylphthalate	ug/L	1	--	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND			0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	6.7		0.5	ND
EPA 525.2	Di-N-octylphthalate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endosulfan I (Alpha)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endosulfan II (Beta)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endosulfan Sulfate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endrin Aldehyde	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	EPTC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	gamma-Chlordane	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Heptachlor Epoxide (isomer B)	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Isophorone	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND			0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Malathion	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Metolachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Metribuzin	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Molinate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND

EPA 525.2	Parathion	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Pendimethalin	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Permethrin (mixed isomers)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Propachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Terbacil	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Terbuthylazine	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Thiobencarb (ELAP)	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND			0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	trans-Nonachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND			0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Trifluralin	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND			0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 531.2	3-Hydroxycarbofuran	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 531.2	Aldicarb (Temik)	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 531.2	Aldicarb sulfone	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 531.2	Aldicarb sulfoxide	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 531.2	Baygon	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 531.2	Carbaryl	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 531.2	Methomyl	ug/L	0.5	--	0.25	ND															0.25	ND							0.25	ND						
EPA 549.2	Paraquat	ug/L	2	--	1	ND															1	ND							1	ND						
EPA 551.1	Dibromochloropropane (DBCP)	ug/L	0.01	0.2	0.005	ND															0.005	ND							0.005	ND						
EPA 625	1,2-Diphenylhydrazine	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	2,4,5-Trichlorophenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2,4,6-Trichlorophenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2,4-Dichlorophenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2,4-Dimethylphenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2,4-Dinitrophenol	ug/L	50	--	25	ND															25	ND							25	ND						
EPA 625	2,4-Dinitrotoluene	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2,6-Dinitrotoluene	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2-Chloronaphthalene	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2-Chlorophenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2-Methylnaphthalene	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2-Methylphenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	2-Nitroaniline	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	2-Nitrophenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	3,3-Dichlorobenzidine	ug/L	50	--	25	ND															25	ND							25	ND						
EPA 625	3-Nitroaniline	ug/L	20	--	10	ND															10	ND							10	ND						
EPA 625	4,6-Dinitro-o-cresol	ug/L	50	--	25	ND															25	ND							25	ND						
EPA 625	4-Bromophenylphenylether	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	4-Chloroaniline	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	4-Chlorophenylphenylether	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	4-Methylphenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	4-Nitroaniline	ug/L	20	--	10	ND															10	ND							10	ND						
EPA 625	4-Nitrophenol	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	Aniline	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	Benzidine	ug/L	50	--	25	ND															25	ND							25	ND						
EPA 625	Benzoic Acid	ug/L	50	--	25	ND															25	ND							25	ND						
EPA 625	Benzyl Alcohol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	bis(2-Chloroethoxy)methane	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	bis(2-Chloroethyl)ether	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	bis(2-Chloroisopropyl)ether	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	Butylbenzylphthalate	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	Dibenzofuran	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	Diethylphthalate	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	Dimethylphthalate	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	Di-n-butylphthalate	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	Di-n-octylphthalate	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	Hexachlorobutadiene	ug/L	10	--	5	ND															5	ND							5	ND						
EPA 625	Hexachloroethane	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	Isophorone	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	Nitrobenzene	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	N-Nitrosodimethylamine	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	N-Nitrosodi-N-propylamine	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	N-Nitrosodiphenylamine	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	p-Chloro-m-cresol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
EPA 625	Phenol	ug/L	5	--	2.5	ND															2.5	ND							2.5	ND						
SM 2130 B	Turbidity (before sample collection)	ntu	0.5	--	7.35		1.05		21.7		11.72		8.86						2.2				6.28		10.5				3.01				42.13		14.44	
SM 2130 B	Turbidity (after sample collection)	ntu	0.5	--	9.75				26.8								13.77		5.51		6.35		6.07		13.3										11.67	
SM 2330B	Langelier Index - 25 degree (Corrosivity)	None	-14	--	-2																-2.2								-2.3							
SM 2510B	Conductivity (before sample collection)	u S/cm^2	1	--	101		58		31		52.7		47.4						40.7		87		36		30				64.2						52.9	
SM 2510B	Conductivity (after sample collection)	u S/cm^2	1	--	79.0		52		26								64.2		34.4		64		31		35								67.3		49.5	
SM 2550 B	Temperature (before sample collection)	^{0}C	0.01	--	8.77		8.45		7.81		15.8		11.85						10.943		8.88		6.96		7.22				13.57						8.869	
SM 2550 B	Temperature (after sample collection)	^{0}C	0.01	--	9.09		8.53		7.68								14.02		8.504		8.04		7.06		7.48								13.99		8.856	

SM 2580 B	ORP (before sample collection)	mV	0.1	--	347.2		361.0		353.7												174.1		230.4		222.7											
SM 2580 B	ORP (after sample collection)	mV	0.1	--	335.7		359.7		355.1												195.2		219.6		220											
SM 4500-O G	Dissolved Oxygen (before sample collection)	mg/L	0.01	--	10.1		9.92		10.7												10.49		11.32		10.86											
SM 4500-O G	Dissolved Oxygen (after sample collection)	mg/L	0.01	--	9.44		10.4		11.0												10.17		10.91		10.74											
SM 6251B	Bromochloroacetic acid	ug/L	1	--	0.5	ND															0.5	ND							0.5	ND						
SM 6251B	Dibromoacetic acid	ug/L	1	--	0.5	ND															0.5	ND							0.5	ND						
SM 6251B	Dichloroacetic acid	ug/L	1	--	0.5	ND															0.5	ND							0.5	ND						
SM 6251B	Monobromoacetic acid	ug/L	1	--	0.5	ND															0.5	ND							0.5	ND						
SM 6251B	Monochloroacetic acid	ug/L	2	--	1	ND															1	ND							1	ND						
SM 6251B	Trichloroacetic acid	ug/L	1	--	0.5	ND															0.5	ND							0.5	ND						
SM2330B	Bicarb.Alkalinity as HCO3, Calculated	mg/L	2	--	43																45								16							
SM2330B	Carbonate as CO3, Calculated	mg/L	2	--	1	ND															1	ND							1	ND						
EPA 100.2	Abestos by TEM ->10 microns	MFL	0.2	--																									0.1	ND						
--	PH (H3=past HT not compliant)	Units	0.1	--																									7.2							

-- = not applicable
ND = not detected
ug/L = micrograms per liter
pCi/L = pico curire/liter
mg/L = millgrams per liter
MPN = most probable number
MCL = maximum contantment level
SMCL = secondary maximum contaminant level
-- = not applicable
NTU = nephelometric turbidity unit
TON = threshold odor unit

[1] The DPD Total Residual Chlorine analysis result includes any chloramines present in the sample.

[2] The DPD Total Residual Chlorine analysis result includes any chlorine dioxide (not likely) at 1/5 the level present in the sample, so the maximum possible would by 5x the CL2 residual result.

† EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to disinfect their water, and filter their water, or meet critieria for avoiding filtration so that Giardia lamblia, Cryptosporidium, and other virus are controlled at the levels indicated at https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

					Sample ID															
					QA/QC Duplicate and Field Blank															
					2/15/2017		2/15/2017		6/8/2017		6/8/2017		10/11/2017		10/11/2017		11/8/2017		11/8/2017	
					WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer
SM 9223B	Total Coliform *(Colilert 18)*	P or A	--	--	Present		Present		Present	NC	Absent	NC	Present		Absent		Present		Absent	
SM 9223B	E. coli *(Colilert 18)*	P or A	--	--	Present		Absent		Present	NC	Absent	NC	Present		Absent		Present		Absent	
SM 9215B	Heterotrophic Plate Count (HPC) †	CFU/mL	1	--																
SM 9223B	Fecal Coliform	MPN/100 mL	1	0	24		0.5	ND	>2420		0.5	ND	1203		0.5	ND	186		0.5	ND
EPA 1623.1	Cryptosporidium spp. Enumeration , Primary Value †	C.O./100 L	4.4/2.0	0																
EPA 1623.1	Cryptosporidium spp. Enumeration , Secondary Value †	P.V.O./100 L	4.4/2.0	0																
EPA 1623.1	Giardia spp. Enumeration, Primary Value †	G.C./100 L	4.4/2.0	0																
EPA 1623.1	Giardia spp. Enumeration, Secondary Value †	P.V.C./100 L	4.4/2.0	0																
SM 9260J	Legionella spp †	L.S./1000 ml	1	0																
EPA 600	Culturable Cytopathic Enteric Viruses, Primary Value †	IU MPN	1	0																
EPA 600	Culturable Cytopathic Enteric Viruses, Secondary Value †	IU MPN	1	0																
EPA 1615	Norovirus RTPCR, Primary Value	P or A	0	0																
EPA 1615	Enterovirus RTPCR, Primary Value	P or A	0	0																
EPA 300.0	Nitrate (measured as Nitrogen)	mg/L	0.1	10	0.294		0.005	ND	0.005	ND	0.005	ND	0.185		0.005	ND	0.118		0.005	ND
EPA 300.0	Nitrite (measured as Nitrogen)	mg/L	0.01	1	0.005	ND	0.247		0.01		0.005	ND	0.0489		0.005	ND	0.005	ND	0.005	ND
Calculate	Total Nitrate + Nitrite (as N)	mg/L	0.01	10	0.299		0.252		0.015		0.005	ND	0.2339		0.005	ND	0.118		0.005	ND
EPA 180.1	Turbidity	NTU	0.1	0.3 - 5 (Goal)	4.5		0.2		4.3		0.3		7.1		0.2		2.6		0.3	
SM 2150B	Odor at 60 degrees	TON	1	3 Threshold Odor Number																
EPA 300.0	Orthophosphate as Phosphate (PO4)	mg/L	0.1	--																
EPA 300.0	Orthophosphate as P	mg/L	0.1	--																
SM 5910B	UV Absorbance at 254 nm	1/cm	0.005	--																
SM 2120B	Apparent Color	CU	5	15 Color Units																
EPA 425.1	Surfactants (MBAs, Foaming agents)	mg/L	0.05	0.5																
EPA 100.2	Asbestos (Subbed)	MFL	0.18	7 MFL1																
SM4500CN-F	Cyanide	mg/L	0.025	0.2																
SM 4500F-C	Fluoride	mg/L	0.05	4																
EPA 300.0	Chloride	mg/L	1	250																
SM 4500-HB	pH (before sample collection)	Std. Units	0.1	6.5 to 8.5 pH Units																
SM 4500-HB	pH (after sample collection)	Std. Units	0.1	6.5 to 8.5 pH Units																
EPA 300.0	Sulfate	mg/L	0.5	250																
E160.1/SM2540C	Total Dissolved Solids (TDS)	mg/L	10	500	34		250	ND	43		250	ND	49		250	ND	38		250	ND
SM 2340B	Total Hardness as CaCO3 by ICP	mg/L	3	250																
EPA 300.0	Bromide	ug/L	5	--																
SM2510B	Specific Conductance, 25 C	umho/cm	2	--	51		1	ND	47		1	ND	63		1	ND	40		1	ND
SM 5310C	Dissolved Organic Carbon	mg/L	0.3	--																
SM5310C/E415.3	Total Organic Carbon	mg/L	0.3	--	1.7		ND		13		ND		8.1		ND		12		0.42	

					Sample ID															
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					2/15/2017		2/15/2017		6/8/2017		6/8/2017		10/11/2017		10/11/2017		11/8/2017		11/8/2017	
					WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer
SM4500-PE/EPA 365.1	Total phosphorus as P	mg/L	0.02	--																
EPA 300.0	Chlorate by IC	ug/L	10	--																
SM 1030E	Cation Sum	meq/L	0.001	--																
SM 1030E	Anion Sum	meq/L	0.001	--																
SM 2320B	Alkalinity in CaCO3 units	mg/L	2	--																
ASTM D3977	Suspended Sediment Concentration	ppm	1	--	3.2		0.5	ND	3		0.5	ND	5.4		0.5	ND	4.4		0.5	ND
SM 2540D	Total Suspended Solids (TSS)	mg/L	10	--	5	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5	ND	5	ND
SM 4500-Cl G	Chlorine (Total Residual)	mg/L	0.01	4.0 (as Cl_2)																
SM 4500-Cl G	Chloramines	mg/L	0.01	0.8 (as ClO_2)																
SM 4500 CLO2-D	Chlorine dioxide	mg/L	0.01	0.8 (as ClO_2)																
SM 6251B	Total Haloacetic Acids (five)(HAA5)	ug/L	2	60																
EPA 524.2	Total THM (Total Trihalomethanes)	ug/L	0.5	80	0.25	ND	0.51		0.25	ND	0.25	ND	0.57		0.25	ND	0.25	ND	0.25	ND
EPA 300.0	Chlorite	mg/L	0.01	1																
EPA 317	Bromate	ug/L	1	10																
EPA 8151A	Bifenthrin	ug/L	0.06	--																
EPA 8151A	Chlorothalonil	ug/L	0.06	--																
EPA 8151A	Cypermethrin	ug/L	0.06	--																
EPA 8151A	Dithiopyr	ug/L	0.06	--																
EPA 8151A	Fipronil	ug/L	0.12	--																
EPA 8151A	Metolachlor	ug/L	0.06	--																
EPA 8151A	Myclobutanil	ug/L	0.06	--																
EPA 8151A	Pendrimethalin	ug/L	0.06	--																
EPA 8151A	Permethrin	ug/L	0.06	--																
EPA 8151A	Propiconazole	ug/L	0.06	--																
EPA 8151A	Trifluralin	ug/L	0.06	--																
EPA 8151A	Triclopyr	ug/L	0.08	--																
EPA 8151A	Carbaryl	ug/L	0.06	--																
EPA 8151A	DCPMU	ug/L	0.06	--																
EPA 8151A	Diuron	ug/L	0.06	--																
EPA 8151A	Imidacloprid	ug/L	0.06	--																
EPA 8151A	Malathion	ug/L	0.06	--																
EPA 200.8	Antimony, Total	ug/L	1	6	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND
EPA 200.8	Arsenic, Total	ug/L	1	10	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND
EPA 200.8	Barium, Total	ug/L	2	2000																
EPA 200.8	Beryllium, Total	ug/L	1	4																
EPA 200.8	Cadmium, Total	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 200.8	Chromium, Total	ug/L	1	100	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND
EPA 200.8	Copper, Total	ug/L	2	1300	1	ND	1	ND	2.6		1	ND	3.8		1	ND	2.9		1	ND
EPA 200.8	Lead, Total	ug/L	0.5	15	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 245.1	Mercury, Total	ug/L	0.2	2	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 200.8	Selenium,Total	ug/L	5	50																
EPA 200.8	Thallium, Total	ug/L	1	2																
EPA 200.8	Zinc, Total	ug/L	20	5000	120		10	ND	150		10	ND	1200		10	ND	160		10	ND
EPA 200.8	Aluminum, Total	ug/L	20	200																
EPA 200.8	Manganese, Total	ug/L	2	50																
EPA 200.8	Silver, Total	ug/L	0.5	100																
EPA 200.7	Iron, Total	mg/L	0.02	0.3																
EPA 505	Alachlor (Alanex)	ug/L	0.1	--																
EPA 505	Chlordane	ug/L	0.1	2																
EPA 505	Endrin	ug/L	0.01	2																
EPA 505	Heptachlor	ug/L	0.01	--																
EPA 505	Heptachlor Epoxide	ug/L	0.01	0.2																
EPA 505	Methoxychlor	ug/L	0.05	40																
EPA 505	Toxaphene	ug/L	0.5	3																
EPA 625	Dibenz(a,h)anthracene	ug/L	10	--																
EPA 505	Dieldrin	ug/L	0.01	--																
EPA 515.4	2,4-D	ug/L	0.1	70																
EPA 515.4	Dalapon	ug/L	1	200																
EPA 515.4	Dicamba	ug/L	0.1	--																
EPA 515.4	Dinoseb	ug/L	0.2	7																
EPA 515.4	Pentachlorophenol	ug/L	0.04	1																
EPA 515.4	Picloram	ug/L	0.1	500																

					Sample ID															
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					2/15/2017		2/15/2017		6/8/2017		6/8/2017		10/11/2017		10/11/2017		11/8/2017		11/8/2017	
					WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer
EPA 515.4	2,4,5-TP (Silvex)	ug/L	0.2	50																
EPA 524.2	Benzene	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Naphthalene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Carbon Tetrachloride	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chlorobenzene	ug/L	0.5	100	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	o-Dichlorobenzene (1,2-DCB)	ug/L	0.5	600	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	p-Dichlorobenzene (1,4-DCB)	ug/L	0.5	75	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2-Dichloroethane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1-Dichloroethylene	ug/L	0.5	--	0.25	ND	0.25	ND					0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	cis-1,2-Dichloroethylene	ug/L	0.5	70	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	trans-1,2-Dichloroethylene	ug/L	0.5	100	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Epichlorohydrin	ug/L	0.4	--																
EPA 524.2	Ethyl benzene	ug/L	0.5	700	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Styrene	ug/L	0.5	100	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Tetrachloroethylene (PCE)	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Toluene	ug/L	0.5	1000	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,4-Trichlorobenzene	ug/L	0.5	70	0.25	ND	0.25	ND												
EPA 524.2	Trichloroethylene (TCE)	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Vinyl chloride (VC)	ug/L	0.3	2	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND
EPA 524.2	Total xylenes	ug/L	0.5	10000	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Alachlor	ug/L	0.05	2	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Atrazine	ug/L	0.05	3	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Acenaphthene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Acenaphthylene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Naphthalene	ug/L	0.3	--	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND	0.15	ND
EPA 525.2	Fluorene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Phenanthrene	ug/L	0.04	--	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND
EPA 525.2	Anthracene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Fluoranthene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Pyrene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Benz(a)Anthracene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Chrysene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Benzo(a)pyrene	ug/L	0.02	0.2	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Benzo(b)Fluoranthene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Benzo(g,h,i)Perylene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Benzo(k)Fluoranthene	ug/L	0.02	--	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND
EPA 525.2	Indeno(1,2,3,c,d)Pyrene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Di-(2-Ethylhexyl)adipate	ug/L	0.6	400	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND	0.3	ND
EPA 525.2	Di(2-Ethylhexyl)phthalate	ug/L	0.6	6	0.3	ND	0.3	ND	0.3	ND		LE, LK, BA, ND	0.63		0.3	ND	0.3	ND	0.3	ND
EPA 525.2	Endrin	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND		LE, ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	Heptachlor	ug/L	0.03	0.4	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND	0.015	ND
EPA 525.2	Hexachlorobenzene	ug/L	0.05	1	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Hexachlorocyclopentadiene	ug/L	0.05	50	0.025	ND	23		0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Lindane	ug/L	0.04	0.2	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND
EPA 525.2	Methoxychlor	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Pentachlorophenol	ug/L	1	--	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND
EPA 525.2	Simazine	ug/L	0.05	4	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Dieldrin	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	4,4-DDE	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	4,4-DDT	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 531.2	Carbofuran (Furadan)	ug/L	0.5	40																
EPA 531.2	Oxamyl (Vydate)	ug/L	0.5	200																
EPA 547	Glyphosate	ug/L	6	700																
EPA 548.1	Endothall	ug/L	5	100																
EPA 549.2	Diquat	ug/L	0.4	20																
EPA 551.1	Ethylene Dibromide (EDB)	ug/L	0.01	0.05																
EPA 625	Acenaphthene	ug/L	5	--																
EPA 625	Acenaphthylene	ug/L	5	--																
EPA 625	Naphthalene	ug/L	5	--																
EPA 625	Fluorene	ug/L	5	--																
EPA 625	Phenanthrene	ug/L	5	--																
EPA 625	Anthracene	ug/L	5	--																
EPA 625	Fluoranthene	ug/L	5	--																
EPA 625	Pyrene	ug/L	5	--																
EPA 625	Chrysene	ug/L	5	--																
EPA 625	Benzo(a)anthracene	ug/L	5	--																
EPA 625	Benzo(a)pyrene	ug/L	5	--																
EPA 625	Benzo(b)fluoranthene	ug/L	5	--																
EPA 625	Benzo(g,h,i)perylene	ug/L	10	--																
EPA 625	Benzo(k)fluoranthene	ug/L	5	--																
EPA 625	Indeno(1,2,3-c,d)pyrene	ug/L	10	--																
EPA 625	Di(2-Ethylhexyl)phthalate	ug/L	4	6																

					Sample ID															
					QA/QC Duplicate and Field Blank															
					2/15/2017		2/15/2017		6/8/2017		6/8/2017		10/11/2017		10/11/2017		11/8/2017		11/8/2017	
					WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer
EPA 625	Hexachlorobenzene	ug/L	5	--																
EPA 625	Hexachlorocyclopentadiene	ug/L	10	--																
EPA 625	Pentachlorophenol	ug/L	20	--																
EPA 625	1,2,4-Trichlorobenzene	ug/L	5	--																
MWH/LCMSMS	Acrylamide	ug/L	0.1	--																
EPA 900.0	Alpha, Gross	pCi/L	3	15																
EPA 900.0	Alpha, Min Detectable Activity	pCi/L	--	15																
EPA 900.0	Alpha, Two Sigma Error	pCi/L	--	15																
EPA 900.0	Beta, Gross (Beta/Photon emitters)	pCi/L	3	4 mrem/yr																
EPA 900.0	Beta, Min Detectable Activity	pCi/L	--	--																
EPA 900.0	Beta, Two Sigma Error	pCi/L	--	--																
EPA 900.0	Gross Alpha + adjusted error	pCi/L	3	15																
Ra-226 GA	Radium 226	pCi/L	1	5																
Ra-226 GA	Radium 226 Min Detect Activity	pCi/L	--	--																
Ra-226 GA	Radium 226 Two Sigma Error	pCi/L	1	--																
RA-228 GA	Radium 228	pCi/L	1	5																
Ra-226 GA	Radium 286 Min Detect Activity	pCi/L	--	--																
Ra-226 GA	Radium 228 Two Sigma Error	pCi/L	1	--																
Calculated	Combined Radium 226 and Radium 228	pCi/L	2	5																
EPA 200.8	Uranium	ug/L	1	30																
EPA 1613B	2,3,7,8-TCDD (Dioxin)	pg/L	1.96	30 pg/L																
EPA 200.7	Calcium Total ICAP	mg/L	1	--																
EPA 200.7	Magnesium Total ICAP	mg/L	0.1	--																
EPA 200.7	Potassium Total ICAP	mg/L	1	--																
EPA 200.7	Sodium Total ICAP	mg/L	1	--																
EPA 505	Aldrin	ug/L	0.01	--																
EPA 505	Lindane (gamma-BHC)	ug/L	0.01	--																
EPA 505	PCB 1016 Aroclor	ug/L	0.08	--																
EPA 505	PCB 1221 Aroclor	ug/L	0.1	--																
EPA 505	PCB 1232 Aroclor	ug/L	0.1	--																
EPA 505	PCB 1242 Aroclor	ug/L	0.1	--																
EPA 505	PCB 1248 Aroclor	ug/L	0.1	--																
EPA 505	PCB 1254 Aroclor	ug/L	0.1	--																
EPA 505	PCB 1260 Aroclor	ug/L	0.1	--																
EPA 505	Total PCBs (Polychlorinated Biphenyls)	ug/L	0.1	0.5																
EPA 515.4	2,4,5-T	ug/L	0.2	--																
EPA 515.4	2,4-DB	ug/L	2	--																
EPA 515.4	3,5-Dichlorobenzoic acid	ug/L	0.5	--																
EPA 515.4	Acifluorfen	ug/L	0.2	--																
EPA 515.4	Bentazon	ug/L	0.5	--																
EPA 515.4	Dichlorprop	ug/L	0.5	--																
EPA 515.4	Tot DCPA Mono&Diacid Degradate	ug/L	0.1	--																
EPA 524.2	1,1,1,2-Tetrachloroethane	ug/L	0.5	--	0.25	ND	0.25	ND		LK,LE, ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1,1-Trichloroethane	ug/L	0.5	200	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1,2,2-Tetrachloroethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1,2-Trichloroethane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1-Dichloroethane	ug/L	0.5	7	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,1-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,3-Trichlorobenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,3-Trichloropropane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2,4-Trimethylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,2-Dichloropropane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,3,5-Trimethylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	1,3-Dichloropropane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	2,2-Dichloropropane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	2-Butanone (MEK)	ug/L	5	--	2.5	ND	2.5	ND	2.5	ND	11		2.5	ND	2.5	ND	2.5	ND	2.5	ND
EPA 524.2	4-Methyl-2-Pentanone (MIBK)	ug/L	5	--	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND	2.5	ND
EPA 524.2	Bromobenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromochloromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromodichloromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromoethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	LK, ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Bromoform	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND

					Sample ID															
					QA/QC Duplicate and Field Blank															
					2/15/2017		2/15/2017		6/8/2017		6/8/2017		10/11/2017		10/11/2017		11/8/2017		11/8/2017	
					WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer
EPA 524.2	Bromomethane (Methyl Bromide)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Carbon disulfide	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	VC, ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chlorodibromomethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chloroethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chloroform (Trichloromethane)	ug/L	0.5	--	0.25	ND	0.51		0.25	ND	0.25	ND	0.57		0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Chloromethane(Methyl Chloride)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	cis-1,3-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Dibromomethane	ug/L	0.5	5	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Dichlorodifluoromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Dichloromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Di-isopropyl ether	ug/L	3	--	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND
EPA 524.2	Hexachlorobutadiene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Isopropylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	m,p-Xylenes	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	m-Dichlorobenzene (1,3-DCB)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Methyl Tert-butyl ether (MTBE)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	n-Butylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	n-Propylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	o-Chlorotoluene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	o-Xylene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	p-Chlorotoluene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	p-Isopropyltoluene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	sec-Butylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	tert-amyl Methyl Ether	ug/L	3	--	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND
EPA 524.2	tert-Butyl Ethyl Ether	ug/L	3	--	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND	1.5	ND
EPA 524.2	tert-Butylbenzene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Total 1,3-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	trans-1,3-Dichloropropene	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Trichlorofluoromethane	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 524.2	Trichlorotrifluoroethane(Freon 113)	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	2,4-Dinitrotoluene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	2,6-Dinitrotoluene	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	4,4-DDD	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Acetochlor	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Aldrin	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Alpha-BHC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	alpha-Chlordane	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Beta-BHC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Bromacil	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	Butachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Butylbenzylphthalate	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Caffeine by method 525mod	ug/L	0.05	--	0.051		0.025		0.025	ND	0.025	ND	0.13		0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Chlorobenzilate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Chloroneb	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Chlorothalonil(Draconil,Bravo)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Chlorpyrifos (Dursban)	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Delta-BHC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Diazinon (Qualitative)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Dibenz(a,h)Anthracene	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Dichlorvos (DDVP)	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Diethylphthalate	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Dimethoate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Dimethylphthalate	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Di-n-Butylphthalate	ug/L	1	--	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND	0.5	ND
EPA 525.2	Di-N-octylphthalate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endosulfan I (Alpha)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endosulfan II (Beta)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endosulfan Sulfate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Endrin Aldehyde	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	EPTC	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	gamma-Chlordane	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Heptachlor Epoxide (isomer B)	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Isophorone	ug/L	0.5	--	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND	0.25	ND
EPA 525.2	Malathion	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Metolachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.063		0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Metribuzin	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Molinate	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND

					Sample ID															
					QA/QC Duplicate and Field Blank															
					2/15/2017		2/15/2017		6/8/2017		6/8/2017		10/11/2017		10/11/2017		11/8/2017		11/8/2017	
					WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer
EPA 525.2	Parathion	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Pendimethalin	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Permethrin (mixed isomers)	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Propachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Terbacil	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Terbuthylazine	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 525.2	Thiobencarb (ELAP)	ug/L	0.2	--	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND	0.1	ND
EPA 525.2	trans-Nonachlor	ug/L	0.05	--	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND	0.025	ND
EPA 525.2	Trifluralin	ug/L	0.1	--	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND
EPA 531.2	3-Hydroxycarbofuran	ug/L	0.5	--																
EPA 531.2	Aldicarb (Temik)	ug/L	0.5	--																
EPA 531.2	Aldicarb sulfone	ug/L	0.5	--																
EPA 531.2	Aldicarb sulfoxide	ug/L	0.5	--																
EPA 531.2	Baygon	ug/L	0.5	--																
EPA 531.2	Carbaryl	ug/L	0.5	--																
EPA 531.2	Methomyl	ug/L	0.5	--																
EPA 549.2	Paraquat	ug/L	2	--																
EPA 551.1	Dibromochloropropane (DBCP)	ug/L	0.01	0.2																
EPA 625	1,2-Diphenylhydrazine	ug/L	10	--																
EPA 625	2,4,5-Trichlorophenol	ug/L	5	--																
EPA 625	2,4,6-Trichlorophenol	ug/L	5	--																
EPA 625	2,4-Dichlorophenol	ug/L	5	--																
EPA 625	2,4-Dimethylphenol	ug/L	5	--																
EPA 625	2,4-Dinitrophenol	ug/L	50	--																
EPA 625	2,4-Dinitrotoluene	ug/L	5	--																
EPA 625	2,6-Dinitrotoluene	ug/L	5	--																
EPA 625	2-Chloronaphthalene	ug/L	5	--																
EPA 625	2-Chlorophenol	ug/L	5	--																
EPA 625	2-Methylnaphthalene	ug/L	5	--																
EPA 625	2-Methylphenol	ug/L	5	--																
EPA 625	2-Nitroaniline	ug/L	10	--																
EPA 625	2-Nitrophenol	ug/L	5	--																
EPA 625	3,3-Dichlorobenzidine	ug/L	50	--																
EPA 625	3-Nitroaniline	ug/L	20	--																
EPA 625	4,6-Dinitro-o-cresol	ug/L	50	--																
EPA 625	4-Bromophenylphenylether	ug/L	5	--																
EPA 625	4-Chloroaniline	ug/L	5	--																
EPA 625	4-Chlorophenylphenylether	ug/L	5	--																
EPA 625	4-Methylphenol	ug/L	5	--																
EPA 625	4-Nitroaniline	ug/L	20	--																
EPA 625	4-Nitrophenol	ug/L	10	--																
EPA 625	Aniline	ug/L	10	--																
EPA 625	Benzidine	ug/L	50	--																
EPA 625	Benzoic Acid	ug/L	50	--																
EPA 625	Benzyl Alcohol	ug/L	5	--																
EPA 625	bis(2-Chloroethoxy)methane	ug/L	10	--																
EPA 625	bis(2-Chloroethyl)ether	ug/L	10	--																
EPA 625	bis(2-Chloroisopropyl)ether	ug/L	10	--																
EPA 625	Butylbenzylphthalate	ug/L	5	--																
EPA 625	Dibenzofuran	ug/L	5	--																
EPA 625	Diethylphthalate	ug/L	5	--																
EPA 625	Dimethylphthalate	ug/L	5	--																
EPA 625	Di-n-butylphthalate	ug/L	10	--																
EPA 625	Di-n-octylphthalate	ug/L	10	--																
EPA 625	Hexachlorobutadiene	ug/L	10	--																
EPA 625	Hexachloroethane	ug/L	5	--																
EPA 625	Isophorone	ug/L	5	--																
EPA 625	Nitrobenzene	ug/L	5	--																
EPA 625	N-Nitrosodimethylamine	ug/L	5	--																
EPA 625	N-Nitrosodi-N-propylamine	ug/L	5	--																
EPA 625	N-Nitrosodiphenylamine	ug/L	5	--																
EPA 625	p-Chloro-m-cresol	ug/L	5	--																
EPA 625	Phenol	ug/L	5	--																
SM 2130 B	Turbidity (before sample collection)	ntu	0.5	--																
SM 2130 B	Turbidity (after sample collection)	ntu	0.5	--																
SM 2330B	Langelier Index - 25 degree (Corrosivity)	None	-14	--																
SM 2510B	Conductivity (before sample collection)	$u\,S/cm^2$	1	--																
SM 2510B	Conductivity (after sample collection)	$u\,S/cm^2$	1	--																
SM 2550 B	Temperature (before sample collection)	^0C	0.01	--																
SM 2550 B	Temperature (after sample collection)	^0C	0.01	--																

					Sample ID															
					QA/QC Duplicate and Field Blank															
					2/15/2017		2/15/2017		6/8/2017		6/8/2017		10/11/2017		10/11/2017		11/8/2017		11/8/2017	
					WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer	WS1D-1S Duplicate collected at WS1B	Qualifer	WS-FB	Qualifer
SM 2580 B	ORP (before sample collection)	mV	0.1	--																
SM 2580 B	ORP (after sample collection)	mV	0.1	--																
SM 4500-O G	Dissolved Oxygen (before sample collection)	mg/L	0.01	--																
SM 4500-O G	Dissolved Oxygen (after sample collection)	mg/L	0.01	--																
SM 6251B	Bromochloroacetic acid	ug/L	1	--																
SM 6251B	Dibromoacetic acid	ug/L	1	--																
SM 6251B	Dichloroacetic acid	ug/L	1	--																
SM 6251B	Monobromoacetic acid	ug/L	1	--																
SM 6251B	Monochloroacetic acid	ug/L	2	--																
SM 6251B	Trichloroacetic acid	ug/L	1	--																
SM2330B	Bicarb.Alkalinity as HCO3, Calculated	mg/L	2	--																
SM2330B	Carbonate as CO3, Calculated	mg/L	2	--																
EPA 100.2	Abestos by TEM ->10 microns	MFL	0.2	--																
--	PH (H3=past HT not compliant)	Units	0.1	--																

-- = not applicable
ND = not detected
ug/L = micrograms per liter
pCi/L = pico curire/liter
mg/L = millgrams per liter
MPN = most probable number
MCL = maximum contantment level
SMCL = secondary maximum contaminant level
-- = not applicable
NTU = nephelometric turbidity unit
TON = threshold odor unit

[1] The DPD Total Residual Chlorine analysis result includes any chloramines present in the sample.

[2] The DPD Total Residual Chlorine analysis result includes any chlorine dioxide (not likely) at 1/5 the level present in the sample, so the maximum possible would by 5x the CL2 residual result.

† EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to disinfect their water, and filter their water, or meet critieria for avoiding filtration so that Giardia lamblia, Cryptosporidium, and other virus are controlled at the levels indicated at https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

Table 4. Detected Analytes

Analyte	Analyte Group	Unit	MCL		Analyte Detections/ Total Samples		Regulatory exceedances/ Total Samples		Basin WS-1A		Basin WS-1B		Geometric Mean	
			MCL	SMCL	Basin WS-1A	Basin WS-1B	Basin WS-1A	Basin WS-1B	Minimum	Maximum	Minimum	Maximum	Basin WS-1A	Basin WS-1B
Calcium	Other	mg/L	--	--	1/1	2/2	0/1	0/2	11.0	11.0	5.2	8.0	11.0	1.0
Magnesium	Other	mg/L	--	--	1/1	2/2	0/1	0/2	2.6	2.6	0.4	2.0	2.6	0.9
Sodium	Other	mg/L	--	--	1/1	2/2	0/1	0/2	5.0	5.0	1.2	4.1	5.0	1.3
2-Butanone (MEK)	Other	ug/L	--	--	0/7	1/8	0/7	0/8	--	--	11.0	11.0	2.5	2.5
Bromoform	Other	ug/L	--	--	0/7	1/8	0/7	0/8	--	--	0.5	0.5	0.3	0.3
Chloroform (Trichloromethane)	Other	ug/L	--	--	2/7	0/8	0/7	0/8	0.5	0.8	0.5	0.6	0.3	0.3
Caffeine	Other	ug/L	--	--	1/7	5/8	0/7	0/8	0.2	0.2	0.1	0.1	0.03	0.04
Di-n-Butylphthalate	Other	ug/L	--	--	0/7	1/8	0/7	0/8	--	--	6.7	6.7	0.5	0.7
Metolachlor	Other	ug/L	--	--	0/7	0/8	0/7	0/8	--	--	0.1	0.1	0.03	0.03
Turbidity	Other	NTU	5	--	8/8	16/16	6/8	5/16	3.6	16.0	0.2	33.0	9.1	2.6
Alkalinity	Inorganics	mg/L	--	--	1/1	2/2	0/1	0/2	36.0	36.0	13.0	37.0	36.0	21.9
Apparent Color	Inorganics	CU	--	15	1/1	2/2	0/1	2/2	15.0	15.0	23.0	30.0	15.0	26.3
Bicarbonate. Alkalinity	Inorganics	mg/L	--	--	1/1	2/2	0/1	0/2	43.0	43.0	16.0	45.0	43.0	26.8
Chloride	Inorganics	mg/L	--	250	1/1	1/1	0/1	0/1	3.8	3.8	4.7	4.7	3.8	1.5
Nitrate	Inorganics	mg/L	10	--	8/8	11/16	0/8	11/16	0.1	0.937	0.101	0.591	0.242	0.217
Nitrite	Inorganics	mg/L	1	--	6/8	12/16	0/8	0/16	0.01	0.0739	0.01	0.676	0.0249	0.0291
Total Nitrate + Nitrite	Inorganics	mg/L	10	--	8/8	13/16	0/8	0/16	0.110	0.948	0.015	0.596	0.275	0.196
Orthophosphate	Inorganics	TON	1	--	1/1	1/1	0/1	0/1	13.0	13.0	0.2	0.2	0.1	0.2
UV absorbance at 254 nm	Inorganics	1/cm	--	--	1/1	2/2	0/1	0/2	0.179	0.179	0.223	0.228	0.179	0.225
Fluoride	Inorganics	mg/L	4	2	0/1	1/2	0/1	0/2	--	--	0.1	0.1	0.0	0.0
Sulfate	Inorganics	mg/L	--	250	1/1	2/2	0/1	0/2	5.5	5.5	2.6	6.6	5.5	4.1
Total Dissolved Solids	Inorganics	mg/L	--	500	8/8	12/16	0/8	0/16	26.0	64.0	27.0	57.0	44.0	38.8
Bromide	Inorganics	ug/L	--	--	1/1	1/2	0/1	0/2	23.0	23.0	41.0	41.0	23.0	10.1
Dissolved Organic Carbon	Inorganics	mg/L	--	--	1/1	2/2	0/1	0/2	2.3	2.3	3.4	8.4	2.3	5.3
Suspended Sediment Concentration	Inorganics	ppm	--	--	8/8	11/16	0/8	0/16	6.0	27.0	1.3	91.4	8.0	5.5
Total Hardness	Inorganics	mg/L	250	--	1/1	2/2	0/1	0/2	38.0	38.0	15.0	28.0	38.0	20.5
Total Organic Carbon	Inorganics	mg/L	--	--	8/8	8/8	0/8	0/8	2.1	13.0	1.7	14.0	5.3	5.8
Total Phosphorus	Inorganics	mg/L	--	--	1/1	2/2	0/1	0/1	0.043	0.043	0.042	0.1	0.043	0.1
Total Suspended Solids	Inorganics	mg/L	--	--	3/8	1/16	0/8	0/16	14.0	20.0	80.0	80.0	9.3	7.4
2,4-D	Organics	ug/L	70	--	1/1	1/2	0/1	0/2	0.2	0.2	1.4	1.4	0.2	0.3
Dicamba	Organics	ug/L	--	--	0/1	0/1	0/1	0/1	--	--	0.2	0.2	0.1	0.1
Toluene	Organics	ug/L	1,000	--	3/8	0/8	0/8	0/8	0.5	0.6	--	--	0.4	0.2
Chrysene	Organics	ug/L	--	--	0/8	1/16	0/8	0/16	--	--	0.1	0.1	0.01	0.01
Benzo(k)fluoranthene	Organics	ug/L	--	--	0/8	1/8	0/8	0/8	--	--	0.1	0.1	0.01	0.01
Di(2-Ethylhexyl)phthalate	Organics	ug/L	6	--	4/8	2/16	0/8	0/16	0.7	1.0	0.6	1.0	0.7	0.3
Hexachlorocyclopentadiene	Organics	ug/L	50	--	0/8	1/8	0/8	0/8	--	--	23.0	23.0	0.03	0.02
Alpha, Min Detectable Activity	Radionuclides	pCi/L	15	--	1/1	2/2	0/1	0/2	1.8	1.8	1.9	2.4	1.8	2.1
Alpha, Two Sigma Error	Radionuclides	pCi/L	15	--	1/1	2/2	0/1	0/2	0.5	0.5	0.5	0.5	0.5	0.5
Beta, Min Detectable Activity	Radionuclides	pCi/L	--	--	--	0/1	--	0/1	0	0	1.8	1.8	--	1.8
Beta, Two Sigma Error	Radionuclides	pCi/L	--	--	--	0/1	--	0/1	--	--	0.5	0.5	--	0.5
Radium 226 Min Detect Activity	Radionuclides	pCi/L	--	--	--	0/1	--	0/1	--	--	0.5	0.5	--	0.5

Analyte	Analyte Group	Unit	MCL		Analyte Detections/ Total Samples		Regulatory exceedances/ Total Samples		Basin WS-1A		Basin WS-1B		Geometric Mean	
			MCL	SMCL	Basin WS-1A	Basin WS-1B	Basin WS-1A	Basin WS-1B	Minimum	Maximum	Minimum	Maximum	Basin WS-1A	Basin WS-1B
Radium 286 Min Detect Activity	Radionuclides	pCi/L	--	--	--	0/1	--	0/1	--	--	0.7	0.7	--	0.7
Barium	Metals	ug/L	2,000	--	1/1	2/2	0/1	0/2	11.0	11.0	19.0	19.0	11.0	11.8
Chromium	Metals	ug/L	100	--	2/8	1/8	0/2	0/8	1.1	1.4	2.5	2.5	0.6	0.6
Copper	Metals	ug/L	1,300	1,000	7/8	5/8	0/8	0/8	2.0	8.8	2.4	2.6	3.8	2.3
Lead	Metals	ug/L	15	--	1/8	1/8	0/8	0/8	0.6	0.6	2.6	2.6	0.3	0.3
Zinc	Metals	ug/L	--	5,000	7/8	13/8	0/8	0/8	54.0	2,700	83.0	1,300	217.1	316.1
Aluminum	Metals	ug/L	--	5 - 200	1/1	2/2	1/1	2/2	320.0	320.0	87.0	460.0	320.0	200.0
Manganese	Metals	ug/L	--	50	1/1	2/2	0/1	0/2	18.0	18.0	11.0	13.0	18.0	12.0
Iron	Metals	mg/L	--	0.3	1/1	2/2	0/1	1/2	0.4	0.4	0.1	0.5	0.4	0.2
Chlorine	Disinfectants	mg/L	--	--	3/3	2/3	0/3	0/3	0.1	0.2	0.2	0.2	0.2	--
Total THM	Disinfectants	ug/L	--	--	2/8	5/8	0/8	0/16	0.5	0.5	0.5	0.5	0.3	0.3
Diuron	Pesticides	ug/L	--	--	0/1	1/2	0/1	0/2	--	--	0.4	0.4	0.03	0.1
Total Coliform	Pathogen	Present/Absent	--	--	7/7	7/7	7/7	7/7	present				present	
E. coli	Pathogen	Present/Absent	--	--	7/7	7/7	7/7	7/7	present				present	
Fecal Coliform	Pathogen	MPN/100mL	0	--	7/7	7/7	7/7	7/7	64.0	15.0	2,420	1,553	407.6	254.7
Culturable Cytopathic Enteric Viruses, Primary Value	Pathogen	IU MPN	1	--	1/1	1/2	1/1	1/2	1.1	1.1	1.1	1.1	1.1	1.1
Culturable Cytopathic Enteric Viruses, Secondary Value	Pathogen	IU MPN	1	--	1/1	1/2	1/1	1/2	0.6	1.8	0.6	1.8	0.6	1.8

Notes

ug/L = micrograms per liter
pCi/L = pico curire/liter
mg/L = millgrams per liter
MPN = most probable number
MCL = maximum contantment level
SMCL = secondary maximum contaminant level
-- = not applicable
NTU = nephelometric turbidity unit
TON = threshold odor unit
(shaded) = Exceeds MCL or SMCL

Table 5. Analytes Detected Above MCL

Analyte	Units	Regulatory Requirements		Location	Geometric Mean	Percent of Total Samples Exceeding the MCL
		1/2 MCL	SMCL			
Fecal Coliform	MPN/100 mL	--	--	WS-1A	408	100
				WS-1B	255	100
Total Coliform	Presence or Absence	--	--	WS-1A	present	100
				WS-1B	present	100
E. Coli	P or A	--	--	WS-1A	present	100
				WS-1B	present	100
Culturable Cytopathic Enteric Viruses, Primary Value	IU MPN	0	--	WS-1A	1	100
				WS-1B	1	50
Culturable Cytopathic Enteric Viruses, Secondary Value	IU MPN	0	--	WS-1A	1	100
				WS-1B	2	50
Apparent Color	Color Units	--	15	WS-1B	23	100
Turbidity	NTU	0.15 - 0.25	--	WS-1A	9	100
				WS-1B	7	100
Aluminum	ug/L	--	200	WS-1A	320	100
				WS-1B	200	100
Iron	mg/L	--	0.3	WS-1B	0	50

Notes
MPN = most probable number
mL = milliliters
IU = infectious units
NTU = Nephelometric Turbidity Unit
TON = threshold odor number
ug/L = micrograms per liter
mg/L = milligrams per liter
SMCL = secondary maximum contaminant level
MCL = maximum contaminant level
-- = not applicable

Table 11. Stormwater, JWC Source Water, and ASR 3 Native Groundwater Quality Summary

				Sterling Park Site Stormwater Quality								Joint Water Commission (JWC) ASR Source Water Quality				City of Beaverton ASR No. 3 Native Groundwater Quality			
Analyte	Unit	Regulatory Standard	Regulatory Criteria	Analyte Detections/Total Samples		Basin WS-1A		Basin WS-1B		Geometric Mean		Analyte Detections/Total Samples	Minimum	Maximum	Geometric Mean	Analyte Detections/Total Samples	Minimum	Maximum	Geometric Mean
				Basin WS-1A	Basin WS-1B	Minimum	Maximum	Minimum	Maximum	Basin WS-1A	Basin WS-1B								
Alkalinity	mg/L	250	SMCL	1/1	2/2	36.0	36.0	13.0	37.0	36.0	21.9	0/27	24.0	48.0	33.3	2/2	103.0	135.0	117.9
Calcium	mg/L	None	None	2/2	1/1	11.0	11.0	5.2	8.0	11.0	6.45	0/27	6.6	14.0	8.7	6/6	47.0	58.0	53.0
Chloride	mg/L	250	SMCL	1/1	1/1	3.8	3.8	4.7	4.7	3.8	4.7	0/27	3.9	12.0	5.4	6/6	170.0	210.0	185.6
Carbonate (CO3)	mg/L	None	None	--	--	--	--	--	--	--	--	20/27	0.0656	0.233	0.1	2/2	0.407	0.427	0.4
Total Hardness, as $CaCO_3$	mg/L	250	SMCL	1/1	2/2	38.0	38.0	15.0	28.0	38.0	20.5	0/27	26.0	51.4	33.2	6/6	82.2	256	200.9
Bicarbonate (HCO_3)	mg/L	None	None	1/1	2/2	43.0	43.0	16.0	45.0	43.0	26.83	0/27	24.0	52.4	35.4	2/2	125.0	165.0	143.6
Potassium	mg/L	None	None	--	--	--	--	--	--	--	--	10/27	0.5	1.4	0.6	6/6	6.9	10.0	7.8
Magnesium	mg/L	None	None	2/2	1/1	2.6	2.6	0.44	2.0	2.6	0.94	0/27	1.36	4.0	2.4	6/6	20.0	27.0	24.4
Manganese	mg/L	0.05	SMCL	1/1	2/2	0.018	0.018	0.011	0.013	0.018	0.012	26/27	0.08	0.08	0.08	4/4	0.065	0.085	0.1
Iron Total	mg/L	None	None	1/1	2/2	0.43	0.43	0.11	0.49	0.43	0.23	21/27	0.14	0.55	0.203	4/4	0.05	0.14	0.1
Iron Dissolved	mg/L	0.3	SMCL	--	--	--	--	--	--	--	--	26/27	0.0038	0.0038	0.0038	1/1	0.05	0.05	0.1
Fluoride	mg/L	2	SMCL	0/1	1/2	--	--	0.051	0.051	--	0.051	5/25	0.25	1.0	0.709	2/2	0.2	0.34	0.3
Sodium	mg/L	20	URC, SMCL	2/2	1/1	5.0	5.0	1.2	4.1	5	2.2	0/27	9	48.6	11.5	6/6	61.0	73.0	66.4
Nitrite as N	mg/L	1	MCL	5/7	8/13	0.02	0.25	0.01	0.07	0.03	0.03	2/27	0.27	1.0	0.6	0/2	--	--	--
Nitrate as N	mg/L	10	MML	7/7	9/13	0.13	0.94	0.10	0.59	0.27	0.25	6/27	0.141	1.5	0.5	0/2	--	--	--
Silica	mg/L	None	None	--	--	--	--	--	--	--	--	0/26	10.0	20.0	15.8	2/2	46	52	48.9
Sulfate	mg/L	250	URC, SMCL	1/1	2/2	5.5	5.5	2.6	6.6	5.5	4.14	0/27	4.5	16.0	11.0	1/1	4.24	4.24	--
Total Dissolved Solids	mg/L	500	SMCL	8/8	12/16	26.0	64.0	27.0	57.0	44.0	38.8	0/27	57.0	170.0	84.1	6/6	480	610	526.5
Total Organic Carbon	mg/L	None	None	8/8	13/16	2.1	13	1.7	14	5.27	4.98	0/27	0.67	2.55	1.0	0/1	--	--	--
Total Suspended Solids	mg/L	None	None	3/3	1/1	14.0	20.0	80.0	80.0	17.1	80.0	25/26	2.0	2.0	2.0	--	--	--	--
Field pH	Units	6 - 8.5	None	11/11	7/7	5.5	7.3	5.3	6.9	6.5	6.1	0/34	6.92	8.3	7.7	5/5	6.78	8	7.0
Field Temperature	Celsius	None	None	11/11	9/9	7.7	15.8	7.0	15.7	9.8	8.5	0/32	6.5	15.3	9.1	5/5	14.0	16.2	15.6
Field Dissolved Oxygen	mg/L	None	None	9/9	9/9	9.2	11.4	9.7	11.3	10.3	10.7	0/33	2.15	12.49	9.6	2/2	6.3	8.6	7.4
Odor	TON	3	SMCL	1/1	1/1	13.0	13.0	1.0	1.0	13	1	5/23	1	4	1.8	2/2	2.0	3.0	2.4
Radon 222	pCi/L	300 or 4000	Proposed MCL	--	--	--	--	--	--	--	--	11/14	2.3	24	7.4	2/2	150.0	740.0	333.2
Eh	mV	None	None	--	--	--	--	--	--	--	--	--	--	--	--	4/4	123.0	339.0	180.4

Notes

SMCL = secondary maximum contaminant level
MCL = maximum contaminant levels
mg/L = milligrams per liter (equivalent to part per million)
umhos/cm = micromhos per centimeters
mV = millivolts
URC
pCi/L = picocurie per liter
[shaded] Analytes with concentrations anticiapted to be reduced by proposed treatment method
* values avilable but still being processed.

Table 12. Summary of Operational Costs and Benefits for Stormwater Management and Stream Augmentation Options

Stormwater Recharge Treatment and Analysis O&M Cost Estimate ($22K to $31K per year)[1]				Regional Municipal Retail Water Costs - 2016 (Irrigation, Commercial, Industrial, Domestic)						Treated Waste Water Costs[2]				Flow Mitigation from Hagg Lake					
Cost per CCF		Cost per Acre-ft		Cost per CCF			Cost per Acre-ft			Cost per CCF		Cost per Acre-ft		Cost per CCF			Cost per Acre-ft		
Low	High	Low	High	Minimum	Maximum	Median	Minimum	Maximum	Median	[2]Capital + O&M	[2]O&M	Capital + O&M	O&M	CWS Stored Water	TVID Reserve Water	TVID tributary augmentation	CWS Stored Water	TVID Reserve Water	TVID tributary augmentation
$ 0.49	$ 0.69	$ 213.99	$ 301.53	$ 1.94	$ 7.76	$ 3.70	$ 845.12	$ 3,380.48	$ 1,611.82	$ 1.01	$ 0.28	$ 440.74	$ 120.35	$ 0.01	$ 0.10	$ 0.11	$ 3.96	$ 45.52	$ 49.00

Notes:

1 CCF = 100 ft^3 or 748 gallons

1 Acre-ft = 325,851 gallons

[1] Stormwater Recharge Operation and Maintenance costs are estimated for the Sterling Park site and are based on a recharge volume of 33,500,000 gallons and an initial cost ranging from $22,000 to $31,000 per year.

If additional recharge volume is available at Sterling Park or future implementation sites, O&M costs are not anticipated to increase significantly, thereby potentially reducing the cost per volume.

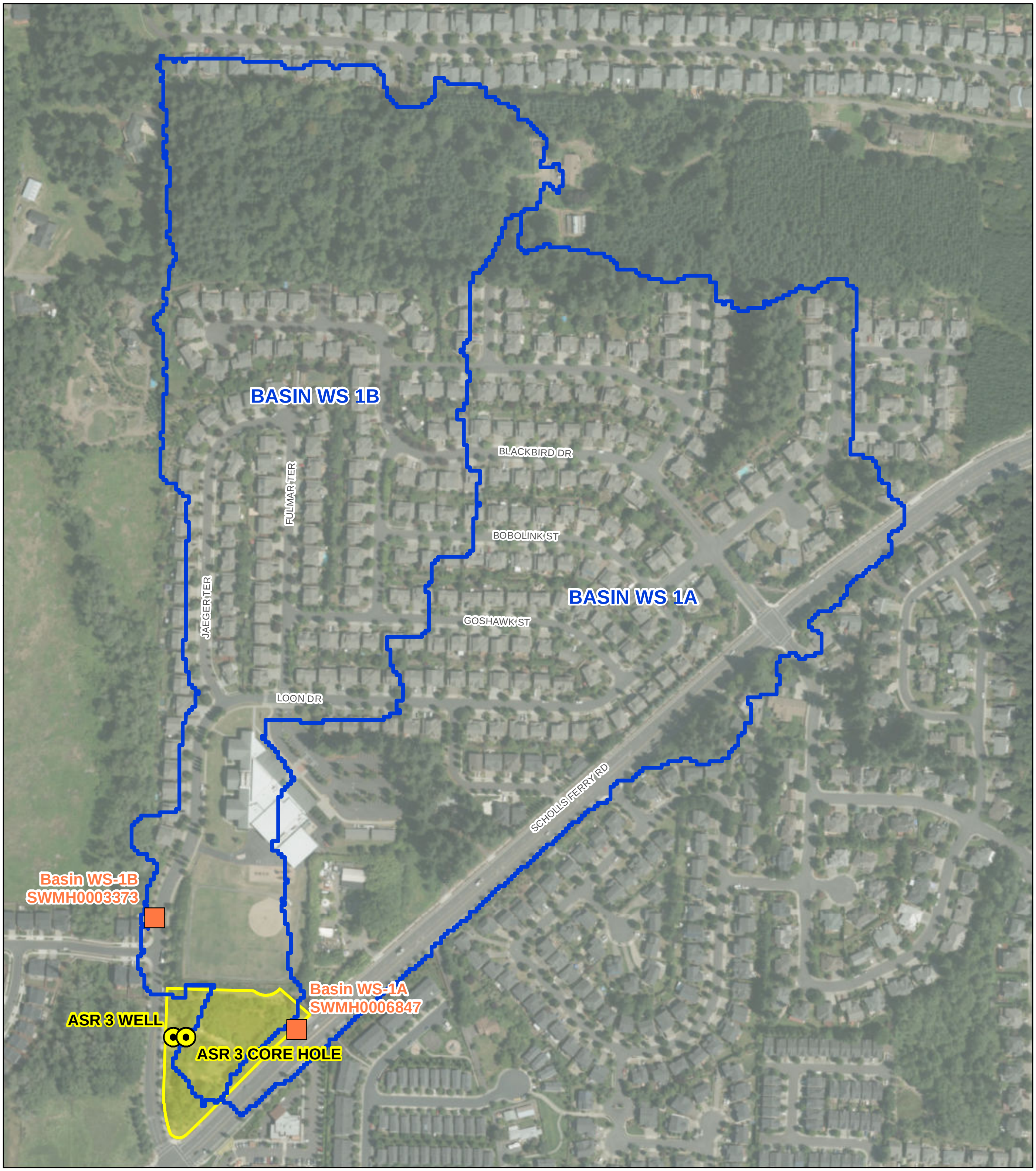
Costs include contractor estimate for filter media replacement at $12K to $16K and analytical costs at $10K to $15K, and does not include consulting costs estimated at $28K to $44K.

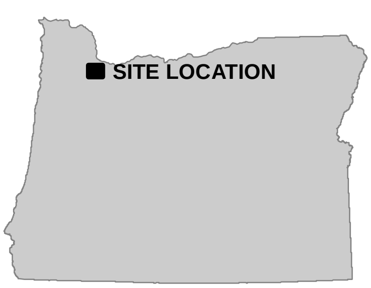
[2] Treated Waste Water Costs do not include treatment plant capital and O&M or reporting costs as compared to stormwater recharge concept. To balance cost comparsion, consulting fees have been excluded from stormwater recharge costs.

Potential Project Benefits	Hydromodification Mitigation	Streamflow Volume/Rate Augmentation	Streamflow Thermal Augmentation	Allows Streamflow and Thermal Augmentation at Locations Distant From Hagg Lake	Reduction In Metals and Turbidity Discharge to Surface Water - Stormwater Treatment	Replenishes Groundwater in a Critical Area
Stormwater Recharge	•	•	•	•	•	•
Municipal Retail Water			•			
Treated Waste Water Costs		•	•			
Flow Mitigation from Hagg Lake		•	•			

Other Potential Benefits of Stormwater Recharge:
Sterling Park site provides a proof of concept that can be used for other implementations
Concept mimics natural process with infiltration of stormwater and reduced impacts to surface water

Figures





LEGEND

- Well Location
- Sampling Location
- Site
- Basin Extent

N

0 200 400
Feet

Date: January 26, 2018
Data Sources: METRO, USGS, COP 2016

FIGURE 1

Project Location Map

Clean Water Services

GSI Water Solutions, Inc.

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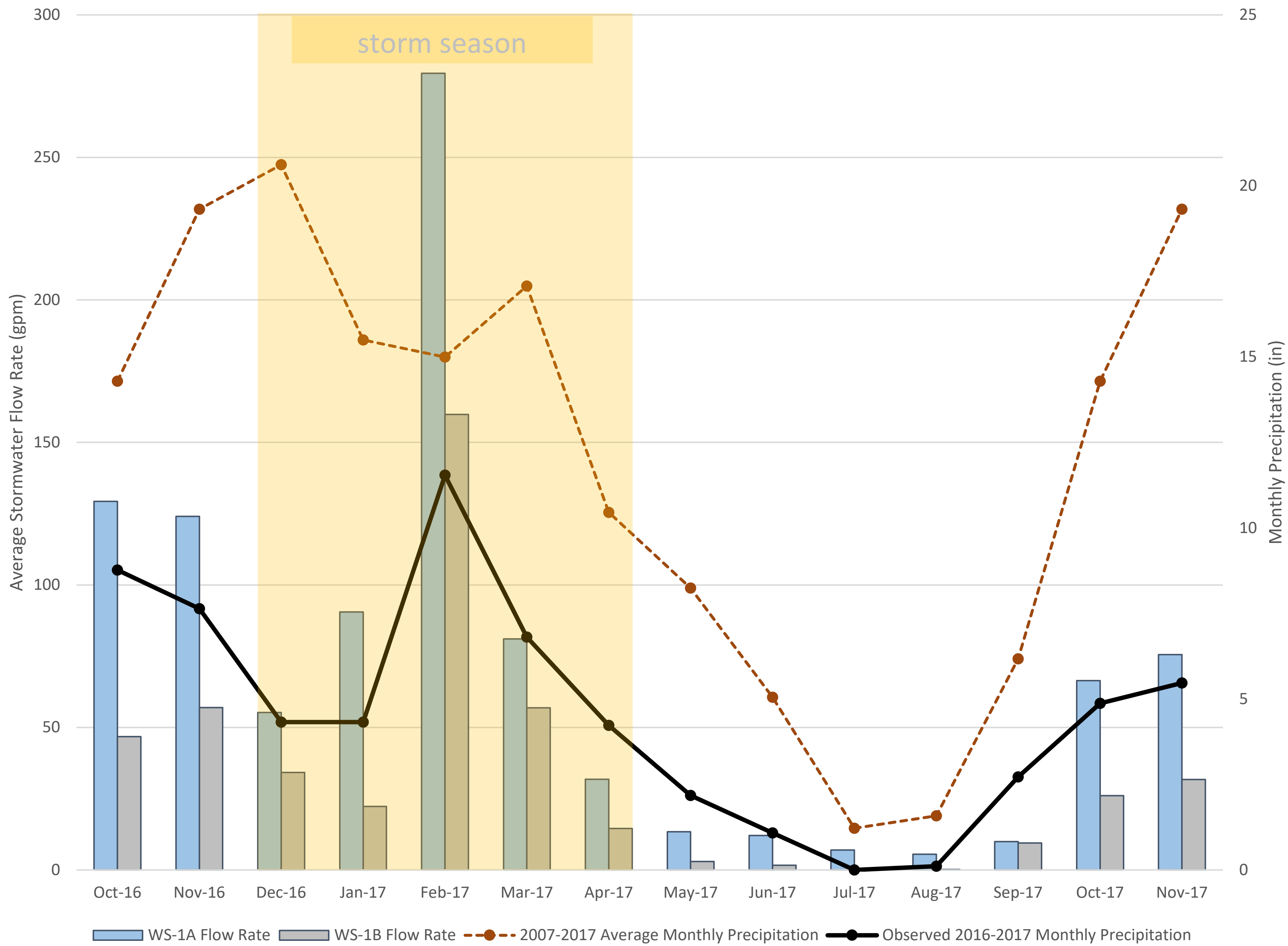


Figure 2. Stormwater Flow and Precipitation

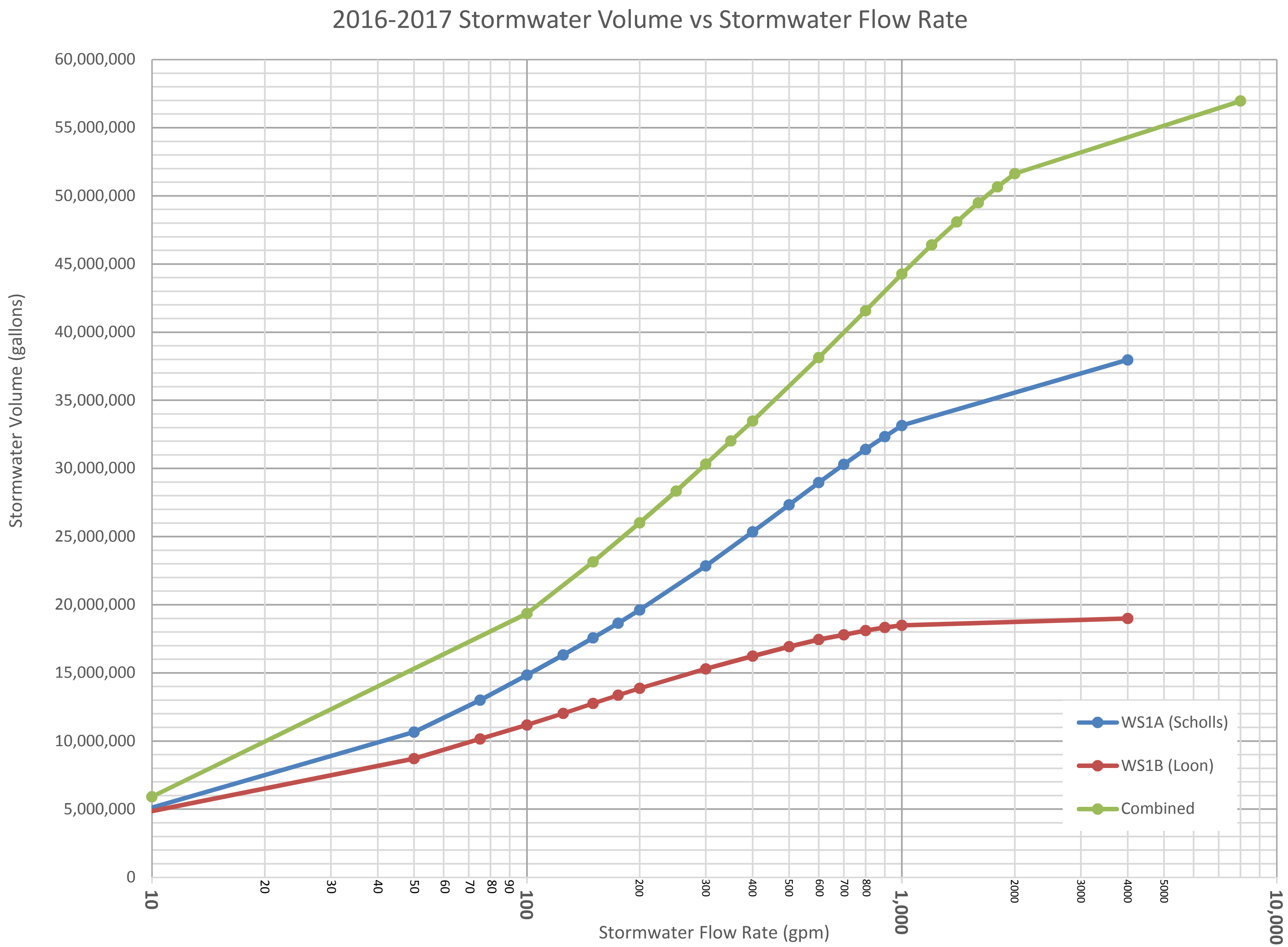
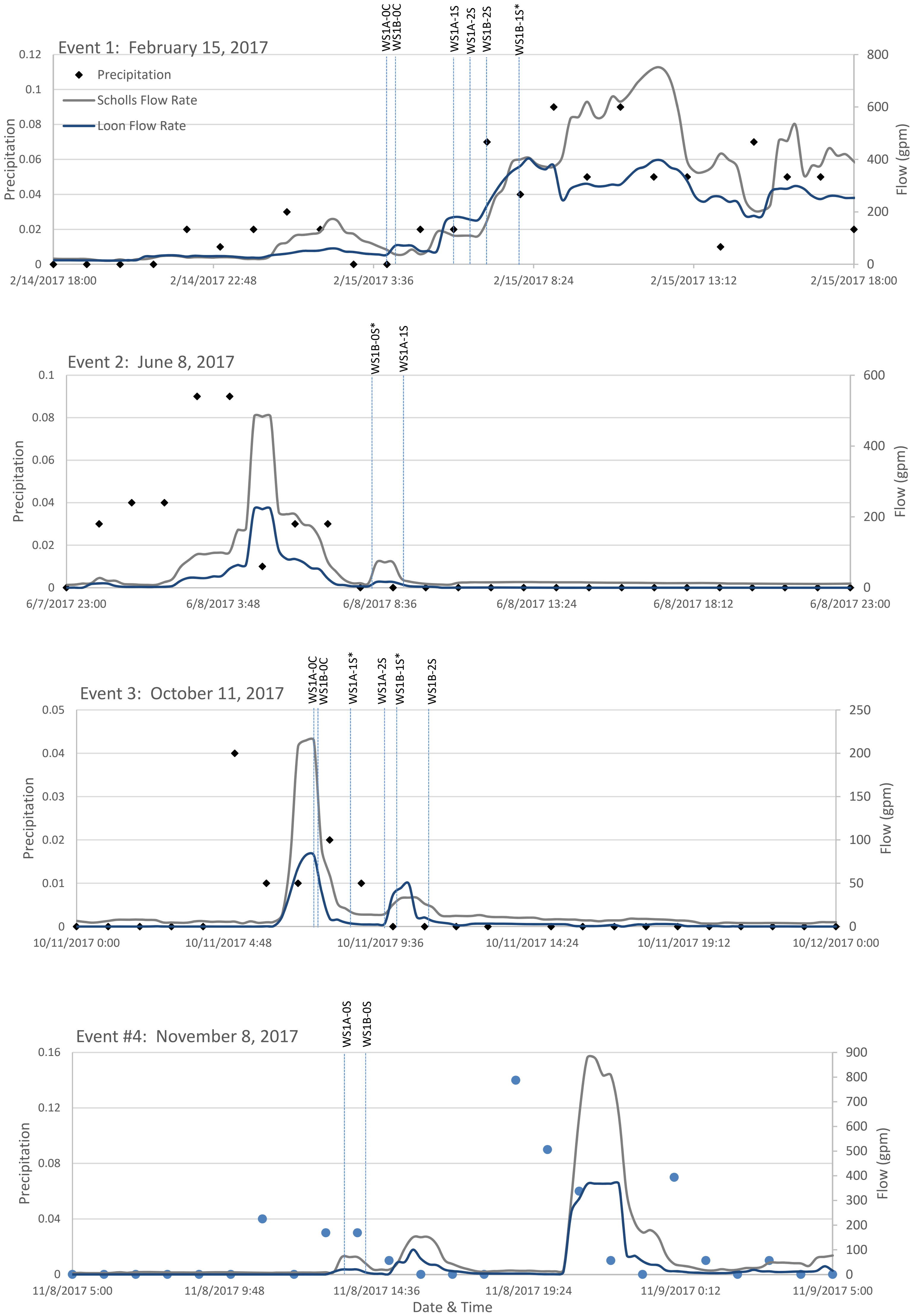


Figure 3

2016-2017 Stormwater Volume vs Stormwater Flow Rate



Event	Date	Time	Sample Type	Antecedent Dry Period (1)	Average Flow Rate	
					Schoolls (gpm)	Loon (gpm)
Event #1	2/15/2017	4 am - 7 am	grab	4.5 days	86.91	114.42
Event #2	6/18/2017	8 am - 10 am	grab	8.5 days	34.29	8.58
Event #3	10/11/2017	9 am - 11 am	grab	11 days	22.99	18.17
Event #4	11/8/2017	1:30 pm - 2:30 pm	grab	2.5 days	55.11	14.27

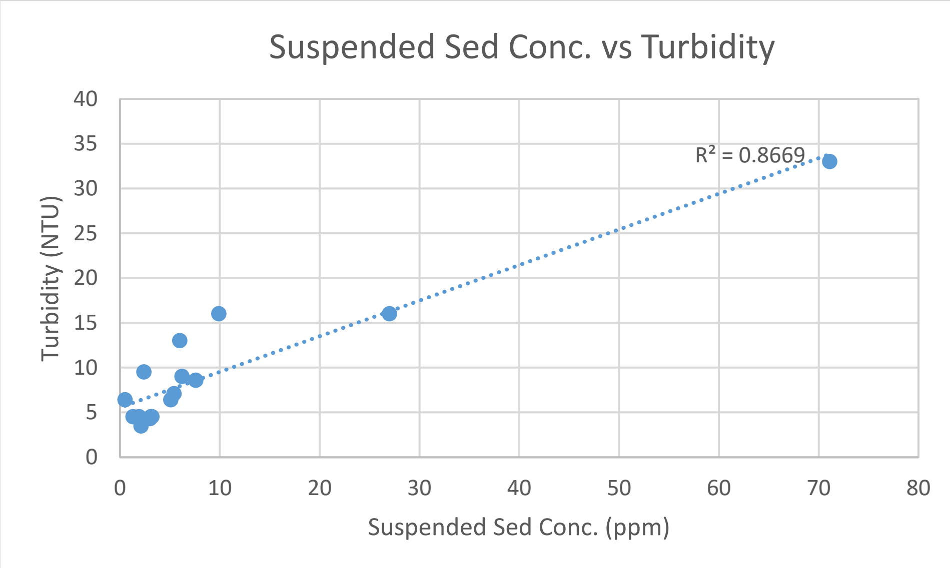
Notes:

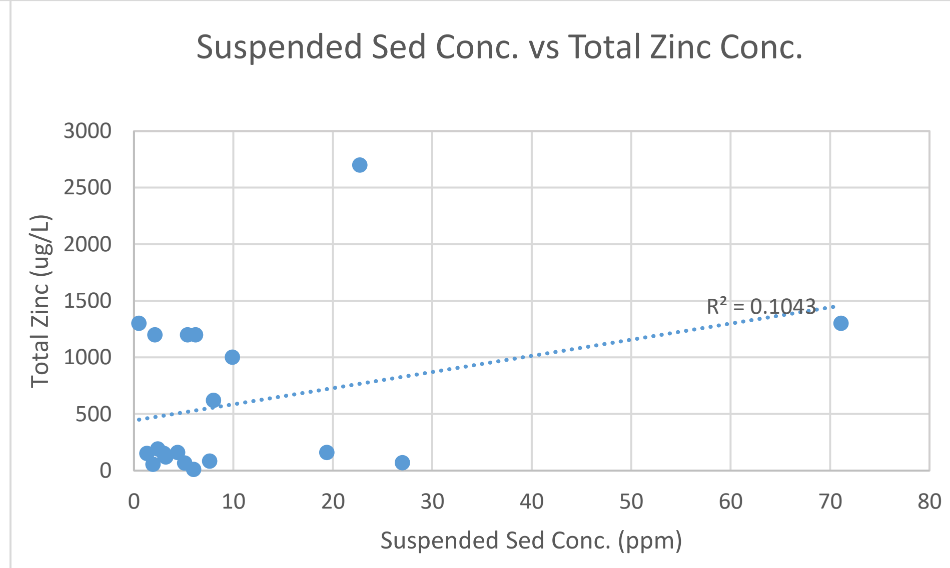
- Average flow determined by the average flow rate observed between the time of sampling.
- Asterik (*) following sample date indicates that a duplicate was collected.

