Scope of Work Outline

Testing the effectiveness of bioretention at reducing the toxicity of urban stormwater to coho salmon

Background/Abstract

Myriad efforts are underway to reduce the ecological impacts of polluted stormwater runoff throughout Puget Sound with Low Impact Development methods (LID) being just one example. While these activities represent an unprecedented societal investment, there is still little known about their effectiveness – specifically, whether toxic loadings are reduced to the extent that the biological integrity of "receiving waters" (aquatic habitats) is ensured. Common metrics for evaluating LID effectiveness have either been physical (e.g., % surface flow reduction) or chemical (e.g., % reduction in mass loading for specific metals or nutrients). Comparatively little research has focused on biological metrics. This is important because a LID approach might be successful from the standpoint of physical and chemical indicators, and yet fail to protect salmonids and other aquatic species from the harmful effects of toxics. In recent years, research by NOAA Fisheries, the U.S. Fish and Wildlife Service (USFWS), and Washington State University (WSU-Puyallup) has shown that degraded stormwater quality can significantly impact the health of fish and the biological communities that support productive aquatic ecosystems. Major findings include mortality in coho salmon adults returning to restored urban streams (pre-spawn mortality; PSM) and mortality and developmental abnormalities in coho embryos rearing in restored urban streams.

For the proposed work, stormwater will be collected from SR 520 near the NOAA Northwest Fisheries Science Center and transported to the Grovers Creek Salmon Hatchery. The water will be treated on-site using bioretention columns and both adult and embryonic coho exposed to either well water, untreated stormwater or treated stormwater. The objective will be to test the biological effectiveness of bioretention for preventing PSM in coho spawners and developmental toxicity in coho embryos exposed to urban runoff. This project will combine research expertise on the toxic impacts of stormwater (NOAA and USFWS), expertise in the design and implementation of LID methods at Washington State University's Stormwater Center, and ongoing salmon management activity at the Suquamish Tribe's Grovers Creek Salmon Hatchery. The objective is to demonstrate the effectiveness of a specific LID strategy (bioretention using rain barrels) at preventing toxic effects to two life stages of coho salmon. New information on bioretention effectiveness will inform a broad diversity of Puget Sound stakeholders as they adaptively manage stormwater runoff in urbanizing watersheds.

See final proposal and QAPP for more details.

Task 1 (Total Cost $26,839)

Build, install and condition bioretention cells

Deliverable 1 = Final design drawings and pictures of the four completed bioretention cells

$26,839 Due Date: September 30, 2014

We will construct four 200-L (55-gallon) bioretention cells at Grovers Creek Salmon Hatchery plumbed with under drains following guidelines outlined in the Stormwater Management Manual for Western Washington (Department of Ecology 12-10-030, Aug 2012). Bioretention cells will be filled with a drainage layer of gravel aggregate overlain by a mixture of 60% sand: 40% compost.

Clean water will be run through the bioretention cells to 'age' them to 20 pore volumes, equivalent to one month of rainfall on an appropriate contributing area (treatment area = 2.5% of contributing area).

Task 2 (Total Cost $2,982)

Compost used in bioretention cells will be tested for metals before conditioning. Water chemistry of effluent following conditioning will be tested for the analytes including several metals; conventionals including nutrients, bacteria; and a suite of PAHs. Tables excerpted from the final proposal appear at bottom of the Scope of Work and these are the parameters that will be summarized in these brief reports.

Deliverable 2.1 = Brief report on metal concentration of compost used in bioretention cells

$800 Due Date: December 31, 2014

Deliverable 2.2 = Brief report on baseline water chemistry of effluent from conditioned bioretention cells

$2,182 Due Date: December 31, 2014

Task 3 (Total Cost $59,642)

Highway runoff transported to the Suquamish Tribal Hatchery at Grovers Creek will be filtered on-site where adult coho spawners and coho embryos will be exposed to one of three treatments; unfiltered runoff, filtered runoff, or well water. Exposures and water chemistry measurements will follow those in our existing EPA QAPP and overall scope of work.

Deliverable 3.1 = Brief report on effects of treated effluent on female adult coho

$22,366 Due Date: December 31, 2014

Healthy female adult coho returning to the Suquamish Tribal Hatchery on Grovers Creek will be placed in PVC holding tubes in experimental waters as described. Each holding tube will be equipped with a hose to pump water flow across the fish gills and each treatment tank will be aerated to maintain dissolved oxygen at optimum levels for adult coho health during exposures.

After 4 hours of exposure, each coho will be removed from the holding tube and released into a tank of clean water for observation. Adults exposed to untreated runoff typically show overt symptoms of pre-spawn mortality (disorientation, unresponsiveness, loss of equilibrium, or death) after 4 h. Exposures will be extended for 24-48 h to compare mortality rates among treatments and to note if there are delayed effects from exposure to treated runoff compared with controls.

The brief report will summarize the number of successful trials performed during the performance period, as well as rates of survival and sublethal symptoms in adults for each treatment for each trial. This report will be used to construct the final report summarizing the findings of the entire study.

Deliverable 3.2 = Brief report on effects of treated effluent on coho embryo development

$29,821 Due Date: March 31, 2015

Coho eggs spawned and fertilized at the Suquamish Tribal Hatchery on Grovers Creek will be reared on-site by hatchery personnel. Eggs will be divided into three treatment groups episodically exposed to untreated runoff, bioretention-treated runoff, or clean well water (no episodic exposures). Between episodic runoff exposures, eggs will be reared in clean well water. The experiment will run for up to six months – covering the developmental period of coho salmon eggs. Replicate exposures will allow for destructive sampling of coho eggs during the experiment (e.g., 1-mo sampling intervals).

