King County

Marine and Sediment Assessment Group 2015 Work Plan

The best decisions are based on Sound information.

Date: January 20, 2015

To: Interested parties

From: Kimberle Stark, Wendy Eash-Loucks, Amelia Kolb, and Bob Bernhard

Subject: Transmittal of the 2015 Work Plan for the Marine and Sediment Assessment Group

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This memorandum and attachments present the 2015 Work Plan for the Marine and Sediment Assessment Group of the King County Department of Natural Resources and Parks Water and Land Resources Division. The work plan includes all aspects of the wide-ranging marine monitoring program, including water quality, sediment, and biological components. Included with this memorandum are matrix tables that provide sampling locations, sampling frequency, and parameters measured for the 2015 routine monitoring programs, as well as maps showing sampling locations and details regarding special projects.

Station locations and analytical parameters may change from year to year. Any changes are based on an evaluation of previous years' data to determine if the data collected are meeting monitoring objectives for the various monitoring programs and/or budgetary constraints. Marine and Sediment Assessment Group staff evaluate data on an annual basis to determine what changes are necessary, including what parameters should continue to be analyzed.

For work expected to occur in 2015, a description of each monitoring component and special projects is provided below along with any sampling changes.

ROUTINE MONITORING

Water Sampling

2015 Marine Offshore Water Column Monitoring

Marine water column samples will be collected at 18 stations in 2015 (Figure 1). Water column samples at 14 of the 18 stations will be collected twice monthly from February through November and monthly January and December. The remaining four stations located in the Duwamish Waterway (three ambient stations and two outfall stations) will be sampled on a monthly basis. Ten of the 18 monitoring stations are located at outfalls for the Brightwater,

West Point, South, and Vashon wastewater treatment plants, the Alki and Carkeek combined sewer overflow (CSO) treatment plants, the Elliott West and Henderson/MLK/Norfolk CSO treatment facilities, and the Barton Street and Hanford Street CSOs. Nine ambient monitoring stations are located at Point Jefferson, Elliott Bay, Fauntleroy/Vashon, East Passage, the Lower Duwamish Waterway (three stations), and Quartermaster Harbor (two stations).

Discrete water samples will be collected from between one and seven depths at each offshore station, depending on the total station depth. For a list of stations, depths sampled, and parameters analyzed, see Table 1. Conductivity, temperature, depth (CTD) profiles will be conducted throughout the entire water column at 15 of the 18 stations – those stations that are sampled from King County's *R/V Liberty* or *Chinook* vessels.

Laboratory analytes of discrete samples will include fecal indicator bacteria (fecal coliform and Enterococcus) , chlorophyll-*a* and pheophytin pigments, suspended solids, and nutrients (ammonia-nitrogen, nitrite/nitrate-nitrogen, orthophosphate phosphorus, and silica). Chlorophyll-*a* and pheophytin will be measured at specific depths (see Table 1) from 1 to 35 m. Total nitrogen will be analyzed on a subset of 13 samples. Bacteria samples will be collected from one to three sampling depths at each of the outfall monitoring stations, including the surface (1 meter[m]), deepest depth, and an intermediate (trapping) depth at the deeper outfall stations. Bacteria samples will only be collected from the surface at ambient monitoring stations, with the exception of the Duwamish Waterway samples. Bacteria samples will be collected from both depths at each Duwamish Waterway station (at 1 m and ~1 m from the bottom). This represents a change from previous years as bacteria samples were analyzed from both depths at each of the Quartermaster Harbor stations. However, based upon an assessment of Quartermaster Harbor bacteria data, it was determined that data from only the surface samples are necessary. All other laboratory parameters will be analyzed on samples collected from every depth.

