

Project title and LOI

Treatment effectiveness of a full-scale stormwater facility using high performance bioretention soil media for 6PPD-quinone and other toxic chemicals.

LOI # 11

Applicant

King County, Department of Natural Resources and Parks (DNRP), Water and Land Resources Division (WLRD)

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Project background and purpose

This study addresses on-site stormwater management best management practices (BMPs) and stormwater flow control and water quality treatment facilities as outlined in Minimum Requirements #5, #6, and #7 in the NPDES municipal western Washington MS4 Permits for Phase 1 and 2 Permittees.

Urban stormwater can contain 6PPD and its oxidative byproduct 6PPD-quinone (6PPD-q), a tire-derived chemical highly toxic to coho salmon. 6PPD-q has been linked Urban Runoff Mortality Syndrome (URMS) in the Pacific Northwest, a phenomenon where adult coho salmon returning to spawn die in polluted streams before spawning. Laboratory studies indicate filtering polluted stormwater through bioretention soil media (BSM) can eliminate toxicity to coho. Navickis-Brasch et al. (2022)¹ assessed the likelihood of 6PPD-q mitigation based on physicochemical properties of conventional and proprietary stormwater treatment facilities. They ranked 'biofiltration' best management practices (BMPs) using BSM or compost as having high potential for reducing 6PPD-q in polluted stormwater; however, compost and the current standard 60:40 (sand:compost ratio) media, while having the potential to mitigate URMS, are net dischargers of some pollutants. The Washington State Department of Ecology (Ecology) approved the use of high performance bioretention soil media (HPBSM) in 2021 to mitigate those problems; but at that time 6PPD-q had just recently been identified as a primary URMS causative agent, and as such HPBSM had not been tested to remove it in stormwater treatment facilities. To the best of our knowledge, no full-scale, in-situ facilities using HPBSM have been monitored to date. In fact, the only laboratory study showing HPBSM mitigation for 6PPD-q and URMS of which we are aware is being conducted currently by King County WLRD and initial results look promising. This data gap creates uncertainty as to whether, and to what degree, application of HPBSM in full-scale stormwater treatment facilities will be effective at treating 6PPD-q and mitigating URMS.

¹ Navickis-Brasch, Aimee S., Mark Maurer, Taylor Hoffman-Ballard, et al. 2022. Stormwater Treatment of Tire Contaminants - Best Management Practices Effectiveness. Prepared for Washington State Department of Ecology. 72 pp.

The purpose of this study is to test the effectiveness of Ecology-approved HPBSM at decreasing the 6PPD-q concentration and aquatic toxicity of stormwater at a full-scale bioretention facility in Bellingham². This information is necessary to validate laboratory testing of HPBSM and to help inform King County and other jurisdictions on effective use of HPBSM in areas with harmful levels of 6PPD-q where compost-based BSM is prohibited or ill-advised due to nutrient and metals release. This study will develop information on HPBSM bioretention effectiveness in-situ, and the results will provide more accurate treatment effectiveness estimates for scientists and planners developing 6PPD-q mitigation plans at regional or watershed scales. In addition, it will improve our understanding of cost-effectiveness for HPBSM application in a full-scale application scenario, information that may help agency leaders decide how best to invest limited resources for 6PPD-q treatment.

Project Objectives

- Measure reduction in concentrations of 6PPD-q and other stormwater contaminants [per- and polyfluoroalkyl substances (PFAS), polycyclic aromatic hydrocarbons (PAHs), and metals] in treated stormwater effluent relative to influent at a full scale bioretention facility.
- Test if acute toxicity to coho salmon (*Oncorhynchus kisutch*) and a representative invertebrate species (*Daphnia pulex*) is reduced or eliminated in treated stormwater effluent relative to influent at the HPBSM project site.
- Explore whether parameters such as dissolved organic carbon (DOC) and total suspended solids (TSS) in influents correlate strongly with 6PPD-q concentrations in project samples.

