Puget Sound Nearshore Sediment Monitoring for the Regional Stormwater Monitoring Program (RSMP)
A proposal prepared by the USGS Washington Water Science Center for the Washington State Department of Ecology

5/24/16

INTRODUCTION

The Stormwater Work Group (SWG) of Puget Sound is a coalition of federal, tribal, state, and local governments; business, environmental, and agricultural entities; and academic researchers. All SWG members have interests and a stake in the Puget Sound watershed. The SWG was convened by the Puget Sound municipal stormwater permittees, other stakeholders, and the Washington State Department of Ecology (Ecology) in October 2008 to develop a regional stormwater monitoring strategy and to recommend monitoring requirements in National Pollutant Discharge Elimination System (NPDES) stormwater permits issued by Ecology. In 2012, the SWG became the first "topical workgroup" included in the Puget Sound Ecosystem Monitoring Program (PSEMP), an organization designed to coordinate regional monitoring efforts to assist in providing information to support Puget Sound recovery efforts.

An overall strategy for monitoring and assessment for the Puget Sound region was developed by the SWG in 2010 (SWG, 2010a). This strategy included recommendations for status and trends monitoring of Puget Sound nearshore sediment, with a focus on an integrated approach to quantify stormwater pollutant impacts in Puget Sound, and providing information to efficiently, effectively, and adaptively manage stormwater to reduce harm to the ecosystem. A Marine Nearshore Status and Trends Subgroup (Subgroup) of the SWG was formed in December, 2010 to developed a set of recommendations to launch a nearshore status and trends monitoring program that would sample 1) sediment quality, and 2) health of the biota (i.e., mussels) and water quality (i.e., presence of fecal coliform bacteria). Based on discussions and recommendations of this Subgroup, it was agreed that a Nearshore Sediment Quality Monitoring Program should be designed and conducted to address the issues identified above.

The SWG also recommended a specific NPDES municipal permittee-funded plan for monitoring the effects of stormwater under the permits in the Puget Sound region (SWG, 2010b). The resulting program, a subset of the overall strategy, is called the Regional Stormwater Monitoring Program (RSMP). Specifically, the RSMP includes status and trends monitoring of water quality and "watershed health" (physical habitat, sediment chemistry, and biological communities) in small streams in the Puget Sound lowlands; and of sediment quality, bacteria, and mussel contaminants in the marine nearshore of Puget Sound. Additional information about the experimental design, the goals, and the objectives for status and trends and other monitoring in the RSMP can be found in Appendix A of the QAPP report, in SWG (2010a and 2010b), and at the RSMP website (http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp/rsmp.html).

The new program will characterize sediment quality in a newly created nearshore sampling framework that intersects with and is adjacent to existing state spatial/temporal sampling framework

(http://www.ecy.wa.gov/programs/wq/stormwater/municipal/RSMPSOW22July2013.pdf). For this study, only the marine shoreline and nearshore parallel to the City and Urban Growth Area (UGA) will be sampled. This sampling frame for Puget Sound was defined to include the basins, channels, and embayment of Puget Sound from the US/Canada border to the southern-most bays and inlets near Olympia and Shelton; Hood Canal; and portions of Admiralty Inlet, the San Juan Islands, and the eastern portion of the Strait of Juan de Fuca. The shoreline master sampling frame was targeted to the land-based UGA boundaries within the Puget Sound basin. All potential monitoring sites within the nearshore UGA will be selected using a probabilistic design (SWG, 2010a). Sediment collection and sample analysis will be implemented based on modified methods from the existing state collection methods (Dutch et al., 2009).

The RSMP Coordinator at Washington Department of Ecology has requested the help of the U.S. Geological Survey's Washington Water Science Center in the technical and logistical oversite of this sampling effort. The USGS will help develop the technical methods used during this project as well as help coordinate the sampling efforts of a small monitoring team made up of state and local government entities which include Washington State Department of Natural Resources (WADNR) and King County. A total of 40 sites will be sampled. The USGS in collaboration with WADNR will be responsible for monitoring at 30 nearshore sites from June to August of 2016 in Whatcom, Snohomish, Thurston, Mason, Kitsap, Jefferson, Clallam, Skagit and San Juan Counties. King County will be responsible for 10 sites in their county. The proposal presented here describes the entire study which encompasses the 40 sites and the interpretation of the data as well as the additional analyses being performed by the USGS, but budget numbers are specifically for USGS staff and expenses. The budget for WADNR and King County staff and expenses are contained within contracts between these agencies and Washington Department of Ecology

PROBLEM

The overall goal of the program is to document whether or not the current requirements in the NPDES permits are protective of nearshore sediment, and if not, adaptively manage the permit requirements to ensure preservation of nearshore health in the future. The RSMP has sought out the USGS to help implement and interpret this first round of nearshore sediment monitoring to assure a successful start to the program, and to draw on USGS expertise to help refine the monitoring for subsequent monitoring rounds. The goals of this effort include:

1. Assess the health of Puget Sound sediment quality in the nearshore urban areas, defined as being inside nearshore areas parallel to established UGAs.
2. Document geographic patterns.
3. Help establish protocol to document natural and human-caused changes over time in Puget Sound nearshore sediments.
4. Identify existing nearshore sediment quality problems and, where possible, provide data to help target sources.
5. Support nearshore research activities by making available uniformly collected, high quality data.
6. Provide nearshore data to assist the regulatory agencies in measuring the success of stormwater and other environmental management programs.