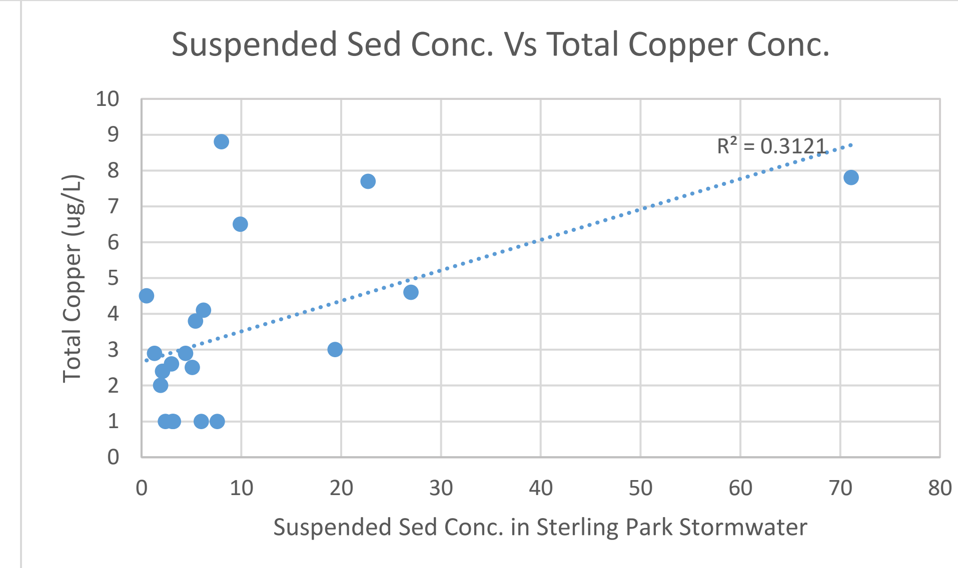
(1) Cumulative rain priot to this event was less than than 0.10 inches.

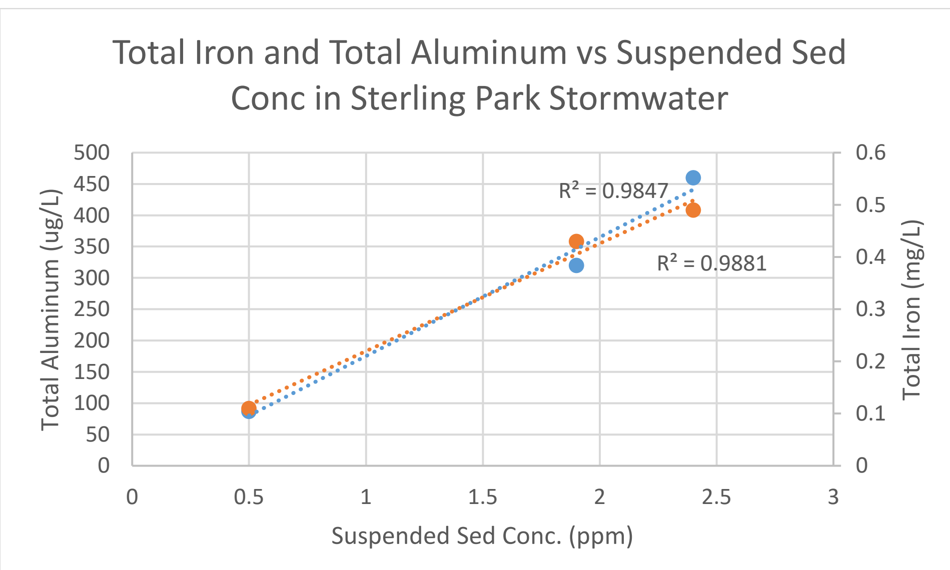
Figure 4. Sampling Event Precipitation and Flow

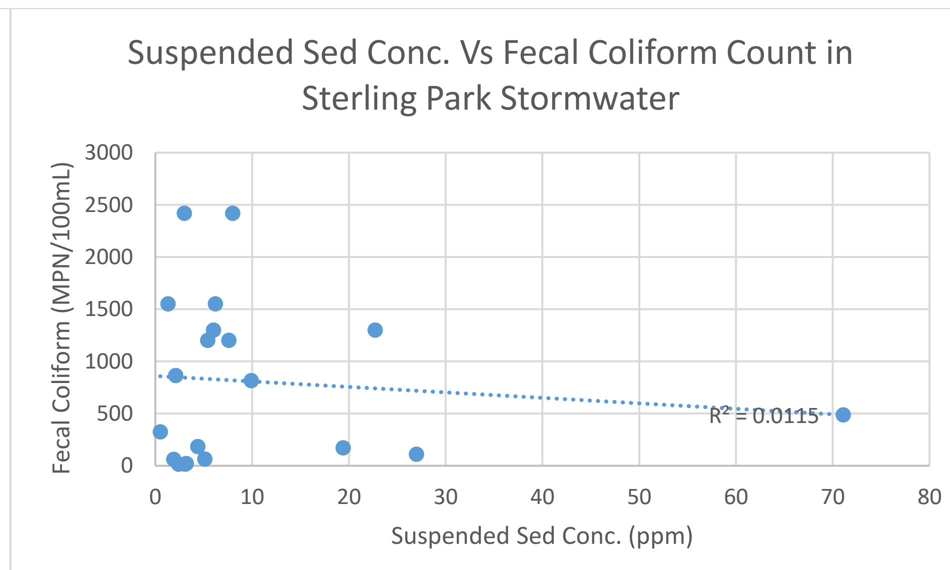
Figure 5 Correlations between Select Stormwater Analytes and Suspended Sediment Concentrations in Sterling Park Stormwater Samples











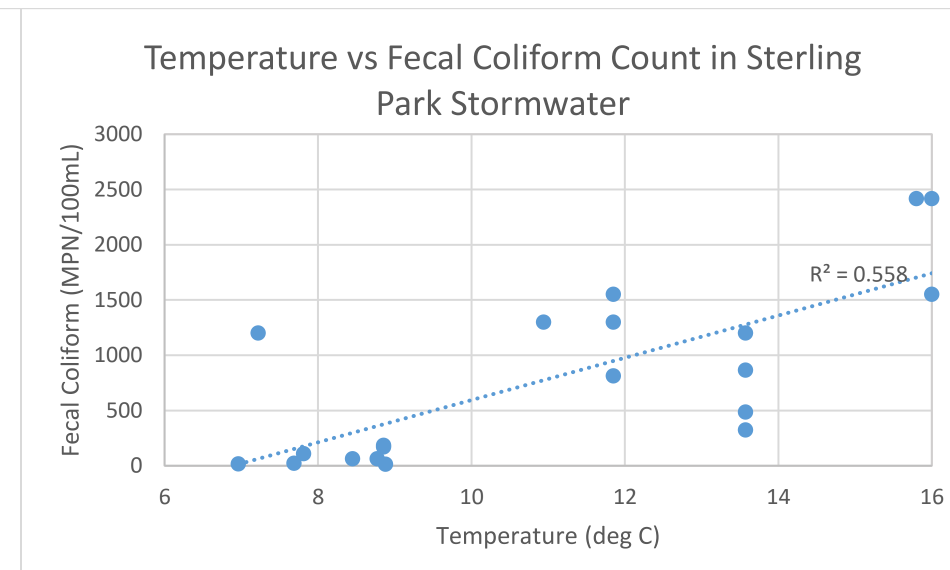
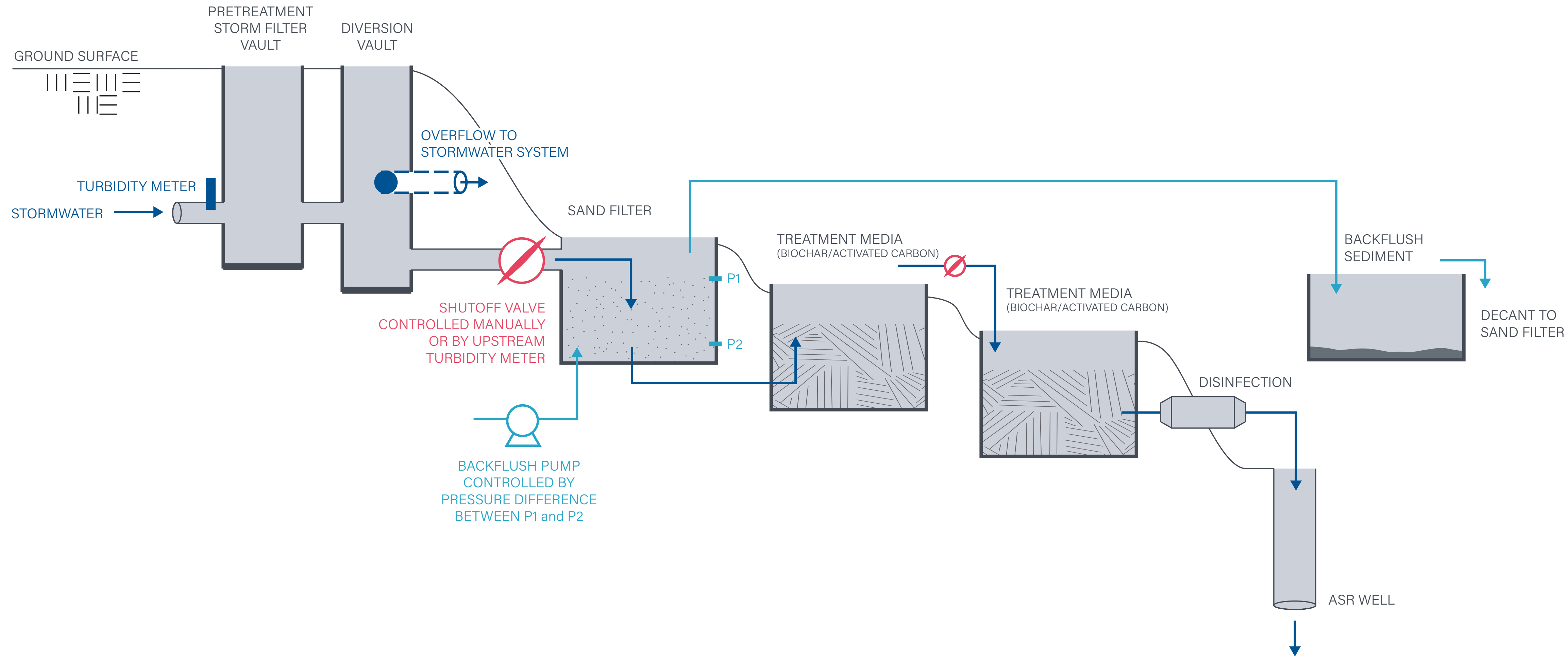


FIGURE 6

Conceptual Stormwater Treatment Train

Clean Water Services



- Sampling Location
- ASR 3
- Outfall
- Inlet
- Stormwater Vault with Pump and Bypass System
- Proposed Stormwater Treatment System Footprint
- Stormwater Conveyance
- Stormwater Flow Direction
- Stormwater Detention Basin
- Site

Clean Water Services

N

0 25 50 75
Feet

Date: January 19, 2018
Data Sources: 2016 Aerial, COP

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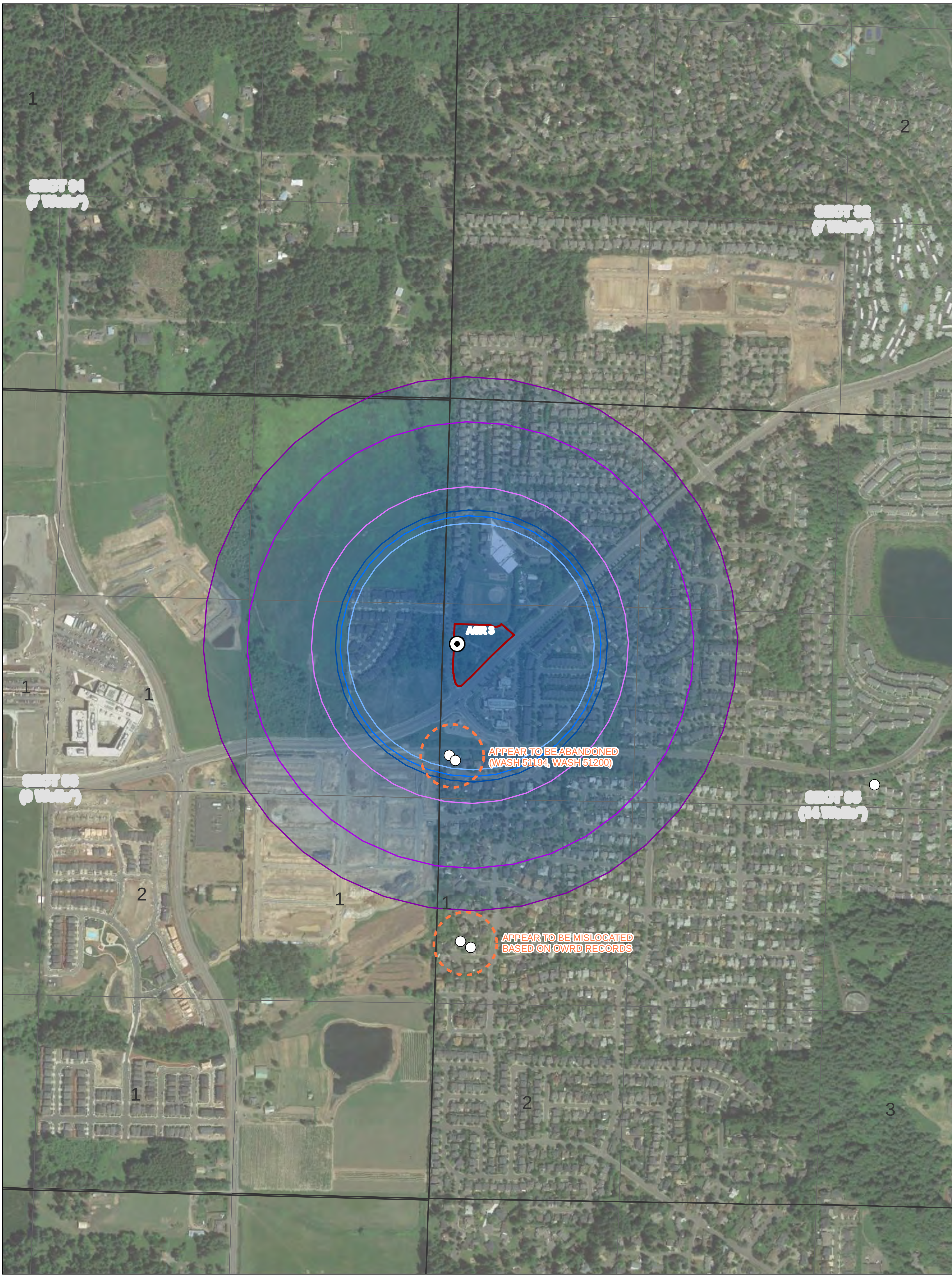

500 Days
1000 Days (2X Safety Factor)
1500 Days (3X Safety Factor)

500 Days
1000 Days (3X Safety Factor)
1500 Days (3X Safety Factor)

Well Location from OWRD, Located by Tax Lot
ASR 3
3 Number of wells within Quarter Quarter
Sterling Park Site

Clean Water Services

Date: January 26, 2018
Data Sources: 2017 Aerial, Google Earth

N

0 325 650 975
Feet

*Number of wells within the Section, no QQ location available.

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Appendix A

Sampling and Analysis Plan

Sampling and Analysis Plan

2016/2017 Stormwater Investigation
Sterling Park Stormwater Quality Facility
Groundwater Recharge Feasibility Evaluation
Beaverton, Oregon

Prepared for

Clean Water Services

and

City of Beaverton

November 2016

Prepared by

Clean Water Services

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Appendices

1. INTRODUCTION

1.1 Purpose

This document presents the *Sampling and Analysis Plan* (SAP) for collecting and characterizing stormwater as part of the Sterling Park Groundwater Recharge Feasibility Evaluation in Beaverton, Oregon (Figure 1). The purpose of this investigation is to assess the quantity, representative quality, and potential suitability of stormwater discharges for Aquifer Storage and Recovery (ASR) recharge at a well referred to as ASR 3 located in close proximity to an existing water quality facility detention basin (Figure 2). To that end, data collected under this SAP are intended to capture the following information over a range of storm events:

- Representative quantity of stormwater (e.g. volume, flow rates) from two stormwater drainage basins (WS-1A and WS-1B) discharging adjacent to ASR 3.
- Representative quality of basin stormwater discharges based upon the variability of concentrations of chemicals/analytes of interest (COIs).

Data collected from the field investigations will be screened against applicable regulatory criteria in order to assess the suitability of injecting stormwater for use in recharge to ASR 3.

This SAP provides detailed information for carrying out sample collection, storage, and analysis as well as general rules for data usability.

1.2 Scope of Initial Stormwater Investigation

The sampling described in this SAP is intended to capture stormwater samples to better understand the variability and correlation in stormwater flows, COI/analyte concentrations, and field parameters discharging to the water quality facility adjacent to ASR 3. The stormwater investigation program will collect data from two residential stormwater basins (WS-1A, WS-1B) including:

- Measuring stormwater discharge flow rates and estimating discharge volumes representative of flow from basins WS-1A and WS-1B during different storm events.
- Collecting first flush stormwater samples from each basin.
- Collecting time-series stormwater grab samples from both basin locations to assess stormwater quality variation over the duration of two different storms.
- Collecting stormwater grab samples from each basin during four planned sampling events to assess potential stormwater quality variation over the duration of the winter which coincides with the anticipated future period of ASR injection.
- Characterizing stormwater quality (e.g., chemical, biological, and physical parameters).
- Comparing stormwater quality data to potentially applicable regulatory screening criteria [e.g., maximum contaminant levels (MCLs) and National Pollutant Discharge Elimination System (NPDES) benchmarks].

Specifically, stormwater basins WS-1A and WS-1B will each be sampled for up to four storm events as shown in Table 1 and as described below:

Basin WS-1A

- **Event 1**: A first flush and two subsequent time-series stormwater grab samples will be collected. The first flush sample will be analyzed for the comprehensive list of analytes (Table 2). The subsequent time-series samples will be analyzed for the shorter list of indicator analytes (Table 3).
- **Event 2**: A first flush and two subsequent time-series stormwater grab samples will be collected. Both the first flush sample and the subsequent time-series samples will be analyzed for the shorter list of indicator analytes (Table 3).
- **Events 3 and 4:** A stormwater grab sample will be collected during each event and analyzed for the shorter list of indicator analytes (Table 3).

Basin WS-1B

- **Events 1 and 2**: Same as procedure for Event 1 for Basin WS-1A.
- **Events 3 and 4:** Same as procedure for Events 3 and 4 for Basin WS-1A.

The goal is to complete the first two stormwater sampling events before the end of 2016, if practicable, and to complete the third and fourth events in the first quarter of 2017 and no later than April 2017 (see Table 1).

Samples collected from two first flush stormwater sampling events will be analyzed for a comprehensive suite of analytes listed in Table 2. This list was developed from constituents referenced in the National Primary Drinking Water Regulations (NPDWR; 40 CFR 141) [i.e., for which an MCL or treatment technology (TT) is available]. Additional constituents were added based on consideration of the following:

- Clean Water Act (CWA; 33 USC Section 1251);
- NPDES program (40 CFR 123);
- Underground Injection Control (UIC) Rules (Federal 40 CFR part 144-146; Oregon OAR 340-044);
- Oregon DEQ's emerging pesticide monitoring or evaluation requirements under its Phase 1 Municipal Separate Storm Sewer System (MS4) permit or municipal region UIC Water Pollution Control Facilities permit, and
- General water chemistry (major anions and cations).

Stormwater events targeted for sampling, sampling methodologies, and analytical test are described in detail in subsequent sections.

Based on the current residential land use within stormwater drainage basins WS-1A and WS-1B, and a review of available municipal stormwater data (GSI, 2015[1]), stormwater discharges are

[1] GSI, 2015. Technical Memorandum: Draft Preliminary Findings and Recommendations, ASR Stormwater Discharge Feasibility Project No. 6660. Prepared by GSI Water Solutions, Inc. (GSI) for Clean Water Services (CWS). Dated November 6, 2015.

not expected to contain all analytes for which a drinking water MCL applies (e.g., radionuclides and disinfection byproducts). However, to conservatively evaluate the suitability of stormwater injection into a drinking water aquifer and to meet ASR water quality requirements, samples collected from two of the four stormwater sampling events will be analyzed for the comprehensive suite of analytes.

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2. PREPARATION FOR MONITORING

2.1 Monitoring Team

Members of the Clean Water Services (CWS) monitoring team will collect and document stormwater discharge measurements and water quality samples, and conduct visual assessments of stormwater discharges. Monitoring team members must be familiar with the contents of this SAP, the layout of the water quality facility and sampling locations, and be available to conduct sampling activities on short notice.

It is important that monitoring team members understand and follow this SAP and quality assurance/ quality control (QA/QC) techniques and procedures to ensure that the data collected during this investigation are of high quality and defensible.

The following individuals are identified as members of the initial stormwater sampling and sampling coordination team. During the sampling event, it is anticipated that two individuals will be required to collect samples from each designated sampling location.

Name	Company	Responsibility	Cell Phone Number
Jadene Stensland	CWS	Project Lead/Coordination	503-550-6126
Jason Melady	GSI Water Solutions	Project Lead/Coordination	503-799-2198
Scott Nys	CWS	Flow Data Collection Lead	NA
Steve Thompson	CWS	Laboratory Services Manager	503-962-9569
Bob Baumgartner	CWS	Assistant Director Regulatory Affairs Department	503-681-4464
David Winship	City of Beaverton	Liaison with COB Eng Staff	503-526-2434
Jesse Wilson	City of Beaverton	Field Contact	(503)209-6430 or (503)310-4895
Doug Lager	CWS	Sampling Team	503-442-8683
Mark Disbury	CWS	Sampling Team	NA

2.1.1 Monitoring Team Training

Key members of the CWS sampling team will visit the site before sampling activities are scheduled to commence and will inspect each of the designated basin locations where samples will be collected (see Section 2.3).

Specifically, the sampling team will be familiar with the following key elements of the SAP including:

- CWS stormwater health and safety requirements (e.g., manhole access; traffic control)
- Stormwater conveyance access and sampling locations
- General water quality facility layout
- How to monitor, record, and report stormwater flow measurements

- How to monitor, record, and report field parameters for stormwater samples
- How to collect and document the collection of stormwater samples
- How to perform and document visual assessments
- How to handle and send the samples to the labs
- How to keep accurate and complete records

2.1.2 Safety

Sampling activities will be conducted in accordance with CWS safety protocols and standard operating procedures.

Collecting stormwater grab samples is a simple process but an important one, since getting good results depends on proper sampling techniques. Samples can be collected easily in most locations, but worker safety should be the primary consideration in sampling. Samples should never be collected in a way that compromises the safety of the sampler. Field members should be aware of any potential physical hazards, such as trip hazards, traffic considerations, etc., and should request assistance if needed. Safety relies on individual judgment. The sampler should never put him or herself in a position that they consider unsafe.

2.2 Sampling Event Preparation

It is important to assemble all field equipment that will be needed for the sampling event ahead of time because little advance notice may be given prior to a storm sampling event.

2.2.1 Team Member Preparation

Individual team members should have field items that they keep with them at work during the anticipated sampling window (November 2016 through April 2017). Field members should be prepared upon short notice to proceed to travel to the designated sampling locations with all personal items needed for the duration of the sampling period (estimated to be 2 – 4 hours). Field items should include the following, as appropriate:

- Rain gear
- Reflective vest
- Cell phone with fully charged battery
- Cell phone car charger or a fully charged external battery power bank.
- Waterproof shoes/boots
- Gloves
- Safety glasses or goggles
- Flashlight and/or head lamp (with extra batteries)
- Drinking water

2.2.2 Sampling Equipment

Field equipment should be inventoried, collected, and prepared by the field team in a clean location before each targeted sampling event (i.e., early November 2016). The following equipment will be needed for each stormwater sampling event:

- *Sampling and Analysis Plan*
- Field notebook
- Permanent markers
- Pens (indelible ink)
- Sampling forms (recommend forms be copied onto waterproof paper)
- Chain-of-custody sheets (pre-filled out to extent possible in the office)
- Sample labels (pre-filled out to extent possible in the office)
- Clip board
- Two 1,000 ml containers (or equivalent) for obtaining field measurement of pH, conductivity, and temperature
- Paper towels
- Laboratory supplied pre-cleaned and preserved sample bottles for analyses. Three (3) complete sets of bottles will be available for collection of time-series samples at each sampling location during the first two sampling events. One (1) set of bottles will be available for each basin during the third and fourth sampling events.
- Laboratory supplied filters/flowmeters for collection of virus and protozoa samples
- Appropriate water sampling pump(s), controller(s), power supply, and tubing with appropriate valves to direct and regulate flow through virus/protozoa collection filters
- Peristaltic sampling pump and dedicated tubing (1 per manhole) or dedicated pole mounted sampling container(s) (500 ml wide mouth stainless steel container attached to a pole to reach into the manhole and grab the sample)
- Ice chests for sample preservation and shipping
- Extra-large ziplock bags (sized to fit chain-of-custody form or sample bottles)
- Hand sanitizer solution
- Powder-free disposable nitrile or latex gloves. Do not use powdered gloves as they may contaminate samples.
- Trash bags
- Duct tape
- Ruler (12") (uses: photo scale, measure water height in discharge pipe, etc.)
- Decontamination equipment
    - 1 gallon tap water
    - 1 gallon deionized or distilled water

2.2.3 Other Equipment

Other equipment will be collected and stored at the facility as appropriate for team members' use. This may include the following:

Sampling Location Preparation Equipment

- Traffic cones, if necessary, to ensure sampler safety at sampling locations within roadway (i.e. on SW Loon Drive).
- Flashing lights, if necessary, to ensure sampler safety at sampling locations within or directly adjacent to roadway.

Equipment to be transported to the Facility at the start of sampling

- Water quality meters (pH, conductivity, temperature)
- Ice or ice packs
- Camera for documenting sample collection conditions or any irregularities (e.g. flow obstruction) at designated sampling locations.

2.3 Sample Location Preparation

Before sampling is conducted, each designated sampling location (i.e., manhole) will be inspected and prepared for sampling by conducting the following activities, as necessary:

- Clean out conveyance lines. CWS will coordinate with conveyance line cleaning/vactor truck company.
- Set up traffic cones and road flares as necessary to protect samplers.
- Set up pump within designated sampling location (e.g. just off bottom of manhole invert elevation) for collection of microbiological samples.

2.4 Facility Coordination

Facility Access: The designated sampling locations can be accessed 24 hours a day/ 7 days but CWS samplers will attempt to contact representatives from the City of Beaverton, CWS, and GSI prior to sampling.

Limitations around sampling event: The sampling locations can be accessed 24 hours a day, but samplers will target storm events that allow samples to be collected during regular business hours. Field team members will follow safe work practices and be aware of street traffic.

Sampling Equipment Storage: Sampling equipment will be kept at the CWS Laboratory or within CWS sampling vehicles until sampling.

2.5 Analytical Testing and Laboratory Coordination

Stormwater samples will be analyzed for a comprehensive suite of constituents to document stormwater quality and to evaluate the suitability and feasibility of stormwater injection into a drinking water aquifer for future use (e.g., irrigation, aesthetic ponds, supplemental summer stream flow). Section 1.2 summarizes how the comprehensive list of analytes was developed. The resulting stormwater data set is intended to be conservative and robust in order to demonstrate that the future injection of stormwater from residential urban basins is protective of beneficial groundwater uses (i.e., drinking water) and will meet surface water discharge requirements if used to supplement summer stream flow. In addition, the number and types of samples were selected to assess the variability of stormwater quality over the course of the stormwater events and over the winter (i.e., anticipated period of ASR injection).

Table 2 presents the comprehensive list of stormwater analytes that will be analyzed on "first flush samples," associated regulatory criteria, analysis methods, and identifies the laboratory that will conduct the analysis. Table 3 presents the pared down list of representative analytes that will be analyzed to assess the variability of stormwater quality in individual time series samples collected subsequent to "first flush" samples and in samples collected during the third and fourth stormwater events (also see Table 1). The representative analytes included in Table 3 were selected based upon a review of available regional stormwater data. For each analyte, Appendix A presents the laboratory method, method reporting limit, appropriate sample container and preservation method, and applicable method holding times for each analyte.

Stormwater samples analyzed for drinking water constituents will be completed by National Environmental Laboratory Accreditation Conference (NELAC) Drinking Water-accredited laboratories.

CWS will contract with accredited laboratories for analyzing stormwater samples [e.g., semi-volatile organic compounds (SVOCs), pesticides & herbicides, and volatile organic compounds (VOCs) and microbiological parameters including total coliforms, Legionella, protozoa and protozoan cysts, and enteric and noroviruses]. Contact information for subcontracted laboratories is as follows:

Eurofins Eaton Analytical, Inc.
1500 NW Bethany Blvd, Suite 200
Beaverton OR 97006
Phone: +1 503 597 1340
Mobile: +1 503 310 3905
Receiving Hours are Monday – Friday: 8 am – 5 pm and Saturday by FedEx/UPS

Pacific Agricultural Laboratory
21830 SW Alexander Lane
Sherwood, OR 97140
(503) 626-7943
www.pacaglab.com
Receiving Hours are Monday – Friday: 8 am – 5 pm and Saturday by FedEx/UPS

Biological Consulting Services dba BCS Laboratories
c/o George Lukasik, Ph.D.
4609 NW 6th Street, Bldg A
Gainesville, FL 32609
(352) 377-9272 office
(352) 377-5630 fax
Receiving Hours are Monday – Friday: 8 am – 6 pm and Saturday (if scheduled in advance) by FedEx/UPS

Sample bottles, preservatives, filters, and labels will be obtained from subcontracted laboratories prior to sampling events and placed in the field sampling kits described in Section 2.2.2.

Subcontracted laboratories will be notified by CWS staff when the sampling event is scheduled and initiated to coordinate sample delivery and the tentative analyses schedule.

3. SAMPLE LOCATIONS

3.1 Sterling Park Stormwater Detention Basin

The Sterling Park Stormwater Detention Basin is a water quality facility that houses Well ASR 3 and receives stormwater discharges from two urban, residential drainage basins, WS-1A and WS-1B. Drainage basin WS-1A collects stormwater discharges from approximately 860,000 ft^2 (WS-1A) of neighborhood streets, roofs, and lawns that are routed through a stormwater main along Scholl's Ferry Road and discharge through an outfall on the NE corner of the upper basin in the Sterling Park water quality facility. Drainage basin WS-1B collects stormwater from approximately 540,000 ft^2 of urban residential area. This runoff is conveyed along SW Loon Drive and discharges through an outfall on the north edge of the upper basin of Sterling Park water quality facility. Figure 2 depicts the drainage basin areas and outfalls for WS-1A and WS-1B.

3.2 Sample Locations

An existing spillway within the Sterling Park Stormwater Detention Basin is higher in elevation than the invert elevations of outfalls for basins WS-1A and WS-1B. During a field investigation, standing water was observed at both outfalls and observed to be backed up into the conveyance lines for each drainage basin. Ponding behind the spillway is expected to be more pronounced during a large storm event. Accordingly, the outfall locations are not ideal locations for collecting stormwater grab samples and flow measurement data. Instead, sampling locations were identified upstream of the outfalls above the elevation of the spillway and outside of the influence of standing water, but still representative of whole basin discharges. Specifically, the sampling locations for each drainage basin are as follows:

- Basin WS-1A: Flow meter and water quality samples will be collected from a manhole on Scholl's Ferry Road, City of Beaverton (COB) manhole number SWMH0006847.
- Basin WS-1B: Flow meter and water quality samples will be collected from a manhole on SW Loon Road, COB manhole number SWMH0003373.

Figure 2 shows the approximate stormwater drainage basins and sample locations.

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4. WHEN TO SAMPLE

The stormwater sampling addressed in this SAP targets up to four storm events between November 2016 and April 2017, with two of those events targeted to occur in 2016, if practicable. It is assumed that all storms targeted as part of this investigation will be sufficient to produce measurable flow at the sampling locations. To the extent practicable, stormwater sampling is scheduled to begin within the early "first flush" stages of the targeted storm events – however, sampling will not be attempted in unsafe conditions or if the storm cannot be accurately tracked and predicted.

4.1 Storm Event Criteria and Selection

CWS will track local precipitation events and identify potential storm events appropriate for sampling. CWS will initiate sampling activities when it is predicted that a storm meeting the Oregon Administrative Rules (OAR) 340-044-0018 storm event criteria will be met:

- Antecedent dry period of at least 72 hours (as defined by <0.1" over the previous 24 hours);
- Minimum predicted rainfall volume of >0.1" per event.
- Expected duration of storm event of at least 3 hours.
- Storm events are forecast to begin during normal working hours or based on the availability of the CWS field sampling crew.

CWS will attempt to collect first flush samples (i.e., samples from within the first 30 minutes of discharge) during the first two storm events from each basin, if practicable. *"First flush"* is defined in OAR 340-044-0018 and DEQ's *Guidance for Evaluating Stormwater Pathways at Upland Sites* (DEQ, 2009, updated 2010) to mean within the first 30 minutes of stormwater discharge. Sampling events are discussed in Section 5.4.

Adhering to target storm event criteria helps to ensure that stormwater runoff will be adequate for sample collection and will be representative of stormwater runoff from each drainage basin.

4.2 Weather Forecasting

Keeping up with the weather forecast and planning so that sampling can be carried out on short notice is critical to successful sampling. Several websites (e.g., www.accuweather.com) and companies (e.g., ERF Company, Inc.) are available to provide detailed daily forecasts and 7-day extended forecasts for the Beaverton area to aid selection of an appropriate target storm meeting the criteria above.

Radar images (i.e., Doppler images) may be viewed by the monitoring team in the field to track the storm. The National Weather Service is an excellent source of information on upcoming storms and provides local current radar and satellite images on their website at http://www.wrh.noaa.gov/index.php.

4.3 Sampling Initiation

The decision to initiate a stormwater sampling event will be made by the CWS Sampling Team in consultation with the Project Leads as necessary. Upon the decision to proceed, the Sampling Team will immediately:

- Coordinate with other CWS Sampling Team members to ensure an adequate number of team members can respond and implement this SAP.
- Notify Laboratory Management to contact the analytical laboratories so they know to expect the samples and have adequate staff available to receive the samples and to conduct the analyses within the applicable holding times.

Once the decision to proceed is made, the Sampling Team will mobilize to the site. For first flush samples, CWS staff will attempt to be at the sampling locations before stormwater begins discharging, if practicable, so the time of discharge can be documented and first flush samples collected.

5. STORMWATER GRAB SAMPLING PROCEDURES

This technical procedure has been established to standardize the sample collection, preservation, and submittal of stormwater grab samples to the appropriate analytical laboratories.

5.1 Outfall Inspections

Upon arriving at the sample location, the manhole and surrounding area should be inspected for possible tampering, contamination sources, or any obstacles that may prevent obtaining accurate samples (e.g., nearby emissions, construction, obstructions, etc.). Observations should be recorded in the field notebook or on the sampling form.

5.2 Visual Assessment of Stormwater Discharges

Sampling Team members will note when stormwater discharge begins (if they arrive prior to first flush) and visually assess the stormwater discharge at each sampling location. The visual assessment should be performed by collecting stormwater in a clear glass or plastic container. The general appearance of the discharges will be noted for the following characteristics:

- ***Color*** – Unusual color, such as a reddish, brown, or yellow hue, may indicate pollutants or suspended sediment.
- ***Odor*** – Noticeable odor, for instance, gasoline fumes, rotten eggs, raw sewage, solvents odor, or a sour smell, could be indicative of pollutants in the discharge.
- ***Clarity*** –Cloudy or opaque discharge could indicate elevated levels of pollutants or suspended sediment.
- ***Floating solids*** –Material floating at or near the top of the bottle should be noted and characteristics described.
- ***Suspended solids*** – Particles suspended in the water will affect its clarity and color.
- ***Oil sheen*** –Rainbow color or sheen on the water surface could indicate the presence of oil or other hydrocarbons in the discharge.
- ***Foam*** – Note whether there is any foam in the container.
- ***Other observations.***

Record visual monitoring results on the Stormwater Sampling Form (See Appendix B).