Project description/scope of work

Scope: For this project, King County DNRP will partner with Whatcom County to monitor 6PPD-q concentration changes and aquatic toxicity reduction at a full-scale bioretention facility constructed with Type 2 HPBSM (18" layer of sand/coir/biochar underlain by a 12" polishing layer of sand/iron/activated alumina) in the Geneva neighborhood of Bellingham (Figure 1). The Geneva site will provide opportunities to evaluate effectiveness of HPBSM at scale with multiple sampling events over two years (2024 to 2025).

King County is currently conducting a laboratory column bench study to determine the extent to which 60:40 BSM and three Ecology-approved HPBSM configurations (Types 1, 2 and 3) decrease 6PPD-q in stormwater to below levels toxic to coho salmon, eliminate acute coho toxicity, or both in that setting. We expect results from the lab study by the end of summer 2023 and will use the findings to inform us on the degree to which the different HPBSM configurations may decrease 6PPD-q in stormwater and/or eliminate toxicity to coho at full scale in-situ, in the assessed facility.

Study Site: At the Geneva Bioretention Pilot Project (Geneva), Whatcom County will replace a set of underperforming bioretention swale cells installed in 2007 in a neighborhood near Lake Whatcom. The site will be reconfigured to include three new components; a pretreatment

² The proposed project as described in the original Letter of Intent has changed; we are no longer able to sample at the Longfellow Creek neighborhood bioretention system in Seattle.

device to reduce sedimentation to the swale, a new bioretention section incorporating Type 2 HPBSM, and a new flow distribution system to evenly distribute influent flows across the facility. Our partnership with Whatcom County will leverage water quality monitoring already planned at the Geneva facility. DNRP will work primarily with Whatcom County's consultant, Herrera Environmental Consultants, Inc. (Herrera) to coordinate monitoring for this site.

Study design: This is a case-study stormwater runoff treatment for 6PPD-q and toxicity to coho using HPBSM in a full-scale, in-situ bioretention facility. Research questions to be investigated in this study include:

1. Does the stormwater treatment facility reduce concentrations of 6PPD-q and other contaminants (PFAS, PAHs, and metals) in treated stormwater effluent relative to influent, and to what degree?
2. Is the treated stormwater effluent non-toxic, or less toxic, to juvenile coho salmon and daphnia relative to influent?
3. Does the treatment rate (i.e., facility performance) change over the monitoring period for either stormwater facility?
4. Does DOC and TSS covary with target analyte concentrations or toxicity?

Sampling: Herrera will obtain stormwater samples for this project from Geneva beginning in October 2023 to spring 2025, targeting 15 storms for chemical analyses and four storms (1 storm per quarter) for acute toxicity testing. Samples will be delivered to the King County Environmental Laboratory (KCEL) for analyses. Herrera is developing a quality assurance project plan (QAPP) for the Geneva facility, which will include the site design and a monitoring and analysis plan following Technology Assessment Protocol – Ecology (TAPE) protocols for total suspended solids (TSS), particle size distribution, hardness, total and dissolved copper and zinc, nitrate+nitrite, total Kjeldahl nitrogen, total and ortho-phosphorus, and fecal coliform. For this SAM project, we anticipate producing a QAPP addendum to address the additional 6PPD-q and aquatic toxicity monitoring, as well as monitoring for dissolved organic carbon (DOC), metals, PFAS, PAHs, pH, redox potential, and specific conductance.

Laboratory analyses: Chemical and toxicity testing for this project will be conducted at KCEL. All stormwater samples will be analyzed for 6PPD-q and metals³. A subset of samples (four per year) will be tested for acute toxicity, including Urban Runoff Mortality Syndrome (URMS) behavioral effects to juvenile coho salmon and acute toxicity to daphnia. Toxicity testing will target storms with variable antecedent dry periods as a proxy for level of toxic contaminants. PFAS and PAHs will also be evaluated in samples to obtain treatment data on additional organic chemicals. TSS, DOC, pH, hardness, oxidation reduction potential, and specific conductance will be tested in each stormwater sample to evaluate if these parameters affect the outcome of the toxicity test, e.g., through binding or transformation of 6PPD-q.