Concurrent with this study is an RSMP study led by Washington State Department of Fish and Wildlife to examine mussel tissue contamination levels at a majority of the sites planned for the sediment sampling. The results from the mussel studies will be examined in collaboration with the proposed sediment work to help address the goals described above. Furthermore, the sediment chemistry results from this study will provide an excellent collaborative opportunity with the on-going USGS funded Coastal Habitats in Puget Sound (CHIPS) program to further identify the role sediment contamination may play in the deterioration of nearshore habitats in the Puget Sound.

OBJECTIVES and SCOPE

The primary objective of this nearshore sediment sampling is to collect data at pre-selected sites within the UGA sampling framework to establish a "pre-permit" baseline of sediment chemistry, quantitatively assess the role natural and anthropogenic factors may play in determining sediment quality and provide scientifically based modifications or updates to the proposed sampling protocol for future sampling activities. A QAPP for how this study will be performed and evaluated is part of the proposed study and will be prepared by the USGS. A detailed scope of work for the effort that has been developed in close cooperation with the RSMP Coordinator at Washington Department of Ecology is included as Attachment A of this proposal.
In addition to the status and trends monitoring described in Attachment A, the USGS will examine the effects of flow alteration at a subset of the RSMP sites. Although previous USGS work has shown that flow in streams is an important stressor to biological communities (Kennen and others, 2008), this type of analysis is currently not included in the RSMP program for small streams. Therefore, information on flow alteration at these sites will be provided on a subset of the RSMP sites to allow Ecology to adaptively manage the stormwater permitting process for the Puget Sound region.

RELEVANCE and BENEFITS

Completion of the proposed work will provide the USGS with additional information on nearshore sediment chemistry adjacent to areas of differing levels of urbanization and associated stormwater that will assist in understanding and describing the Nation's water resources. This data addresses a key aspect of the current USGS science strategy to report on the nature of the nation's marine ecosystems and to provide information to policy makers to make decisions to maintain ecosystem health and sustainability (USGS, 2007). It will also provide additional and invaluable information to the USGS funded CHIPS program charged with providing scientific information necessary to help restore the Puget Sound Ecosystem.

This study will provide Municipal Stormwater Permittees throughout Puget Sound with documentation of nearshore sediment chemical levels at the beginning of the Regional Stormwater Monitoring Program that will serve as a baseline for monitoring trends in the status of these chemicals over multiple 5-year permit cycles. This information will also help the permittees, along with EPA and the Department of Ecology; evaluate the combined effectiveness of current and future stormwater management activities on protecting or improving nearshore sediments on a regional scale. The permittees will benefit by having the USGS serve as an unbiased third party with extensive technical expertise in the collection and analysis of sediment

chemistry data. In addition to providing consistent and reproducible data, USGS expertise will be used to suggest any refinements that may improve this and similar regional-scale nearshore sediment monitoring programs. The public will gain an improved understanding of the status of nearshore sediment chemistry and will be provided information on the benefits that are expected to result from the costs of implementing municipal stormwater permits.

APPROACH

The USGS will coordinate and collaborate in the collection of marine sediments from nearshore environments at 40 sites within the Puget Sound during the summer of 2016. The USGS in partnership with WADNR will be responsible for sampling 30 sites, while King County will sample 10. The 30 sites the USGS is responsible for sampling were selected to coordinate where possible with the RSMP's Puget Sound Mussel Monitoring sample sites. The intent of the study design was to create a random list of sites, using a Generalized Random Tesselation Stratified (GRTS) model for drawing spatial samples, from a population of sites along urban growth areas (UGAs) of the Puget Sound. Each site represents an average shoreline length of 800 meters (m). The RSMP used an 800 m length of shoreline to represent a sampling site based on criteria used by the National Centers for Coastal Ocean Science's COAST National Status & Trends Mussel Watch Contaminant Monitoring program. The GRTS algorithm resulted in a total of 2,048 sites in Puget Sound's UGAs, of which 40 locations were selected based on a randomized numerical ordering of potential sites (Figure 1). If any of the original 40 sites cannot be sampled, the next randomly ordered site within the 2048 sites will be sampled until 40 (30 by USGS) sites have been sampled.