5.3 Outfall Flow Measurements

Prior to the sampling events, CWS field staff installed a Hach flow logger Fl901 with a FLO-DAR model 4000 radar / ultrasonic height sensor to monitor flow data at each sampling location. Data gathered from the flow meters will include date/time in a minimum of 15-minute intervals, pipe diameter (inches), water depth (inches), flow velocity (feet per second), and flow rate (cfs or gpm). These data will be reported in MS Excel or CSV file format.

CWS will inspect and maintain the flow meters on a regular basis. Flow meters will be inspected at the start of each sampling events to ensure that they are functioning properly and that no obstructions are preventing accurate measurements.

Flow data will be collected monthly by CWS. In the case of a sampling event, CWS staff will be notified and flow data will be collected after the sampling event. If monthly flow data collection has yet to occur during the month the sampling event occurs, the data collected after the sampling event will suffice for the flow data collection for that month.

5.4 Sampling Events

Up to four stormwater sampling events from each basin (WS1A and WS1B) will be targeted for sample collection and laboratory analyses (see Table 1).

- Sampling events 1 and 2 will be targeted to capture first flush conditions and subsequent time-series samples in both basins. Time-series samples will be collected at approximately 1 hour intervals after the first flush (i.e., first flush, ~1 hour after first sample, ~2 hours after first sample). The first flush samples will be analyzed for the comprehensive list of analytes presented in Table 2 for Event 1 (both basins) and Event 2 (Basin WS-1B only). All other sample events will be analyzed for the representative list of analytes presented in Table 3.
- Sampling events 3 and 4 will be comprised of a single grab sample from both basins. Samples will be analyzed for the representative list of analytes presented in Table 3.

5.5 Stormwater Grab Samples

The goal of the first two stormwater sampling events is to collect two to three stormwater time-series grab samples from the two designated sampling locations. Ideally, the samples would be collected across the discharge event with the first sample being collected within the first approximately 30 minutes of first flush discharge, the second sample being collected near the estimated midpoint of the discharge, and the third sample being collected near the estimated end of the discharge. However, due to the known variations in storm forecasting, storm intensity, and storm duration, it is recognized that it is unlikely that these samples will be collected. Therefore, grab samples will be collected at set intervals (about 1 hour) over a fixed time period (2 – 3 hours). The length of the sampling event will be determined by the Sampling Team, based on the weather forecast and the expected duration of the storm. Sampling over the first three hours of the storm would meet the criteria listed in DEQ's stormwater sampling guidance (DEQ, 2009, updated 2010).

5.5.1 Grab Sample Frequency

A grab sample is a single sample "grabbed" by filling up a container. It is the simplest type of sample, and is collected at a discrete moment during the timeline of a storm event for the purpose of characterizing the nature of stormwater at that time. Time-series grab samples will be collected, to the extent practicable at each sampling location:

- During the first 30 minutes of discharge;

- At one hour intervals over the first two to three hours of the storm;
- In the event the flow changes significantly due to heavy precipitation intervals, additional samples may be obtained or if precipitation stops sampling may be terminated.

5.5.2 Sample Collection

Collecting a grab sample can be as simple as holding a decontaminated container on a pole under the stormwater discharge (i.e., directly under the inlet within the manhole) and using the container to fill the sample bottles. Stormwater samples can also be collected using a low-flow peristatic pump. However, sampling should be completed with care in accordance with the principles outlined below so that the sample will be representative of site stormwater.

Simple principles of sample collection include:

- Wear disposable powder-free gloves when sampling.
- Grab samples with a pre-cleaned (decontaminated) stainless container on an extension pole or use dedicated pump tubing and intake valve.
- Carefully lower the sampling equipment into the manhole while avoiding touching the sides of the manhole.
- Take care to only place sampling equipment on a clean surface between samples (Do not place sampling equipment on the bare ground, truck bed, etc.)
- Carefully transfer the stormwater sample into bottles supplied by the analytical laboratory. Avoid placing fingers into the sample container or the water stream when transferring.
- When holding the sample bottle, keep hands away from the opening in order to prevent contaminating the sample.
- Always hold the sample container so that the opening faces upstream (into the flow of water) allowing flow to enter directly into the bottle.
- Sample to the extent practicable from a central portion of the stormwater flow, avoiding touching the manhole surface so as not to stir up solid particles.
- Do not rinse or overfill the analytical sample bottles. Some of the bottles supplied by the analytical laboratory will include small amounts of liquid preservative (generally a few drops). Fill the bottle to about ½ inch of the top (not quite full) to ensure that no preservative is lost, except that no headspace should be present for volatiles samples.
- As soon as the sample bottle is filled, cap the bottle and complete the label. It is important that the bottles are labeled correctly so that the lab will be able to identify samples by sample location and ensure proper preservation for each parameter. Place sample bottles in sealable bags. Place the sample bags in a cooler partially filled with ice. Plan to maintain enough ice in the cooler until the samples arrive at the lab.

- Deliver or ship samples to the laboratory to make certain that the analyses can be conducted by the laboratory within holding times (Appendix A).

5.5.3 Collection of Microbiological Samples

Stormwater samples collected for the analyses of viruses and the protozoa, *Cryptosporidium* and *Giardia,* require larger sample volumes [100-300 L (26 – 79 gallons) for viruses and 100 L for protozoa] that must be slowly passed through a collection filter. In order to collect these samples, appropriate water sampling pump(s), controller(s), power supply, and tubing with appropriate valves to direct and regulate flow through virus/protozoa collection filters must be used. Samples will be collected by pumping stormwater through the individual collection filters at a designated flow rate for a set length of time or a set volume of water pumped. In the event that field personal are unable to collect microbiological samples through pumping and filtration methods, ten sterile 1-L sample containers will be filled with stormwater and submitted to the analytical laboratory for each of the protozoa and virus analyses.

Due to cost and time considerations, one sample for each of the microbiological components will be collected during storm events 1 and 2 from each stormwater basin. An effort will be made to begin collection of the microbiological samples during the first flush conditions at the beginning of the storm. Samples may take up to an hour to collect.

Sample collection filters, flow meters, and tubing will be provided by the subcontracted laboratory. More detailed sampling instructions are provided in Appendix C.

5.6 Field Parameters

Various field parameters such as pH, conductivity, total chorine residual and temperature can be useful to the data interpretation process. Field parameters will be collected when each stormwater sample set is collected. Field parameters will be measured at the sample collection site as samples are being collected, and will be performed either inside the sampling van or in the open, depending on conditions and convenience. Field measurements will be performed by qualified CWS sampling staff.

Field meters will be calibrated and checked according to CWS Laboratory Standard Operating Procedures (SOPs). Procedures for the collection of field parameters include:

- Follow CWS Laboratory SOP's for field measurements. Always measure conductivity prior to pH as the electrolyte from the pH probe will affect the conductivity reading.
- Field parameters having methods that require immediate analysis should be performed within fifteen minutes of sample collection.
- Record the time of field parameter sampling, analysis and observations of odor, color, etc. (See Section 5.2). Record the pH, conductivity, total chlorine residual and temperature.

6. SAMPLE HANDLING

Sample handling, labeling, documentation, and chain-of-custody procedures will be performed in accordance with the procedures described below.

All samples transferred to the laboratory for analysis will follow standard documentation, packing, and chain-of-custody procedures. Samples will be stored in iced coolers or refrigerated following collection, and, where feasible, hand-delivered to the laboratory in iced coolers to maintain sample temperatures of approximately <6 degrees Celsius (°C). For samples that must be shipped to subcontracted laboratories out of the Portland area, samples will be placed in thoroughly iced coolers and shipped to the laboratory overnight.

6.1 Sample Containers

Pre-cleaned, preserved sample containers or filters will be obtained from the analytical laboratories prior to sample collection. Sample containers will be kept in a cool, dry place until use for sampling activities. Filled sample containers will be sealed, labeled, and placed in a cooler or refrigerator. Appendix A presents the stormwater analytical laboratory method, sample containers, holding time and preservation method for all of the analytes considered in this stormwater investigation.

6.2 Labeling

Each sample container will be labeled to prevent misidentification. Sample labels will be filled out using waterproof ink before the sampling event begins, to the extent practicable. Each sample label will have a unique identification that includes: unique sample number, sample point identification, date and time of sample, name of sampler, and analysis requested. Sample labels will allow the sample to be referenced to the project name (Sterling Park Detention Pond), the drainage basin number (WS-1A or WS-1B) and the time-series sample set.

Additional information to be included on the sample label **must** include:

- Date and time (24-hour style, e.g. 1400 for 2:00 p.m.);
- Requested analysis and preservative (whether a preservative has been used, and the type of preservative); and
- Sampling personnel names or initials.

Any corrections made to sample labels, should be made by crossing out the incorrect information with a single line, entering the correct information, and signing and dating the correction.

6.3 Sample Preservation and Holding Times

Appendix A lists the sample preservation method and holding time for each analytical parameter.

6.4 Sample Packaging and Shipping

After the samples have been collected:

- Samples should be stored immediately after collection in an ice chest containing sufficient ice to cool the samples to <6°C. Use "blue ice" or bagged ice. Samples should remain cooled at <6°C until the cooler is delivered to the lab, however, sample volume and transit time may not allow samples to be cooled to <6°C before delivery to the lab.
- Put a completed CWS chain of custody form enclosed in a sealable plastic bag inside the cooler.
- Deliver the samples to the lab as soon as possible, bearing in mind the holding times for each parameter sampled.
- For samples for Alexin Analytical Laboratories, Inc., samples must arrive a minimum of two hours before they expire during normal business hours Monday through Friday 8:00 AM to 5:00 PM. In case of an emergency bacteria testing, an appointment can be made for Saturday mornings. Samples can be dropped off Monday through Thursday after hours using the Drop Box located at the front door at 13035 SW Pacific Hwy, Tigard, OR 97223.
- Andrew Davidson of GSI will be responsible for shipping the samples to BCS Laboratories.

6.5 Chain of Custody Procedures

Samples must be traceable from the point of collection until the sampling results are reported. To do this, document who is in possession of the samples using CWS chain of custody procedures that may include the procedures below. One person should be responsible for the care and custody of the samples, and for generating the chain of custody record until the samples are properly transferred or relinquished to the laboratory. Chain of custody tasks include:

- Ensure that the sample labels are properly filled in.
- Complete the chain of custody form with the date, time, parameter and sample locations for each sample, and sign the form.
- During the transfer of custody of the samples, both the persons relinquishing and receiving the cooler (including lab personnel) must record the date and time on the chain of custody form and sign it.
- Record the shipping method, courier name(s), and other pertinent information as remarks on the chain of custody form.
- The original chain of custody form remains with the samples and a copy must be provided to the facility for inclusion in project records.

Sample custody (responsibility for the integrity of samples and prevention of tampering) will be the responsibility of sampling personnel until samples are shipped or delivered to the appropriate laboratories. Upon arrival at the laboratory, sample custody shifts to laboratory personnel, who are responsible for tracking individual samples through login, analysis, and reporting. At the time of sample login, the laboratory will assign a unique laboratory sample number (if not already done), which can be cross-referenced to the field sample number and used to track analytical results.

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7. SAMPLE DOCUMENTATION

This section presents general guidance on recording field activities in dedicated project notebooks. Field books are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the implementation of the project. One notebook will be prepared for each sampling location and will clearly state in the initial entry what tasks will be recorded in the particular book.

7.1 Rainfall Event Documentation

Rainfall amounts, intensities, and durations corresponding to the outfall observations and stormwater sampling events will be obtained from local weather stations.

The closest weather station information can be accessed at the following web page:
https://www.wunderground.com/personal-weather-station/dashboard?ID=KORPORTL534

Other weather stations (e.g., Hillsboro Airport) in the area will be periodically checked to confirm the accuracy of the KORBEAVE534 data.

7.2 Keeping records

A monitoring record will be maintained for each basin. The following information will be recorded as appropriate on either the field sampling form (Appendix B) or in the field notebook:

- Sample date(s)
- Sample time (s)
- Method of sampling and method of sample preservation, if varies from this SAP
- Name of the individual who performed the sampling
- Weather condition observations
    - Time (days) since last significant rainfall
    - Estimate of time it began raining
    - Estimate of time that discharge began at the sampling point
    - Intensity of precipitation
- Flow measurements (including notes regarding observed variations)
- The number and types (parameters) of samples collected
- Field meter calibration information
- Measured field parameters
- Appearance of water (color, obvious odor, etc.)
- Sample filtration
- Descriptions of photos taken
- Any unusual circumstances that may affect the sample results

Additional documents that will be generated during sample collection will consist of:

- Sample collection forms
- Chain-of-custody forms
- Shipping receipts in the event that samples are sent to a laboratory via independent courier

The sampling team will use the chain-of-custody forms required by CWS. Hand entries will be made in permanent ink. Corrections to field notebooks or sheets will be made by crossing out erroneous information with a single line and initialing the correction. Field books or sheets will be signed and dated at the bottom of each page by personnel making entries on that page. Do not erase or obliterate incorrect entries, or remove pages from the notebook. Blank and unused portions of notebook pages should be crossed out with a single line.

At the conclusion of the field event, review notebook or sheet entries, sign and date each page (if not already done), and photocopy notebook pages for inclusion in the project file. Original documents will be maintained by the CWS Laboratory.

Standard procedure requires review of field notes by a person other than the person who recorded the field notes, prior to entering the information into the project files, to check for inaccurate, incomplete, or unclear entries, blank pages, or other problems with documentation.

8. QUALITY ASSURANCE PLAN

Standard quality assurance/quality control (QA/QC) practices will be employed for the stormwater sampling and analysis including use of clean, decontaminated sampling equipment, proper field protocols, proper chain-of-custody procedures, and analytical laboratory QA/QC procedures (e.g., laboratory blanks, laboratory spike and spike duplicates, and surrogate analyses). The results of the laboratory QA/QC procedures, as well as holding times and detection limits, will be reviewed to assess the quality of the laboratory data.

The overall data quality objective (DQO) for this investigation is to collect representative data of known, acceptable, and defensible quality that can be used to characterize stormwater quality and evaluate the feasibility of stormwater injection into a drinking water aquifer. The analytical methods and target reports limits were set to meet federal drinking water standards. Samples will be analyzed in accordance with established methods (Appendix A).

8.1 Field Quality Control

The following steps and activities will ensure QC to achieve data quality objectives (DQOs) during field activities:

- Close adherence to the SAP, and documentation of any deviations from the SAP
- Maintain a detailed field notebook and field logs
- Collection of one field duplicate sample during each sampling event (total of 4 duplicate samples) and analyses of the samples for the constituents listed in Table 3. Original sample and duplicate will be collected immediately in sequential order.
- Collection of one equipment rinsate blank for each sampling event (total of 4 rinsate samples, for a total of 8 QC samples) and analyses of the samples for the constituents listed in Table 3
- Use of appropriate, lab-supplied sample containers and preservatives (Appendix A)
- Adherence to appropriate holding times (Appendix A)
- Daily calibration of field instruments, and documentation of standards used
- Completion and appropriate use of chain-of-custody documentation
- Obtaining photographs of site and each site sampling event

Field QA/QC samples will be blind-labeled and preserved. A label list will be prepared prior to the sample collection. Field QA/QC samples will be clearly identified on the sample collection logs. Analytical results from the blanks facilitate crosschecking of the data. Detection of analytes in blanks may indicate possible contamination introduced by field or laboratory procedures. All field QA/QC samples will be documented in the field logbook.

Field samples and QA/QC samples will be packaged, managed, and transferred to the primary contract laboratory according to the appropriate procedures and with sufficient time and coordination to meet analytical holding times.

8.2 Laboratory QA/QC Procedures

Laboratory QA/QC will be maintained through the use of standard EPA methods and other accepted methods and standard analytical procedures for the target analytes. Analytical methods and QC measurements and criteria are based on the current drinking water methods and EPA guidance, and are listed in Table 2 and in Appendix A. The CWS Laboratory Services Manager will coordinate with the contract laboratories during performance of the chemical analyses and through delivery and validation of the laboratory results.

As noted for the field QC protocols, the field samples will be packaged, managed, and transferred to the primary contract laboratory according to the appropriate procedures and with sufficient time and coordination to meet analytical holding times, as generally summarized in Appendix A. Following the successful delivery of samples, the laboratory will follow the method-specific and other analytical and laboratory QC procedures and protocols for the methods requested (see Tables 2 and 3).

The contract laboratories are responsible for performing the following QC testing, as appropriate and as required by the analytical method:

- **Internal QC Samples:** Various QC samples are used to evaluate the precision, accuracy, representativeness, completeness, and comparability of the analytical results. Analytical methods specify routine procedures that are required to evaluate if data are within proper QC limits.

- **Method Reporting Limit (MRL) Check:** MRL checks, as applicable, are made to ensure that primary contract laboratory instrumentation can achieve the required MRLs. If the initial calibration curve contains a standard at the MRL, the laboratory may forgo analyzing a daily MRL check standard. If not, the laboratory will run an MRL check standard per analytical sequence. This sample will be after the instrument blank check sample and before analyzing samples from this group. The instrument must be able to achieve the requested MRLs without interference. If the instrument cannot achieve these levels, the samples must be analyzed on a different instrument that is able to achieve the required MRLs for this project.

- **Method Blanks:** Introduction of chemicals during sampling and analytical activities will be assessed by the analysis of blanks. Method blanks, as applicable, are used to check for laboratory contamination and instrument bias. Laboratory method blanks will be analyzed at a minimum frequency of 5 percent for all chemical parameter groups.

- **Laboratory Duplicates:** Sample analytical variability and laboratory precision and accuracy will be determined by the analysis of primary contract laboratory-generated sample splits. The duplicate results will be used for determination of relative percent difference (RPD).

- **Surrogate Spikes:** Surrogate compound analysis for organic analyses also will follow the guidance in the primary contract laboratory's SOPs and will evaluate the laboratory's ability to recover the analytes of interest. If data fall outside the established limits for the surrogates, a corrective action must be implemented, and the Chemistry QA Manager will be notified. The corrective action can range from re-analysis to re-extraction/re-analysis of the sample. If after these actions the surrogates are still outside of established limits, it will be considered matrix effects and narrated in the final data validation report. Qualification of data will occur when organic compound surrogate recoveries fall outside acceptance limits and will be noted in the laboratory case narrative.

- **Laboratory Control Samples:** LCS, as applicable, are used to monitor the primary contract laboratory's day-to-day performance of routine analytical methods independent of matrix effects. For inorganic samples, a standard reference material (SRM) also will be run. If the laboratory runs a blank spike and blank spike duplicate for organics, then it also will run an appropriate SRM.
- **Matrix Spike and Matrix Spike Duplicates:** Variability in organic compound analysis will be evaluated by analysis of matrix spike (MS) and matrix spike duplicate (MSD) samples. MS and MSD samples, as applicable, provide information to assess precision and accuracy. The primary contract laboratory will follow EPA guidance for MS/MSD sample analysis. Percent recoveries, including RPD, will be assessed for organic compounds from the MS/MSD and for inorganic compounds from the MS.

The laboratories will comply with all SOPs, analytical methods, and their own QA plans.

Results of QC samples from each group will be reviewed by the analyst immediately after a sample group has been analyzed. QC sample results will then be evaluated to determine if control limits have been exceeded. If control limits are grossly exceeded in the sample group, the CWS Laboratory Services Manager will be contacted immediately and corrective action (e.g., method modifications followed by reprocessing the affected samples) will be initiated prior to processing a subsequent group of samples.

Data will be reviewed by the laboratory, as generated. The Laboratory PM will be responsible for ensuring that the data generated meet minimum QA/QC requirements, and that instruments are operating under acceptable conditions during generation of data. DQOs will also be assessed by comparing the results of QC measurements with pre-established criteria, as a measure of data acceptability. The Laboratory PM will ensure that appropriate QC procedures have been followed at the laboratory, and that data are correct and complete.

Undetected data will be reported at the MRL. The MRL will be adjusted by the laboratory as necessary to reflect sample dilution or matrix interference.

8.3 Analytical Data Management

8.3.1 Laboratory Sample Receipt and Review

After samples are submitted to the laboratories, the laboratories will submit a sample receipt (or other confirmation that the analyses have been added to their logs) to CWS to confirm delivery. Upon receipt of the laboratory deliverable, the CWS data manager will compare the number, type, and location (including depth) of samples submitted to the laboratory relative to the COC. Any discrepancies will be resolved with the field task leader and the analytical laboratory. The sample confirmation deliverable will be stored with final laboratory deliverables.

8.3.2 Laboratory Data Reporting Requirement

Upon completion of the analyses listed on the COC, the laboratory will submit an analytical report (PDF format) with accompanying laboratory electronic data deliverables (EDDs or Excel spreadsheets) to CWS. If the EDD will be used for uploading data into a CWS data management system, CWS will provide the required formats and fields to include in the lab EDDs to the laboratories prior to submittal of the samples and COCs.

The laboratory report and EDD should include but not be limited to the following information:

- **General Project Information**
  - Site Name
  - Laboratory Coordinator's name
  - CWS Project Manager and Project Number

- **Case Narrative**

  In the form of a cover letter, this summary will discuss problems, if any, encountered during any aspect of analysis. This summary should discuss, but is not limited to, QC, sample shipment, sample storage, and analytical difficulties. Any problems encountered (actual or perceived) and their resolutions will be documented in as much detail as appropriate.

- **COC Records**

  Legible copies of COC forms will be provided as part of the data package. Forms will include the time of receipt and condition of each sample received by the laboratory. Additional internal tracking of sample custody by the laboratory will also be documented on a sample receipt form. The form must include all sample shipping container temperatures measured at the time of sample receipt.

- **Sample Results**
  - Field sample ID and corresponding laboratory sample number
  - Sample matrix (e.g., stormwater)
  - Date sampled
  - Date and time sample received
  - Analytical Method – MDLs and MRLs (including sample – specific factors such as dilution, total solids, etc.)
  - Sample preparation
  - Extraction date and time
  - Instrument used for analysis
  - Date and time of analyses
  - Analytical results with reporting units
  - Analytical methods
  - Analyte group (e.g., metals, PAHs, PCB Aroclors)
  - Analytes

- CAS Number
- Method detection limits (MDLs)
- Method reporting limits (MRLs)
- Dilution
- Total or dissolved indicator
- Laboratory data flags or qualifiers
- Data flag or qualifier definitions

- **QA/QC Results**

  The results of laboratory QA/QC procedures will be summarized in the data package. QA/QC sample analysis will be documented with the same information required for sample results (see above). No recovery or blank corrections will be made by the laboratory. The required summaries are listed below, though additional information may be requested:
  - Laboratory QA/QC sample type (e.g., lab duplicates, lab method blanks, calibration standards)
  - Laboratory QA Manager sign-off sheet
  - MS and MSD data
  - Method blank analyses
  - Surrogate spike recoveries
  - Replicate results
  - Internal standard recoveries
  - LCS results

Following receipt of the analytical report and EDDs, the analytical reports and EDDs will be reviewed by CWS for the following:

- Data Completeness—Confirm that all requested analyses have been performed and that the EDD contains all required fields.
- Method Reporting Limits (MRLs)—Confirm that MRLs are at or below specified limits.
- Laboratory Narrative and Data Qualifiers—Review laboratory-identified QC issues.

After validation, electronic data will be saved in final Excel spreadsheets or uploaded into the appropriate CWS data management system. CWS will retain the final laboratory report PDFs and EDDs/Excel Spreadsheets as part of the project file. Analytical data records will be retained by the laboratories and stored electronically in the CWS and GSI project files. Because data are a direct electronic output from the Laboratory Information Management System (LIMS), hard-copy data packages will not be requested or stored for this project.

8.4 Data Validation and Usability

Data validation or a data usability review will be performed by the CWS Laboratory Services Division and documented in a brief technical memorandum. CWS will coordinate with the contract laboratories during sample analysis and delivery of analytical results. CWS will determine whether the data are usable for meeting project objectives. CWS will review data packages for completeness immediately upon receipt from the laboratory to ensure that data are complete, QA/QC information requested are present, and the data meet the project targets and/or objectives for the following :

- QC analysis frequency
- Analysis holding times
- MDLs
- MRLs
- Chain-of-custody documentation and sample receipt condition
- Field duplicate results
- Surrogate recoveries
- LCS/LCSD recoveries
- LCS/LCSD RPDs
- MS/MSD recoveries
- MS/MSD RPDs

CWS will review the field notebooks, laboratory reports, and the data usability report to determine if the DQOs have been met. Instances where DQOs were not met will be documented. Data that have been rejected will be flagged as "R."

Tables

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Table 1. Summary of Stormwater Sampling and Analyses

Sampling Event	Time Series	Time (hours after start of sampling)	WS-1A	WS-1B
1	1*	0	◆	◆
	2	1	●	●
	3	2	●	●
2	1*	0	●	◆
	2	1	●	●
	3	2	●	●
3	1	0	●	●
4	1	0	●	●

Notes

* Targeted 1st flush sample

◆ Indicates sample will be analyzed by subcontracted accredited laboratories, see Section 2.5, for the *comprehensive* list of COIs presented in Table 2.

● Indicates sample will be analyzed by subcontracted accredited laboratories, see Section 2.5, for the list of *indicator* stormwater analytes identified in Table 3.

Table 2. Stormwater Analyte List - Comprehensive (Events 1 and 2 First Flush)

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	Contaminant Group	Laboratory	Analytical Method
Pathogens					
Cryptosporidium	zero	TT[3]	DW - Microorganisms	BCS	EPA 1623.1
Giardia lamblia	zero	TT[3]	DW - Microorganisms	BCS	EPA 1623.1
Heterotrophic plate count (HPC)	n/a	TT[3]	DW - Microorganisms	Alexin	SM 9215 B
Legionella	zero	TT[3]	DW - Microorganisms	BCS	SM 9260J
Total Coliforms (including fecal coliform and E. Coli)	zero	5.00%	DW - Microorganisms	Alexin	SM 9223 B
Viruses (noro- and enteric)	zero	TT[3]	DW - Microorganisms	BCS	EPA 600/EPA1615
Inorganics					
Asbestos (fiber > 10 micrometers)	7 million fibers per liter (MFL)	7 MFL	DW - Inorganics	Eurofins	EPA 100.2
Cyanide (as free cyanide)	0.2	0.2	DW - Inorganics	Eurofins	SM 4500 CN-F
Fluoride	4	4	DW - Inorganics	Eurofins	SM 4500 F-C
Nitrate (measured as Nitrogen)	10	10	DW - Inorganics	Alexin	EPA 300.0
Nitrite (measured as Nitrogen)	1	1	DW - Inorganics	Alexin	EPA 300.0
Chloride		250	DW - Secondary Stanard	Eurofins	EPA 300.0 A
Apparent Color		15 color units	DW - Secondary Stanard	Alexin	SM 2120 B
Corrosivity (Langier Method)		Non-corrosive	DW - Secondary Stanard	Eurofins	SM 2330 B
Hydrogen Ion (pH)		6.5 to 8.5 pH Units	DW - Secondary Stanard	CWS/Eurofins	SM 4500 H-B
Fluoride		2	DW - Secondary Stanard	Eurofins	SM 4500 F-C
Sulfate – Method 300.0		250	DW - Secondary Stanard	Eurofins	EPA 300.0 A
Turbidity		TT[3]	DW - Secondary Stanard	Alexin	EPA 180.1
Odor at 60 degrees		3 threshold odor number	DW - Secondary Stanard	Alexin	SM 2150 B
Total Dissolved Solids (TDS)		500	DW - Secondary Stanard	Eurofins	SM 2540 C
Total Hardness		250.00	DW - Secondary Stanard	Eurofins	SM 2340 B
Surfactants/Foaming Agents (MBAS)		0.50	DW - Secondary Stanard	Alexin	EPA 425.1
Major Cations (Ca, K, Mg, Na)	NA	NA	General chemistry	Eurofins	EPA 200.7
Major Anions (Cl, CO3 HCO3, SO4)	NA	NA	General chemistry	Eurofins	SM 2330 B
Total Phosphorus	NA	NA	CWA	Eurofins	SM 4500 P-E
Total Organic Carbon	NA	NA	General chemistry	Eurofins	SM 5310C/E415.3
Chlorate by IC	NA	NA	General chemistry	Eurofins	EPA 300.0
Alkalinity in CaCO3 units	NA	NA	General chemistry	Eurofins	SM 2320B
pH (H3 = HT not compliant)	NA	NA	General chemistry	Eurofins	SM 4500-H-B
Specific Conductance (Conductivity)	NA	NA	General chemistry	CWS	SM 2510B
Orthophosphate as P	NA	NA	General chemistry	Alexin	EPA 300.0
Orthophosphate as Phosphate	NA	NA	General chemistry	Alexin	Calculate
Bromide by 300	NA	NA	General chemistry	Eurofins	EPA 300.0 A
Dissolved Organic Carbon	NA	NA	General chemistry	Eurofins	SM 5310 C
Specific UV Absorbance, L/mg,	NA	NA	General chemistry	Alexin	SM 5910B
Suspended Sediment Concentration (SSC)	NA	NA	General chemistry/treatability	Eurofins	ASTM D3977-97B
Total Suspended Solids (TSS)	NA	NA	General chemistry/treatability	Eurofins	SM 2540 D
Grainsize (filtered stormwater solids)	NA	NA	Treatability	Eurofins	ASTM D422
Disinfectants and Disinfection Byproducts					
Total Chlorine Residual	MRDLG=5	MRDL=4.1	DW - Disinfectants	CWS	SM 4500 CL-G
Chloramines (as Cl2)	MRDLG=4	MRDL=4.0	DW - Disinfectants	NA	estimated (see footnotes)
Chlorine (as Cl2)	MRDLG=5	MRDL=4.1	DW - Disinfectants	NA	estimated (see footnotes)
Chlorine dioxide (as ClO2)	MRDLG=0.8	MRDL=0.8	DW - Disinfectants	NA	estimated (see footnotes)
Haloacetic acids (HAA5)	--	0.06	DW - Disinfection Byproducts	Eurofins	SM 6251 B
Total Trihalomethanes (TTHMs)	--	0.08	DW - Disinfection Byproducts	Eurofins	EPA 524.2
Bromate	zero	0.01	DW - Disinfection Byproducts	Eurofins	EPA 317
Chlorite	0.8	1	DW - Disinfection Byproducts	Eurofins	EPA 300.1 B/300
Emerging Urban-Use Pesticides	**(USGS, 2016; Phase 1 MS4)**				
Bifenthrin	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Carbaryl	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Chlorothalonil	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Cypermethrin or Permethrin	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Diuron	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Dithiopyr	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Fipronil	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Imidacloprid	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Malathion	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Metolachlor	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Myclobutanil	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Pendrimethalin	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Propiconazole	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	Contaminant Group	Laboratory	Analytical Method
Triclopyr	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Trifluralin	NA	NA	Emerging Pesticide (Multiresidues Pesticides Screen)	PAL	EPA 8081B, 8141B, 8270D, 8321B
Metals					
Antimony	0.006	0.006	DW - Inorganics	Eurofins	EPA 200.8
Arsenic	0	0.01	DW - Inorganics	Eurofins	EPA 200.8
Barium	2	2	DW - Inorganics	Eurofins	EPA 200.8
Beryllium	0.004	0.004	DW - Inorganics	Eurofins	EPA 200.8
Cadmium	0.005	0.005	DW - Inorganics	Eurofins	EPA 200.8
Chromium (total)	0.1	0.1	DW - Inorganics	Eurofins	EPA 200.8
Copper	1.3	TT[7]; Action Level=1.3	DW - Inorganics	Eurofins	EPA 200.8
Lead	zero	TT[7]; Action Level=0.015	DW - Inorganics	Eurofins	EPA 200.8
Mercury (inorganic)	0.002	0.002	DW - Inorganics	Eurofins	EPA 245.1
Selenium	0.05	0.05	DW - Inorganics	Eurofins	EPA 200.8
Thallium	0.0005	0.002	DW - Inorganics	Eurofins	EPA 200.8
Uranium	zero	30 ug/L	DW - Radionuclides	Eurofins	EPA 200.8
Aluminum		0.05 to 0.2	DW - Secondary Stanard	Eurofins	EPA 200.8
Beryllium		0.004	DW - Secondary Stanard	Eurofins	EPA 200.8
Copper		1.0	DW - Secondary Stanard	Eurofins	EPA 200.8
Manganese		0.05	DW - Secondary Stanard	Eurofins	EPA 200.8/EPA 200.7
Silver		0.10	DW - Secondary Stanard	Eurofins	EPA 200.8
Zinc		5.00	DW - Secondary Stanard	Eurofins	EPA 200.8
Iron		0.30	DW - Secondary Stanard	Eurofins	EPA 200.7
Organics					
Acrylamide	zero	TT [8]	DW - Organic Compounds	Eurofins	LC/MS/MS
Alachlor	zero	0.002	DW - Organic Compounds	Eurofins	EPA 505/525.2
Atrazine	0.003	0.003	DW - Organic Compounds	Eurofins	EPA 525.2
Benzene	zero	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
Polycyclic armatic hydrocarbons (PAHs) and phthalates	NA	NA	Organic compounds	Eurofins	EPA 525.2
naphthalene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
acenaphthylene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
acenaphthene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
fluorene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
phenantrene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
anthracene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
fluoranthene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
pyrene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
benz[a]anthracene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
chrysene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
benzo[b]fluoranthene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
benzo[k]fluoranthene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
benzo[a]pyrene	zero	0.0002	DW - Organic Compounds	Eurofins	EPA 525.2
dibenz[a,h]anthracene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
benzo[g,h,i]perylene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
indeno[1,2,3-cd]pyrene	NA	NA	EPA PAH list	Eurofins	EPA 525.2
Carbofuran	0.04	0.04	DW - Organic Compounds	Eurofins	EPA 531.2
Carbon tetrachloride	zero	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
Chlordane	zero	0.002	DW - Organic Compounds	Eurofins	EPA 505
Chlorobenzene	0.1	0.1	DW - Organic Compounds	Eurofins	EPA 524.2
2,4-D	0.07	0.07	DW - Organic Compounds	Eurofins	EPA 515.4
Dalapon	0.2	0.2	DW - Organic Compounds	Eurofins	EPA 515.4
1,2-Dibromo-3-chloropropane (DBCP)	zero	0.0002	DW - Organic Compounds	Eurofins	EPA 551.1
o-Dichlorobenzene	0.6	0.6	DW - Organic Compounds	Eurofins	EPA 524.2
p-Dichlorobenzene	0.075	0.075	DW - Organic Compounds	Eurofins	EPA 524.2
1,2-Dichloroethane	zero	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
1,1-Dichloroethylene	0.007	0.007	DW - Organic Compounds	Eurofins	EPA 524.2
cis-1,2-Dichloroethylene	0.07	0.07	DW - Organic Compounds	Eurofins	EPA 524.2
trans-1,2-Dichloroethylene	0.1	0.1	DW - Organic Compounds	Eurofins	EPA 524.2
Dichloromethane	zero	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
1,2-Dichloropropane	zero	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
Di(2-ethylhexyl) adipate	0.4	0.4	DW - Organic Compounds	Eurofins	EPA 525.2
Di(2-ethylhexyl) phthalate	zero	0.006	DW - Organic Compounds	Eurofins	EPA 525.2
Dicamba	NA	NA	Organic compound	Eurofins	EPA 515.4
Dinoseb	0.007	0.007	DW - Organic Compounds	Eurofins	EPA 515.4
Dioxin (2,3,7,8-TCDD)	zero	0.00000003	DW - Organic Compounds	Eurofins	EPA 1613 B
Diquat	0.02	0.02	DW - Organic Compounds	Eurofins	EPA 549.2
Endothall	0.1	0.1	DW - Organic Compounds	Eurofins	EPA 548.1
Endrin	0.002	0.002	DW - Organic Compounds	Eurofins	EPA 505
Epichlorohydrin	zero	TT8	DW - Organic Compounds	Eurofins	EPA 524.2
Ethylbenzene	0.7	0.7	DW - Organic Compounds	Eurofins	EPA 524.2
Ethylene dibromide	zero	0.00005	DW - Organic Compounds	Eurofins	EPA 551.1
Glyphosate	0.7	0.7	DW - Organic Compounds	Eurofins	EPA 547
Heptachlor	zero	0.0004	DW - Organic Compounds	Eurofins	EPA 505
Heptachlor epoxide	zero	0.0002	DW - Organic Compounds	Eurofins	EPA 505
Hexachlorobenzene	zero	0.001	DW - Organic Compounds	Eurofins	EPA 525.2
Hexachlorocyclopentadiene	0.05	0.05	DW - Organic Compounds	Eurofins	EPA 525.2

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	Contaminant Group	Laboratory	Analytical Method
Lindane	0.0002	0.0002	DW - Organic Compounds	Eurofins	EPA 505
Methoxychlor	0.04	0.04	DW - Organic Compounds	Eurofins	EPA 505
Oxamyl (Vydate)	0.2	0.2	DW - Organic Compounds	Eurofins	EPA 531.2
Polychlorinated biphenyls (PCBs)	zero	0.0005	DW - Organic Compounds	Eurofins	EPA 505
Pentachlorophenol	zero	0.001	DW - Organic Compounds	Eurofins	EPA 515.4
Picloram	0.5	0.5	DW - Organic Compounds	Eurofins	EPA 515.4
Simazine	0.004	0.004	DW - Organic Compounds	Eurofins	EPA 525.2
Styrene	0.1	0.1	DW - Organic Compounds	Eurofins	EPA 524.2
Tetrachloroethylene	zero	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
Toluene	1	1	DW - Organic Compounds	Eurofins	EPA 524.2
Toxaphene	zero	0.003	DW - Organic Compounds	Eurofins	EPA 505
2,4,5-TP (Silvex)	0.05	0.05	DW - Organic Compounds	Eurofins	EPA 515.4
1,2,4-Trichlorobenzene	0.07	0.07	DW - Organic Compounds	Eurofins	EPA 524.2
1,1,1-Trichloroethane	0.2	0.2	DW - Organic Compounds	Eurofins	EPA 524.2
1,1,2-Trichloroethane	0.003	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
Trichloroethylene	zero	0.005	DW - Organic Compounds	Eurofins	EPA 524.2
Vinyl chloride	zero	0.002	DW - Organic Compounds	Eurofins	EPA 524.2
Xylenes (total)	10	10	DW - Organic Compounds	Eurofins	EPA 524.2
DDT	NA	NA	TMDL Impairment Pollutant	Eurofins	EPA 525.2
DDT Metabolite (DDE)	NA	NA	TMDL Impairment Pollutant	Eurofins	EPA 525.2
Dieldrin	NA	NA	TMDL Impairment Pollutant	Eurofins	EPA 505/525.2
Radionuclides					
Alpha particles	zero	15 picocuries per Liter (pCi/L)	DW - Radionuclides	Eurofins	SM7110B/EPA 900.0
Beta particles and photon emitters	zero	4 millirems per year	DW - Radionuclides	Eurofins	SM7110B/EPA 900.0
Radium 226 and Radium 228 (combined)	zero	5 pCi/L	DW - Radionuclides	Eurofins	SM7500-Ra B/D

Notes

[a] **Chloramines** (i.e., bound chlorine) is the product of the chemical reaction between chlorine and an amine compound. There is no direct chemical method for measuring chloramine. The amount of chloramine is calculated by subtracting free chlorine from the total chlorine. The concentration of chloramines will be conservatively estimated using the field measured total chlorine (residual) results. The chloramines concentration will be reported as "≤ Total Chlorine."