In situ data will be collected at all but three offshore stations using a CTD SeaBird SBE 25 Plus profiler with a sensor array. CTD profile data will include the following parameters; dissolved oxygen, salinity, temperature, density (calculated), transmissivity, photosynthetically active radiation (PAR), and fluorescence (as a measure of chlorophyll). Surface PAR measurements will also be collected at all of the offshore stations collected from the *R/V Liberty* or *Chinook*. Secchi depth measurements will be collected at all the offshore stations, including the two Quartermaster Harbor stations, with the exception of those sites in the Duwamish. This represents a change from previous years when Secchi measurements were collected for the Duwamish River stations. However, based upon the limited use of those data, this parameter was deemed unnecessary. Field measurements for dissolved oxygen, salinity, and temperature will be collected using a YSI EXO2 data sonde instrument at the two Quartermaster Harbor stations and the Henderson/MLK/Norfolk CSO station (LTXQ01). Dissolved oxygen measurements for the other three Duwamish River sites (HNFD01, LTKE03, and LTUM03) will be collected using the CTD as well as collecting discrete samples for laboratory analysis by Winkler titration (Table 2).

The overarching marine monitoring program sampling and analysis plan (SAP), which includes the water column sampling component, was last updated in 2003 and is now outdated given changes to the sampling program and equipment since this time. Although various sampling components have SAPs that are current or expected to be updated in 2015, the primary marine monitoring program SAP will be revised and updated in 2015.

2015 Marine Beach Water Quality Monitoring

Water samples will be collected monthly from 20 marine beach stations and one stream station located in Piper's Creek (Figure 2). Nine outfall-vicinity monitoring stations are located inshore of the West Point (two stations) and Vashon treatment plant outfalls, the Alki (two stations), Carkeek, and Elliott West CSO treatment plant outfalls, and the South Magnolia and Barton CSO outfalls. All 20 of the monitoring stations will be sampled monthly for analysis of fecal coliform and Enterococcus bacteria, temperature, salinity, and nutrients (ammonia-nitrogen, nitrite/nitrate- nitrogen, and orthophosphate phosphorus) (Table 3). The Piper's Creek stream station will be monitored for bacteria, temperature, and nutrients. A subset of six beach water samples will also be analyzed for Total Nitrogen.

2015 Marine Moorings

Marine moorings that include *in situ* water quality data-gathering sensors (YSI EDS 6600 V2) are currently deployed at four locations – the Seattle Aquarium (two depths), Dockton Park (one depth), the Quartermaster Harbor Yacht Club (one depth) and on a buoy off of Point Williams in southwest Seattle (one depth) (see Figure 1). These marine mooring systems gather data at 15-minute intervals for dissolved oxygen, salinity, temperature, fluorescence (chlorophyll), and turbidity (Table 4). Turbidity is not measured at the Quartermaster Harbor Yacht Club due to the shallow depth of the mooring. The Seattle Aquarium, Dockton Park, and the Quartermaster Harbor Yacht Club moorings currently include standard pH sensors that do not collect high-precision data. An assessment will be made in mid-to late 2015 to determine the usefulness of these data and whether to continue to deploy these sensors.

A SUNA nitrate sensor also collects data at the Point Williams mooring site. Meteorological data are also collected by the mooring systems deployed at the Seattle Aquarium and Dockton Park.

Due to communication/equipment failure at both Quartermaster Harbor sites in fall of 2014, new integrated datalogger/telemetry systems (WaterLOG Storm 3) were purchased in November 2014 and expect to be installed on all four systems by the end of February 2015. However, it is necessary to update the marine mooring webpage to incorporate the new data format of the Storm 3 dataloggers. It is expected that the webpage data access changes will be completed by mid-2015.

In mid-2014, the Point Williams buoy broke free of the anchoring system and was retrieved from a nearby beach and transported back to the KCEL dock. It is expected that the buoy will be equipped with a new anchoring system and redeployed in the same location in early 2015. Due

to the expected weight of the anchoring system and the weight limitations of the *R/V Liberty's* winch, it will be necessary to utilize a larger boat to deploy the buoy.