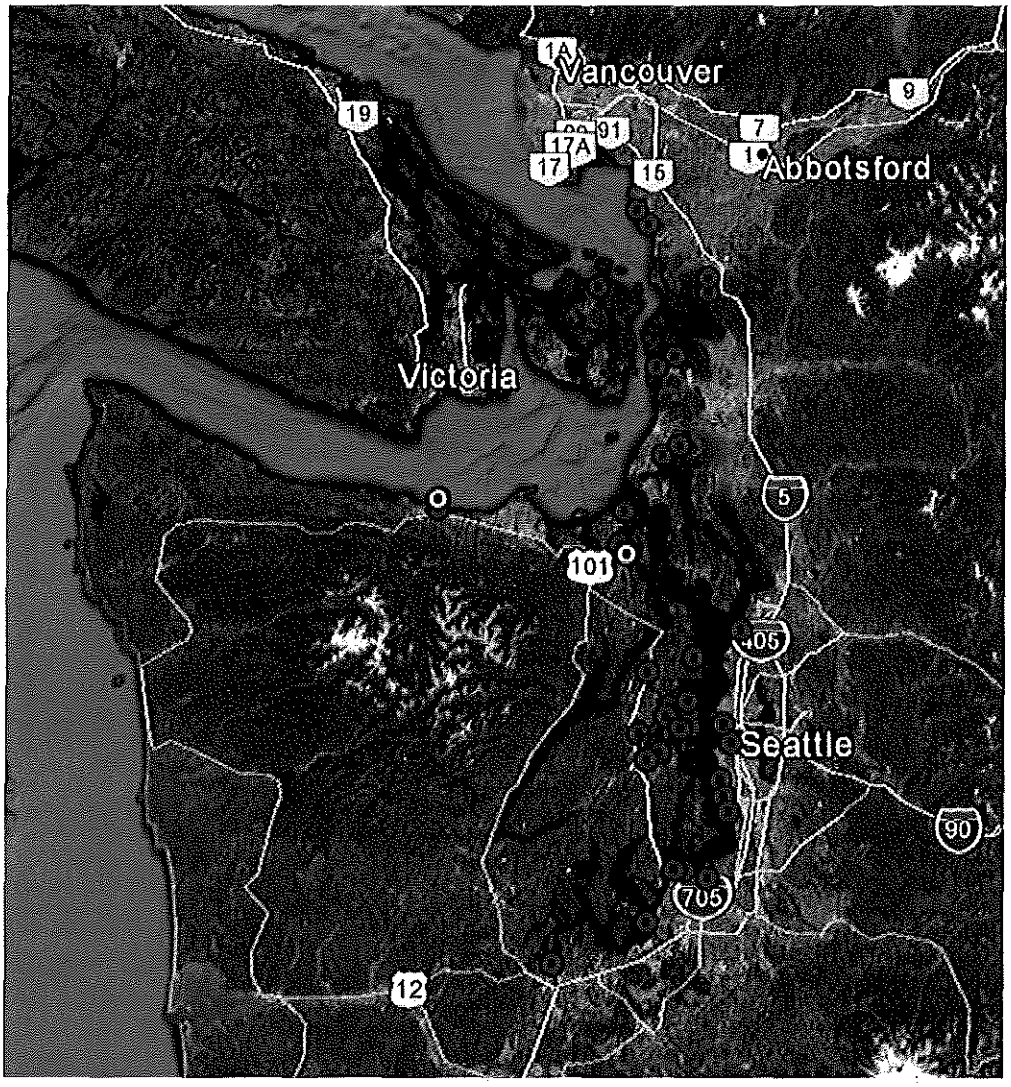
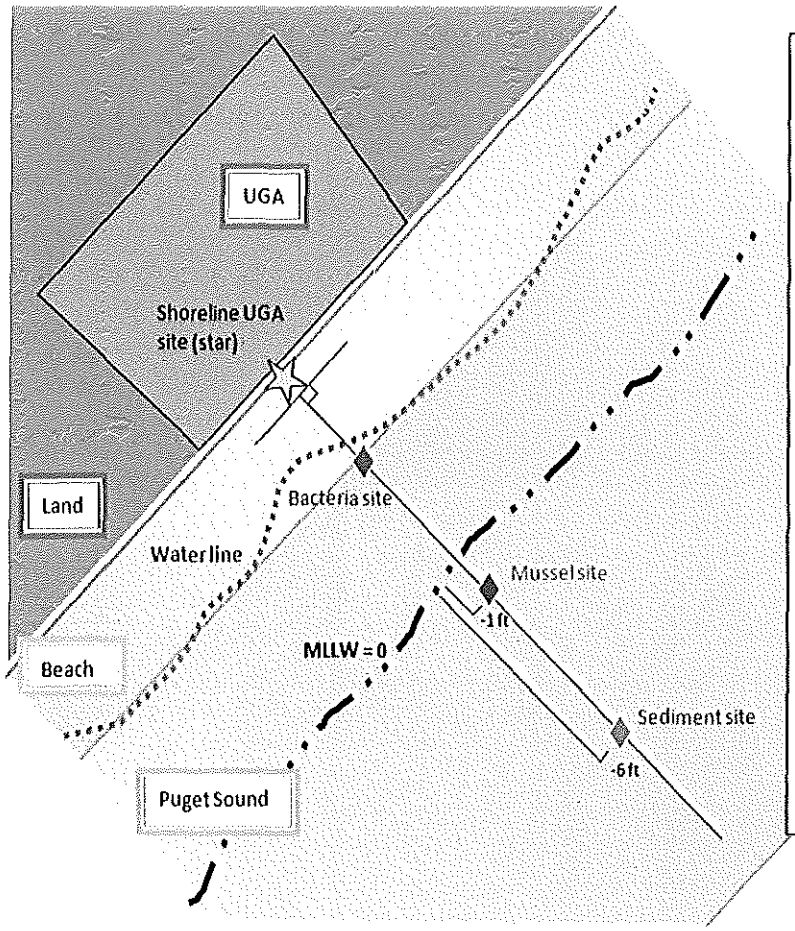


Figure 1 Nearshore sediment sampling locations (40 sites). Puget Sound is black in the figure.