[b] **Chlorine (as Cl2)** (i.e., free chlorine). Free chlorine refers to both hypochlorous acid (HOCl) and the hypochlorite (OCl–) ion or bleach. Free chlorine is typically measured in drinking water disinfection systems to find whether the water system contains enough disinfectant to inactivate most of the bacteria and viruses. Free chlorine residual needs to analyzed immediately and is not anticipated to be present in stormwater samples. The concentration of chlorine will be conservatively estimated using the field measured total chlorine (residual) results. The chlorine concentration will be reported as "≤ Total Chlorine."

[c] **Chlorine dioxide** is marketed for use as a disinfectant and is also the name for the neutral ClO2 molecule, while Chlorite is a –ClO2 anion of a molecule. For accurate results, chlorine dioxide needs to be analyzed immediately. Given the short holding time for chlorine dioxide, Eurofins will substitute Chlorite. However, for the purposes of this study the concentration of chlorine dioxide will be conservatively estimated by using the field measured total chlorine (residual) results and the concentration will be reported as "≤ Total Chlorine".

Table 3. Stormwater Analyte List - Time-Series and Events 3 and 4

Analytes	MCLG (mg/L)	MCL, TT or SMCL (mg/L)	Contaminant Group	Laboratory	QA[a]	Analytical Method
Inorganics						
Total Coliforms and E. Coli	zero	5.00%	DW - Microorganisms	Alexin	x	SM 9223 B
Nitrate (measured as Nitrogen)	10	10	DW - Inorganics	Alexin	x	EPA 300.0
Nitrite (measured as Nitrogen)	1	1	DW - Inorganics	Alexin	x	EPA 300.0
Hydrogen Ion (pH)		6.5 to 8.5 pH Units	DW - Secondary Stanard	CWS	x	SM 4500 H-B
Turbidity	-	TT[3]	DW - Secondary Stanard	Alexin	x	EPA 180.1
Total Dissolved Solids (TDS)	-	500	DW - Secondary Stanard	Eurofins	x	SM 2540 C
Total Organic Carbon	-	-	General chemistry	Eurofins	x	SM 5310 C/E415.3
Specific Conductance (conductivity)	-	-	General chemistry	CWS	x	SM 2510B
Suspended Sediment Concentration (SSC)	-	-	General chemistry/treatability	Eurofins		ASTM D3977-97B
Total Suspended Solids (TSS)	-	-	General chemistry/treatability	Eurofins		SM 2540 D
Grainsize (filtered stormwater solids)	-	-	Treatability	Eurofins		ASTM D422
Metals						
Antimony	0.006	0.006	DW - Inorganics	Eurofins	x	EPA 200.8
Arsenic	0	0.01	DW - Inorganics	Eurofins	x	EPA 200.8
Cadmium	0.005	0.005	DW - Inorganics	Eurofins	x	EPA 200.8
Chromium (total)	0.1	0.1	DW - Inorganics	Eurofins	x	EPA 200.8
Copper	1.3	TT[7]; Action Level=1.3	DW - Inorganics	Eurofins	x	EPA 200.8
Lead	zero	TT[7]; Action Level=0.015	DW - Inorganics	Eurofins	x	EPA 200.8
Mercury (inorganic)	0.002	0.002	DW - Inorganics	Eurofins	x	EPA 245.1
Copper		1.0	DW - Secondary Stanard	Eurofins	x	EPA 200.8
Zinc		5.00	DW - Secondary Stanard	Eurofins	x	EPA 200.8
Organics						
Benzene	zero	0.005	DW - Organic Compounds	Eurofins	x	EPA 524.2
Benzo(a)pyrene (PAHs)	zero	0.0002	DW - Organic Compounds	Eurofins	x	EPA 525.2
Polycyclic armatic hydrocarbons (PAHs) and phthalates	NA	NA	Organic compounds	Eurofins	x	EPA 525.2
Ethylbenzene	0.7	0.7	DW - Organic Compounds	Eurofins	x	EPA 524.2
Pentachlorophenol	zero	0.001	DW - Organic Compounds	Eurofins	x	EPA 515.4
Toluene	1	1	DW - Organic Compounds	Eurofins	x	EPA 524.2
Xylenes (total)	10	10	DW - Organic Compounds	Eurofins	x	EPA 524.2

Note

[a] Duplicate and rinsate samples will be collected and analyzed for quality assurance (QA) for these parameters.

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Figures

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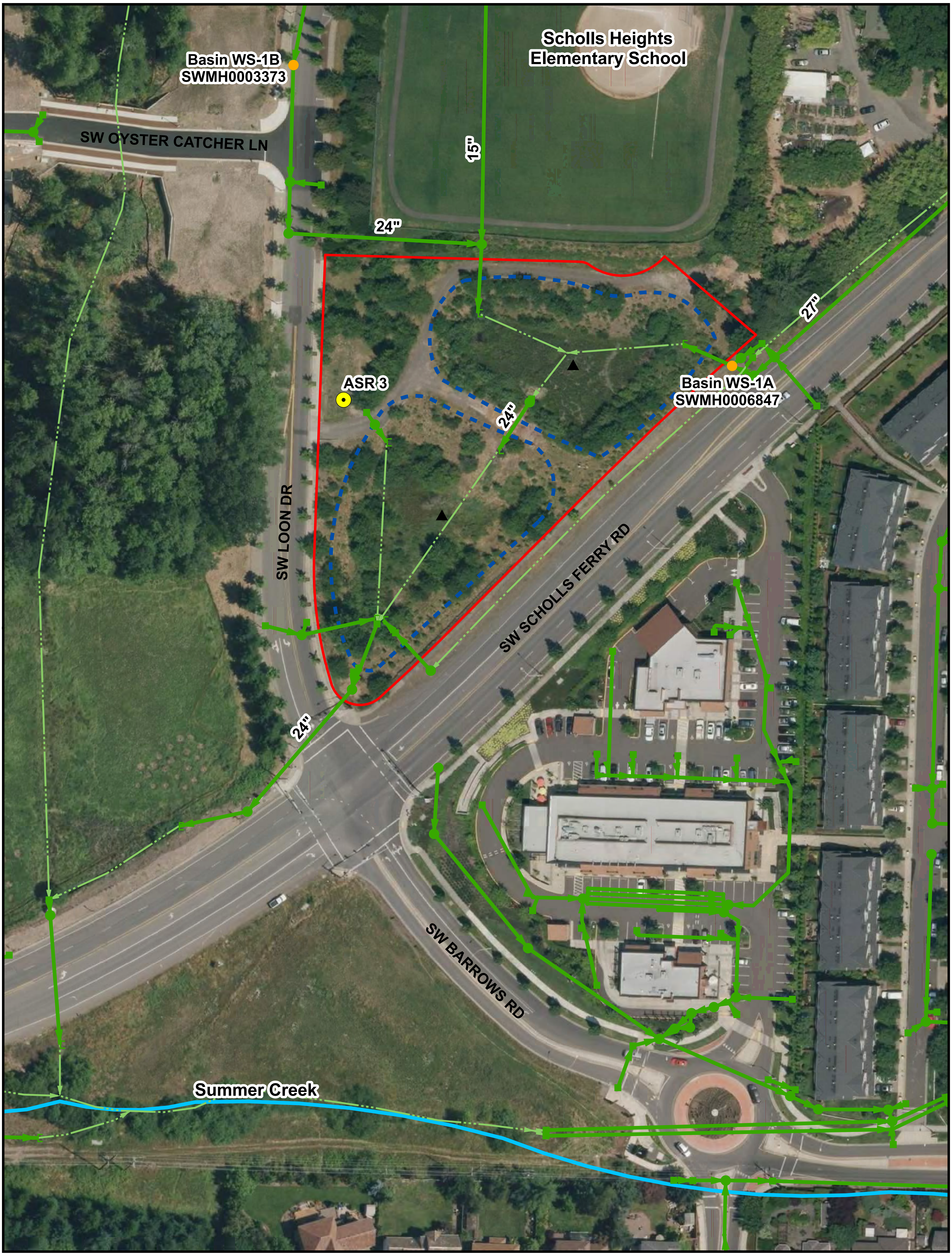

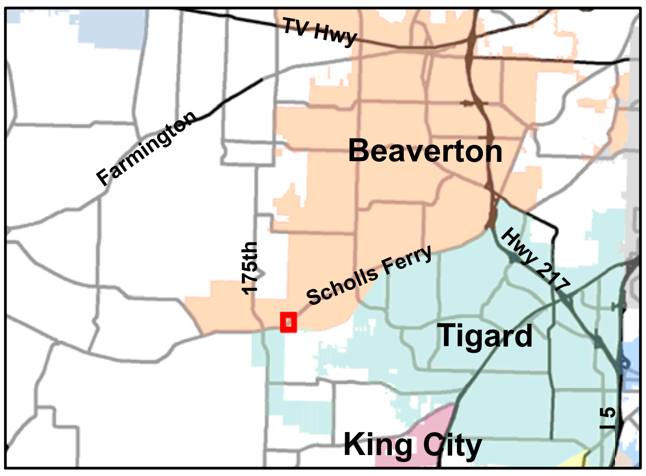

LEGEND

- ASR Well
- Sampling Locations
- Storm Manholes
- Storm Inlets
- Storm Open Conveyance
- Storm Closed Conveyance
- Site
- Stormwater Facilities

0 50 100 200 Feet

FIGURE 1

ASR 3/Sterling Park Stormwater Reuse Site Map

Oregon Water Resources Department Water Conservation, Reuse, and Storage Feasibility Study Grant Program

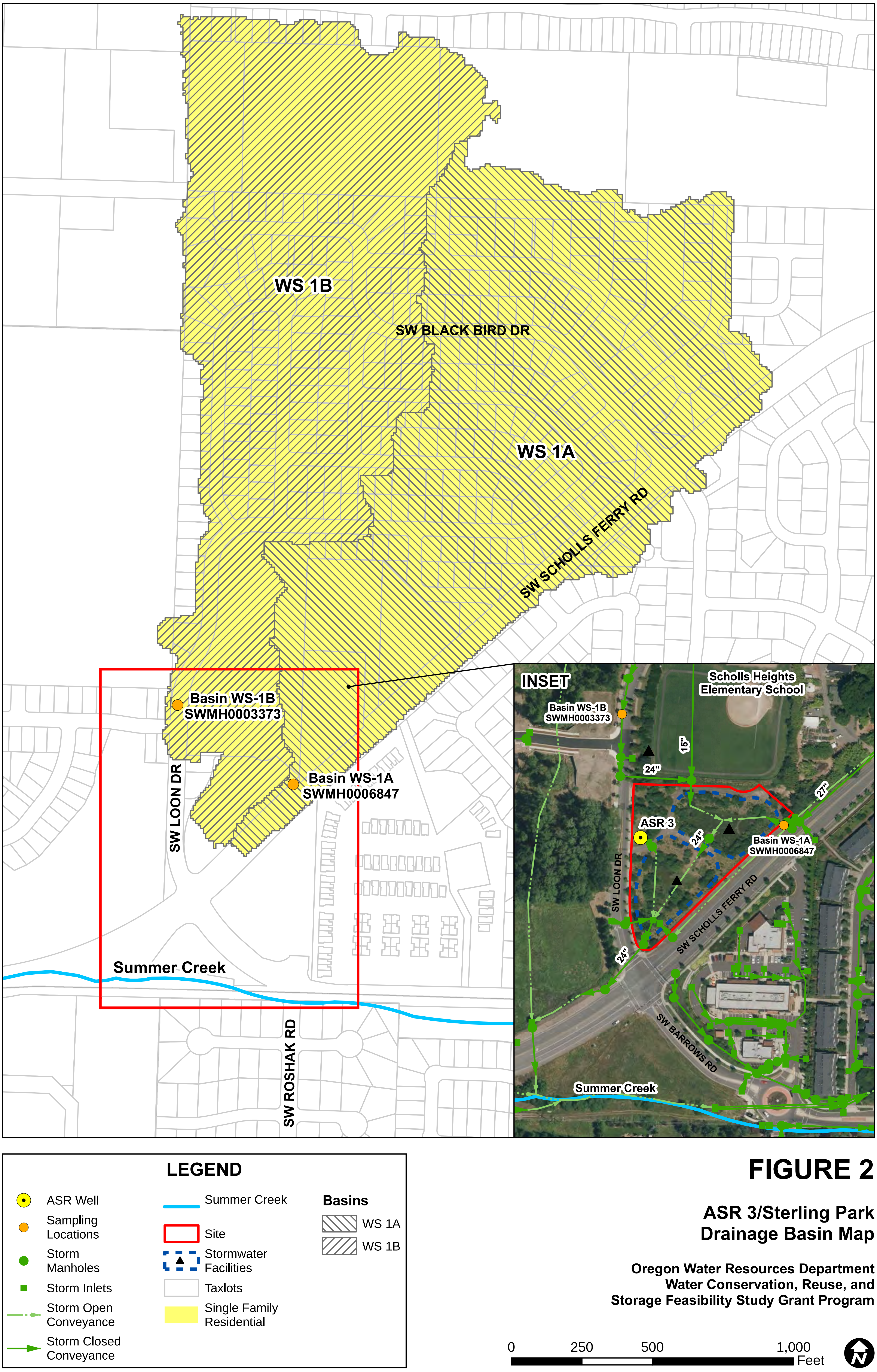

FIGURE 2

ASR 3/Sterling Park Drainage Basin Map

Oregon Water Resources Department
Water Conservation, Reuse, and Storage Feasibility Study Grant Program

Appendix A

Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times

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Appendix A: Alexin Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times

Analysis	Method	MRL	Sample container	Preservative	Holding Time
Heterotrophic plate count (HPC)	SM 9215B	1	IDEXX	Cool, 4 °C	24 hours
Total coliform	SM 9223B	1	IDEXX	Cool, 4 °C	30 hours
E. coli	P/A	1	IDEXX	Cool, 4 °C	30 hours
Fecal coliform	SM 9223B	1	IDEXX	Cool, 4 °C	8 hours
Nitrate (measured as Nitrogen)	EPA 300.0	0.1 mg/L	P, 500 mL	Cool, 4 °C	48 hours.
Nitrite (measured as Nitrogen)	EPA 300.0	0.01 mg/L	P, 500 mL	Cool, 4 °C	48 hours.
Apparent color	SM 2120B	5 CU	P, 500 mL	Cool, 4 °C	48 hours.
Odor at 60 degrees	SM 2150B	1 TON	A Glass, 500 mL	Cool, 4 °C	24 hours
Orthophosphate as P	EPA 300.0	0.1 mg/L	P, 500 mL	Cool, 4 °C	48 hours.
Orthophosphate as Phosphate	Calculate		P, 500 mL	Cool, 4 °C	48 hours.
Surfactants (MBAs)	EPA 425.1	0.05 mg/L	P, 500 mL	Cool, 4 °C	48 hours.
Turbidity	EPA 180.1	0.1 NTU	P, 500 mL	Cool, 4 °C	48 hours.
UV 254	SM 5910B	0.005 1/cm Ab	A Glass, 125 mL	Cool, 4 °C	48 hours

Appendix A: Pacific Agricultural Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times

Analysis	Analytical Method	Method Reporting Limit (MRL)	Sample Container	Preservative	Holding Time
Bifenthrin	**Multi-residue Pesticides Profile** Halogenated Pesticides (EPA 8081B - GC-EID) Organophosphorous Pesticides (EPA 8141B - GC-FPD) Organonitrogen Pesticides (EPA 8270D -GC-MS/MS Misc. Pesticides (EPA 8321B- HPLC-MS/MS)	0.12 ug/L	1 liter amber glass	no preservative	7 days
Carbaryl		0.06 ug/L			
Chlorothalonil		0.12 ug/L			
Cypermethrin or Permethrin		0.30 g/L			
Diuron		0.06 ug/L			
Dithiopyr		0.12 ug/L			
Fipronil		0.12 ug/L			
Imidacloprid		0.06 ug/L			
Malathion		0.30 ug/L			
Metolachlor		0.12 ug/L			
Myclobutanil		0.12 ug/L			
Pendrimethalin		0.06 ug/L			
Propiconazole		0.30 ug/L			
Trifluralin		0.12 ug/L			
Triclopyr	EPA 8151A (GC-MS/MS)	0.12 ug/L	1 liter amber glass	no preservative	7 days

Appendix A: Eurofins Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times (Sorted by Method)

Analyte	Method	Sample Container	Preservative	Holding Time	MRL	MDL
Grainsize	ASTM D422	2 - 8oz jars	no preservative			
Total Dissolved Solid (TDS)	E160.1/SM2540C	500ml poly	TDS - no preservative	7 DAY	10	4.224
Asbestos by TEM - >10 microns	EPA 100.2	1L poly sonicated	no preservative	48 HOUR	0.2	0.2
2,3,7,8-TCDD	EPA 1613B	1L amber glass	D1613_1ML_8% THIOSULFATE	40 DAY	5	2.1
C12-2,3,7,8-TCDD	EPA 1613B	1L amber glass	D1613_1ML_8% THIOSULFATE	40 DAY	137	31
Calcium Total ICAP	EPA 200.7	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.118
Iron Total ICAP	EPA 200.7	500ml acid poly	2ml HNO3 (18%)	180 DAY	0.02	0.00262
Magnesium Total ICAP	EPA 200.7	500ml acid poly	2ml HNO3 (18%)	180 DAY	0.1	0.003
Potassium Total ICAP	EPA 200.7	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.13
Sodium Total ICAP	EPA 200.7	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.113
Aluminum Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	20	0.782
Antimony Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.159
Arsenic Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.06
Barium Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	2	0.171
Beryllium Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.054
Cadmium Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	0.5	0.012
Chromium Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.088
Copper Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	2	0.197
Lead Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	0.5	0.038
Manganese Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	2	0.056
Selenium Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	5	0.153
Silver Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	0.5	0.014
Thallium Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.02
Uranium ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	1	0.05698
Zinc Total ICAP/MS	EPA 200.8	500ml acid poly	2ml HNO3 (18%)	180 DAY	20	1.235
Mercury	EPA 245.1	250ml acid rinsed	no preservative	28 DAY	0.2	0.0424
Chloride	EPA 300.0	125ml poly	no preservative	28 DAY	1	0.025
Sulfate	EPA 300.0	125ml poly	no preservative	28 DAY	0.5	0.06
Bromide	EPA 300.0	60mL poly	0.6mL 1% EDA solution	28 DAY	5	2.25
Chlorate by IC	EPA 300.0	60mL poly	0.6mL 1% EDA solution	28 DAY	10	1.32
Chlorite	EPA 300.1B/300	60mL poly	0.6mL 1% EDA solution	29 DAY	10	1.32
Bromate by UV/VIS	EPA 317	60mL poly	0.6mL 1% EDA solution	28 DAY	1	0.196
Alachlor (Alanex)	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.041
Aldrin	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.01	0.002
Chlordane	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.032
Dieldrin	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.01	0.005
Endrin	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.01	0.005
Heptachlor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.01	0.003
Heptachlor Epoxide	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.01	0.005
Lindane (gamma-BHC)	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.01	0.007
Methoxychlor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.05	0.022

Appendix A: Eurofins Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times (Sorted by Method)

Analyte	Method	Sample Container	Preservative	Holding Time	MRL	MDL
PCB 1016 Aroclor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.08	0.022
PCB 1221 Aroclor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.079
PCB 1232 Aroclor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.085
PCB 1242 Aroclor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.072
PCB 1248 Aroclor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.023
PCB 1254 Aroclor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.035
PCB 1260 Aroclor	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.033
Tetrachlorometaxylene	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	130	70
Total PCBs	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.1	0.1
Toxaphene	EPA 505	40ml amber glass vial	1drop thio (8%)	8 DAY	0.5	0.083
2,4,5-T	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.2	0.03
2,4,5-TP (Silvex)	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.2	0.022
2,4-D	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.1	0.028
2,4-DB	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	2	0.524
2,4-Dichlorophenyl acetic acid	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	130	70
3,5-Dichlorobenzoic acid	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.5	0.069
4,4-Dibromooctafluorobiphenyl	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	150	50
Acifluorfen	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.2	0.035
Bentazon	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.5	0.063
Dalapon	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	1	0.122
Dicamba	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.1	0.017
Dichlorprop	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.5	0.056
Dinoseb	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.2	0.024
Pentachlorophenol	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.04	0.005
Picloram	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.1	0.015
Tot DCPA Mono&Diacid Degradate	EPA 515.4	60ml amber glass	3 mg NaSulfite	14 DAY	0.1	0.044
Trihalomethanes	EPA 524.2					
Volatile Organics	EPA 524.2					
1,2-Dichloroethane-d4	EPA 524.2	40ml amber glass vial	EPI_no preservative	7 DAY	130	70
Epichlorohydrin	EPA 524.2	40ml amber glass vial	EPI_no preservative	7 DAY	0.4	0.126
Toluene-d8	EPA 524.2	40ml amber glass vial	EPI_no preservative	7 DAY	130	70
1,1,1,2-Tetrachloroethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.149
1,1,1-Trichloroethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.079
1,1,2,2-Tetrachloroethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.101
1,1,2-Trichloroethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.075
1,1-Dichloroethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.133
1,1-Dichloroethylene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.11
1,1-Dichloropropene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.113
1,2,3-Trichlorobenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.105
1,2,3-Trichloropropane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.054
1,2,4-Trichlorobenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.07

Appendix A: Eurofins Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times (Sorted by Method)

Analyte	Method	Sample Container	Preservative	Holding Time	MRL	MDL
1,2,4-Trimethylbenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.112
1,2-Dichloroethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.119
1,2-Dichloroethane-d4	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	130	70
1,2-Dichloropropane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.071
1,3,5-Trimethylbenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.066
1,3-Dichloropropane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.101
2,2-Dichloropropane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.154
2-Butanone (MEK)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	5	1.061
4-Bromofluorobenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	130	70
4-Methyl-2-Pentanone (MIBK)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	5	0.683
Benzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.117
Bromobenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.086
Bromochloromethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.177
Bromodichloromethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.117
Bromoethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.182
Bromoform	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.142
Bromomethane (Methyl Bromide)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.118
Carbon disulfide	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.085
Carbon Tetrachloride	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.087
Chlorobenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.066
Chlorodibromomethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.062
Chloroethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.078
Chloroform (Trichloromethane)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.113
Chloromethane(Methyl Chloride)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.113
cis-1,2-Dichloroethylene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.138
cis-1,3-Dichloropropene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.108
Dibromomethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.099
Dichlorodifluoromethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.099
Dichloromethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.074
Di-isopropyl ether	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	3	0.107
Ethyl benzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.112
Hexachlorobutadiene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.085
Isopropylbenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.084
m,p-Xylenes	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.226
m-Dichlorobenzene (1,3-DCB)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.084
Methyl Tert-butyl ether (MTBE)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.074
Naphthalene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.146
n-Butylbenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.056
n-Propylbenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.088
o-Chlorotoluene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.057
o-Dichlorobenzene (1,2-DCB)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.076

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Analyte	Method	Sample Container	Preservative	Holding Time	MRL	MDL
o-Xylene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.072
p-Chlorotoluene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.122
p-Dichlorobenzene (1,4-DCB)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.092
p-Isopropyltoluene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.099
sec-Butylbenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.102
Styrene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.114
tert-amyl Methyl Ether	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	3	0.112
tert-Butyl Ethyl Ether	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	3	0.171
tert-Butylbenzene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.094
Tetrachloroethylene (PCE)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.276
Toluene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.057
Toluene-d8	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	130	70
Total 1,3-Dichloropropene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.108
Total THM	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.062
Total xylenes	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.298
trans-1,2-Dichloroethylene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.105
trans-1,3-Dichloropropene	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.135
Trichloroethylene (TCE)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.097
Trichlorofluoromethane	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.183
Trichlorotrifluoroethane(Freon)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.5	0.14
Vinyl chloride (VC)	EPA 524.2	40ml amber glass vial	4drops 6N HCL (36%)	14 DAY	0.3	0.077
1,3-Dimethyl-2-nitrobenzene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	130	70
2,4-Dinitrotoluene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.013
2,6-Dinitrotoluene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.036
4,4-DDD	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.015
4,4-DDE	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.018
4,4-DDT	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.031
Acenaphthene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.016
Acenaphthene-d10	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	150	50
Acenaphthylene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.014
Acetochlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.009
Alachlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.022
Aldrin	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.042
Alpha-BHC	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.018
alpha-Chlordane	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.029
Anthracene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.02	0.019
Atrazine	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.048
Benz(a)Anthracene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.011
Benzo(a)pyrene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.02	0.011
Benzo(b)Fluoranthene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.02	0.011
Benzo(g,h,i)Perylene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.012

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Analyte	Method	Sample Container	Preservative	Holding Time	MRL	MDL
Benzo(k)Fluoranthene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.02	0.017
Beta-BHC	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.02
Bromacil	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.2	0.029
Butachlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.033
Butylbenzylphthalate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.5	0.063
Caffeine by method 525mod	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.02
Chlorobenzilate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.019
Chloroneb	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.016
Chlorothalonil(Draconil,Bravo)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.016
Chlorpyrifos (Dursban)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.019
Chrysene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.02	0.014
Chrysene-d12	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	150	50
Delta-BHC	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.033
Di-(2-Ethylhexyl)adipate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.6	0.063
Di(2-Ethylhexyl)phthalate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.6	0.149
Diazinon (Qualitative)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.025
Dibenz(a,h)Anthracene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.033
Dichlorvos (DDVP)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.022
Dieldrin	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.2	0.017
Diethylphthalate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.5	0.051
Dimethoate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.033
Dimethylphthalate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.5	0.039
Di-n-Butylphthalate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	1	0.074
Di-N-octylphthalate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.027
Endosulfan I (Alpha)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.058
Endosulfan II (Beta)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.052
Endosulfan Sulfate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.04
Endrin	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.2	0.038
Endrin Aldehyde	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.084
EPTC	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.013
Fluoranthene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.01
Fluorene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.014
gamma-Chlordane	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.021
Heptachlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.03	0.013
Heptachlor Epoxide (isomer B)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.023
Hexachlorobenzene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.041
Hexachlorocyclopentadiene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.038
Indeno(1,2,3,c,d)Pyrene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.027
Isophorone	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.5	0.02
Lindane	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.04	0.022
Malathion	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.025

Appendix A: Eurofins Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times (Sorted by Method)

Analyte	Method	Sample Container	Preservative	Holding Time	MRL	MDL
Methoxychlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.032
Metolachlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.016
Metribuzin	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.016
Molinate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.015
Naphthalene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.3	0.014
Parathion	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.037
Pendimethalin	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.047
Pentachlorophenol	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	1	0.324
Permethrin (mixed isomers)	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.037
Perylene-d12	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	130	70
Phenanthrene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.04	0.008
Phenanthrene-d10	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	150	50
Propachlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.02
Pyrene	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.008
Simazine	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.028
Terbacil	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.069
Terbuthylazine	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.023
Thiobencarb	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.2	0.017
trans-Nonachlor	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.05	0.026
Trifluralin	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	0.1	0.044
Triphenylphosphate	EPA 525.2	1L amber glass	2ml of 6N HCl	30 DAY	130	70
3-Hydroxycarbofuran	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.143
4-Bromo-3,5-dimethylphenyl- N-methylcarbamate	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	130	70
Aldicarb (Temik)	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.16
Aldicarb sulfone	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.172
Aldicarb sulfoxide	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.142
Baygon	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.247
Carbaryl	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.16
Carbofuran (Furadan)	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.104
Methomyl	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.174
Oxamyl (Vydate)	EPA 531.2	40ml amber glass vial	0.37g KH2Citrate+6mg ThioSO4	28 DAY	0.5	0.173
Glyphosate	EPA 547	125ml amber glass	0.2ml thio (8%)	14 DAY	6	1.6
Endothall	EPA 548.1	250ml amber glass	0.25ml thio (8%)	14 DAY	5	2.653
Diquat	EPA 549.2	1L amber poly	1ml thio (8%)	21 DAY	0.4	0.344
Paraquat	EPA 549.2	1L amber poly	1ml thio (8%)	21 DAY	2	0.18
1,2-Dibromopropane	EPA 551.1	60ml amber glass vial	1g (1%NaPhos/99%KPhos+ 0.6%NH4CL /vial	14 DAY	120	80
Dibromochloropropane (DBCP)	EPA 551.1	60ml amber glass vial	1g (1%NaPhos/99%KPhos+ 0.6%NH4CL /vial	14 DAY	0.01	0.0084
Ethylene Dibromide (EDB)	EPA 551.1	60ml amber glass vial	1g (1%NaPhos/99%KPhos+ 0.6%NH4CL /vial	14 DAY	0.01	0.0057
Alpha, Gross	SM 7110B/EPA 900.0	500ml poly	2ml 18%HNO3+125ml poly/no pres	180 DAY	3	2.68
Alpha, Min Detectable Activity	SM 7110B/EPA 900.0	500ml poly	2ml 18%HNO3+125ml poly/no pres	180 DAY		2.68

Appendix A: Eurofins Laboratory Methods, Reporting Limits, Sample Containers, Preservatives and Holding Times (Sorted by Method)

Analyte	Method	Sample Container	Preservative	Holding Time	MRL	MDL
Alpha, Two Sigma Error	SM 7110B/EPA 900.0	500ml poly	2ml 18%HNO3+125ml poly/no pres	180 DAY		
Beta, Gross	SM 7110B/EPA 900.0	500ml poly	2ml 18%HNO3+125ml poly/no pres	180 DAY	3	2.66
Beta, Min Detectable Activity	SM 7110B/EPA 900.0	500ml poly	2ml 18%HNO3+125ml poly/no pres	180 DAY		2.66
Beta, Two Sigma Error	SM 7110B/EPA 900.0	500ml poly	2ml 18%HNO3+125ml poly/no pres	180 DAY		
Gross Alpha + adjusted error	SM 7110B/EPA 900.0	500ml poly	2ml 18%HNO3+125ml poly/no pres	180 DAY	3	
Acrylamide	MWH/ LCMSMS	125ml amber glass	ACRYL_no preservative	28 DAY	0.1	0.051
Acrylamide C13	MWH/ LCMSMS	125ml amber glass	ACRYL_no preservative	28 DAY	200	30
Radium 226	Ra-226 GA	1L poly	4ml HNO3 (18%)	180 DAY	1	
Radium 226 Min Detect Activity	Ra-226 GA	1L poly	4ml HNO3 (18%)	180 DAY		
Radium 226 Two Sigma Error	Ra-226 GA	1L poly	4ml HNO3 (18%)	180 DAY		
Radium 228	RA-228 GA	1L poly	4ml HNO3 (18%)	180 DAY	1	
Radium 228 Min Detect Activity	RA-228 GA	1L poly	4ml HNO3 (18%)	180 DAY		
Radium 228 Two Sigma Error	RA-228 GA	1L poly	4ml HNO3 (18%)	180 DAY		
Dissolved Organic Carbon	SM 5310C	125ml amber glass	no preservative	28 DAY	0.3	0.02
Anion Sum - Calculated	SM 1030E	N/A	N/A	NA	0.001	
Cation Sum - Calculated	SM 1030E	N/A	N/A	NA	0.001	
Alkalinity in CaCO3 units	SM 2320B	250ml poly	no preservative	14 DAY	2	0.834
Corrosivity	SM 2330B	see Langelier Index	no preservative			
Langelier Index - 25 degree	SM 2330B	N/A	no preservative	180 DAY	-14	-14
Total Hardness as CaCO3 by ICP	SM 2340B	N/A	no preservative	180 DAY	3	3
Total Suspended Solids (TSS)	SM 2540D	500ml poly	TDS - no preservative	7 DAY	10	4.441
Fluoride	SM 4500F-C	250 ml poly	FLUORIDE_no preservative	28 DAY	0.05	0.007
Haloacetic Acids	SM 6251B					
1,2,3-Trichloropropane	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	120	80
2,3-Dibromopropionic acid	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	130	70
Bromochloroacetic acid	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	1	0.053
D/DBP Haloacetic Acids (HAA5)	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	2	2
Dibromoacetic acid	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	1	0.054
Dichloroacetic acid	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	1	0.105
Monobromoacetic acid	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	1	0.055
Monochloroacetic acid	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	2	0.41
Trichloroacetic acid	SM 6251B	40ml amber glass vial	65mg NH4Cl	21 DAY	1	0.103
Bicarb.Alkalinity as HCO3calc	SM2330B	N/A	N/A	999 DAY	2	2
Carbonate as CO3 Calculated	SM2330B	N/A	N/A	180 DAY	2	2
Specific Conductance	SM2510B	250ml poly	no preservative	28 DAY	2	0.509
Cyanide	SM4500CN-F	250 ml poly	2 ml NaOH (30%)+6 scoops AA	14 DAY	0.025	0.006
Total Organic Carbon	SM5310C/E415.3	125ml amber glass	0.5ml H2SO4 (50%)	28 DAY	0.3	0.042
pH (H3= past HT not compliant)	SM4500-HB	250 ml poly	No preservative	7 Day	0.1	0.1

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Appendix B

Sampling Form

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Stormwater Observations and Sampling Sheet

Sample Location _______________________________ Date_________________

Sample Number _______________________________

Basin #___________________________________ Manhole #____________________

Sampler __________________________

Rainfall Event information (amt of rainfall/time) ___________________(source______________)

Flow Rate (approximate rate if obtained from flow meter)

Character of stormwater: turbid, slightly turbid, clear, translucent

Color:_____________________

Odor:________________________

Sheen: none, blocky, iridescent

Other observations (i.e. floating material…):____

Photo Log (include direction of shot and description of photo)

Photo 1:

Photo 2:

Photo 3:

Sample Collection

Date:________________ Time:______________

Field Parameters

Before sampling:

pH_________ Temperature ^{o}C________ Conductivity (uS/cm^{2}) _________Turbidity___________

After Sampling:

pH_________ Temperature ^{o}C ________ Conductivity (uS/cm^{2}) _________Turbidity___________

Sample Bottles: (add list of bottles or prefilled chain-of-custody)

Notes:____

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Appendix C

Microbiological Sampling Methods

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Overview of Sample Collection Process:

Stormwater samples collected for the analyses of enteroviruses, noroviruses, and the protozoa, *Cryptosporidium* and *Giardia* require larger sample volumes that must be passed through a specialized collection filter via EPA Method 1615 and Method 1623.1. Personnel from BCS Laboratory recommend the following collection volumes for the samples.