As part of the Ocean Acidification Monitoring Program, a high-precision pH (SeaFET) sensor will be installed on two of the moorings in 2015: the Quartermaster Harbor Yacht Club and on the Point Williams buoy. The sensors will be installed at the surface depth on both moorings. A third SeaFET will be installed on the University of Washington's (UW) mooring located off Richmond Beach near Point Wells. Monthly quality control (QC) samples will be collected by FSU staff for dissolved inorganic carbon (DIC) and total alkalinity at the Quartermaster Harbor Yacht Club (1 m and near bottom) and the Point Williams buoy (1 and 25 m) to assess sensor performance and provide full characterization of the carbonate system. DIC and total alkalinity values will be used to calculate pH and other ocean acidification parameters. Monthly QC samples at UW's Richmond Beach buoy will be collected by staff from the UW School of Oceanography. All DIC and alkalinity samples will be analyzed by staff at the Pacific Marine Environmental Laboratory (PMEL).

Additional salinity and temperature QC samples will be collected at the Point Williams buoy and the Quartermaster Harbor Yacht Club mooring to assess the YSI salinity and SeaFET temperature sensor data. Orthophosphate-phosphorus and silica will also be collected concurrently. All of these parameter values are used in the carbonate system calculations. QC samples at the Point Williams buoy will be collected monthly at 1 and 25 m and twice monthly (monthly in January and December) at 1 m and near bottom at the Quartermaster Harbor Yacht Club.

Continuous data gathering involves a high degree of data management, quality control, and website maintenance to make the data available publicly. The Marine and Sediment Assessment Group will continue to provide support for webpage updates and maintenance, quality control, and data analysis.

Biological Sampling

2015 Marine Phytoplankton Monitoring

For 2015, there is one large change to the phytoplankton sampling program due to the water quality proviso received from the King County Council in 2014 and the implementation of the new quantitative phytoplankton method in mid-2014. In 2015, the semi-quantitative phytoplankton component will be replaced by the quantitative FlowCam method. In addition, the number of phytoplankton stations will increase from three to eight and samples will be collected year-round (see Figure 1). Phytoplankton samples will be collected twice monthly from February through November and monthly in January and December at the same time samples are collected for the offshore ambient and outfall water-column monitoring program.

Species identification (via microscopy) will occur for all samples in order to obtain a species composition list and as a secondary check against the FlowCam results. The lowest taxonomic

level the FlowCam can generally achieve is at the genera level, whereas analysts using a compound microscope can typically achieve results down to the species level. Having phytoplankton community composition data down to the species taxonomic level, whenever possible, is valuable for assessing ecosystem change.

Samples will be collected at two depths at the Point Jefferson and East Passage stations (1 m and the chlorophyll maximum layer as determined by the fluorometer on the CTD) and only at the 1 m depth for the other sites. Nutrient and chlorophyll-*a* samples will be collected and analyzed concurrent with the phytoplankton samples.

The existing phytoplankton SAP will be updated in 2015 to reflect the new method changes and sampling design.

The FlowCam generates biovolume data (which can be converted to organic carbon content using established biovolume-carbon relationships) and in order to determine the relationship between these data and actual carbon content, a special study will begin in mid-to late 2015. This study will include measuring particulate organic carbon (POC) along with the other parameters listed above. This study will require method development by the KCEL Conventionals Unit as POC is not a parameter typically measured. Once method development is completed, it is anticipated that approximately 5-10 samples will be analyzed for POC each month from various depths at a subset of the phytoplankton stations. Once sufficient biovolume and POC data are collected, an assessment of the relationship between these parameters will be conducted by Marine and Sediment Assessment Group staff.