Each candidate site's coordinates mark a location in the center of an 800 meter (m) long shoreline segment within the Puget Sound (hereafter called the candidate "site center"). The site center is located in the high intertidal zone. Figure 1 illustrates the layout of the sampling locations at each candidate marine site. Extending from the candidate site center (shown with a star in Figure 2) in a straight line perpendicular to the shoreline and into the subtidal zone are three distinct marine sampling locations. The first of the three locations (at the waterline), is intended for sampling of bacteria, the second location (in the intertidal zone) is designated for mussel cage deployment, and the third location (in the subtidal zone) is intended for sediment sampling, the focus of this study.



Sampling Site Descriptions

The shoreline UGA list gives coordinates for the shoreline location (star). A perpendicular line from the shoreline is drawn through the coordinates. An initial sediment sampling site is located on this perpendicular line 6 feet below mean low low water (MLLW).

Additional sampling sites for bacteria and mussels are also located along this perpendicular line. Bacteria and mussel sampling are not part of this study's sampling objectives, but the results from these sampling efforts may be examined as part of this studies interpretation.

Figure 2 Detailed sample site location.

A marine research vessel of adequate size provided by the Washington State Department of Natural Resources, and suitably equipped for deployment of sample collection equipment and shipboard sample processing will be reserved for this work. From this platform, sites locations will be identified using a Global Positioning System (GPS) with expected accuracy of better than 3 meters. Variable radar ranging, water depth, and line-of-sight fixes on land objects may supplement the GPS if necessary.

A field log will be completed for each sediment monitoring site. The field log will consist of the following information:

- Sample identification, date, time, location, depth, description
- Sampling crew
- Weather and sea state
- Collection gear
- Collection status (i.e., successful, site rejected, site moved)
- Visual description of sediments
- Field measurements
- Parameters sampled
- Information for individual sediment grabs

- Observations of adjacent shoreline land uses, beach condition, and other landscape features
- Who generated the field log
- Comments

Observations of the shoreline will include a photo and description of the adjacent shoreline, including land uses, beach condition, municipal or private outfalls, streams, and other significant landscape features or in-water activities within approximately one-half mile in either direction along the shoreline from the sampling location. Field log information must document rejected sites, if and when sites are found to be unsuitable. A daily log will also be generated with information on samples collected from each day.

Sediment samples will be collected using a stainless-steel vanVeen grab sampler or similar sampler to collect a volume of sediment, which will allow sediment for chemistry, TOC, and grain size to be collected simultaneously. The mass of sediment needed under this monitoring program will likely require 1 to 3 grab samples using a single vanVeen. Once in position, the grab sampler will be lowered to the bottom with the vessel's cable and winch system where it will be triggered and close upon contact with the sediment surface, and a sample will be collected. The grab sampler will then be raised back up to the vessel and landed on a grab stand.

The collected sediment sample will be visually inspected. Any grab sample lacking fine-grained particles in the sediment (e.g., composed of all cobble, shell hash, or wood), or for which the jaws of the grab sampler do not close completely, will be rejected. Any grab sample that has either a less-than-adequate penetration depth or over-penetration will be discarded. If a sample is rejected, it is dumped overboard after the vessel has been repositioned away from the target location. If a site lacks fine-grained particles in the sediment (e.g., rocks prevent grab closure or the substrate is composed of all shell hash), location within a short distance (~100 M) in either direction parallel to the beach coordinates will be examined. However in some cases it will be necessary to reject that site after 3 failed attempts, document it, and proceed to the next site on the list of replacement sites.

A successful sediment sample will capture sediments with overlying water. Using a stainless-steel spoon, sediments from the top two to three centimeters are scooped up being careful to avoid the sediment touching the sides of the vanVeen. The sediment will be put in a pre-cleaned stainless-steel bowl and covered with a lid or foil. On subsequent grabs, if necessary, the top two to three centimeters of sediment on both sides of the grab are collected and added to the bowl. Grabs are taken until enough sediment is collected to fill all necessary sample containers for the site. The composited sediment in the bowl will be homogenized by stirring with a pre-cleaned, stainless-steel spoon until a uniform texture and color are achieved. Samples to be analyzed for organics will be sieved at 2mm and metals will be sieved at 63 microns as described in Shelton and Capel (1994). After the sample jars are filled, they are placed in polyethylene bags, and set in coolers on ice and will be delivered to the lab within 24 to 48 hours. Leftover sediment is returned to the water column at the site or kept for an archive sample.

After an acceptable grab sample is taken, field observations will be made of the grab sample. One side of the double vanVeen device, or the samples' periphery area, is used for determining

physical/environmental characteristics including sample penetration depth, sediment temperature, salinity of the overlying water, and sediment texture, color, and odor (Table 1). Chemical analyses of the sediment samples will be performed at a combination of 3 laboratories: Washington States Manchester Environmental Laboratory (MEL), King County's Environmental Laboratory (KCEL) and Axys Analytical in Vancouver Canada as noted in Table 1.

Historic inter-lab comparisons between MEL and KCEL have shown that methods used to characterize conventional parameters are comparable. For metals, PAHs and phthalates, MEL will analyze samples from all 40sites. An additional 10 duplicate samples will also be analyzed by KCEL for these parameters to help evaluate laboratory differences.