- Enteric/Norovirus Sample Volume: 100 – 300 Liters ~ 25 – 80 gallons
- Protozoa *Cryptosporidium* and *Giardia* Sample Volume: 100 Liters ~ 25 gallons

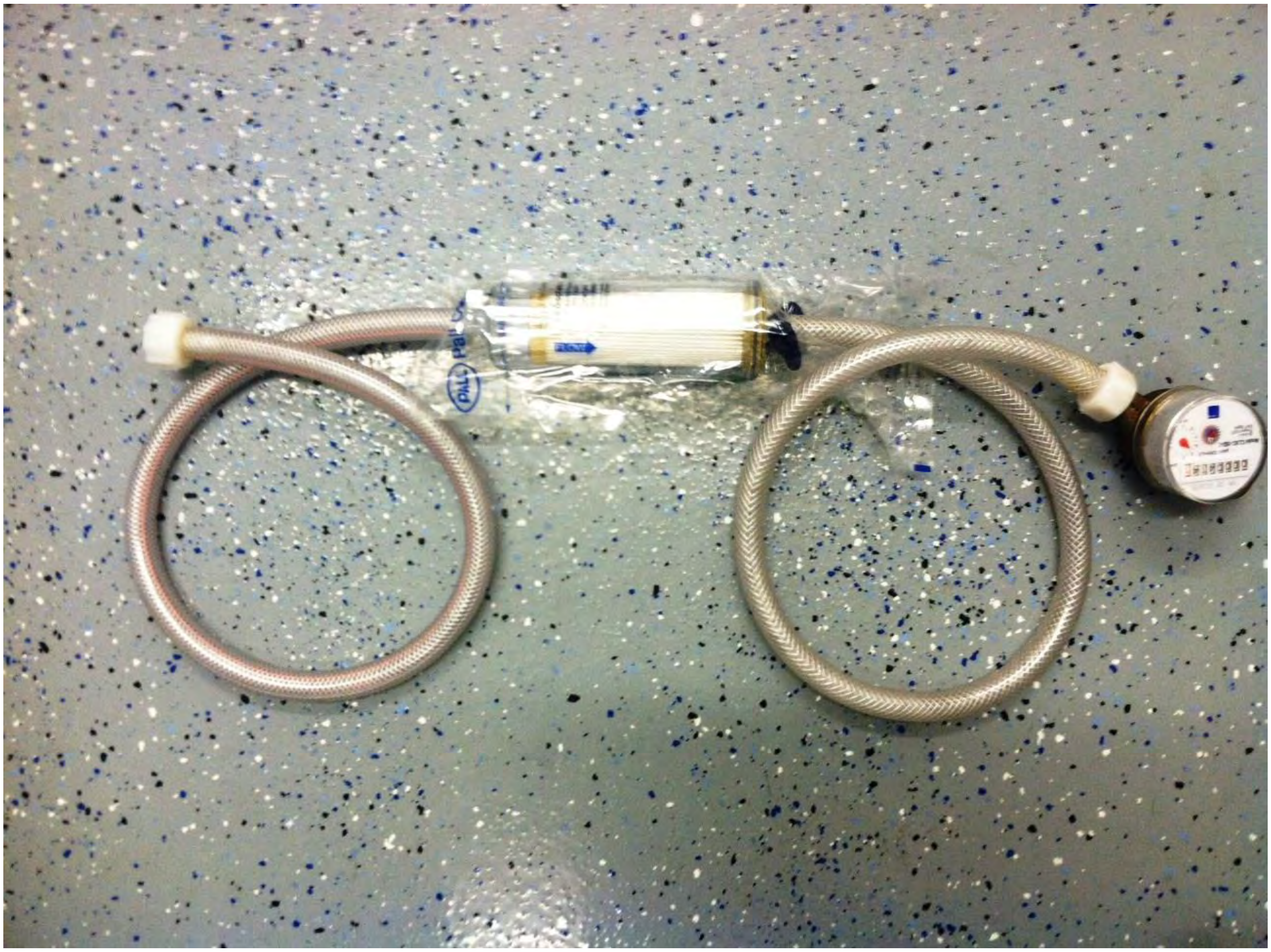
In order to collect these samples, stormwater must be pumped from each sample location manhole and slowly passed through collection filters and tubing. Simplified sampling diagrams and sample methodologies are provided by the laboratory and attached to this Appendix. For the protozoa samples, flow rates should not exceed 0.5 gallons per minute (gpm). For the virus samples, the recommended flow rate is 1 gpm and should not exceed 2 gpm. Due to the required volumes for both virus and protozoa samples, sample collection may take as long as an hour per sample. To expedite the sample collection process, it is recommended that virus and protozoa samples are collected simultaneously at each manhole. This can be accomplished by splitting the flow of stormwater pumped from the manhole with a t-fitting. Appropriate flowrates through each of the two sample collection filters can be achieved by controlling flow through globe valves or ball valves downstream of the t-fitting. A figure depicting the preferred sample collection setup is attached.

Sample tubing, pumps and valves should be thoroughly cleaned prior to collection of virus and protozoa samples to ensure that outside contamination is not introduced into collection filters. Additionally, stormwater should be pumped through the tubing connected to the t-fitting and flow control valves for several minutes prior to attaching collection filters and associated tubing provided by the laboratory in order to flush the system. Allow the source water to flow until any debris that has accumulated has cleared.

A field data sheet is attached to this Appendix to document flow volumes, flow rates, sampling times, and additional sample information.

A low flow (~ 2 -5 gpm) purge pump or sampling pump is recommended for this sampling application to attain and control ideal flow rates. Specifications for one such pump (Geosquirt™ 12V DC Purge Pump) are attached to this Appendix.

Water flow meter/totalizer shall be connected post filter. Meter Sterility cannot be guaranteed. Please note flow direction on filter. Following Filtration, do not drain water from filter. Please disconnect filter and place caps on ends while avoiding water loss. If Dechlorination is necessary, add Sodium Thiosulfate crystals to inlet side of filter capsule and seal with cap.



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Water flow direction during sampling

Flow rate shall not exceed 0.5 gallons/ minute

File: CRYPTO AND GIARDIA SIMPLIFIED SAMPLING DIAGRAM VERSION A 01 12 2010

Method EPA 1623.1
Cryptosporidium oocysts and *Giardia* Cysts Analysis

Water samples are typically field filtered through capture capsules (Envirochek HV, Pall corp., USA). The filter's 1 µM size rating captures potential parasites that may be in the water. It is imperative that pressure & flow rates are not exceeded as that may affect capture efficacy. Following the concentration of the water sample onto the filter, the filter is packaged into a cold insulated shipper & sent to the laboratory for processing. BCS Laboratories recommends passing 100 liters of sample water through the capsule filter (Envirochek HV). Alternatively under restricting circumstances, sample may be collected in 20 liter sterile sampling bladder (cubitainers or equivalent container) & shipped to the laboratory on ice for processing by filtration.

Sampling supplies include: Sterile sampling capsule, insulated shipper, Female Garden Hose (FGH) connector attached to a pre-cleaned & disinfected 0.5" ID inlet tubing, 0.5" ID outlet tubing connected to a flow totalizer, pump if needed (submersible, peristaltic, or transfer capable of 0.5 gallon/ min), freezer packs (contained ice is acceptable), sterile container (if shipping water), & sampling form.

SAMPLING

1. Field Data Sheet: Name of sampler, date/ time, source, location, turbidity/pH/water temp (if applicable), total volume, & signature.

2. Sample Volume: Typically, 10-50 liters (2.7-13 gallons) of source or surface water is collected through the supplied Envirochek® HV filter capsule. If clogging occurs, cease sampling when 50% reduction in flow rate occurs. If field filtration is not possible, 10L or more water samples may be sent to the lab (Grab Sampling). For Finished, treated water, and drinking water, 100-1,000 liters (26.5-270 gallons) are collected through the filter unit.

3. Matrix Spike (optional): A raw or finished water matrix spike sample should be analyzed when a new field sample is received from a client for which the laboratory has never analyzed samples and every 20 samples thereafter (e.g. 21, 41, etc.). When the first raw water sample from a field site is taken, a second 10 L aliquot should be sampled and sent to the laboratory for analysis. BCS Labs will spike the 10 liters and pass the volume through the filter. Note: BCS Laboratories recommends that a sampling program begin with development of a mean recovery percentage from that matrix.

4. Sample Collection: Dawn protective attire, connect inlet tubing using the FGH connector (or alternative), turn on water supply, and flush the system by allowing the source water to flow for >10 gallons or until any accumulated debris has cleared. Well samples shall be flushed until water parameters have stabilized and a representative sample of the ground water is obtained.

Grab Water Raw Sample: Fill the 10 or 20 L container (if two containers have been provided because a matrix spike sample is required, fill one container immediately after the other). BCS labs does not accept bulk water samples unless prior arrangements have been placed.

For Field Filtration: Turn off water supply. Remove filter end caps. **Save end caps in a secure place as they are needed for sealing the filter post-collection.** Connect the filter to a pressurized water source via the tubing. Alternatively, if a pressurized port is not available, a submersible pump with a variable flow valve can be used to pass the water through the filter. Connect the "outlet" end of filter to the flow meter and record initial meter (in gallons) reading. When connecting the filter system, please ensure that the water flow is in the correct direction of the arrows on the filter capsule. **Initiate water flow through the filter. Adjust to 0.5 gallons per minute maximum flow rate.** Vent the filter through the valve to remove any trapped air. *Please Note: A head pressure of 0.5 bar (7.5 psi) is required for flow.* ***The maximum pressure should not exceed 30psi.*** **http://www.pall.com/main/laboratory/literature-library-details.page?id=7353#1b**

For finished water, collect min of 26.5 gallons or 100 L sample. Collect up 1,000 for finished/drinking water. For source/ surface water collect 10-50 liters. Should the filter start to clog and flow rate drop below 50%, sample collection may be stopped, volume recorded, & noted on the Field Data Sheet. At the end of the sampling, turn off water supply, drain tubing, & record final meter reading. When detaching filter from the hoses, ensure to **attach the end caps securely to the filter**. Do not drain excess liquid from the filter. Disconnect the filter system & drain any excess water from hoses, & meter. Label filter with all parameters on the label & on the field data sheet**. Should Dechlorination be required, add sodium thiosulfate directly to filter inlet following tube disconnection and cap ends.**

If collecting additional sample, flush the system (after removing the filter) for a >10 minutes at high flow (pass >20 gallons to flush system). Attach a new filter. Repeat the above process.

5. Sample preservation, hold time, & shipping: following sample collection, **replace filter capsule caps**, and place in a storage cooler with ice/ice packs or in a refrigerator to chill prior to shipping. Store the 10 or 20 L water container or filter at 0° C to 10° C between collection & shipment to the laboratory. Do not freeze. Ship sample to arrive within 72 hours of completion of sampling. Maximum holding time between initiation of sampling/filtration & elution is 96 hours. **Sample must arrive below 20°C.**

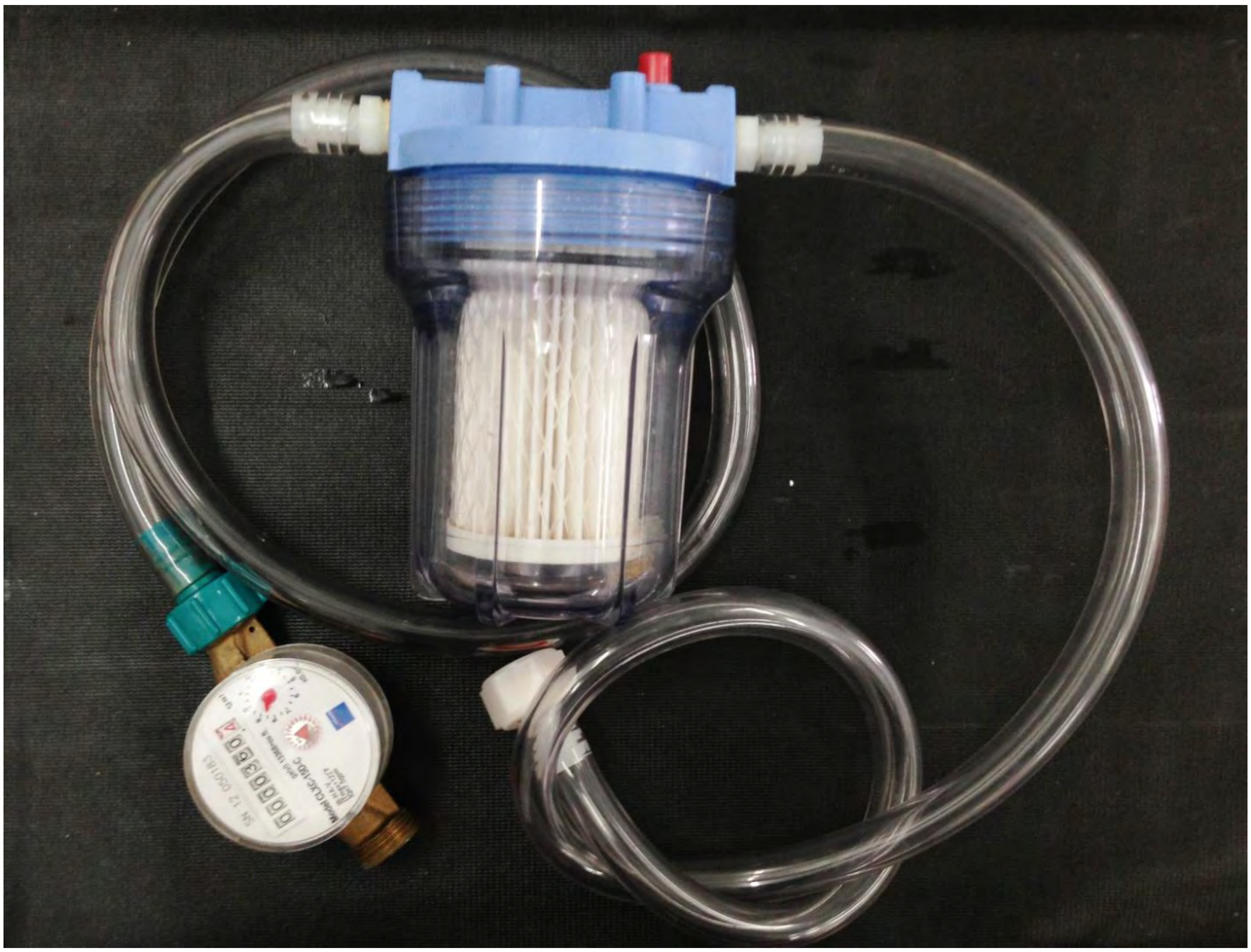
Please note the EPA has made the following statement regarding the shipping of the samples to a laboratory:

U.S. Department of Transportation (DOT) regulations (49 CFR172) prohibit interstate shipment of more than 4 L of solution known to contain infectious materials. State regulations may contain similar regulations for intrastate commerce. This method requires a minimum sample volume of 10 L. Unless the sample is known or suspected to contain Cryptosporidium or other infectious agents (e.g., during an outbreak), samples should be shipped as non-infectious and should not be marked as infectious. If a sample is known or suspected to be infectious, and the sample must be shipped to a laboratory by a transportation means affected by DOT or state regulations, it is recommended that the sample be filtered in the field, and that the filter be shipped to the laboratory to avoid violating transport regulations.

BCS Laboratories, Inc.
4609 NW 6th street, Building A Gainesville, FL 32609
Gainesville, FL 32609
E-Mail: lukasik@gator.net
www.microbioservices.com
Tel. (352) 377-9272; Fax. (352)-377-5630

Water flow meter/totalizer shall be connected post filter. Meter Sterility cannot be guaranteed. Please note flow direction on filter housing (IN and OUT). Following Filtration, do not drain water from filter. Disconnect filter and place caps on ends while avoiding water loss. If sampling chlorinated waters, use injector containing sodium thiosulfate to ensure chlorine residual neutralization. Following filtration, add Sodium Thiosulfate crystals to inlet side of filter housing and seal with cap.

Effluents containing low chlorine residuals (<0.5ppm) may be dechlorinated following sample collection by addition of thiosulfate to filter housing)



Recommended Flow Rate 1.0 gallon/minute

Flow rate shall not exceed 2.0 gallons/ minute

File: VIRUS SIMPLIFIED SAMPLING DIAGRAM VERSION A 01 12 2010

EPA 600/R-95/178 Enteric Virus Analysis

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Enteric viruses are a group of pathogens that include over 100 viral species that are shed with human feces. The health implications of these agents in humans include paralyzing polio, hepatitis, encephalitis, mild or sever gastroenteritis, myocarditis, and innocuous infections. Viruses are extremely small particles ranging from 20-85 nanometers in diameter. In comparison, a bacterial cell averages 1,000 nanometers in diameter. Each virus contains nucleic acid, either RNA or DNA, and is enclosed by a protein coat called a capsid. Viruses only replicate in a living host cell. Viruses are very specific as to what host cells they infect. Enteric viruses are typically ingested and transmitted along the fecal oral route. They have a very small infectious dose and high morbidity. Once ingested, they attach specifically to cells in the host and cause infection. Once attached, they enter the cell and take over the cell's machinery to produce more virus particles and ultimately cause cell death or cytopathy. In the case of enteric viruses, these particles are released along with the person's feces.

Enteric viruses are true human pathogens unlike coliform or fecal coliform bacteria that are considered an indicator. Compared to bacteria, many viruses are more resistant to commonly employed water and wastewater disinfection.

The process of the recovery of enteric viruses from environmental samples is tedious, labor intensive, and often lacks the sensitivity. Therefore, large volumes of water are sampled. In surface and treated wastewater, culturable virus concentrations are typically low and less than 10 per liter. The number of viruses may in actuality be greater, but based upon the virus assay methods presently available, these are the orders of magnitude observed. Due to the low numbers and restrictions in assay procedure, virus concentration must be first conducted. Large sample volumes, as much as 1,500 Liters, are passed through specialized filters that allow the adsorption of viruses to the filter medium. The filter has an electropositive net charge and adsorbs the viruses from the water. The sample water is passed at a rate of approximately 1-2 gallons per minute. In the Laboratory, adsorbed viruses are then eluted from the collection filter and further concentrated into a small volume. The concentrate is assayed for the presence of culturable infectious viruses. The virus assay is performed inoculating the concentrate onto monolayers of mammalian tissue culture cells, the most common of which is a Buffalo Green Monkey Kidney (GBMK) cell line. If viruses are present, they will infect, multiply, and destroy the host cells (cytopathic effect (CPE)) usually within 28 days of incubation. Volumes of the sample concentrate are inoculated into separate flasks and the condition and cell monolayer sheet is observed by microscopy. A most probable number (MPN) method is then employed to estimate virus concentration in the original. This statistical method calculates concentration based on the number of flasks demonstrating CPE and the volumes inoculated into the flasks.

1. Sample: Min. volume 135 gallons; 500-1500 Liters recommended unless filter clogging occurs. Sample pH must be 6-8, have low salinity, and undetectable chlorine residual. Please contact lab with any questions.

2. Data Sheet: Name of Sampler; Source; Location; chlorine residual; Date; Collection Time; pH; Water Temp (C); Total Volume; Assay Requested; and Signature.

3. Collection: Use protective wear. Turn on the tap/pump to flush the system. Allow source water to flow until any debris that has accumulated has cleared and water physical parameters have equilibrated. The supplied, filter, housing, and tubing have already been decontaminated. Place supplied electropositive filter into provided housing. Label filter with site ID, initials, and date.

Connect the filtration set up to a pressurized unchlorinated water source via the provided tubing and connector. Alternatively, if a pressurized port with connections is not available a submersible pump with a variable flow valve can be used to pass the water through the filter. Connect other end of filter to the water flow meter and record initial meter (in Gallons) reading. Ensure that the filter is connected as per the correct orientation as the labels on filter cartridge. Turn on water slowly and **filter water at 1.0 gallons per minute (approximately 4.0 liters/minute).** *A head pressure of 0.5 bar (7.5 psi) is required for flow through the filter. The recommended pressure of 5 bar (75 psi) produces a flow rate of 1.0 gallon per minute per minute.* If sampling Chlorinated Effluent a dechlorination step is necessary prior to filtration. Dechlorination is achieved by injecting sodium thiosulfate solution into the water prior to filtration. The filter effluent must be monitored for chlorine residual throughout the sampling to ensure dechlorination. If chlorine residual be detected, immediately adjust parameters to neutralize disinfectant. Collect 135 gallons (500 L) or more. Turn off water supply and record final meter reading. Detach filter and drain water from filter housing prior to placing into sterile sealable bag.

If collecting additional samples using the sample apparatus flush the system (after removing the filter for a minimum of ten minutes at high flow. Then insert a new filter (ensure the direction of the arrow on the filter is the same as the flow direction in the set-up) and repeat the above process.

Place filters in storage cooler with ice brix or in a refrigerator to chill prior to shipping. Do not allow to freeze. Ship samples to arrive within 72 hours of completion of sampling. Maximum holding time between sample collection initiation and processing of the filter by the laboratory is 72 hours. **Sample must arrive at 4°C ± 2°C. Do not freeze.** Please note the EPA has made the following statement regarding shipping of the samples to a laboratory:

U.S. Department of Transportation (DOT) regulations (49 CFR172) prohibit interstate shipment of more than 4 L of solution known to contain infectious materials. State regulations may contain similar regulations for intrastate commerce. This method requires a minimum sample volume of 10 L. Unless the sample is known or suspected to contain Cryptosporidium or other infectious agents (e.g., during an outbreak), samples should be shipped as noninfectious and should not be marked as infectious. If a sample is known or suspected to be infectious, and the sample must be shipped to a laboratory by a transportation means affected by DOT or state regulations, it is recommended that the sample be filtered in the field, and that the filter be shipped to the laboratory to avoid violating transport regulations.

Biological Consulting Services

of North Florida, Inc.

File:Field Data Sheet Version B 04 21 2016

Client: Project Facility:	Sample Site/Number: Sample Collection Date:

Analysis Requested: < enteric viruses EPA 600/r-95/178> <Enteric viruses in saline water SM9510B> <Crypto and Giardia EPA1623> <Helminth Ova> <Amoeba: N. Fowleri> other: >

Purge Time (for wells):_____________________

Water pH (for viruses; obtain 3 readings 10-15 minutes apart):__________________

Turbidity (for LT-2 Crypto):_________ Dechlorinated:__________

Dechlorination method: _______________ Post Chlorine residual:________

Chlorine residual Measurment_______________________________________

Volume Collected (gallons/liters):	
Meter Start Reading:	Meter End Reading:

Sampling Time (minutes)	
Start:	End:

Sampling Conditions:

Estimated volume or weight of sample collected (only for solids):

Rush processing: yes / no (surcharges apply for rush processing)

Collected By:	Method of Transportation:	Complete if no COC is submitted along with sample Received By: Time: Date: Temp:

BCS Laboratories, Inc. – Gainesville

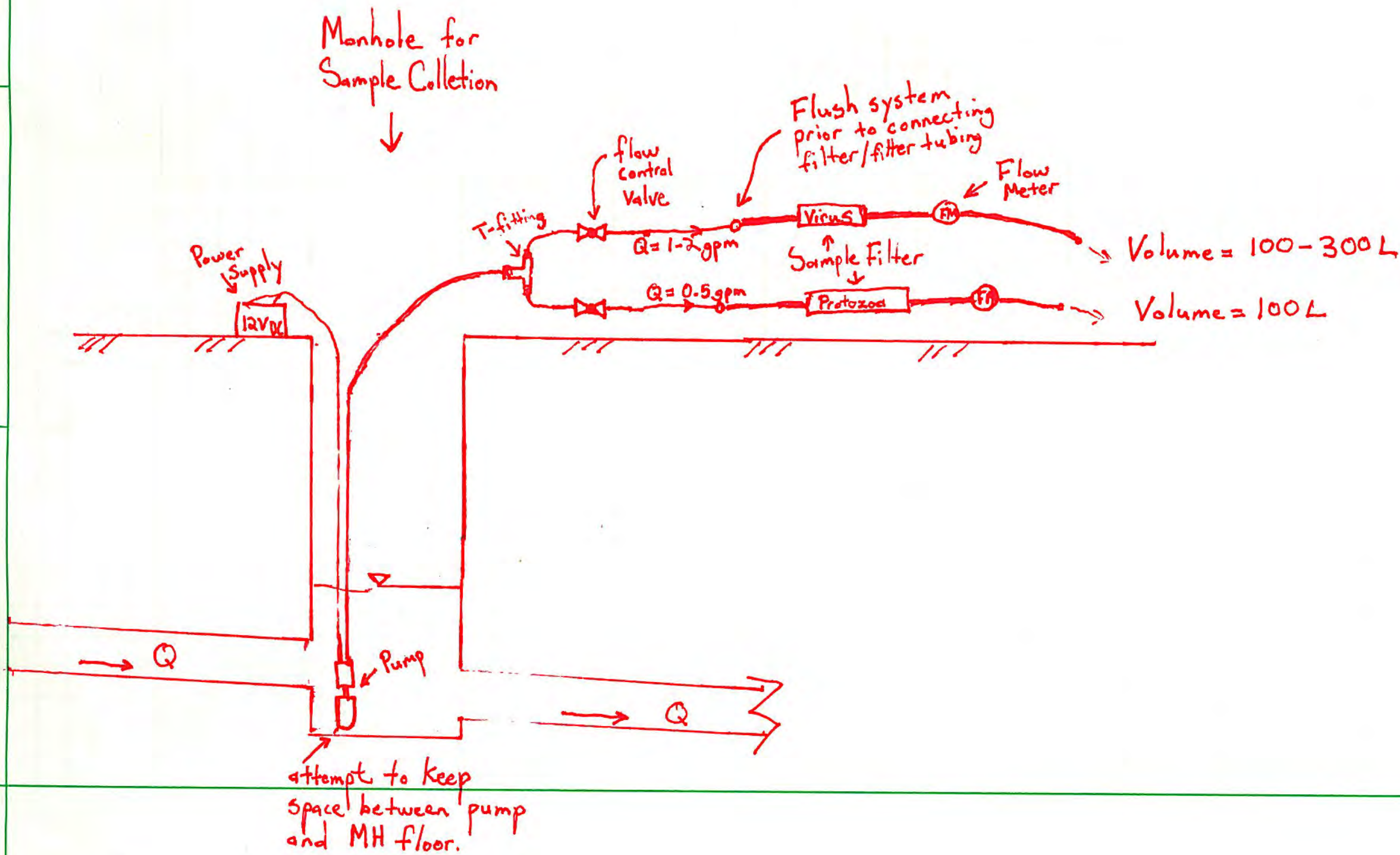
4609 NW 6th Street, Building A, Gainesville, Florida 32609,

Tel. (352) 377-9272, Fax. (352) 377-5630

www.microbioservices.com

FL DOH Laboratory #E82924, EPA# FL01147

Setup for Virus & Protozoa Sampling



GO TO GEOTECH

geotech

Purge Pumps

geosquirt™ 12V DC Purge Pump

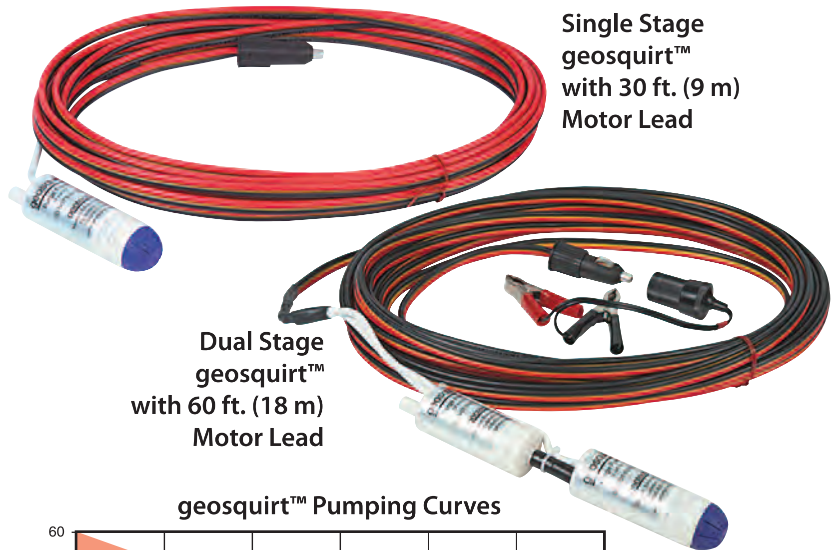
The geosquirt™ Purge Pump is designed for purging shallow wells up to a maximum depth of 55 feet (17 m). The pump is completely sealed and designed to be operated while completely submerged in water.

FEATURES

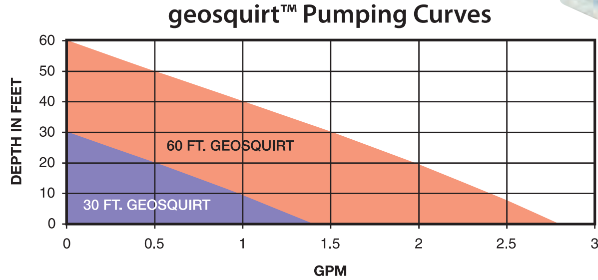
- **Operates to depths of 55' (17 m)**
- **Very economical and reliable**
- **Flow rates up to 2.75 GPM (11 LPM)**
- **Ideal for 2" (5 cm) diameter or larger monitoring well**
- **Operates with 3.5 amps (Single), 7.0 amps (Dual)**
- **Requires an independent 12V DC power supply**
- **Optional portable reel system with tubing**

OPERATION

The geosquirt™ purge pump can be purchased alone or as a complete system with reel and tubing. It is used to pump large quantities from shallow wells. Pump should be allowed to cool for 5 minutes for every 15 minutes of operation. It can operate in water temperatures as high as 140°F (60°C), but must be submerged at all times.



geosquirt™ Pumping Curves



SPECIFICATIONS

	Single Stage	Double Stage
Dimensions	1.5" D x 6.5" L (4 cm D x 17 cm L)	1.5" D x 13" L (4 cm D x 33 cm L)
Outlet	Requires 3/8" (10 mm) I.D. tubing	Requires 3/8" (10 mm) I.D. tubing
Optional Outlet Adapter	Optional fitting allows 1/2" (13 mm) tubing	Optional fitting allows 1/2" (13 mm) tubing
Power	Requires an independent 12V DC source	Requires an independent 12V DC source
Current Draw	3.5 amps	7.0 amps
Principle of Operation	Intermittently rated centrifugal pump	Intermittently rated centrifugal pump
Operating Temperature	In water up to 140°F (60°C) do not freeze pump	In water up to 140°F (60°C) do not freeze pump
Flow Rate	Up to 1.5 GPM (6 LPM)	Up to 2.75 GPM (11 LPM)
Maximum Recommended Depth	30 feet (9 m)	55 feet (17 m)
Material of Casing	ABS plastic	ABS plastic
Material of Pump Impeller	Stainless steel	Stainless steel
Material of Seal	Rubber	Rubber
Length of Motor Lead	30 feet (9 m)	60 feet (18 m)
Recommended Duty Cycle	5 min. off/15 min. on	5 min. off/15 min. on

CALL GEOTECH TODAY (800) 833-7958

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2650 East 40th Avenue • Denver, Colorado 80205
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Appendix B

Stormwater Flow Data

(electronic format on CD)

Appendix C

Stormwater Quality Laboratory Reports

(electronic format on CD)

Appendix D

Five-Year Net Present Value Cost Estimate

Present Value Analysis for Implementation of Treatment Pilot Plan and

Year	Pilot Study	Full Scale Implementation	Operation and Maintenance Costs	Total Annual Expenditure	Discount Factor[1]	Present Value
1	$225,000	$0	$0	$225,000	0.98522	$221,675
2	$0	$710,000	$0	$710,000	0.97066	$689,170
3	$0	$0	$85,000	$85,000	0.95632	$81,287
4	$0	$0	$75,000	$75,000	0.94218	$70,664
5	$0	$0	$75,000	$75,000	0.92826	$69,620
Totals	$225,000	$710,000	$235,000	$1,170,000		$1,132,415
					Total Present Value of Pilot and Full-Scale Treatment System over 5 year Period	**$1,133,000**

[1] **Discount Factor Table - Real Treasury Interest Rates**

Source	Discount Rate %	Associated PVA Cost
Office of Management and Budget 2017	**0.70%**	**$1,153,000**
Office of Management and Budget 2016	**1.50%**	**$1,133,000**
Office of Management and Budget 2011 - Used by Duwamish	**2.30%**	**$1,114,000**
June 2016 Portland Harbor FS	**7%**	**$1,011,000**
Discount Rate for PVA	**1.50%**	**$1,133,000**

Reference: https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/a94/dischist-2017.pdf

Pilot Test (year 1)

Cost Component	QTY	Units	Unit Cost		Line Item Cost	Overhead	Profit	Bur Line Item Cost	Assumptions
StormwaterRX 10gpm Pilot System	1	LS	$20,000.00	/unit	$20,000	0%	5%	$21,000	Estimate from contractor including 15K for equipment and 5k for labor with 5% markup
Analytical Testing for Influent/Effluent	1	LS	$18,000.00	/sample set	$18,000	0%	5%	$19,000	Assumes 2 full suite samples (influent/effluent) at $6,000/each and 4 partial suite samples at $1,000 each
Treatment Pilot Testing SAP	1	LS	$13,000.00	/report	$13,000	0%	0%	$13,000	Based on previous SAP development LOE
Sample Collection	2	Events	$7,500.00	/event	$15,000	0%	0%	$15,000	Sample Collection labor plus 1 full suite/1 time series sampling event.
Sample Analysis and Report Documentation	80	hr	$150.00	/hr	$12,000	0%	0%	$12,000	Assumes 80 hrs at $150/hr
Recharge Pilot Testing	1	LS	$20,000.00	/implementation	$20,000	0%	5%	$21,000	Includes assistance with temporary conveyance from treatment to wellhead and downhole piping with pump system to collect water samples following storage.
Recharge Pilot Testing Samples	1	LS	$26,000.00	/sample set	$26,000	0%	0%	$26,000	includes 3 full suite samples at $6K/each, 6 partial suite samples at $1K/each, and 2 microbio samples at $1k/each
Sample Collection following Recharge	3	Events	$7,500.00	/event	$22,500	0%	0%	$23,000	Includes 3 events (pre-recharge, recharge, recovery)
Sample Analysis and Report Documentation following Recharge	130	hr	$150.00	/hr	$19,500	0%	0%	$20,000	Assumes 130 hrs at $150/hr
Regulatory Assessment	125	hr	$160.00	/hr	$20,000	0%	0%	$20,000	Assumes 125 hrs at $160/hr. Includes evaluation, discussions, with regulatory agencies, and documentation
Project Report Documentation and Preliminary Full Scale Design	125	hr	$160.00	/hr	$20,000	0%	0%	$20,000	Assumes final summary report to implement full scale design
Project Management	72	hr	$200.00	/hr	$14,400	0%	0%	$15,000	Assumes 6 hrs/month for 12 months
								Total Cost:	$225,000

Full Scale Implementation (year 2)

Cost Component	QTY	Units	Unit Cost		Line Item Cost	Overhead	Profit	Bur Line Item Cost	Assumptions
Prepackaged 400 gpm treatment unit or comparable treatment system built and operated by CWS/COB	1	unit	$350,000.00	/unit	$350,000	0%	5%	$370,000	Includes all treatment system components (conveyance, settling, filtration, adsorption, disinfection) to handle a flow rate of 400 gpm. Costs based on StormwaterRX estimate for pump vaults, Aquip 400SBE system, and Purus Model 400V disinfection system. A 100 gpm system with similar treatment components was priced at $120K.
Contractor Installation and Construction Costs	1000	Hr	$54.00	/hr	$54,000	0%	0%	$54,000	Assume 40 hour weeks for a crew of 5 working for five weeks. Unit cost based on 2017 ENR Construction Cost Indices.
Material Costs (foundations, piping, infrastructure, wellhead modifications)	1	LS	$125,000.00	LS	$125,000	0%	0%	$125,000	Professional Judgment based on similar construction projects
Analytical Costs	1	LS	$20,000.00	/sampling set	$20,000	0%	0%	$20,000	Professional Judgement based upon Feasibility Evaluation costs
Consulting/Analyses/Documentation	875	Hr	$160.00	/hr	$140,000	0%	0%	$140,000	Assume consultation required for one project per year
								Total Cost:	$710,000

Operation and Maintenance (year 3)

Cost Component	QTY	Units	Unit Cost		Line Item Cost	Overhead	Profit	Bur Line Item Cost	Assumptions
Contractor Costs	1	LS	$20,000.00	/annual costs	$20,000	0%	0%	$20,000	Assume 2 team contractor crew working total of 200 hours over course of year. Unit Cost based on 2017 ENR Construction Cost Indices. Additional $10K in material (filter media) replacement costs.
Power Costs	1	LS	$5,000.00	/annual power	$5,000	0%	0%	$5,000	Annual power costs estimated at $0.10/kWh for 50000 kWh/year
Analytical Costs	1	LS	$10,000.00	/sampling set	$10,000	0%	0%	$10,000	Professional Judgment based upon Feasibility Evaluation costs
Consulting/Analyses/Documentation	320	Hr	$150.00	/hr	$48,000	0%	0%	$50,000	Assume consultation for data analysis, treatment modification and maintenance, and reporting.
								Total Cost:	$85,000

Operation and Maintance (year 4 and 5)

Cost Component	QTY	Units	Unit Cost		Line Item Cost	Overhead	Profit	Bur Line Item Cost	Assumptions
Contractor Costs	1	LS	$20,000.00	/annual costs	$20,000	0%	0%	$20,000	Assume 2 team contractor crew working total of 200 hours over course of year. Unit Cost based on 2017 ENR Construction Cost Indices. Additional $10K in material (filter media) replacement costs.
Power Costs	1	LS	$5,000.00	/annual power	$5,000	0%	0%	$5,000	Annual power costs estimated at $0.10/kWh for 50000 kWh/year
Analytical Costs	1	LS	$10,000.00	/sampling set	$10,000	0%	0%	$10,000	Professional Judgment based upon Feasibility Evaluation costs
Consulting/Analyses/Documentation	260	Hr	$150.00	/hr	$39,000	0%	0%	$40,000	Assume consultation for data analysis, treatment modification and maintenance, and reporting.
								Total Cost:	$75,000

APPENDIX F

SSPA Memorandum: Water Quality Mixing Evaluation

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Environmental & Water-Resource Consultants

Date:	October 21, 2021
From:	Brad Bessinger
To:	Jason Melady, GSI Water Solutions, Inc.
Project:	City of Beaverton AR Project
Subject:	

This memorandum presents results of a geochemical evaluation in support of the City of Beaverton's Sterling Park Artificial Recharge (AR) project. The objective of the evaluation was to identify potential adverse interactions between AR source water (consisting of treated storm water) and the City of Beaverton's ASR aquifer.