Data analysis approach: In the final report we will make statistical comparisons, summary tables, and graphical presentations of the HPBSM treatment performance at the Geneva

³ Though Whatcom will be analyzing copper and zinc, we are including additional metals to expand this list.

bioretention facility. We will test for significant differences in 6PPD-q concentrations between the influent and effluent across individual sampling events (as percent reduction for chemistry), and whether the treatment rate (i.e., facility performance) changes over the monitoring period. Similar comparisons will be made for concentrations of PFAS, PAHs, and metals data. Toxicity test results will be evaluated by the change in relative rate of mortality (and presence of behavioral effects for coho) with a target of zero mortality. Correlations between water quality parameters (e.g., TSS and DOC) and 6PPD-q concentration will also be tested. In addition, for the Geneva project (bioretention facility with Type 2 HPBSM), we will compare the in-situ treatment performance (e.g., relative reduction of metals and other chemicals) against that of the Type 2 HPBSM in prior laboratory tests.

Major tasks and deliverables:

Task 1.0 Project Development and Planning

- 1.1 Organize a Technical Advisory Committee (TAC) – the TAC will be asked to review the study design, as well as key and final deliverables.
- 1.2 Project team meetings – Establish, monitor, and control project scope, schedule, budget. Assign roles and responsibilities, delegate tasks. Schedule project team meetings with various bioretention partners for planning purposes and to assign subtasks, coordinate sampling, identify and solve challenges, and assess project status and schedule.
- 1.3 QAPP addendum
 - Deliverable - Geneva Bioretention Pilot Project QAPP addendum – adding 6PPD-q and toxicity testing to monitoring QAPP already developed by Whatcom County

Task 2.0 Field Sampling and Laboratory Analysis

- 2.1 Field sampling – inlet and outlet sampling and sample processing at Geneva Bioretention Pilot Project (15 storm events targeted for sampling between 2024 to 2025)
- 2.2 Analytical work – King County Environmental Lab (KCEL) analyzes stormwater samples for 6PPD-q, metals, PFAS, PAHs, TSS, DOC, and other water quality parameters and performs toxicity tests.

Task 3.0 Data Analysis and Final Report

- 3.1 Data management – compile and store analytical data in a secure database.
- 3.2 Data review and validation – will be conducted by the project manager.
- 3.3 Data analysis – prepare data and conduct statistical and graphical analyses, evaluate, and compare chemistry and toxicity within treatment types, summarize data for use in final report.
- 3.4 Deliverable - Final report – summarizing project methods and findings, conduct internal/external review, produce final report for delivery to Ecology and distribution to Permittees.

Task 4.0 Distribution of Findings

4.1 Deliverable - EIM data submittal – organize and submit analytical data to the EIM database.

4.2 Deliverable – Presentations of findings – present findings and project dashboard (see Task 4.3) to the SAM workgroup, to Permittees and to other interested parties. Possible presentation venues include interested Puget Sound Partnership workgroups and the 2026 MuniCon conference.

4.3 Deliverable – Web-based data dashboard – produce a web-based project dashboard designed to make the study data easily downloadable by Permittees and other interested parties

4.4 Deliverable - SAM Fact Sheet – produce 2-page SAM factsheet summarizing findings of project

Task 5.0 Project Administration

5.1 Subcontractor management – manage contract with consulting firm(s)

5.2 Budget management – monitor financial reports regularly to assure project stays within budget

5.3 Deliverable - Semi-annual invoice/progress reports – submit invoices and reports to Ecology on project status and payment requests.

Project team description

The project core team includes staff from King County DNRP, KCEL, Whatcom County, and Herrera. A Technical Advisory Committee will be organized as part of Task 1, with members recruited from the SWG subgroup as well as other local NPDES permittees. The project team anticipates Ecology will be a project partner providing input at milestones outlined in Tasks 1, 3, 4, and 5 above. Meetings with the project team and partners will provide opportunities at key milestones to review project progress and consider adaptive management, if necessary. See Table 1 for a summary of project partners and roles and responsibilities.