At a subset of the sites (~30), an additional sediment sample will be collected from the homogenized sample for microplastic analysis. The WAWSC is currently developing a new laboratory designed to determine the amount of plastics found in both water and sediment. For this project the focus will be on sediment and we will look for plastics down to ~100 microns. Currently, there are no USGS or EPA approved methods for this analysis. Therefore, this study will utilize the methods outlined in Masura and others (2015) and modify the method to include plastics between 300 and 100 microns.

Table 1. Marine sediment chemistry monitoring field measurements and observations, and parameters analyzed in the laboratory. MEL = Washington State's Manchester Environmental Laboratory, KCEL= King County's Environmental Laboratory and Axys = Axys Analytical in Vancouver Canada

Field Measurements and Observations
Sediment temperature
Sample penetration depth
Salinity of overlying water
Sediment texture, color, and odor
Laboratory Analyses
Conventional Parameters: • Grain size (MEL, KCEL) • Total organic carbon (TOC) (MEL, KCEL)
Metals: • Priority pollutant metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. (MEL, KCEL) • Metalloids: tin(MEL, KCEL)
Organics: • Low molecular weight polynuclear aromatic hydrocarbons (LPAHs) (MEL, KCEL): o 1,6,7-trimethylnaphthalene, 1-methylnaphthalene, 1-methylphenanthrene, 2,6-dimethylnaphthalene, 2-methylnaphthalene, 2-methylphenanthrene, acenaphthene, acenaphthylene, anthracene, biphenyl, dibenzothiophene, fluorene, naphthalene, phenanthrene, and retene • High molecular weight polynuclear aromatic hydrocarbons (HPAHs) (MEL, KCEL): o benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, perylene, and pyrene • Phthalates(MEL, KCEL): o bis(2-ethylhexyl) phthalate, butyl benzyl phthalate, diethyl phthalate, dimethyl phthalate, di-n-butyl phthalate, and di-n-octyl phthalate • Polybrominated diphenylethers (PBDEs) (Axys): o 47, 49, 66, 71, 99, 100, 138, 153, 154, 183, 184, 191, 209 • Polychlorinated biphenyls all 209 congeners (Axys)

QUALITY ASSURANCE/QUALITY CONTROL

Sediment samples for this project will be collected using grab samples and processing methods standardized from existing Ecology methods (Ecology 2007) and shared by all parties in the larger project (USGS, King County, DNR and Pierce County) so all samples will match protocols for project consistency. At 4 of the 40 sites, double the amount of sediment will be collected and homogenized for a field replicate. Two sets of sample containers for chemistry, TOC, and grain size analyses will be filled. The 4 sites will be chosen by the project lead. The second set of sample containers will be assigned a different sample identification number and submitted to the laboratory as a blind field replicate.

In addition, 10 additional samples will be split for conducting an inter-laboratory comparison of the labs outlined in Table 1 to ensure data quality and consistency throughout the project. The MEL is an EPA lab and NELAP certified and the King County Lab is accredited by Ecology in Washington State. Both these labs conduct regular performance testing (PT) and this data is available to end users. Therefore these labs are considered Level-1 laboratories and do not require a formal lab evaluation package (Office of Water Quality Technical Memorandum 2014.01). USGS will monitor the quality of the data we collect and request PT data as needed.

The microplastics analysis will generally follow the methods outlined in Masura and others, 2015. Given that microplastic laboratory methods are still under development, the focus of this part of the proposed study are to examine different approaches and compare these methods to laboratory and field spikes using recently developed spike material (personal communication, Julie Masura). As such, oversampling for this component of the project will occur to help develop appropriate and effective lab methods and QA/QC methods.

Field work will be conducted in a manner as to prevent the spread of invasive species. It is possible that during sampling invasive species of benthic invertebrates or marine plants could be collected. To avoid the spread of these species to other areas, procedures applicable to the marine environment from Ecology's SOP, *Minimizing the Spread of Aquatic Invasive Species* (Ecology, 2012), will be implemented. All sediment material not retained for analyses or archiving is washed overboard at or near the sampling location. Additionally, both the sediment sampler (e.g., vanVeen grab) and the bowls or buckets used for homogenization will be rinsed with seawater at each site and also scrubbed clean of any residual sediment and organisms immediately after completion of sampling at each site.

Equipment that comes into contact with the sediment sample must be cleaned prior to sampling and between sampling sites. The grab and all other sampling equipment that comes in contact with the sampled sediment will be scrubbed with a soft brush and Alconox soap and rinsed with *in situ* seawater. This removes any sediment and contaminants from previous sites. The equipment will then be rinsed with acetone, again followed by *in situ* seawater. Residual acetone used for decontamination evaporates quickly and is not produced in sufficient quantity to need to be collected for disposal.

The spoons, spatulas, and homogenization paddle will be placed in the decontaminated sample collection bucket, and a decontaminated lid will be placed over them until needed for the next sample. These precautions are taken to avoid contamination of the samples from engine exhaust, atmospheric particulates, and rain.