2015 Marine Zooplankton Monitoring

The zooplankton sampling component that began in 2014 will continue in 2015 with no anticipated sampling changes. Zooplankton samples will be collected from three stations in the Central Puget Sound Basin: Point Jefferson, off Point Williams, and East Passage (see Figure 1). Vertical zooplankton tows using a ring-net will be conducted twice-monthly February through November at all stations and monthly January and December. These tows will be to a maximum depth of 200 m, dependent upon overall station depth. Oblique zooplankton tows using duel side-by-side nets attached to a frame (bongo nets) will be performed twice-monthly only off of Point Williams during the months of February through November to focus on salmonid prey. These tows will be to a depth of 30 m. One tow will be conducted at station LSNT01 and the other at station PWBONGO off of Point Williams. This work will be performed in partnership with the University of Washington, staff from which will identify and enumerate zooplankton species in each sample.

In order to start building a zooplankton image library, the second bongo net sample which is usually discarded, will be kept for at least one station each month. A portion of the sample will be poured into a Petri dish, or other appropriate container, and observed using a dissecting scope equipped with an trinocular digital camera objective and USB connection. This work will occur in the laboratory. The digital camera will be used to capture still images of various

zooplankton and stored on a network drive. These images will be uploaded at a later date to King County's marine life image library.

The zooplankton SAP that was started in late 2014 will be finalized in 2015 and available on the marine monitoring webpage.

Sediment Sampling

2015 Marine Offshore Sediment Monitoring

The marine offshore sediment program was restructured in 2007 to focus primarily on sediment quality in Elliott Bay and to supplement Ecology's sediment monitoring program. Since 2007, sediments from eight stations in Elliott Bay have been collected every two years and every five years from six ambient sites located outside of Elliott Bay in the Central Basin (Figure 3). All 14 sites were sampled in 2007 and the Elliott Bay stations were sampled again in 2009, 2011, and 2013. The six ambient stations were last sampled in 2012 and will not be sampled again until 2017.

In June 2015, the eight Elliott Bay stations will be sampled. Samples will be analyzed for conventional parameters (total solids, total organic carbon, grain size, ammonia, and total sulfides), metals, and organic compounds (semivolatiles, chlorinated pesticides, PCBs, butyltin isomers, and PBDEs) (Table 5). One new organic compound, coprostanol, will be added for the 2015 sampling event. Another organic compound which was added to the parameter list in 2011, 4-nonylphenol, will again be analyzed in 2015. Also new for the 2015 sampling event, benthos samples (three replicates per site) will be collected at four of the eight stations: LTED04 (central Elliott Bay), LTGF01 (off Harbor Island), LTDF01 (Seattle waterfront), and LTAA02 (north of Myrtle Edwards Park). The sampling and analysis plan (SAP) will be updated and amended to include the new compounds and benthic samples.

2015 Marine Beach Sediment Monitoring

The beach sediment monitoring program was restructured in 2005 following a programmatic review by an outside peer review group. The formerly annual sampling schedule was changed to sample collection every five years, with the new schedule beginning in 2010. In August 2015, beach sediments will be collected from 19 stations (see Figure 3). Seven outfall-vicinity stations are located onshore of the West Point (two stations) and Vashon Treatment Plant outfall, the Alki, Carkeek, and Elliott West CSO Treatment Plant outfalls, and the Magnolia CSO outfall. The 10 ambient stations are located at Point Wells, Carkeek Park, Golden Gardens Park, Fauntleroy Cove, Seahurst Park, Normandy Park, Des Moines Creek Park, Redondo Beach, Dumas Bay, Tramp Harbor, and Burton Acres Park in Quartermaster Harbor. Sediments from the Tramp Harbor and Des Moines Creek Park sites were not sampled during the 2010 event, although sediments from Tramp Harbor have been previously sampled.

The existing SAP for this sampling effort will be updated in mid-2015. Beach sediments will be analyzed for conventional parameters (total solids, total organic carbon, grain size), metals, and organic compounds (semivolatiles, PCBs, and PBDEs) (see Table 3).