DNRP's primary role will be grant administration, project development and coordination, and delivery of all deliverables. KCEL will perform all chemical analyses and toxicity testing for this project, except for analysis of TSS for the Geneva samples which will be conducted at Exact Scientific Services Inc., Ferndale as part of Whatcom County's water quality monitoring. Whatcom County will be project partners and provide access to the Geneva Bioretention Pilot Project for sample collections.

Herrera will be the technical lead for Geneva and will assist with development of the QAPP addendum for this project. Also, Herrera will collect all water samples from the Geneva facility in Bellingham, collect pH and hardness field measurements, and ship samples to KCEL for further analyses. Herrera will also provide technical assistance with other aspects of this project as needed.

Table 1. Project team and partners, roles, and contact information

Organization	Roles and Responsibilities	Contact
King County, Toxicology and Contaminant Assessment Unit	Grant management & Project Manager (project team)	Water Quality Planner/Project Manager III (unfilled position)
	Science advisor (project team)	Jenée Colton, 206-477-4075, jenee.colton@kingcounty.gov
	Technical support (project team)	Jennifer Lanksbury, 206-263-3674, jlanksbury@kingcounty.gov
King County, Stormwater Services	Technical advisors (project team)	Todd Hunsdorfer, 206-263-0922, thunsdorfer@kingcounty.gov
		David Batts, 206-477-4636, david.batts@kingcounty.gov
King County Environmental Lab (KCEL)	Toxicological test lead (project team)	Fran Sweeney, 206-477-7117, Francis.Sweeney@kingcounty.gov
	Laboratory Project Manager (project team)	Meghan Elkey, 206-477-7154, Meghan.Elkey@kingcounty.gov
Whatcom County, Stormwater Program	Manager of the Geneva Bioretention Pilot Project (project partner)	Kraig Olason, 360-778-6301, kolason@co.whatcom.wa.us
Herrera Environmental Consultants, Inc	Technical manager Geneva Bioretention Pilot Project, Technical support (project team)	Dylan Ahearn, 206-787-8244, dahearn.herrerainc.com
	Technical support (project team)	Timothy Clark, 971-361-2238, tclark@herrerainc.com

Project management strategy

King County and its staff have a wealth of experience in managing grants and water quality projects. Our project management strategy will be to use well-established project management tools for monitoring and controlling scope, and establishing clear roles, responsibilities, and lines of communication. For example, we will include a project team kickoff meeting (reviewing project goals, team member roles, deliverable deadlines), defining a project schedule (e.g., Gantt chart) with interim deadlines and explicit buffer time, defining task and deliverables assignments, scheduling regular team check-ins, and communicating with team members, partners, and advisors regularly to anticipate and resolve risks to the project. Our project status and progress will be documented in semi-annual progress reports. The King County project manager will be the central point of contact for Ecology, the TAC, and our project partners.

Project budget and schedule

This project is expected to begin in January 2024 and continue through the end of May 2026, when the final report and presentations have been delivered. Specific time periods expected for planning and sampling at the two project sites are outlined below in Table 2. This project is estimated to cost \$267,000 as outline below in Table 3.

Table 2. Project Schedule - Geneva Bioretention Pilot Project

Task	Schedule
Task 1: Project Development and Planning	Jan 2024 – Aug 2024
Deliverable: QAPP addendum (Geneva)	Feb 2024
Task 2: Field Sampling and Analysis	Jan 2024 – June 2025 (Geneva sampling) Jan 2024 – Aug 2025 (Lab analyses)
Task 3: Data Analysis and Final Report	Sept 2026 – Mar 2026
Deliverable: Final report	Mar 2026
Task 4: Distribution of Findings	Feb – Mar 2026
Deliverable: EIM submittal	Nov - Dec 2025
Deliverable: Presentations	Feb – May 2026
Deliverable: Data dashboard	Feb – April 2026
Deliverable: SAM Fact Sheet	Feb 2026
Task 5: Project Administration	Throughout project
Deliverable: Invoice and progress reports	Semi-annually