SAFETY

Collection of sediment samples aboard a research vessel poses a number of potential safety hazards to the field crew including falling overboard, being struck by heavy equipment, coming into contact with hazardous materials (e.g., acetone), and exposure to extreme temperatures and sunlight. To ensure their safety all crew members are required to follow appropriate jurisdictional guidelines including Ecology's SOP, *Marine Sediment Sample Collection* (Ecology, 2007), and to wear the following safety gear at all times while collecting samples:

- Life vest or floatation suit
- Hard hat
- Closed toed shoes
- Protective gloves
- Temperature and weather appropriate clothes

DATA MANAGEMENT

The field and sediment chemistry data will be stored in Ecology's Environmental Information Management (EIM) database. That database is the primary repository for all RSMP data. Additional data, primarily the microplastics results, will be archived in ScienceBase as a companion data stream to the project report. All relevant components of any statistical models developed as part of the study will be archived according to the USGS guidelines for the archival of surface-water, groundwater, and water quality models (OWQ memo 2015.01). The model archive will fully describe and contain the input data and sources and statistical results to allow for reproduction of the statistical results, in accordance to the USGS Fundamental Science Practices and USGS Office of Water Quality Technical Memorandum 2015.01."

PRODUCTS

A USGS SIR report will be produced based on the results from this study. This work will represent the first known statistically randomized assessment of nearshore sediment chemistry in the Puget Sound. The following issues will be assessed within the report:

1. All field and sediment chemistry results will be summarized and spatially characterized. These summaries will be in the form of tables and figures and will provide the baseline information necessary for the first cycle of nearshore sediment sampling as part of the RSMP. These results will be compared to other historic sediment assessment activities that have been performed in specific locations and at deeper depths.

2. Organic and metal sediment concentrations will be statistically compared to levels of anthropogenic disturbance based on available GIS coverages of land cover data (road density, impervious surface, population densities, etc.) within the watershed adjacent to the sampling site. Site condition information collected during sampling and developed from available GIS coverages will also be utilized in these analyses. In addition to the chemical concentrations, chemical metrics (PAH and PCB ratio analysis) will also be examined to further evaluate potential anthropogenic factors responsible for the potential levels of observed sediment contamination. These statistical comparisons will take the form of correlations and parametric and non-parametric regression techniques. The specific types of analyses will be dependent on the structure of the data.
3. As noted previously, a caged mussel experiment is also occurring at ~ 30 of the 40 sediment sites (http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp/status.html). To date, a statistically randomized assessment of the relationship between sediment chemistry and mussel tissue contamination has not been performed. Using similar statistical tools to those described above, these relationship will be examined along with the interactions with the GIS based anthropogenic disturbance levels described above.
4. Concerns over microplastics in aquatic environments have increased over the past few years (Andrady 2011, Cole and others. 2011). The abundance of microplastics in surface waters in the Puget Sound have recently been examined, but an assessment of microplastics in marine sediments has not been done. At ~30 of the 40 sites, sediment samples will be examined for microplastics at the WAWSC's microplastics lab. Results from this effort will be summarized using the statistical methods outlined in issue number 2. Given that recent studies have found that microplastics can impact shellfish health (Sussarellu and others, 2016.), the results from this effort could provide valuable insight into the role microplastics play in evaluating sediment quality as well has help identify additional analyses appropriate for future nearshore sediment assessment activities.

REFERENCES

Andrady, A.L., 2011. Microplastics in the marine environment. Mar. Poll. Bull. 62: 1596–1605.

Cole, M., Lindeque, P., Halsband, C., and Galloway, T.S. 2011. Microplastics as contaminants in the marine environment: A review. Mar. Poll. Bull. 62: 2588-2597.

Dutch, M., V. Partridge, S. Weakland, K. Welch, and E. Long, 2009. Quality Assurance Project Plan: The Puget Sound Assessment and Monitoring Program Sediment Monitoring Component. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-121. 98 pp.

Ecology, 2007. Standard Operating Procedures for Obtaining Marine Sediment Samples. Washington State Department of Ecology, Olympia, WA. Approved October, 31, 2007. SOP EAP039. www.ecy.wa.gov/programs/eap/quality.html

Ecology, 2012. Standard Operating Procedure to Minimize the Spread of Invasive Species. Washington State Department of Ecology, Olympia, WA. Approved April 30, 2012. SOP EAP070. www.ecy.wa.gov/programs/eap/quality.html

Kennen, J.G., Kauffman, L.J., Ayers, M.A., Wolock, D.M., and Colarullo, S.J., 2008, Use of an integrated flow model to estimate ecologically relevant hydrologic characteristics at stream biomonitoring sites. Ecological Modelling, vol. 211, p. 57-76.

Masura, J., Baker J., Foster, G. and Arthuret, C. 2015. Laboratory methods for the analysis of microplastics in the marine environment: recommendations for quantifying synthetic particles in waters and sediments. NOAA Technical Memorandum NOS-OR&R-48

Sussarellu, R., Suquet, M., Thomas, Y., Lambert, C., Fabious, C., Pernet, M.E.J., Goic, N.L., Quillien, V., Mingant, C., Epelboi, Y., Corporeau, C., Guyomarch, J., Robbens, J., Paul-Pont-I., Soudant, P., Huvet, A. 2016. Oyster reproduction is affected by exposure to polystyrene microplastics. PNAS, February 1, 2016 Early Edition.

SWG, 2010a. 2010 Stormwater Monitoring and Assessment Strategy for Puget Sound Region. Written by the Puget Sound Stormwater Work Group. www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmpdocs/2010swampps.pdf

SWG, 2010b. Recommendations for Municipal Stormwater Permit Monitoring. Written by the Puget Sound Stormwater Work Group. www.ecy.wa.gov/programs/wq/psmonitoring/ps_monitoring_docs/SWworkgroupDOCS/SWGfinalreportoct292010.pdf

U.S. Geological Survey, 2007, Facing tomorrow's challenges—U.S. Geological Survey science in the decade 2007–2017: U.S. Geological Survey Circular 1309, x + 70 p.