PROJECT-SPECIFIC MONITORING

Brightwater Marine Outfall

The following Brightwater marine outfall project work will occur in 2015:

Brightwater Marine Outfall Eelgrass Restoration Project

The final report and final agency meeting was completed in December 2014. Although all monitoring activities and reports were completed in late 2014, consultant contract (eelgrass dive surveys) closeout will occur in early 2015. A webpage detailing the eelgrass restoration project is expected to be created in 2015 by both Marine & Sediment Assessment Group and WTD staff as well as preparation of other outreach materials.

Brightwater Marine Outfall Structural Integrity and Biological Assessment Project

The purpose of this project is to determine if marine organisms attached to the pipe may affect the structural integrity of the Brightwater marine outfall HDPE pipes over time. A secondary purpose is to document the presence and abundance of marine organisms on the pipes over time. A goal of this project is to obtain sufficient and quality data to aid state natural resource agencies in assessing the effectiveness and amount of habitat artificial structures provide to various marine organisms.

HDPE pipe segments were placed on the seafloor in 2012 at three locations in close proximity to the marine outfall and also a reference site further away. The pipe material will be allowed to remain in place for pre-defined time intervals: 2, 5, and 10 years. Twenty-seven approximately 2-ft^2 portions of pipe were placed at the -100 ft, -300 ft, and -600 ft mean lower low water (MLLW) depths adjacent to the south outfall pipe (3 replicates were placed at each depth and for each time interval). In fall of 2014, the first 12 samples were retrieved (3 from each depth and the reference site). Each 2-ft^2 portion was assessed for total percent cover by placing a mesh grid over the sample and estimating the biota coverage in each grid cell. The mesh grid contained 21 cells and each cell (~4 x 4 inches) was photographed. In 2015, work will entail analyzing the photographs and preparation of a survey report.

Brightwater Marine Outfall Nearshore Benthos

Preparation of the final report summarizing results of the nearshore benthic surveys at the trench construction site for the Washington State Departments of Fish and Wildlife and Natural Resources began in late 2014. The report will be finalized in 2015 and sent to the agencies to fulfill permit requirements.

Brightwater Marine Outfall ROV Survey

An ROV survey will be conducted at the Brightwater outfall pipes from the -80 ft MLLW depth where the pipes daylight to approximately the -300 ft MLLW depth. As in previous surveys, the ROV will collect video from about -80 to -120 ft MLLW and then surface and be redeployed at about -300 ft MLLW. The purpose of the ROV video survey is to document various marine organisms, including various rockfish species, utilizing the habitat created by the outfall pipes. The ROV survey will occur in summer or early fall.

Inter-Laboratory Nutrient Calibration Study

King County will continue to partner with the Washington State Department of Ecology on an inter-laboratory nutrient calibration study. Ecology nutrient samples are analyzed by the University of Washington Marine Chemistry Laboratory. The goals of the study are to:

- determine direct comparability of nutrient data currently collected and analyzed for central Puget Sound sites;
- provide a means to share data and utilize each agency's results collected for current and historical monitoring projects in Puget Sound;
- provide an understanding (degree, extent, and affected species) of similarities/differences of nutrient results provided by each agency to be used for a combined trend analysis for Central Basin stations; and
- provide comparative data for evaluation of laboratory performance and methods, should a transition or need for utilization of another analytical lab arise for future monitoring/projects.
- Previous rounds of nutrient standards analysis and field side-by-side split sample analysis have been completed. The standards component entailed four nutrients (nitrate, nitrite, ammonia, and silica) in a range of concentrations that were analyzed by both laboratories as a continuing inter-laboratory calibration check. The side-by-side field sample splits from both the King County and Ecology water quality monitoring programs were analyzed by both laboratories for all four nutrients of interest.