Table 3. Project budget

Task	Estimated Cost
1. Project Development and Planning	\$42,000
1.1 Organize TAC	\$3,000
1.2 Project team meetings	\$30,000
1.3 QAPP addendum	\$9,000
2. Field Sampling and Analysis	\$92,000
2.1 Geneva field sampling	\$5,000
2.2 Analytical work	\$87,000
3. Data Analysis and Final Report	\$53,000
3.1 Data management	\$4,000
3.2 Data review and validation	\$7,000
3.3 Data analysis	\$8,000
3.4 Final report	\$40,000
4. Distribution of Findings	\$30,000
4.1 EIM data submittal	\$1,000
4.2 Presentation of findings	\$13,000
4.3 Data dashboard	\$11,000
4.4 SAM Fact Sheet	\$5,000
5. Project Administration	\$20,000
5.1 Subcontractor management	\$13,000
5.2 Budget management	\$4,000
5.3 Invoices and progress reports	\$3,000
Contingency (10%)	\$24,000
TOTAL	\$267,000

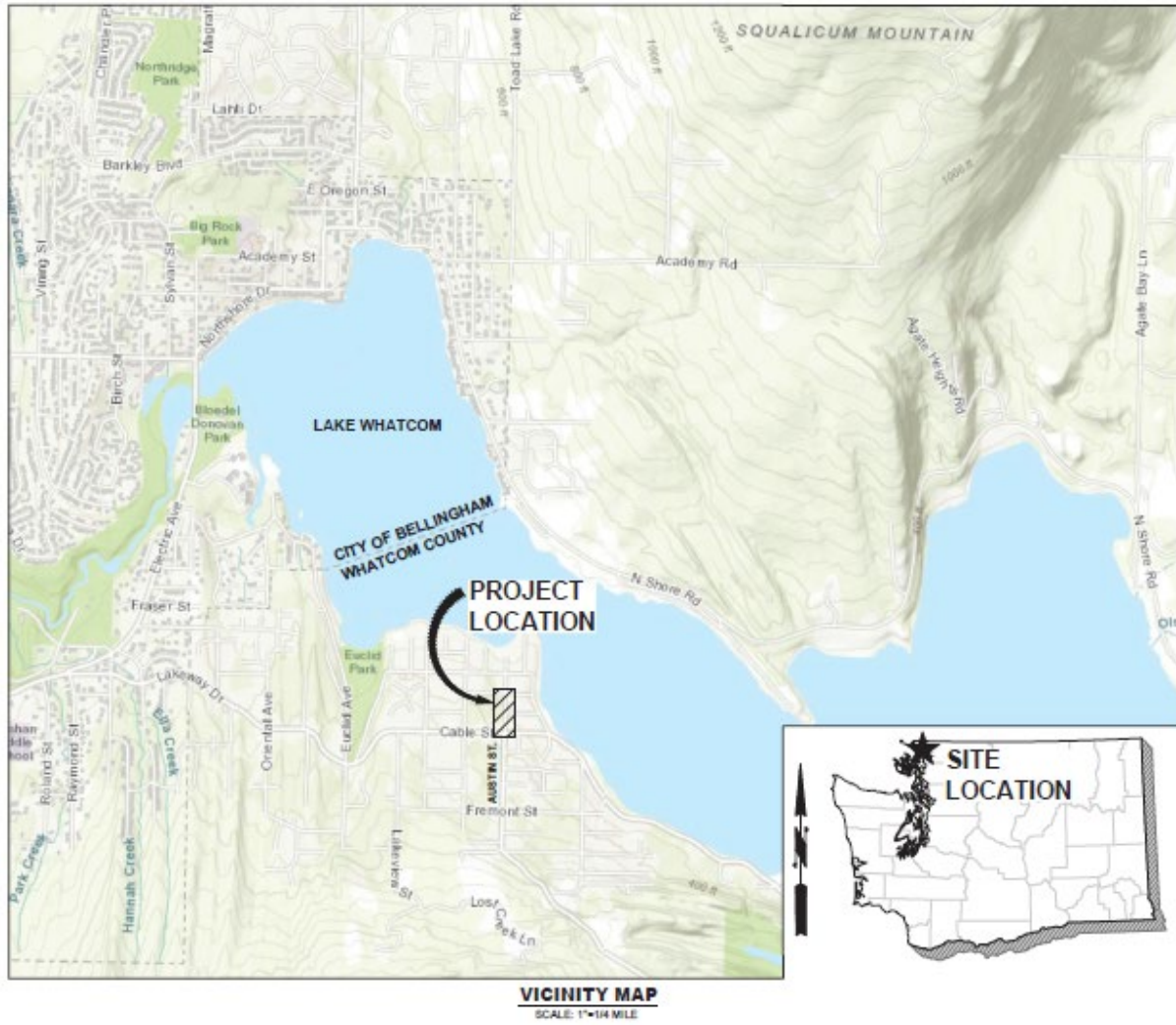


Figure 1. Location of Geneva Bioretention Pilot Project (Herrera 2022⁴)

⁴ Herrera. 2022. Design Report Geneva Bioretention Pilot Project. Prepared for Whatcom County Public Works Department. Prepared by Herrera Environmental Consultants, Inc. May 27, 2022.

**WHATCOM COUNTY
PUBLIC WORKS DEPARTMENT**



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ELIZABETH KOSA
DIRECTOR

May 18, 2023
Josh Baldi
Water and Land Resources Division Director
King County Department of Natural Resources and Parks
King Street Center
201 South Jackson St., Suite 5600
Seattle, WA 98104

RE: Letter of support – In-situ Bioretention Effectiveness Monitoring Study grant application

Dear Mr. Baldi,

This is a letter of support for the *In-situ Bioretention Effectiveness Monitoring Study* grant application. We are excited to have King County Department of Natural Resources and Parks (DNRP) join our project to analyze the potential for 6PPD-quinone treatment in our Geneva bioretention facility, which is being upgraded with high performance bioretention soil media (HPBSM) and an improved distribution system.