TIMELINE

Fiscal Year	2016	2017

Calendar Year	2016			2017		
Task	Q3	Q4	Q1	Q2	Q3	Q4
1. Prepare Study QAPP	X					
2. Site Confirmation	X					
3. Sediment Sampling		X				
4. Sample Shipping		X	X			
5. Microplastic analysis		X	X			
6.Data QA/QC			X			
7.Data entry into EIM				X		
8.Data Analysis					X	
9.Report Writing and Publications						X

PERSONNEL

The project will require approximately 0.15 FTE of a Hydrologist (Project Chief), 0.15 FTE of Hydrologic Technicians, and 0.05 FTE for database management.

BUDGET SUMMARY

The total budget for completing the proposed work is $122,640. However, Task 5 will be funded by Federal Matching Funds. The Cooperator – Ecology -will be responsible for the remaining $102,640.

Budget for complete work described above and in Attachment A:

Agency	Total Budget
Washington State Department of Ecology	$102,640
USGS Federal Matching Funds	$20,000
Total	$122,640

Details of the budget for completing work given in Attachment A:

	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9	Total
USGS Salaries and Benefits	$3600		$14580		**$8820**	$3515	$900	$12400	$7030	$50845
Travel			$1300							$1300
Supplies and shipping				$2000	**$1000**					$3000
Equipment		$50	$1500		**$1500**					$3050
Publication									$15000	$15000
Overhead	$3145		$15755		**$8680**	$3215	$820	$11330	$6500	$49445
Total	$6745	$50	$33135	$2000	**$20000**	$6730	$1720	$23730	$28530	$122640

Attachment A

United States Geological Survey -Detailed Scope of Work

NEARSHORE SEDIMENT STATEMENT OF WORK

Project Background: Puget Sound Marine Nearshore Sediment Monitoring for the RSMP
Based on recommendations for the Stormwater Work Group Based on recommendations from the Stormwater Work Group, Washington State's Regional Stormwater Monitoring Program (RSMP) includes a component to monitor the status and trends of contaminants in sediments in the marine nearshore of Puget Sound in 2016. This status and trends monitoring follows a probabilistic sample design such that data gathered can be summarized across the Puget Sound ecoregion. Forty (40) marine nearshore sites that are adjacent to Puget Sound's Urban Growth Areas (UGAs) have been selected for inclusion in this sediment monitoring study. This monitoring will occur in the summer of 2016 and will be implemented by a team. The United State Geological Survey (USGS) will be the project lead and will coordinate for sampling being conducted by field crews from both the Washington Department of Natural Resources (WDNR) and King County. Sediment samples will be analyzed by two primary labs (King County and Ecology's Manchester Laboratory (MEL). Contaminants to be assessed include polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCBs), polybrominated diphenyl ethers (PBDEs), a range of chlorinated pesticides and metals.

The objectives of this project are to:

- Evaluate the range of chemical contamination in UGA shoreline sediments from 40 sites.
- Measure the magnitude of contamination in nearshore sediments from the 40 sites and compare to other marine sediment monitoring programs in the Puget Sound/Salish Sea.
- Provide recommendations for future status and trends monitoring of nearshore sediments to answer questions about stormwater management.

The purpose of this Statement of Work (SOW) is to define and describe the RSMP activities and products that will be delivered to the Washington State Department of Ecology (Ecology) by the USGS from the initiation of this contract through December 30, 2017. This SOW describes the work to be completed for each task, the deliverables to be submitted upon completion of each task, and the total estimated cost and schedule per task.

Tasks and Costs

Task 1 – Quality Assurance Project Plan - QAPP

USGS will develop a QAPP based on existing knowledge, protocols and procedures. The QAPP will guide nearshore sediment monitoring by King County, WDNR and USGS staff. The QAPP will identify a list of sampling sites that overlap with the Mussel sampling sites where possible, field and laboratory activities, analytical procedures and data summary methods.

1. USGS will complete the overall QAPP, which includes finalizing labs and methods with clarification from MEL and King County labs.
2. King County and WDNR staff time to provide input on the initial draft QAPP and review time of the final QAPP

Deliverable 1.1: Draft QAPP. Target date: (30 days after agreement is signed)
Deliverable 1.2: Final QAPP. Target date: (30 days after Draft)

Task 1 Estimated Total Cost: $6745

Task 2 – Site Confirmations and permissions

Given that the preferred sediment sampling sites will be adjacent to the RSMP Mussel sites, a list of candidate sites is already available. A protocol will be established in the QAPP that will provide a sampling team reasoning to reject unsuitable sediment sampling sites. Preliminary field notes taken during deployment of the mussel cages have been made available to the sediment sampling team, and some sites may be deemed unsuitable for sediment sampling based on those notes. If a site is determined to be unsuitable, the protocol in the QAPP will be followed to find the next qualifying site in the list that is consistent with the goals of probabilistic sampling as well as the preferred collocation of sediment sampling and mussel sites. The enclosed spreadsheet identifies each of the proposed mussel sites and the next 20 randomly selected sites. A preliminary identification has been completed of potentially problematic sites based on the general sediment characterization contained in the meta data in the original list of mussel sites. USGS will coordinate with WDNR and King County to continue evaluating sites, moving numerically through the site list, until 40 sites are confirmed for the 2016 monitoring. Locations of the final sampled sites will be submitted to Ecology's EIM database.