Geochemical modeling was performed using reported storm water and groundwater chemistry and modeling results were used to evaluate the following potential compatibility issues:

1) Potential changes in water quality caused by mixing of native groundwater with an injected source water;
2) Potential changes in water quality caused by geochemical reactions between source water and native aquifer minerals; and,
3) Mineral precipitation, which can potentially lead to clogging issues in the ASR system.

No adverse geochemical compatibility issues were identified. Recovered water from the ASR is predicted to meet drinking water quality criteria. Also, no significant mineral precipitation should occur.

Water chemistry data was provided in spreadsheet format by GSI Water Solutions (GSI) for the following two waters: 1) groundwater from the City's ASR 3A Well (10/9/2019); and 2) Pilot Test 2 Final Treated Stormwater, which is the recharge water being proposed for injection into the ASR aquifer. As shown in Table 1, neither water exceeds any primary or secondary maximum contaminant levels (MCLs). In general, treated stormwater has lower TDS and higher dissolved oxygen (DO) than groundwater.

Geochemical Mixing Modeling

The USGS-supported geochemical model PHREEQC[1] (Parkhurst and Appelo 1999) was used to simulate geochemical mixing of recharge water and groundwater during ASR operations. Model

---

[1] PHREEQC is based on chemical thermodynamics and the energetics of possible chemical reactions are supplied to the program through the thermodynamic database. PHREEQC uses this information, along with a chemical description of any solid and aqueous phases, to predict the equilibrium distribution of elements between individual dissolved (aqueous) species and solid (mineral) forms. PHREEQC simultaneously solves expressions relating the mass of each

input included the water chemistry reported in Table 1. Model output included (1) concentrations of dissolved constituents in recharge water-groundwater mixtures, and (2) mineral saturation indices (SI), which measure the potential for mineral precipitation to occur during mixing[2]. Model predictions were tabulated as a function of the percentage of treated stormwater (i.e., recharge water) in the mixture (from 0 to 100%).

Geochemical Reactive Transport Modeling

The USGS-supported geochemical model PHAST[3] (Parkhurst et al. 2004) was used to simulate geochemical mixing and mineral reactions during a hypothetical ASR operation using treated stormwater. Model input to the reactive transport model (RTM) included the following:

- **Aquifer Description:** The simulated ASR aquifer consisted of a two-dimensional cross section assumed to be 660-feet (200 m) long and 66 ft (20 m) high (representing a hypothetical screened interval around an ASR injection/recovery well) (Figure 1). The maximum extent of the domain was selected to exceed the ASR injection volume, thereby allowing native groundwater to be present at the boundaries farthest from the injection well. As shown in Figure 1, the top and bottom of the model domain was assumed to consist of dense Columbia River Basalt Group (CRBG) and no flow was allowed to occur in those units. Further descriptions of the model domain and aquifer transport parameters are included in Table 2.
- **ASR Operational Data:** The model simulated a hypothetical ASR cycle consisting of the injection of twenty-six million gallons of treated stormwater into the aquifer over a period of 90 days, storage for 230 days, and finally, recovery for 45 days (Table 2).

element to its distribution between different forms (mass balance equations), expressions representing the Gibbs free energy change of prescribed reactions (mass action equations), and an expression for electrical neutrality (the charge balance equation). PHREEQC can simulate several types of geochemical processes that can occur during mixing and/or aquifer interactions, including aqueous phase reactions, ion exchange reactions, surface complexation reactions, and mineral precipitation and dissolution reactions. These reactions can be represented as equilibrium or kinetically controlled.

[2] As concentrations of dissolved aqueous species that comprise a particular mineral increase, the tendency for that mineral to precipitate out of groundwater is enhanced. This tendency is defined mathematically by a value called the saturation index (SI), which is expressed on a logarithmic scale as the ratio of the concentration of ions in solution to the concentration required for mineral precipitation to occur. SI values greater than or equal to zero represent groundwater that is saturated or supersaturated (under these conditions, there is a thermodynamic driving force for mineral precipitation to occur). Conversely, values less than zero imply that a mineral is unstable, and if present in aquifer soils, will dissolve into groundwater.

[3] PHAST is a geochemical reactive transport model that simulates multicomponent, reactive solute transport in three-dimensional saturated groundwater flow systems. Flow and transport calculations in PHAST are based on a modified version of HST3D (which is restricted to constant fluid density and constant temperature). Equilibrium and kinetic geochemical reactions are simulated with PHREEQC, which is embedded in PHAST.

- **Water Chemistry:** The composition of waters used in the evaluation are reported in Table 1. ASR 3A groundwater was used as the initial groundwater present in the aquifer prior to ASR operations. Treated stormwater was used as the injectate.
- **Aquifer Mineralogy:** The mineralogy and chemistry of the Columbia River Basalt Group (CRBG) has been extensively investigated and reported in the scientific literature. It consists of basaltic glass (~45% by mass), a suite of primary minerals formed during emplacement (e.g., plagioclase feldspar, pyroxenes (augite/pigeonite), iron oxides), a set of accessory minerals (e.g., apatite, olivine, and metallic sulfides) (Ames 1980; Schaef and McGrail 2009; Steinkampf and Hearn 1996), and secondary minerals formed during low-temperature water-rock interactions, which includes various clays (e.g., kaolinite and nontronite), silica polymorphs (e.g., SiO_2(am)), zeolites (e.g., clinoptilolite and stilbite), and lesser quantities of calcite and iron oxyhydroxides (e.g., $Fe(OH)_3$(am)) (Benson and Teague 1982; Hearn et al. 1985). The model assumed glass, plagioclase, augite, and magnetite are the primary minerals in the CRBG aquifer, with smectite clay and amorphous silica occurring as minor secondary minerals (Table 2). The relative mineral abundances used were based on Schaef and McGrail (2009) and Reidel (2005) (see Van Pham et al. 2012).
- **Mineral Dissolution Rates:** Chemical reactions in the aquifer, especially heterogenous reactions between minerals and water, are time-dependent and require input of reaction rates. Mineral dissolution was simulated using time-dependent kinetic reactions that vary with reactive surface area. Kinetic rate laws were based on Gislason and Oelkers (2003) and Palandri and Kharaka (2004) for glass and minerals, respectively. Also, reactive surface areas were calculated using the method of Van Pham et al. (2012). Age-dependent surface roughness effects on the reactive surface area were simulated using methods described in White and Brantley (2003). Applicable reaction rate constants are reported in Table 2.
- **Mineral Precipitation Rates:** Secondary minerals such as carbonates and metal oxides/oxyhydroxides (Table 2) were allowed to precipitate in the model instantaneously when their respective SI values were predicted to be greater than zero (i.e., $SI > 0$). This fast/equilibrium approach was a conservative assumption used to maximize the amount of mineral precipitation predicted.

Model-predicted recovered water quality was evaluated to identify potential incompatibilities during ASR operations. Changes in aquifer porosity were also predicted and used to the mineral precipitation/clogging potential. A description of model output includes the following:

- **Water quality:** The composition of water recovered from the ASR aquifer was tabulated as a function of overall recovery (0-100%) and compared to MCLs to understand potential water quality issues.
- **Mineral precipitation/clogging:** The effect of mineral precipitation on aquifer porosity was explicitly calculated by the model using reported amounts of precipitates and their molar volumes (Robie and Bethke 1962; Johnson et al. 1992; Jun and Martin 2003).

Geochemical Mixing Results

Mixtures of treated recharge water and groundwater were evaluated to identify potential adverse changes to water quality during mixing. Predicted mineral saturation states were also evaluated to identify the potential for mineral precipitation/clogging issues in the ASR aquifer. Model results include the following:

- **Water Quality:** The model predicts no exceedances of primary or secondary MCLs during mixing of recharge water with groundwater in the aquifer (Table 3). This prediction is consistent with the Table 1, which similarly reports no exceedances of primary or secondary maximum contaminant levels (MCLs) for any constituent in the two end-member waters used in the model.
- **Mineral Precipitation:** The model predicts no significant mineral precipitation during recharge water-groundwater mixing. Results for specific mineral suites includes the following (Table 4):
  - **Silica Minerals:** Native groundwater (0% treated stormwater in Table 4) is close to equilibrium with most silica (SiO_2) minerals (i.e., SI values are within ±1 unit of zero). This finding is consistent with the natural occurrence of silica in the aquifer and the buffering of dissolved SiO_2 concentrations in groundwater by these minerals. Although quartz has the most-positive SI value, it is unlikely to precipitate as a result of ASR operations. This is because quartz precipitation kinetics are extremely slow, and its precursor is SiO_2(am), which is undersaturated (SI<0). Importantly, SI values decrease as a function of the amount of treated stormwater in the recharge water-groundwater mixture, which means mixing decreases the likelihood of mineral precipitation occurring relative to existing conditions. In summary, significant silica mineral precipitation is not predicted.
  - **Carbonate Minerals:** Dolomite and witherite are supersaturated (SI > 0) in some mixtures (Table 4); however, saturation is generally stable or decreases as the amount of recharge in the mixture increases. SI values typically required for

nucleation and crystal growth of dolomite are greater than 2.5, and the lower values predicted by the model indicates dolomite precipitation is unlikely[4]. Witherite ($BaCO_3$) is closer than dolomite to the degree of supersaturation required for its precipitation (SI = 1.3 to 2.5); however, model-predicted SI values are still less than this range. The potential for witherite precipitation during ASR operations was evaluated using the RTM (see below).

- **Sulfate Minerals:** Gypsum and other $MgSO_4$ are undersaturated in all mixtures, and therefore, unlikely to precipitate (Table 4). By contrast, there is a potential for barite to precipitate due to its low solubility. The potential for barite precipitation during ASR operations was evaluated using the RTM (see below).
- **Clay Minerals:** Many clay minerals are predicted to be supersaturated (SI>0) in recharge water-groundwater mixtures, which implies a potential for clay mineral formation; however, no significant precipitation is likely to occur. This is due, in part, to relatively low aluminum concentrations available for precipitation. In addition, clay formation is typically a slow process that is preceded by other precursor minerals. For example, nontronite—the mineral with the highest SI value—forms during aging and reactions between precursor iron oxyhydroxides and other clay minerals such as amorphous halloysite and/or saponite (which are solid solutions with nontronite) (Deutsch 1982; Hearn et al. 1985; Huertas 2007; Petit et al. 2017). The fact that clay mineral precipitation has not been reported as an issue for other City of Beaverton ASR systems is consistent with insignificant precipitation and/or clogging. In summary, significant clay precipitation is unlikely.
- **Zeolites:** Model predictions for zeolites are similar to the clay minerals in Table 4. Many zeolites are supersaturated in recharge water-groundwater mixtures; however, like clay minerals, zeolite precipitation is slow and preceded by other minerals such as—in this case—nontronite during basalt alteration/weathering (Hearn et al. 1985). To the extent that there is no significant nontronite precipitation (see above), zeolite precipitation is also unlikely to be significant.
- **Iron Minerals:** Several iron oxides and oxyhydroxides are predicted to be supersaturated (SI>0), and therefore, could precipitate during mixing in the ASR aquifer (Table 4). This result is consistent with oxidation of dissolved iron during groundwater mixing. The potential for iron oxyhydroxide precipitation to occur during ASR operations was evaluated using the RTM (see below).

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[4] Seawater does not precipitate dolomite even for SI values that are higher than 2.4, and it has been reported that dolomite precipitation in laboratory conditions typically requires temperatures between 100 and 300°C (Morse et al. 2007). Modern dolomite is only believed to be forming from high ionic strength solutions that are typically derived from the evaporation of seawater or lakes in arid regions.

- **Manganese Minerals:** Several manganese oxides and oxyhydroxides are predicted to be supersaturated (SI>0), and therefore, could precipitate during mixing in the ASR aquifer (Table 4). This result is consistent with oxidation of dissolved manganese during groundwater mixing. The potential for manganese oxyhydroxide precipitation to occur during ASR operations was evaluated using the RTM (see below).
- **Other Minerals:** Aluminum oxhydroxides are predicted to be supersaturated (SI>0), and therefore, could precipitate during mixing in the ASR aquifer (Table 4). The potential for aluminum oxyhydroxide precipitation to occur during ASR operations was evaluated using the RTM (see below).

In summary, several minerals have SI values greater than zero, which indicates they could precipitate during mixing. The primary minerals include (1) barium carbonate and sulfate (witherite and gypsum, respectively), and (2) iron, manganese, and aluminum oxyhydroxides. It is important to note that the amount of precipitation of these minerals is expected to be relatively insignificant given the relatively low concentrations of elements that constitute the minerals. The effect of mineral precipitation on aquifer porosity was evaluated using the RTM (see below).

Reactive Transport Modeling Results

The RTM predicts that the water quality of recovered treated stormwater recharge will be good, with no primary or secondary MCL exceedances predicted (Table 5). The RTM also predicts the precipitation of several minerals in minor amounts in the ASR aquifer ($Al(OH)_3$, $Fe(OH)_3$(am), pyrolusite, and witherite); however, the maximum amount of precipitation (<0.001 mg/kg of $Al(OH)_3$) is an imperceptible amount of precipitation. As shown in Table 5, both the initial (pre-injection) and final (post-recovery) porosity are the same (0.23).

No detrimental water quality changes are predicted by operation of the ASR system. Geochemical mixing modeling predicts no exceedances of primary or secondary MCLs during mixing. Also, although geochemical modeling predicts there is some potential for metal oxyhydroxide minerals to precipitate, the actual quantities precipitated are insignificant and produce no measurable change in porosity.

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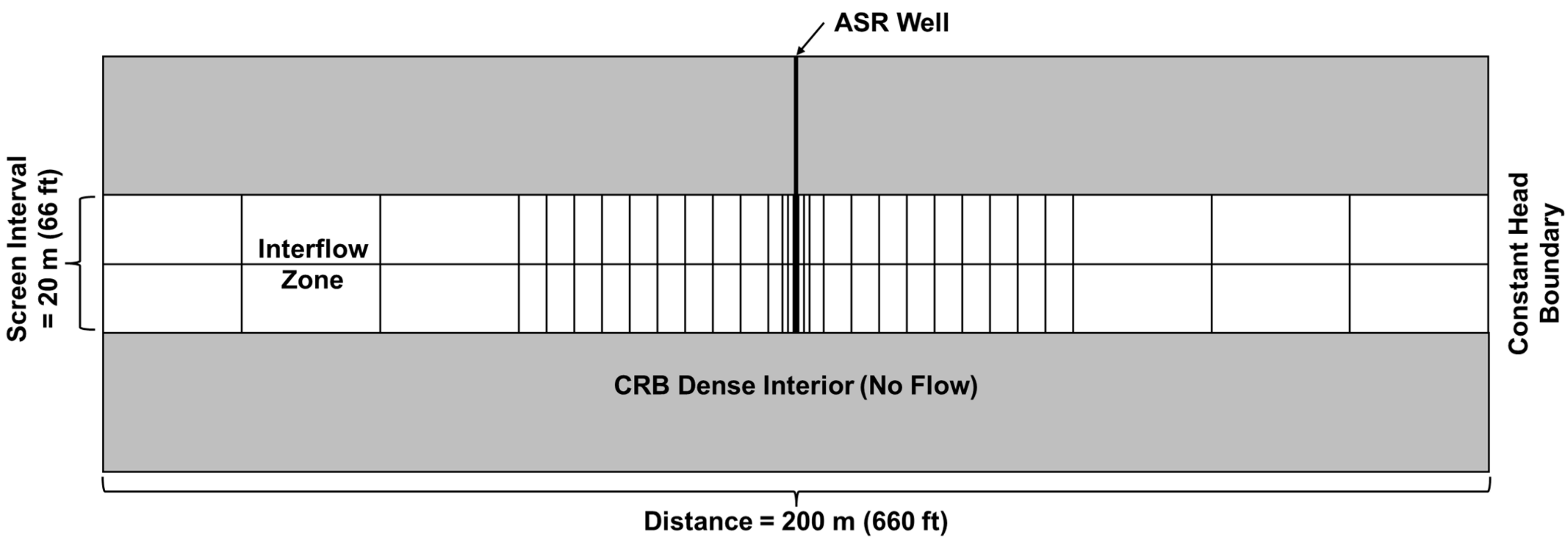

Figure 1. PHAST geochemical model grid used to evaluate aquifer compatibility.

Table 1. Summary of Water Quality of Waters Used in Mixing Analysis

Type	Parameter	Units	Primary MCL	Secondary MCL	ASR 3A Groundwater	Treated Stormwater
General	Conductivity	us/cm			544.1	171.7
	Dissolved Oxygen	mg/L			0.76	6.44
	ORP	mV			-14	38
	pH	unitless		6.5-8.5	7.48	7.62
	Temperature	degC			15	10
	Total Dissolved Solids	mg/L		500	340	130
Cations	Calcium	mg/L			40	14
	Magnesium	mg/L			19	5.1
	Potassium	mg/L			5.9	2.3
	Sodium	mg/L			41	14
Anions	Alkalinity, Total as CaCO3	mg/L			130	25
	Bicarbonate	mg/L			160	31
	Carbonate	mg/L			ND	ND
	Chloride	mg/L		250	94	3.6
	Sulfate	mg/L		250	1.6	59
Redox Species	Ammonia as N	mg/L			NA	NA
	Iron, Dissolved	mg/L		0.3	ND	0.027
	Manganese, Dissolved	mg/L		0.05	0.049	NA
	Methane	mg/L			NA	NA
	Nitrate as N	mg/L	10		ND	0.28
	Nitrite as N	mg/L	1		ND	ND
	Sulfide	mg/L			NA	NA
Metals	Aluminum	mg/L		0.05 to 2	ND	0.33
	Antimony	mg/L	0.006		ND	ND
	Arsenic	mg/L	0.01		ND	ND
	Barium	mg/L	2		0.023	0.063
	Beryllium	mg/L	0.004		ND	ND
	Cadmium	mg/L	0.005		ND	ND
	Chromium	mg/L	0.1		ND	ND
	Copper	mg/L	1.3	1	0.0150	ND
	Lead	mg/L	0.015		0.00065	0.00068
	Mercury	mg/L	0.002		ND	ND
	Nickel	mg/L			ND	ND
	Radium, Total	pCi/L	5		ND	ND
	Selenium	mg/L	0.05		ND	ND
	Silver	mg/L		0.1	ND	ND
	Thallium	mg/L	0.002		ND	ND
	Uranium	mg/L	0.03		ND	ND
	Zinc	mg/L		5	0.022	ND
Other Parameters	Color	c.u.		15	ND	30
	Corrosivity	--		NC	0.15	-1.20
	Cyanide	mg/L	0.2		ND	ND
	Fluoride	mg/L	4	2	0.23	ND
	Odor	ton		3	2	ND
	Orthophosphate as P	mg/L			NA	0.026
	Silica	mg/L			50	2
	Total Organic Carbon	mg/L			2.2	0.63
	Total Suspended Solids	mg/L			ND	NA
Disinfection Byproducts (DBPs)	Residual Chlorine	mg/L			NA	NA
	Total Haloacetic Acids	mg/L	0.06		ND	NA
	Total Trihalomethanes	mg/L	0.08		0.0017	NA

Notes

NA = Not Analyzed; NC = Noncorrosive; ND = Non-detect

Shaded = Value greater than MCL

Table 2. Input Parameters Used in ASR Reactive Transport Model

Parameter	Units	Value	Footnote
Model Description:			
Storage Zone Radius	m	100	
Storage Zone Thickness	m	20	
Injection Amount	MG	26	
Storage Time	days	230	
Recovery Amount	MG	26	
Transport Parameters:			
Porosity	unitless	0.23	
Hydraulic Conductivity	m/s	1×10^{-4}	
Storativity	/m	5×10^{-4}	
Diffusion Coefficient	m^2/s	3×10^{-10}	
Dispersivity	m	5	
Primary (Dissolving) Minerals:			
Glass	wt-%	45	1,2
Plagioclase	wt-%	35	1
Augite	wt-%	19	1
Magnetite	wt-%	1	1
Secondary (Dissolving) Minerals:			
Smectite	wt.-%	0.5	
SiO2(am)	wt.-%	0.1	
Secondary (Precipitating) Minerals:			
$Al(OH)_3$	wt.-%	0	3
Barite	wt.-%	0	3
Birnessite	wt.-%	0	3
Bixbyite	wt.-%	0	3
Calcite	wt.-%	0	3
$Fe(OH)_3$	wt.-%	0	3
Hausmannite	wt.-%	0	3
Manganite	wt.-%	0	3
Pyrolusite	wt.-%	0	3
Rhodochrosite	wt.-%	0	3
Siderite	wt.-%	0	3
SiO_2(am)	wt.-%	0	3
Witherite	wt.-%	0	3
Primary Mineral Kinetic Reactions:			4
Rate - Glass	log(mol-Si/m^2/s)	-7.56	5
Rate - Plagioclase	log(mol/m^2/s)	-8.88, -11.47	6
Rate - Augite	log(mol/m^2/s)	-6.82, -11.97	6
Rate - Magnetite	log(mol/m^2/s)	-8.59, -10.78	6
Rate - Smectite	log(mol/m^2/s)	-10.96, -12.78, -16.52	7
Rate - SiO_2(am)	log(mol/m^2/s)	-12.31	8
Surface Area	m^2/g-basalt	1.52×10^{-5}	9

Footnotes: 1) Van Pham et al. (2012); 2) Glass composition from Steinkampf and Hearn (1996); 3) Minerals assumed present based on Deutsch et al. (1982) and Van Pham et al. (2012); 4) BET surface area-normalized rates reported; converted to geometric surface area-normalized rates after correcting BET surface area for surface roughness (White and Brantley 2003); 5) Gislason and Oelkers (2003) rate constant reported; 6) Palandri and Kharaka (2004) acid and neutral rate constants reported; 7) Palandri and Kharaka (2004) acid, neutral, and base rate constants reported; 8) Palandri and Kharaka (2004) neutral rate constant reported; 9) Geometric surface area calculated by method of Van Pham et al. (2012) (selected reactive surface area accounted for weathering effects (White and Brantley 2003))

Table 3. Mixing Model Predicted Composition of Recharge Water-Groundwater Mixtures

Type	Parameter	Units	Primary MCL	Secondary MCL	Treated Stormwater (Recharge) in Mixture										
					0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
General	Dissolved Oxygen	mg/L			0.8	1.3	1.9	2.5	3.0	3.6	4.2	4.7	5.3	5.9	6.4
	Eh	mV			777	781	784	786	788	789	790	791	792	792	792
	pH	s.u.		6.5-8.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6	7.6	7.6
	Temperature	degC			15	15	14	13	13	12	12	11	11	10	9.5
	Total Dissolved Solids	mg/L		500	412	384	355	327	299	271	242	214	186	158	129
Cations	Calcium	mg/L			40	37	35	32	30	27	24	22	19	17	14
	Magnesium	mg/L			19	18	16	15	13	12	11	9.3	7.9	6.5	5.1
	Potassium	mg/L			5.9	5.5	5.2	4.8	4.5	4.1	3.7	3.4	3.0	2.7	2.3
	Sodium	mg/L			41	38	36	33	30	28	25	22	19	17	14
Anions	Bicarbonate	mg/L			171	156	142	128	114	100	86	72	58	44	30
	Chloride	mg/L		250	94	85	76	67	58	49	40	31	22	13	3.6
	Sulfate	mg/L		250	1.6	7.3	13	19	25	30	36	42	48	53	59
Redox Species	Iron, Dissolved	mg/L		0.3	ND	0.003	0.005	0.008	0.011	0.014	0.016	0.019	0.022	0.024	0.027
	Manganese, Dissolved	mg/L		0.05	0.049	0.044	0.039	0.034	0.029	0.025	0.020	0.015	0.010	0.005	ND
	Nitrate as N	mg/L	10		ND	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3
	Nitrite as N	mg/L	1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metals	Aluminum	mg/L		0.05 to 2	ND	0.033	0.066	0.099	0.132	0.165	0.198	0.231	0.264	0.297	0.330
	Antimony	mg/L	0.006		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Arsenic	mg/L	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Barium	mg/L	2		0.023	0.027	0.031	0.035	0.039	0.043	0.047	0.051	0.055	0.059	0.063
	Beryllium	mg/L	0.004		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Cadmium	mg/L	0.005		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chromium	mg/L	0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Copper	mg/L	1.3	1	0.015	0.014	0.012	0.011	0.009	0.008	0.006	0.005	0.003	0.002	ND
	Lead	mg/L	0.015		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Mercury	mg/L	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Nickel	mg/L			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Radium, Total	pCi/L	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Selenium	mg/L	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Silver	mg/L		0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Thallium	mg/L	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Uranium	mg/L	0.03		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Zinc	mg/L		5	0.022	0.020	0.018	0.015	0.013	0.011	0.009	0.007	0.004	0.002	ND
Other Parameters	Fluoride	mg/L	4	2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	ND
	Orthophosphate as P	mg/L			ND	0.003	0.005	0.008	0.010	0.013	0.016	0.018	0.021	0.023	0.026
	Silica	mg/L			50	45	40	36	31	26	21	16	11	6.6	1.8
	Total Organic Carbon	mg/L			2.2	2.0	1.9	1.7	1.6	1.4	1.3	1.1	0.95	0.79	0.63
Disinfection Byproducts (DBPs)	Residual Chlorine	mg/L	4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Total Haloacetic Acids	mg/L	0.06		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Total Trihalomethanes	mg/L	0.08		0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	ND

Notes

NA = Not Analyzed; ND = Non-detect

Shaded = Value greater than MCL

Table 4. Mixing Model Predicted Mineral Saturation Indices of Recharge Water-Groundwater Mixtures

Type	Mineral	SI Units	Critical Value[1,2]	Treated Stormwater (Recharge) in Mixture										
				0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
				0	10	20	30	40	50	60	70	80	90	100
Silica Minerals	Chalcedony	unitless	>0	0.9	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.3	0.1	-0.4
	Cristobalite-a	unitless	>0	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.2	0.0	-0.2	-0.7
	Cristobalite-b	unitless	>0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.4	-0.7	-1.2
	Quartz	unitless	>0	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.8	0.6	0.4	-0.2
	SiO2(am)	unitless	>0	-0.2	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5	-0.6	-0.8	-1.0	-1.6
	Tridymite	unitless	>0	1.0	0.9	0.9	0.9	0.8	0.7	0.7	0.6	0.4	0.2	-0.4
Carbonate Minerals	Calcite	unitless	>0	-0.3	-0.4	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-1.0	-1.2	-1.4
	Dolomite	unitless	>0	0.4	0.3	0.1	0.0	-0.2	-0.4	-0.6	-0.8	-1.1	-1.5	-1.9
	Magnesite	unitless	>0	-1.0	-1.0	-1.1	-1.2	-1.3	-1.4	-1.5	-1.7	-1.8	-2.0	-2.3
	Witherite	unitless	>0	1.0	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.0
Sulfate Minerals	Barite	unitless	>0	-1.7	-1.0	-0.7	-0.4	-0.2	-0.1	0.1	0.2	0.3	0.4	0.5
	Gypsum	unitless	>0	-3.6	-3.0	-2.8	-2.6	-2.5	-2.5	-2.4	-2.4	-2.4	-2.4	-2.4
	MgSO4	unitless	>0	-13.6	-13.0	-12.8	-12.7	-12.7	-12.7	-12.7	-12.7	-12.7	-12.8	-12.8
Clay Minerals	Celadonite	unitless	>0	U	5.6	5.6	5.4	5.2	4.8	4.4	3.9	3.2	2.2	-0.1
	Chamosite	unitless	>0	U	-21.7	-20.7	-20.5	-20.4	-20.5	-20.6	-20.7	-20.9	-21.2	-21.8
	Clinochlore-14A	unitless	>0	U	-0.8	-0.6	-1.0	-1.4	-1.9	-2.5	-3.2	-4.0	-5.1	-7.1
	Clinochlore-7A	unitless	>0	U	-4.3	-4.1	-4.4	-4.9	-5.4	-6.0	-6.7	-7.5	-8.6	-10.6
	Halloysite	unitless	>0	U	4.1	4.6	4.6	4.5	4.3	4.1	3.9	3.5	3.0	1.9
	Illite	unitless	>0	U	8.4	9.0	8.9	8.7	8.4	8.1	7.6	7.0	6.2	4.2
	Kaolinite	unitless	>0	U	7.2	7.7	7.7	7.6	7.4	7.2	7.0	6.7	6.2	5.1
	Montmor-Ca	unitless	>0	U	8.0	8.3	8.2	7.9	7.6	7.3	6.8	6.2	5.2	3.0
	Montmor-K	unitless	>0	U	7.6	8.0	7.8	7.6	7.3	6.9	6.5	5.8	4.9	2.6
	Montmor-Mg	unitless	>0	U	8.0	8.4	8.2	8.0	7.7	7.3	6.9	6.2	5.3	3.0
	Montmor-Na	unitless	>0	U	7.6	7.9	7.8	7.6	7.3	6.9	6.4	5.8	4.8	2.6
	Nontronite-Ca	unitless	>0	U	16.9	17.5	17.7	17.7	17.6	17.5	17.2	16.8	16.0	14.1
	Nontronite-K	unitless	>0	U	16.5	17.1	17.2	17.3	17.2	17.1	16.8	16.4	15.6	13.7
	Nontronite-Mg	unitless	>0	U	16.9	17.5	17.7	17.7	17.6	17.5	17.2	16.8	16.0	14.1
	Nontronite-Na	unitless	>0	U	16.5	17.1	17.2	17.3	17.2	17.0	16.8	16.3	15.6	13.6
	Saponite-Ca	unitless	>0	U	1.6	1.3	1.0	0.7	0.3	-0.2	-0.8	-1.5	-2.6	-4.8
	Saponite-K	unitless	>0	U	1.2	0.9	0.6	0.3	-0.1	-0.6	-1.2	-1.9	-3.0	-5.2
	Saponite-Mg	unitless	>0	U	1.6	1.3	1.0	0.7	0.3	-0.2	-0.8	-1.5	-2.6	-4.8
	Saponite-Na	unitless	>0	U	1.1	0.9	0.6	0.2	-0.2	-0.7	-1.2	-2.0	-3.0	-5.3
	Sepiolite	unitless	>0	-2.8	-3.2	-3.6	-4.1	-4.6	-5.2	-5.9	-6.8	-7.9	-9.5	-13.1
	Smectite-high-Fe-Mg	unitless	>0	U	-1.3	-1.0	-1.1	-1.3	-1.6	-2.0	-2.4	-3.0	-3.9	-6.0
	Smectite-low-Fe-Mg	unitless	>0	U	2.1	2.4	2.3	2.0	1.7	1.4	0.9	0.3	-0.7	-2.8
Zeolite Minerals	Analcime	unitless	>0	U	1.7	1.9	1.8	1.6	1.5	1.2	1.0	0.6	0.1	-1.1
	Clinoptilolite-Ca	unitless	>0	U	18.7	19.1	18.5	17.7	16.7	15.4	13.8	11.6	8.2	0.1
	Clinoptilolite-K	unitless	>0	U	15.6	16.0	15.4	14.6	13.5	12.3	10.6	8.4	5.0	-3.2
	Clinoptilolite-Na	unitless	>0	U	15.0	15.4	14.8	14.0	12.9	11.6	9.9	7.6	4.1	-4.1
	Heulandite	unitless	>0	U	U	U	U	U	U	U	U	U	U	U
	Laumontite	unitless	>0	U	5.7	6.1	6.0	5.7	5.4	5.0	4.5	3.9	2.9	0.6

Table 4. Mixing Model Predicted Mineral Saturation Indices of Recharge Water-Groundwater Mixtures

Type	Mineral	SI Units	Critical Value[1,2]	Treated Stormwater (Recharge) in Mixture 0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
				0	10	20	30	40	50	60	70	80	90	100
Zeolite Minerals	Mesolite	unitless	>0	U	7.9	8.3	8.2	8.0	7.7	7.4	7.0	6.5	5.7	4.0
	Mordenite	unitless	>0	U	4.7	4.8	4.6	4.3	3.9	3.5	2.9	2.2	1.0	-1.9
	Natrolite	unitless	>0	U	1.5	1.9	1.8	1.5	1.2	0.9	0.5	-0.1	-0.9	-2.7
	Scolecite	unitless	>0	U	6.5	6.9	6.8	6.6	6.4	6.0	5.7	5.1	4.4	2.7
	Stilbite	unitless	>0	U	13.1	13.4	13.2	12.8	12.3	11.7	10.9	9.9	8.2	4.4
	Wairakite	unitless	>0	U	1.0	1.4	1.2	0.9	0.6	0.2	-0.3	-1.0	-2.0	-4.3
Iron Minerals	Fe(OH)3(am)	unitless	>0	-2.6	2.2	2.5	2.7	2.9	3.0	3.0	3.1	3.2	3.3	3.3
	Goethite	unitless	>0	0.0	4.8	5.1	5.3	5.4	5.4	5.5	5.6	5.6	5.7	5.7
	Hematite	unitless	>0	0.9	10.6	11.1	11.4	11.7	11.8	12.0	12.1	12.2	12.3	12.3
	Magnetite	unitless	>0	-16.9	-2.6	-1.8	-1.4	-1.2	-1.0	-0.8	-0.7	-0.7	-0.6	-0.5
	Siderite	unitless	>0	-17.1	-12.4	-12.2	-12.2	-12.2	-12.2	-12.2	-12.3	-12.4	-12.5	-12.7
Manganese Minerals	Birnessite	unitless	>0	41	42	42	42	41	41	40	40	39	36	U
	Bixbyite	unitless	>0	7.6	7.6	7.6	7.6	7.5	7.4	7.3	7.1	6.8	6.3	U
	Hausmannite	unitless	>0	4.7	4.7	4.6	4.5	4.4	4.2	4.0	3.7	3.2	2.4	U
	Manganite	unitless	>0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.0	3.9	3.7	U
	Pyrolusite	unitless	>0	7.9	8.0	8.0	8.0	8.0	8.0	8.0	7.9	7.8	7.6	U
	Rhodochrosite	unitless	>0	-1.3	-1.4	-1.5	-1.6	-1.7	-1.8	-2.0	-2.1	-2.4	-2.8	U
Other Minerals	Al(OH)3	unitless	>0	U	1.4	1.8	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0
	Gibbsite	unitless	>0	U	2.1	2.4	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4

Footnotes: 1) Shading for mineral saturation indices shown where supersaturation indicated (SI > 0)
2) Shading for corrosion indices shown where corrosion indicated
3) U = mineral undersaturated (SI could not be calculated due to non-detect constituent concentrations)

Table 5. Reactive Transport Model Predicted Recovered Water Quality and Aquifer Porosity

Type	Parameter	Units	Primary MCL	Secondary MCL	Percent Recovery of Treated Stormwater (Recharge)										
					0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
General	Dissolved Oxygen	mg/L			6.4	6.2	5.9	5.7	5.3	5.0	4.7	4.4	4.0	3.7	3.4
	Eh	mV			788	788	788	788	788	788	788	787	787	787	786
	pH	s.u.		6.5-8.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Temperature	degC			15	15	15	15	15	15	15	15	15	15	15
	Total Dissolved Solids	mg/L		500	118	124	134	144	157	168	183	194	207	217	229
Cations	Calcium	mg/L			14	15	16	17	19	20	22	23	25	26	28
	Magnesium	mg/L			5.5	5.8	6.5	7.1	7.9	8.6	9.5	10	11	12	12
	Potassium	mg/L			2.4	2.5	2.7	2.8	3.1	3.2	3.5	3.6	3.9	4.0	4.2
	Sodium	mg/L			14	15	17	18	19	21	22	24	25	27	28
Anions	Bicarbonate	mg/L			30	33	40	45	53	60	68	75	83	89	96
	Chloride	mg/L		250	4.8	7.4	12	16	21	26	32	36	42	46	51
	Sulfate	mg/L		250	58	57	54	51	48	45	41	38	35	32	29
Redox Species	Iron, Dissolved	mg/L		0.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Manganese, Dissolved	mg/L		0.05	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Nitrate as N	mg/L	10		0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
	Nitrite as N	mg/L	1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metals	Aluminum	mg/L		0.05 to 2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Antimony	mg/L	0.006		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Arsenic	mg/L	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Barium	mg/L	2		0.009	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.004	0.003	0.003
	Beryllium	mg/L	0.004		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Cadmium	mg/L	0.005		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chromium	mg/L	0.1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Copper	mg/L	1.3	1	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.003	0.004	0.005	0.006
	Lead	mg/L	0.015		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Mercury	mg/L	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Nickel	mg/L			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Radium, Total	pCi/L	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Selenium	mg/L	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Silver	mg/L		0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Thallium	mg/L	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Uranium	mg/L	0.03		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Zinc	mg/L		5	0.002	0.003	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.010	0.011
Other Parameters	Fluoride	mg/L	4	2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
	Orthophosphate as P	mg/L			0.025	0.024	0.023	0.022	0.021	0.020	0.018	0.017	0.015	0.014	0.013
	Silica	mg/L			2.5	3.9	6.3	8.4	11	14	17	19	22	25	27
	Total Organic Carbon	mg/L			0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
Disinfection Byproducts (DBPs)	Residual Chlorine	mg/L	4		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Total Haloacetic Acids	mg/L	0.06		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Total Trihalomethanes	mg/L	0.08		0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001

APPENDIX G

Underground Injection Control (UIC) Application

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General Permit
Water Pollution Control Facilities Permit
For Class V Stormwater Underground Injection Control Systems

Department of Environmental Quality

700 NE Multnomah Street, Suite 600, Portland, Oregon 97232; (503) 229-5263

Issued pursuant to ORS 468B.195 and OAR 340-044 adopting 40 CFR Parts 144, 145 and 146, implementing the Federal Safe Drinking Water Act requirements for Underground Injection Control.