Whatcom County has been an eager and early adopter of various methods to extract phosphorus from surface waters in the Lake Whatcom watershed. The original Geneva Swale project, installed in 2006, was an effort to reduce phosphorus transport to Lake Whatcom, the primary drinking water source for over 100,000 residents in Whatcom County. However, the system did not perform as intended due to excessive infiltration and low efficiency of the original engineered soil. Whatcom County is moving forward with the Geneva Bioretention Pilot Project to improve the facility's water quality treatment performance as part of our ongoing retrofit program.

The pilot project is situated in a residential neighborhood, but receives much of its water from a busy street. Identifying stormwater-management approaches to treat and remove 6PPD-q before it reaches salmon-bearing streams is a high priority in our region. We are happy to play even a minor role in that process. An analysis of the HPBSM's effect on 6PPD-q and other vehicle-related contaminants will provide valuable information for future projects in the region and may lead to a reduction of pre-spawn mortality in coho salmon. Working with Herrera Environmental, Whatcom County's consultant for this project, also adds to overall project efficiencies.

We strongly support this application and look forward to working with DNRP staff and our consultants to complete this important work. For any questions, please contact Kraig Olason at kolason@co.whatcom.wa.us or 360-778-6301.

Sincerely,

A handwritten signature in cursive script, appearing to read "Kraig Olason".

Kraig Olason, Stormwater Division Manager
Whatcom County Public Works
322 North Commercial Street, 4th Floor
Bellingham, WA 98225


Certifications and Assurances Form

SIGNATURE AND CERTIFICATION

I CERTIFY TO THE BEST OF MY KNOWLEDGE THAT THE INFORMATION IN THIS APPLICATION IS TRUE AND CORRECT AND THAT I AM **THE LEGALLY AUTHORIZED SIGNATORY OR DESIGNEE** FOR THE SUBMITTAL OF THIS INFORMATION ON BEHALF OF THE APPLICANT.

Josh Baldi

PRINTED NAME

DocuSigned by:

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SIGNATURE

WLR Division Director, DNRP

TITLE

5/30/2023

DATE

This page may be submitted on the reverse side of the project proposal cover page or submitted as a separate PDF.