Deliverable 2.1: Map and spreadsheet of all evaluated candidate sites based on desktop site confirmation listing field lead agency and back-up sites. Target date: (with final QAPP
Deliverable 2.2: PDF of all permits or MOUs necessary for access and nearshore sediment monitoring.

Task 2 Estimated Costs: $50

Task 3 – Sampling Travel, Equipment, and Labor

USGS will provide/procure equipment necessary for travel, sampling and consumable supplies identified below:

1. Travel costs (land and marine including fuel, boat usage)
2. Equipment (Not including sample bottles; those costs are included in lab costs)
3. Labor (USGS will provide 1 person for each WDNR field trip. King County will provide all labor for their sites)

USGS will conduct marine sediment sampling per the QAPP at the pre-selected (Task 2) marine nearshore sediment sites from June – to October 15, in 2016. As we work through these costs, we need to consider the location of sites and the ability to sample near-by back-up sites.

Deliverable 3.1: List of equipment/supplies ordered and procured by USGS in support of the 2016 RSMP marine nearshore sediment monitoring survey.
Target date: (June, 2016)

Deliverable 3.2: Filled out spreadsheet, in EIM Location Data format, for each sampled sediment site.
Deliverable 3.3: Filled out spreadsheet, in EIM Results data format, for field measurement data and PDFs of field notes made at the RSMP marine sediment sites. Target date: (August 30, 2016)

Task 3 Estimated Cost: $33,135

Task 4 – Sample Shipping and Chemical Analysis

Sediment samples will be transported to the lab(s) identified in the QAPP using the appropriate storage and transport methods using sample bottles provided by the lab(s) within holding times.

1. USGS shipping or delivering samples to the labs.
2. King County in-house chemical analysis and any shipping to other labs.
3. USGS estimate for total laboratory costs by constituent and sample bottles.

Deliverable 4.1: Status report and schedule on chemical analysis completeness for each laboratory. Target date: (November 30, 2016)

Task 4 Estimated Cost: $2,000

Task 5 – Microplastic Analysis

During the field work described in Task 3, a USGS scientist will collect additional sediment for microplastics analysis. The microplastics analysis will generally follow the methods outlined in Masura and others, 2015. Given that microplastic laboratory methods are still under development, the focus of this task will be to examine different approaches and compare these methods to laboratory and field spikes using recently developed spike material (personal communication, Julie Masura). As such, oversampling for this component of the project will occur to help develop appropriate and effective lab methods and QA/QC methods.

Deliverable 5.1: Analysis of these samples will be completed by December 2016 and the results will be presented in the final report in September 2017.

Task 5 Estimated Costs: $20,000 (USGS Federal Matching Funds)

Task 6 – Data Quality Assurance and Quality Control (QA/QC) check

[USGS, King County] staff will evaluate quality assurance metrics and track quality control measures to ensure high quality data is received from the analytical laboratories. Error checking and data validation procedures will be performed on all chemistry data received from the labs.

Deliverable 6.1: Compiled data review summary and usability statement. Target Date (December 30, 2016)

Task 6 Estimated Costs: $6,730

Task 7 – Data Entry into Ecology's Environmental Information Management (EIM) Database

Once Task 6 is completed, King County and USGS will ensure all data collected during the sediment sampling is entered in Ecology's EIM database once the data has been checked by King County, USGS and WDNR.

Deliverable 7.1: EIM submission of complete data set. Target Date (January 30, 2017)

Task 7 Estimated Costs: $1,720

Task 8 – Data Analysis

It is anticipated that USGS, with support from King County and WDNR, will all be involved in data analysis. Provided below is a preliminary list of deliverables and associated costs that anticipated for the report.

Deliverable 8.1 Summary of field parameters, sediment conditions, organic contaminant and metal concentrations by site. (April 30, 2017)

a. Includes relations between each constituent and adjacent watershed/shoreline conditions using existing GIS coverages (road density, impervious surface, pop. density)
b. Comparison to Phase I stormwater outfall reported concentrations

Deliverable 8.2 Summary of organic contaminant potential origins and a comparison of organic and metal concentrations to mussel tissue concentrations by site (July 1, 2017)

a. PAH Ratio Analysis ("fingerprinting")
b. PCB Ratio Analysis ("light vs heavy" congeners)
c. Organic and metal sediment concentrations vs. mussel tissue concentrations.

Deliverable 8.3 Comparison to Ecology's Marine Sediment Monitoring program results (Regional, Urban Bays, Long-term and EPA Joint Monitoring) (July 15, 2017)

Total Task 8 Estimated Cost: $23,730

Task 9 – Report and Review

A final report will be prepared by USGS with review provided by King County and WDNR.

Deliverable 9.1: Draft Report Including future recommendations for RSMP marine sediment Status and Trends. Target Date (July 30, 2017)

Deliverable 9.2: Final Report. Target Date (September 30, 2017)

Task 9 Estimated Costs: $28,530

TOTAL PROJECT COST = $122,640