REGISTERED TO:

SOURCES COVERED UNDER THIS PERMIT:
This permit covers injection of stormwater and incidental fluids at individual Class V Underground Injection Control (UIC) systems.

SYSTEM TYPE:
Class V Stormwater Underground Injection Control Systems

SYSTEM LOCATIONS:
County:
Facility Address:

ELIGIBILITY:

- Permittee owns or operates fewer than 50 stormwater UIC systems within a single tax lot or multiple contiguous tax lots, or, for a municipality or other government agency, fewer than 50 stormwater UIC systems within the jurisdiction.
- At least one Underground Injection Control system does not meet the conditions for authorization by rule in OAR 340-044-0018(3)(a)(D), (E), or (G).

Waters of the State: Groundwater

Effective Permit Issuance Date: December 14, 2015
Permit Number:
WQ File Number:
UIC Facility Number:

Matthew Kohlbecker Senior UIC Hydrogeologist	Date
Christine Svetkovich Water Quality Manager	Date
Lydia Emer Operations Division Administrator	Date

HOW TO APPLY FOR COVERAGE UNDER THIS GENERAL PERMIT

New Permit Application Requirements

1. UIC owners seeking coverage under this 1200-U General Permit (2015-2025) for the first time must do the following:

   a. Applicants must complete an application. Applicants may obtain an Oregon Department of Environmental Quality (DEQ) application form by:

      i. Calling one of the DEQ offices listed below and requesting that a form be sent by mail

      ii. Obtaining a form in person from the DEQ regional offices listed below, or

      iii. Downloading the application from the DEQ website at: http://www.deq.state.or.us/wq/uic/forms.htm.

   b. Applicants must submit a completed application to DEQ, requesting coverage under this permit at least 30 days prior to construction of new injection systems.

   c. Applicants must submit all applicable fees with the application.

   d. DEQ will review the application information and will take one of the following actions:

      i. Issue written notice of approval of the registration and coverage.

      ii. Request additional information.

      iii. Deny coverage under this permit. The applicant will be notified if the applicantôs operation cannot be approved for coverage under this general permit, and that the applicant may need to obtain an individual permit.

Transfer of Permit Registration

1. To transfer permit registration, the new owner or permit registrant must submit a DEQ-approved transfer form and applicable fees prior to permit expiration and within 30 calendar days of the planned transfer.

2. If ownership changes (through sale, foreclosure or other means) the new owner may be required to register for coverage under the permit in accordance with Schedule F, condition 4.d.

Permit Renewal Requirements

1. Permittees registered under this general permit may operate until the expiration date on the cover page (unless terminated or extended under ñOther Application Conditions,ò below). Underground Injection Control (UIC) owners requiring renewal of their registration under this general permit must apply for and have the registration renewed to DEQ no later than October 1, 2025, which is 60 calendar days prior to the expiration date of this permit indicated on the cover page. The DEQ Director may grant permission to submit the application less than 60 calendar days in advance but no later than the permit expiration date.

2. DEQ will review the application and will take one of the following actions:

   a. Issue written notice of approval.

b. Request additional information.

c. Deny coverage under this permit. The applicant will be notified if the applicantǿs operation cannot be approved for coverage under this general permit, and that the applicant may need to obtain an individual permit.

Other Application Conditions

1. Coverage under a general permit will continue for a permittee after the expiration date if the permittee submits a complete renewal application as described above.

2. When your registration is expired you must register to continue operations.

3. Any person not wishing to be covered or limited by this general permit may apply for an individual permit in accordance with the procedures in OAR 340-045-0030.

DEQ Regional Office Locations

Northwest Region
700 NE Multnomah Street
Suite 600
Portland, Oregon 97232

Western Region
4026 Fairview Industrial Drive
Salem, Oregon 97302

Eastern Region
800 SE Emigrant
Suite 330
Pendleton, Oregon 97801

DEFINITIONS

1. *Adaptive Management* is a structured, iterative process designed to refine and improve stormwater programs over time by evaluating results and adjusting actions on the basis of what has been learned.
2. *Best Management Practices* or *BMPs* means the schedule of activities, controls, prohibition of practices, maintenance procedures and other management practices designed to prevent or reduce pollution. BMPs also include treatment requirements, operating procedures, and practices to control stormwater runoff.
3. *Corrective action* means measures taken to improve a situation that may adversely affect groundwater quality or supply, endanger groundwater, or violate the prohibition of fluid movement standard.
4. *Endangerment* is defined in 42 United States Code (USC) 300h(d)(2) and occurs when injection may result in the presence of any contaminant in underground water which supplies or can reasonably be expected to supply any public water system, if the presence of such contaminant may result in such systemǿs not complying with any national primary drinking water regulation or may otherwise adversely affect the health of persons.
5. *Groundwater protectiveness* means that a discharge will not endanger groundwater or violate the prohibition of fluid movement standard.
6. *Groundwater protectiveness demonstration* and *demonstrate that groundwater is protected* mean that you have scientifically shown that the discharge will not endanger groundwater or violate the prohibition of fluid movement standard.
7. *Hazardous materials* or *hazardous substances* are hazardous waste, any substance defined as a hazardous substance pursuant to section 101(14) of the federal Comprehensive Environmental Response, Compensation

and Liability Act, oil or petroleum products, or any substance designated by the Environmental Quality Commission under ORS 465.400.

8. *Practicable* means possible to do or put into practice.
9. *Prohibition of Fluid Movement* is defined in 40 Code of Federal Regulations (CFR) 144.12 (ñNo owner or operator shall construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of a fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR part 142 or may otherwise adversely affect the health of persons.ò)
10. *Retrofitting* means physically modifying an existing Underground Injection Control (UIC) system. Example retrofits include backfilling to increase the vertical separation distance between the bottom of the UIC and seasonal high groundwater, or implementing a variety of passive, structural, and/or technological controls to reduce or eliminate pollutants.
11. *Source controls* are methods to decrease the amount of pollutants entering stormwater runoff by preventing the contact of pollutants with rainfall and runoff.
12. *Structural spill control* is a device that is built or constructed to prevent the spread of a spill or release. A concrete containment structure is an example of a structural spill control. Spill response materials (e.g., spill mats) are not a type of structural spill control.
13. *Super-chlorinated* water is water with chlorine concentrations above 4 milligrams per liter.
14. *Visual Inspection* is an evaluation of facility conditions using human senses (e.g., vision) and non-specialized equipment (e.g., a tape measure to measure the depth below the bottom of an outfall pipe in a catch basin).
15. *We* or *us* means the Oregon Department of Environmental Quality (DEQ).
16. *You* means the permittee, person, legal entity, organization, or municipality that is applying for or has received coverage under this permit.

Definitions of 40 CFR part 141.2 and 144.3 and Oregon Administrative Rules (OAR) 340 Divisions 040, 044, and 045 apply to this permit.

PERMITTED ACTIVITIES

You own or operate UICs to manage stormwater. These UICs are individual point sources that discharge stormwater and other incidental fluids below the ground surface.

As provided under federal law, this is an *area permit*, which means it covers all private UICs for stormwater and incidental fluids at a single tax lot or multiple contiguous tax lots, or publically owned UICs within your jurisdiction. Until we revoke this permit or your coverage under this permit or until this permit expires, we authorize you to construct, install, modify, operate, or close (decommission) UICs in accordance with this permit. We also authorize you to discharge stormwater or other fluids specifically identified in this permit into UICs that are under your ownership or operation, or that you will construct, or that will be transferred to your ownership or operation while the permit is in effect, provided you conform to the requirements, limitations, and conditions described in the following schedules:

Any other direct or indirect discharge of waste to waters of the state or to a UIC is prohibited, unless specifically authorized by this permit; by another DEQ permit, agreement, authorization, or order; or by Oregon state or administrative rule.

SCHEDULE A
CONTROL AND LIMITATION CONDITIONS

1. **Authorized Discharges.** You may discharge stormwater into your UICs in accordance with the conditions of this permit. You may also discharge the incidental non-stormwater fluids listed below into your UICs.
   a. Water line flushing (excluding super-chlorinated discharges);
   b. Landscape irrigation;
   c. Uncontaminated groundwater infiltration;
   d. Uncontaminated pumped groundwater;
   e. Discharges from potable water sources;
   f. Water from potable groundwater monitoring wells;
   g. Draining and flushing of municipal potable water storage reservoirs;
   h. Foundation drains;
   i. Air conditioning condensate;
   j. Springs;
   k. Water from crawl space pumps that has not been contaminated with oils or other chemicals;
   l. Footing drains;
   m. Lawn watering;
   n. Individual residential car washing;
   o. Charity car washing, provided that chemicals, soaps, detergents, steam or heated water are not used, and washing is restricted to the outside of the vehicle (no engines, transmissions or undercarriages);
   p. Other vehicle washing, in addition to paragraphs n and o above, provided that chemicals, soaps, detergents, steam or heated water are not used, and washing is restricted to the outside of the vehicle (no engines, transmissions or undercarriages);
   q. De-chlorinated swimming pool and fountain discharges;
   r. Street wash water, provided that street wash water is applied using best management practices that minimize debris and sediment entering the UIC. Washing any spill of any substance (including any oil or hazardous material as defined in Oregon Revised Statute 466.605) into any UIC is prohibited;
   s. Routine external building wash-down and pavement wash waters provided that chemicals, soaps, detergents, steam or heated water are not used;
   t. Discharges or flows from emergency fire-fighting activities provided you take precautions, to the extent practicable, to protect UICs during emergency fire-fighting activities, and clean the UIC system after the fire-fighting event if fluids from the fire fighting activities reach the UIC system. Wash down of spills of oil or hazardous materials into any UIC is prohibited;
   u. Start-up flushing of groundwater wells; and
   v. Other similar temporary discharges of uncontaminated water.

2. **Action Levels.** The exceedance of a pollutant action level in Table 1 below requires you to take corrective action in accordance with Schedule A, condition 3.

TABLE 1—Pollutant Action Levels	
Pollutant	**Action Level (ug/L)**
Pentachlorophenol (PCP)	1.0
Total Lead	15

Note:
ug/L = micrograms per liter

3. **Action Level Exceedance.** The permittee must take corrective action if pollutant concentrations exceed the action levels in Table 1. Permittee must take the steps listed in paragraphs 3.a and 3.b below, and as many additional steps (3.c through 3.f) as are required to protect groundwater or to demonstrate that groundwater is protected. You must obtain written approval from DEQ that the action(s) you take in conditions 3.c through 3.e, and the schedule for taking the actions, are sufficiently protective of groundwater quality. Corrective actions include:
   a. Identify the source(s) of the discharge that exceeds the action level(s);
   b. When source identification efforts are complete, determine the set of UICs that require corrective action, based on the identified source(s) or other factors;
   c. Assess whether best management practices need adjustment to eliminate or reduce influent concentrations and make appropriate, practicable changes;
   d. Demonstrate that groundwater is protected through modeling or another approved approach;
   e. Retrofit or implement singly or in combination a variety of passive, structural, or technological controls to reduce or eliminate pollutants to the UIC to provide protection; or
   f. Decommission the UIC.

4. **Spills.** Spills of oil and hazardous materials that impact UICs are subject to the emergency response requirements of ORS 466 and OAR 340-142. Emergency response actions must be taken as soon as practicable. As the UIC owner or operator, you must also:
   a. Take corrective action in accordance with Schedule A, condition 5;
   b. Take spill response measures in your Stormwater Management Plan, if a plan is required by Schedule D, condition 5; and
   c. Clean the UIC system.

5. **Endangerment and Prohibition of Fluid Movement**. If discharges from one or more UICs endanger human health or the environment or violate the prohibition of fluid movement standard, you must:
   a. Inform us consistent with Schedule F.4.f; and
   b. Take corrective action to eliminate any endangerment of health or the environment as defined in 42 USC 300h(d)(2) (see definitions). You must complete all corrective actions as soon as practicable. With the exception of initial spill response activities, DEQ must approve your work scope and schedule before corrective action begins. You must submit updates on your corrective action progress to us at least annually.

6. **Source Control Measures and Best Management Practices.** With the exception of UICs used to drain roof-only runoff, you must implement and maintain source control measures and operational and structural best management practices to reduce or eliminate pollutants from entering UICs in accordance with OAR 340-040-0020(11). Structural best management practices must include devices that allow for separation of oil and settlement of solids. It is not a permit violation if UICs are not equipped with these devices at the time of permit issuance (as long as the lack of these structural best management practices does not violate another condition of the permit); however, DEQ must approve a schedule for implementation of structural best management practices at the time of permit issuance, and you must comply with this schedule. Stormwater entering the UIC must not be exposed to hazardous substances, toxic materials, or petroleum products. Your UIC designs or practices must allow you to block discharge into the UIC in the event of an accident, spill, or emergency fire-fighting activity. You must document these designs and practices, sample stormwater if necessary to verify that the designs and practices are effective, provide employee education (about spill risks, identification, prevention, and response) as necessary, visually inspect UICs on a regular interval, maintain UICs, and you must provide us with this documentation when we ask for it.

7. **Horizontal Setbacks.** If a UIC is located within the horizontal setbacks in Table 2, you must take the action identified in condition 7.a if it applies to your facility, and any additional actions identified in conditions 7.b through 7.d as required to protect groundwater quality or demonstrate that it is already protected. You must obtain written approval from DEQ that the action(s) you take in conditions 7.b through 7.d are sufficiently protective of groundwater quality. The actions include:

TABLE 2 – Horizontal Setbacks between Water Wells and Stormwater UICs	
Water Well Type	**Horizontal Setback**
Public Water Supply Well with a delineated Wellhead Protection Area	Two-year time-of-travel designated by the Oregon Health Authority
Public or Private Drinking Water or Irrigation Water Supply Well without a delineated Wellhead Protection Area	500 feet

a. If hazardous substances, toxic materials as defined in OAR 340-044-0005(45), or petroleum products are handled at your facility and have the potential to drain to the UIC in the case of a spill, you must install structural spill control;
b. Within one year of being assigned coverage under this permit, demonstrate that the UIC is protective of groundwater;
c. Retrofit or implement singly or in combination a variety of passive, structural, or technological controls to reduce or eliminate pollutants to the UIC or provide protection; and
d. Decommission the UIC.

SCHEDULE B
MONITORING AND REPORTING CONDITIONS

1. **Inventory.** You must maintain a current inventory of your UICs that includes:
a. A table with the following information for each UIC you own or operate:
   i. DEQ UIC identification number, if the DEQ UIC identification number has been assigned;
   ii. The name or number that you use to identify your UICs;
   iii. Environmental Protection Agency well code;
   iv. Latitude and longitude in decimal degrees using the NAD 83 datum;
   v. UIC depth and diameter (if known);
   vi. Best management practices and source controls in use (including structural spill control);
   vii. An estimate of vehicle trips per day on the street or parking lot drained by the UIC;
   viii. Whether the UIC discharges directly to groundwater;
   ix. Whether the UIC is within the setback distances listed in Schedule A, condition 7. If a UIC is within the setback distance listed in Schedule A, condition 7, you must either cite the study that demonstrates your UIC is protective, or indicate the additional action identified in conditions 7.b through 7.d that you will take;
   x. Whether the UIC is prohibited by OAR 340-044-0015(2), which includes UICs in vehicle maintenance areas, fuel dispensing areas, floor pits, non-vehicle maintenance facilitiesô floor drains, and fire station bay floor drains. For these prohibited systems, you must decommission the UICs as described in Schedule B, condition 3;
   xi. Risk category;
   xii. Interval for visually inspecting UICs (see Schedule A, condition 6); and
   xiii. Interval for employee education (see Schedule A, condition 6).
b. A map showing:
   i. Property boundary, site features and adjacent streets;
   ii. Hazardous waste treatment, storage, or disposal facilities;
   iii. The name or number that you use to identify your UICs;

iv. Springs and surface water bodies within a quarter mile of the property boundary;
v. Two year time of travel zones and water wells with 500-foot buffers, if the time of travel zone or water well is located within a quarter mile of the property; and
vi. All industrial facilities and commercial properties that pose a risk of pollutant discharge to UICs that you own or operate that could affect groundwater quality or endanger health or the environment.

2. **Stormwater Monitoring.** Stormwater monitoring is required if your UIC drains an industrial, commercial, municipal, or residential facility with parking lots and/or traffic areas handling an average of 1,000 or more vehicle trips per day; or your UIC drains an industrial, commercial or municipal facility that handles or stores hazardous substances, toxic materials, or petroleum products that could reach the UIC if a spill occurs:
   a. Stormwater monitoring must be conducted twice in the first full sampling year after the permit is assigned, and annually in subsequent sampling years. A stormwater sampling year is from July 1 to June 30 of the following year;
   b. A total of one UIC or 5 percent of the UICs that you own or operate (whichever is greater) must be sampled, and sampling must focus on UICs within the Schedule A, Table 2 setbacks to water wells.
   c. You must submit stormwater monitoring data to DEQ by November 1 of each year and document corrective actions that were taken or that you plan to take in response to any exceedance of Schedule A, Table 1 action levels, using a template provided by DEQ;
   d. Stormwater sampling procedures (including monitored pollutants, sampling locations, sampling schedule, sample collection methods, and sample collection criteria), quality assurance/quality control (including criteria for selecting a laboratory, duplicates, blanks, and indicators), and reporting must be documented in an appendix to the Stormwater Management Plan, if required by Schedule D, condition 5.

3. **UIC Decommissioning.** When you plan to close a UIC, you must decommission the UIC in accordance with OAR 340-044-0040, submit an updated inventory in accordance with Schedule B, condition 1, and pay required fees.

4. **Reporting Installation of New UICs and Discovery of Existing UICs.** You must report new UICs that are constructed and existing UICs that are discovered or later acquired by submitting an updated inventory in accordance with Schedule B, condition 1, and paying required fees. The following timeframes apply to reporting:
   a. Construction of new UICs must be reported to us 30 calendar days before the UIC is constructed;
   b. Discovery of a new UIC must be reported to us 30 calendar days after the UIC is discovered.

5. **Best Management Practices.** Refer to Schedule A condition 6 for reporting requirements related to Best Management Practices.

SCHEDULE C
SAFE DRINKING WATER ACT COMPLIANCE SCHEDULE

This permit does not require a Safe Drinking Water Act compliance schedule (see 40 CFR 144.53) if you do not own any UICs known to violate the Safe Drinking Water Act, state or federal underground injection control rules or regulations, or state groundwater quality protection rules, as you certified in your application.

SCHEDULE D
SPECIAL CONDITIONS

1. **Legal Authority**. If you are a municipality, you must adopt and maintain, through ordinance or other means, adequate legal authority to implement and enforce the provisions of this permit. At a minimum, the legal authority must enable you to:
   a. Implement underground injection control system management activities, including construction, repair, maintenance, and decommissioning;
   b. Prohibit discharge to an underground UIC that may cause a violation of the conditions of this permit from publicly or privately owned properties; and
   c. Carry out all inspections, surveillance, and monitoring procedures necessary to determine compliance and noncompliance with the conditions of this permit.

2. **Permittee Personnel Responsible for Permit.** You must notify us in writing of any changes to the key personnel positions and contact information responsible for establishing and maintaining compliance with all conditions of the permit included in your application. Contact information includes the employee's name, phone number, business section where the employee works, and the employee's area of responsibility for the permit.

3. **Adaptive Management**. You must follow an adaptive management approach to assess annually, and modify as necessary, any or all existing source controls and best management practices to ensure that you minimize the amount of contamination that can affect the stormwater you are injecting. You must routinely assess the need to further improve groundwater quality and protect groundwater beneficial uses, and review available technologies and practices.

4. **Rule Authorization.** This permit covers all UICs owned or operated by you, including those that have been previously rule authorized as well as those that do not meet the conditions for authorization by rule.

5. **Stormwater Management Plan.** A written Stormwater Management Plan is required if your UIC drains an industrial, commercial, residential, or municipal facility with parking lots and/or traffic areas handling an average of 1,000 or more vehicle trips per day; or your UIC drains an industrial, commercial or municipal facility where hazardous substances, toxic materials, or petroleum products are used, handled or stored. The stormwater Management Plan must include:
   a. Best management practices implemented at the facility for source control and treatment;
   b. Spill prevention and spill response plans;
   c. Maintenance procedures;
   d. Employee education; and
   e. Stormwater sampling procedures, quality assurance / quality control, and reporting.

6. **Permit Shield.** Compliance with this permit constitutes compliance, for purposes of enforcement, with the UIC provisions of the federal Safe Drinking Water Act and OAR Chapter 340, Division 040 and 044. This provision, however, does not preclude modification, revocation and reissuance, or termination of this permit or coverage under this permit as authorized by applicable federal and state law.

SCHEDULE F
GENERAL CONDITIONS

1. **Standard Conditions.**
   a. **Duty to Comply.** You must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Safe Drinking Water Act, a violation of Oregon Revised Statutes (ORS) 468B.025, or is grounds for enforcement action. It is also grounds for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application; except that you need not comply with the provisions of this permit to the extent and for the duration such noncompliance is authorized in an emergency permit under 40 CFR 144.34.
   b. **Penalties for Violations of Permit Conditions.** ORS 468.140 allows us to impose civil penalties up to $25,000 per day for each violation of a term, condition, or requirement of a permit. ORS 468.943 creates the criminal offense of unlawful water pollution in the second degree, for the criminally negligent violation of ORS chapter 468B or any rule, standard, license, permit or order adopted or issued under ORS chapter 468B. In some situations, violations of a term, condition or requirement of the permit may also be a criminal offense, specifically unlawful water pollution in the first degree (a felony) or unlawful water pollution in the second degree (a misdemeanor). [ORS 468.943 and ORS 468.946].
   c. **Duty to Mitigate.** You must take all reasonable steps to minimize or correct any adverse impact on the environment resulting from noncompliance with this permit. You must take all reasonable steps to minimize or prevent any discharge in violation of this permit that has a reasonable likelihood of adversely affecting human health or the environment. In addition, you must correct any adverse impact on the environment or human health or safety resulting from noncompliance with this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the non-complying discharge.
   d. **Duty to Reapply.** If you wish to continue an activity regulated by this permit after the expiration date of this permit, you must apply for and have the permit registration renewed. In accordance with OAR 340-045-0040(1), you must submit the application at least 60 calendar days before the expiration date of this permit. We may grant you permission to submit an application less than 60 calendar days in advance of the permit expiration date. We will not grant permission for a renewal application that you submit later than the expiration date of the existing permit.
   e. **Permit Actions.**
      i. We may modify, revoke and reissue, or terminate your coverage under this permit for cause including, but not limited to, the following:
         (1) <u>Violation.</u> The violation of any term, condition, or requirement of this permit, or a related state rule or statute, or a federal regulation related to underground injection control for injection wells; or
         (2) <u>Misrepresentation</u>. Obtaining this permit by misrepresentation or failure to disclose fully all material facts.
      ii. You may request permit coverage revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, but this request does not stay the effectiveness of any permit condition.
   f. **Property Rights.** The issuance of this permit does not convey any property rights of any sort or any exclusive privileges.
   g. **Permit Reference.** All rules and statutes referred to in this permit are those in effect on the date we issue this permit, or the date we modify the permit to incorporate new provisions as provided in OAR 340-045-0055, whichever occurs later.
   h. **Penalties for False Information.** Under ORS 486.953, any person who supplies false information to us commits a Class C felony. Under OAR 340-012-0053(1)(b), providing us with false information is a Class 1 civil violation. Providing us with false information includes the following:
      i. Falsifying, tampering with, or knowingly rendering inaccurate, any monitoring device or method required to be maintained under this permit;
      ii. Making any false material statement, representation or certification knowing it to be false, in any application, notice, plan, record, report or other document required by any provision of ORS chapter 465, 466, 468, 468A or 468B or any rule adopted pursuant to ORS chapter 465, 466, 468, 468A or 468B;
      iii. Omitting any material or required information, knowing it to be required, from any document described in paragraph (a) of this subsection; or
      iv. Altering, concealing or failing to file or maintain any document described in paragraph (a) of this

subsection in knowing violation of any provision of ORS chapter 465, 466, 468, 468A or 468B or any rule adopted pursuant to ORS chapter 465, 466, 468, 468A or 468B.

i. **Duty to Provide Information.** You must furnish to us, within a time specified, any information that we may request to determine whether cause exists for modifying, revoking and reissuing, or terminating coverage under this permit, or to determine compliance with the permit. You must also furnish to us upon request, copies of records that this permit requires you to keep.

j. **Need to Halt or Reduce Activity not a Defense.** It is not a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of the permit.

2. Operation and Maintenance.

a. **Proper Operation and Maintenance.** You must at all times properly operate and maintain all facilities and systems of treatment and control (and related equipment) that you install or use to comply with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of a back-up or auxiliary facilities or similar systems only when necessary to comply with the conditions of the permit.

b. **Removed Substances.** You must dispose of or otherwise manage any soil, gravel, sludge, liquids, or other materials removed from or adjacent to a UIC in accordance with 40 CFR 144.82(b).

3. Monitoring and Records. You must comply with monitoring requirements of 40 CFR 144.51(j) and this condition:

a. Samples and measurements taken for monitoring must be representative of the monitored activity.

b. **Records Contents.** Records of monitoring information that you must retain include:

   i. The date, exact place, time and methods of sampling or measurements;
   ii. The name(s) of the individual(s) who performed the sampling or measurements;
   iii. The date(s) analyses were performed;
   iv. The name(s) of the individual(s) who performed the analyses;
   v. The analytical techniques or methods used;
   vi. The results of such analyses;
   vii. Calibration and maintenance records and all original strip chart recordings for continuous monitoring instruments, copies of all reports required by this permit, and records of all data used to complete the application for this permit for a period of at least 10 years from the date of the sample, measurement, report, or application. We will consider extending this period if you request it;
   viii. The nature and composition of all injected fluids until three years after completion of any plugging and decommissioning procedures; and
   ix. We may require the owner or operator to deliver the records to us at the conclusion of the retention period.

c. **Inspection and Entry.** You must allow us, or an authorized representative, upon the presentation of credentials and other documents as may be required by law, to:

   i. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
   ii. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and
   iii. Sample or monitor at reasonable times, for the purposes of ensuring permit compliance or as otherwise authorized by the Safe Drinking Water Act or state law, any substances or parameters at any location.

d. **Retention of Records.** You must retain records of all monitoring and maintenance information, including all field notes, calibration and maintenance records, all original strip chart recordings for continuous monitoring instrumentation, all analyses of the data generated, all reports required by this permit, and records of all data used to complete the application for this permit. You must keep them for a period of at least 10 years from the date of the sample, measurement, report, or application. You must make the records available to us upon request.

4. **Reporting and Signatory Requirements.** You must comply with the reporting requirements of 40 CFR 144.51(j) and this condition:
   a. **Planned changes.** You must give us notice as soon as possible of any planned physical alterations or additions to the permitted facility.
   b. **Anticipated noncompliance.** You must give us advance notice of any planned changes in the permitted facility or activity that may result in noncompliance with permit requirements.
   c. **Anticipated Violations.** You must give us advance notice of any planned changes in the permitted facilities or activities that may result in violations of permit requirements.
   d. **Transfers** This permit is not transferrable to any person except after giving us notice and meeting the conditions of OAR 340-045-0045. We may require modification or revocation and reissuance of the permit to change the name of the permittee and incorporate such other requirements as may be necessary under the federal Safe Drinking Water Act (see 40 CFR 144.38; in some cases, modification or revocation and reissuance is mandatory).
   e. **Compliance Schedule.** You must make compliance reports on all interim and final requirements contained in any compliance or implementation schedule included in this permit. The reports must explain the cause of any noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirements.
   f. **Twenty-Four-Hour and Five-Day Reporting.** Unless a different compliance schedule and reporting requirements are otherwise noted in this permit, you must report any noncompliance that endangers health or the environment in accordance with 40 CFR 144.51(l)(6). You must provide any information of noncompliance that endangers health or the environment orally within 24 hours from the time you become aware of the circumstances. You must submit a written report within 5 days of the time you become aware of the circumstances. The written report must contain:
      i. A description of the non-compliance and its cause, if known;
      ii. the period of the noncompliance if known, including exact dates and times, and if the noncompliance has not been corrected,
      iii. The anticipated time it is expected to continue; and
      iv. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.
   g. **Other Noncompliance**. In accordance with 40 CFR 144.51(l)(7), you must report all instances of noncompliance not reported elsewhere in this Schedule at the time you discover them. The reports must contain the information listed in Schedule F.4.f.
   h. **Other Information.** If you become aware that you failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to us, you must promptly submit such facts or information to us.
   i. **Signatory Requirements.** All applications, reports or information submitted to us must be signed and certified as provided in of 40 CFR 144.32.

APPENDIX H

Table 9A – Water Quality Monitoring Analyte List

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Table 9A. Water Quality Monitoring Analyte List
City of Beaverton – Sterling Park AR Limited
License Application

Analyte	Full Suite (Group A)	Mixing Indicators (Group B)	Treatment Effectiveness (Group C)	Removal of Constituents (Group D)
Geochemical				
Bicarbonate as $CaCO_3$	X	X		
Calcium	X	X		
Carbonate as $CaCO_3$	X	X		
Chloride	X	X		
Cyanide (Total)	X			
Fluoride	X	X		
Hardness (as $CaCO_3$)	X			
Langelier Saturation Index	X			
Magnesium	X	X		
Nitrite as N	X		X	X
Nitrate as N	X		X	X
Potassium	X	X		
Silica	X	X		
Sodium (Total)	X	X		
Sulfate	X	X	X	X
Total Alkalinity	X			
Total Organic Carbon	X			
Total Suspended Solids	X			
Metals				
Antimony (Total)	X			
Aluminum (Total)	X		X	X
Arsenic (Total)	X			
Barium (Total)	X			
Beryllium (Total)	X			
Cadmium (Total)	X			
Chromium (Total)	X			
Copper (Total)	X			
Iron (Total)	X		X	X
Lead (Total)	X			
Manganese (Total)	X		X	X
Mercury (Total)	X			
Nickel (Total)	X			
Selenium (Total)	X			
Silver (Total)	X			
Thallium (Total)	X			
Zinc (Total)	X		X	X
Pesticides/Herbicides, PAHs, VOCs, and PCBs				
2, 4-D	X		X	
2, 4, 5-TP (Silvex)	X			
Alachlor (Alanex)	X			
Atrazine	X			
Benzo(a)Pyrene	X			
BHC-gamma (Lindane)	X			
Carbofuran	X			
Chlordane	X			
Dalapon	X			
Di(2-ethylhexyl)adipate *(adipates)*	X			
Di(2-ethylhexyl)phthalate *(phthalates)*	X			
Di-n-octyl phthalate	X		X	
Dibromochloropropane (DBCP)	X			
Dinoseb	X			
Diquat	X			
Diuron	X		X	
Ethylene Dibromide (EDB)	X			
Endothall	X			
Endrin	X			
Glyphosate	X			
Heptachlor	X			
Heptachlor Epoxide	X			
Hexachlorobenzene (HCB)	X			

Table 9A. Water Quality Monitoring Analyte List
City of Beaverton – Sterling Park AR Limited
License Application

Analyte	Full Suite (Group A)	Mixing Indicators (Group B)	Treatment Effectiveness (Group C)	Removal of Constituents (Group D)
Hexachlorocyclopentadiene	X			
MCPP-p	X		X	
Methoxychlor	X			
Paraquat	X		X	
Pentachlorophenol	X			
Picloram	X			
Simazine	X			
Total Polychlorinated Biphenyls (PCBs)	X			
Toxaphene	X			
Vydate (Oxamyl)	X			
1, 1-Dichloroethylene	X			
1, 2-Dichloroethane (EDC)	X			
1, 2-Dichloropropane	X			
1, 2 ,4-Trichlorobenzene	X			
1, 1, 1-Trichloroethane	X			
1, 1, 2-Trichloroethane	X			
Benzene	X			
Chlorobenzene (monochlorobenzene)	X			
cis-1,2-Dichloroethylene	X			
Ethylbenzene	X			
Methylene Chloride	X			
Styrene	X			
Tetrachloroethylene (PCE)	X			
Toluene	X		X	
Total Xylenes	X			
trans-1,2-Dichloroethylene	X			
Trichloroethylene (TCE)	X			
Triclopyr	X		X	
Vinyl chloride	X			
Radionuclides				
Alpa, Gross	X			
Beta, Gross	X			
Radium 226	X			
Radium 228	X			
Uranium	X			
Per- and Polyfluoroalkyl Subtances (PFAS)				
Perfluorohexanoic acid (PFHxA)	X		X	
Perfluoroheptanoic acid	X		X	
Perfluorooctanoic acid (PFOA)	X		X	
Perfluorononanoic acid	X		X	
Perfluorodecanoic acid	X		X	
Perfluoroundecanoic acid	X		X	
Perfluorododecanoic acid	X		X	
Perfluorotridecanoic acid	X		X	
Perfluorotetradecanoic acid	X		X	
Perfluorobutanesulfonic acid	X		X	
Perfluorohexanesulfonic acid	X		X	
Perfluorooctanesulfonic acid (PFOS)	X		X	
N-ethyl perfluorooctanesulfonamidoacetic acid	X		X	
N-methyl perfluorooctanesulfonamidoacetic acid	X		X	
Perfluoro-2-proxypropanoic acid	X		X	
Dodecafluoro-3H-4,8-dioxanonanoic acid	X		X	
9-chlorohexadecafluoro-3-oxanonane-1 sulfonate	X		X	
11-chloroeicosafluoro-3-oxanonane-1-sulfonate	X		X	
Bacteriological				
Fecal Coliform	X		X	

Notes
$CaCO_3$ = calcium carbonate
PAHs = polycyclic aromatic hydrocarbons
PCBs = polychlorinated biphenyls
VOCs = volatile organic compounds