Endpoints will include coho egg survival and development including morphometrics previously shown to be affected by stormwater runoff including length, eye size, and pericardial area. Developing fish are particularly susceptible to cardiotoxic contaminants in stormwater runoff, thus special attention will be paid to cardiovascular abnormalities in coho embryos. Stereomicroscopic digital images will be taken of each embryo sampled for later analysis.

This experiment will make use of the expertise of our multiple partners including GSI treatment (WSU), salmon rearing (Suquamish Tribe), fish developmental toxicity (NOAA), and fish health (USFWS).

The brief report will summarize the number of exposures performed on coho embryos, the conditions of each exposure (diluted vs whole runoff, durations of exposure), and the results in terms of survival and sublethal effects on coho embryos. This report will be used to construct the final report summarizing the findings of the entire study.

Deliverable 3.3 = Brief report on chemistry of treated effluent

$7,455 Due Date: June 30, 2015

For each coho exposure, water samples will be taken from each treatment. Analytes to be measured include metals (Cd, Cu, Ni, Pb, Zn, Ag, As, Cr), a suite of conventional water chemistry parameters (including nutrients), bacteria, and a suite of parent and alkylated homologue polycyclic aromatic hydrocarbons (PAHs). Tables excerpted from the final proposal appear at bottom of the Scope of Work. PAH analyses will be performed by the Environmental Chemistry Program at NOAA Fisheries' Northwest Fisheries Science Center. Additional analyses will be performed by AmTest Laboratory (Kirkland, WA). Dissolved oxygen, pH, temperature and conductivity will be measured on-site. Water chemistry measurements for PAHs will follow QA/QC established by NOAA-Fisheries (Sloan et al. 2014).

A brief report will summarize the chemistry findings and this report will be used to construct the final report summarizing the findings of the entire study.

Task 4 (Total Cost $59,642)

Two presentations and final, cumulative report

Analysis for effect of treatment on water chemistry, adult coho, and coho embryos will culminate in a final report. This final report constructed in part by using the brief reports that were deliverables in task 3. The final report will summarize the findings of the entire study.

Results will also be directly presented to public, regulatory, and/or scientific audiences in at least two formal presentations.

Deliverable 4.1 = Presentation (#1) on study findings

$2000 Due Date: June 30, 2015

Results of this project will be presented at a minimum of two public meetings; including the SWG meeting in June 2015 (presentation #1) and at another regional stormwater forum (presentation #2); perhaps like at the 2015 WSU LID Annual Review in Puyallup, WA. The WSU LID Annual Review is widely attended and draws a mixed public, regulatory, and scientific audience.

Deliverable 4.2 = Presentation (#2) and Final, cumulative report

$57,642 Due Date: September 30, 2015

The final report will describe the entire study and will include all prior deliverables. Following Ecology's approval, and publication of the data in a peer-reviewed scientific journal, the report will be available on the Washington Stormwater Center's website.

Calendar Year	**2014**		**2015**		
Task and Deliverables	3	4	1	2	3
1. Build & condition bioretention cells D1. Bioretention cells for treatment of runoff					
2. Baseline water quality & compost testing D2. Brief report on baseline conditions					
3. Coho exposures & chemistry D3. Brief preliminary reports					
4. Data analysis and communications D4. Presentations & final, cumulative report					

Budget Detail by Task

	Task 1	Task 2	Task 3	Task 4	Total by Object
Salaries & Benefits	$12,816	$1,424	$28,480	$28,480	$71,200
Supplies	$540	$60	$1,200	$1,200	$3,000
Equipment	$2,340	$260	$5,200	$5,200	$13,000
Travel	$918	$102	$2,040	$2,040	$5,100
Subcontracts	$6,300	$700	$14,000	$14,000	$35,000
Indirect/Overhead	$3,925	$436	$8,722	$8,722	$21,805
Total Task	$26,839	$2,982	$59,642	$59,642	$149,105

List of metals, conventionals, and bacteria to be analysed

Analytes to be measured
Total and dissolved Cd, Cu, Ni, Pb, Zn, Ag, As, Cr
Total suspended solids
Suspended sediment concentration
Dissolved organic carbon
Chemical oxygen demand
Hardness
Alkalinity
pH
Ammonia
Total nitrogen and nitrates
Total Phosphorus and ortho-P
E. coli, fecal coliform

List of PAHs to be analyzed

Abbreviation	Rings	PAH Name
NPH	2	Naphthalene
C1-C3NPH	3	Alkylated naphthalenes
ACY	3	Acenaphthylene
ACE	3	Acenaphthene
FLU	3	Fluorene
C1-C4FLU	3	Alkylated fluorenes
DBT	3	Dibenzothiophene
C1-C4DBT	3	Alkylated dibenzothiophenes
PHN	3	Phenanthrene
C1-C4PHN	3	Alkylated phenanthrenes
ANT	3	Anthracene
PYR	4	Pyrene
FLA	4	Fluoranthene
C1-C4FLA	4	Alkylated fluoranthenes
CHR	4	Chrysene
C1-C4CHR	4	Alkylated chrysenes
BAA	4	Benzo[*a*]anthracene
BBF	5	Benzo[*b*]fluoranthene
BKF	5	Benzo[*k*]fluoranthene
BEP	5	Benzo[*e*]pyrene
BAP	5	Benzo[*a*]pyrene
PER	5	Perylene
IDP	5	Indeno[*1,2,3-cd*]pyrene
DBA	5	Dibenz[*a,h*]anthracene (and [*a,c*])
BZP	6	Benzo[*ghi*]perylene