In 2015, another round of standards analysis will be undertaken in support of this ongoing inter-laboratory calibration effort. Delivery of nutrient standards to the King County Environmental Laboratory (KCEL) by Ecology staff and the University of Washington will be coordinated between agency staff. The KCEL will provide RO water to Ecology staff in order to prepare the standards. An additional round of side-by-side field sample splits may occur in late summer, dependent upon both laboratories time constraints. King County and the University of Washington laboratories will follow their standard protocols for analysis of nutrients.

Combined Sewer Overflow Water Quality Assessment

A draft area report summarizing current conditions and long-term trends in water quality in Elliott Bay as well as the results of the literature review was completed in late 2014. A similar draft report summarizing current conditions and long-term water quality trends is currently in

preparation for the Duwamish River, including both the East and West Waterways and expected to be completed in February 2015. This report includes a summary of existing data from the many reports prepared for the Lower Duwamish River Remedial Investigation/Feasibility Study effort as well as summarizing new data. In 2015, work will entail preparation of the sediment section of the Duwamish River Area Report. In addition, a final synthesis report will be prepared incorporating summaries of all the area reports as well as results of the data gap studies. The data gap studies began in 2014 which includes monitoring efforts for bacteria and chemicals of emerging concern as well as conservative sewage tracers. These two monitoring efforts will continue in early 2015 and data analysis reports prepared.

The information from this study will be used to evaluate the best way to control pollution and improve water quality in relation to the county's CSO update plan.

National Pollutant Discharge Elimination Permit (NPDES) Related Work

The NPDES permits for the West Point and South Treatment Plants expired in 2014 but were administratively extended by Ecology until new permits are issued. A draft of the new West Point TP permit was received in late 2014 and it is expected that a draft permit for the South TP will be available in early 2015. New NPDES permits for the Brightwater and Vashon treatment plants were issued in 2011 and expire in July and August 2016, respectively. The following work will be performed in 2015 in support of the wastewater treatment plant NPDES permits:

- Assist with water quality assessments at the Denny/Elliott West Storage and CSO TP as needed. A special condition regarding the Elliott West facility included in the draft West Point permit (CSO facilities are covered under the West Point permit) is to conduct an evaluation of copper concentrations in effluent and to assess potential to exceed the criterion in receiving waters.
- The Marine and Sediment Assessment Group will provide technical assistance during negotiations and data needs for the Brightwater and Vashon Wastewater Treatment Plant NPDES permits renewal process, which may begin in late 2015.
- The Marine and Sediment Assessment Group will provide technical assistance as needed for the new Georgetown Wet Weather Treatment Station which will include a new outfall to be located in the Lower Duwamish River. In preparation for the new outfall, a new ambient sampling location will be placed near the first Ave South bridge at the current expected location of the outfall. This new sampling location (station identifier GTPP01) will have water samples collected monthly for the same parameters as the other Duwamish River stations.

Denny Way CSO Control Project Sediment Monitoring

On-going sediment monitoring at this project site is being done in accordance with the Biological Opinion issues for the project under the Endangered Species Act Section 7

consultation. The new Elliott West CSO Treatment Facility became operational in May 2005. The fifth post-operation sediment monitoring event at the Elliott West and Denny Way CSO outfalls occurred in April 2010 and the sixth sampling event will occur in April 2015. The 2015 sampling event will include the collection of surface sediment samples from 16 previously sampled stations. Samples will be analyzed for sediment chemistry (all 16 stations) and benthic infauna (8 stations). One of the 16 stations collected also provides support for post-construction monitoring for Areas A & B nearshore interim sediment cleanup project. An updated addendum to the 2009 SAP will be created for the 2015 sediment sampling event.

Miscellaneous 2015 Work Items

- Support for the completion of Phase II of the Marine Monitoring web page, including uploading historical data for discrete data (e.g., nutrients) and creation of web reporting tools.
- Support for the completion of a new, web-based, marine water quality (including biological data) monitoring reporting system.
- Preparation of annual data summaries for the various monitoring components to be accessible via the new updated marine webpage.
- Support for the creation of a new marine benthic data website, including design, data population, testing, and reporting tools.
- Performance measure and environmental indicator updates.
- Preparation of sections for the Regional Wastewater Services Plan (RWSP) Update report.
- Update the KingStat marine indicators for the County's performance measures.
- Preparation of the 2016 marine and sediment assessment group work plan.
- Technical support for the Wastewater Treatment Division's Sediment Management Plan.
- Transferring marine group technical reports, work plans, presentations, and posters to the new Science Section library database.
- Data downloading and analysis for outside agencies, educational facilities, private entities, and the general public.
- Puget Sound Ecosystem Monitoring Program (PSEMP) support. Participation in and presentation at the Marine Waters Work Group workshop of 2014 monitoring data. Follow-up to the workshop will include an analyses and write-ups of King County marine data for the 2014 Puget Sound Marine Waters Overview report. Work for 2015 will also involve participation on the editorial team for the overview report, participation in Marine Waters Workgroup activities, including products to support PSEMP and the Puget Sound Partnership activities and requests.
- Prepare Quartermaster Harbor sediment monitoring report.
- Prepare final shellfish and algae tissue monitoring report.
- Prepare intertidal sediment data report from the 2010 sampling event.
- Evaluation of sediment monitoring program and prepare tech memo with recommended changes to sampling design and/or sampling frequency.

- Participation in the Pacific Estuarine Research Society's (PERS) annual science meeting in April. PERS is the regional society of the larger Coastal and Estuarine Research Federation (CERF), a multidisciplinary organization focusing on the structure and function of coastal and estuarine systems. Marine and sediment assessment group staff will attend and prepare presentations for the bi-ennial CERF conference in early November.
- Participation in the annual Sediment Management Annual Review Meeting (SMARM) in May.

SUMMARY OF MONITORING CHANGES FOR 2015

The following summarizes sampling changes in 2015 for the routine sampling and mooring programs. Also included is a summary of rotational sampling (i.e., 5-year cycle) scheduled for 2015.

- No Secchi measurements for the Duwamish River stations.
- For the two Quartermaster Harbor stations sampled off docks/piers, bacteria analysis will occur for surface samples only.
- New pH sensors will be installed on the Quartermaster Harbor Yacht Club and Point Williams buoy moorings.
- The Point Williams buoy will be redeployed in early 2015.
- Additional water samples will be collected by FSU staff and analyzed monthly at the Point Williams buoy at the 1 and 25 m depths in order to perform quality control on the in situ sensors and to characterize the carbonate system. Parameters measured by FSU/KCEL staff will include temperature and salinity and parameters analyzed by NOAA PMEL will include dissolved inorganic carbon (DIC), total alkalinity (TA).
- Additional water samples will be collected by FSU staff and analyzed twice monthly at the Quartermaster Harbor Yacht Club mooring at the 1 m and bottom depths in order to perform quality control on the in situ sensors and to characterize the carbonate system. Parameters measured by FSU/KCEL staff will include temperature and salinity and parameters analyzed by NOAA will include dissolved inorganic carbon (DIC), total alkalinity (TA). Temperature and salinity samples are currently collected monthly at this site, however, additional samples are needed to assess the in situ sensors.
- The only change to the marine phytoplankton monitoring program is that all samples will be observed with a compound microscope in order to develop a species list in addition to analysis by the FlowCam.
- The only addition to the marine zooplankton monitoring program is to start developing a zooplankton photo library by capturing photographs using the dissecting microscope equipped with digital optics.
- 2015 is a rotational year for the eight Elliott Bay sediment sampling. Two additional compounds, 4-nonyphenol and coprostanol, will be analyzed. New for this sampling event, benthic infauna will be sampled and analyzed at four of the eight stations.

- 2015 is also a rotational year for the 17 intertidal sediment stations.
- Work for the CSO WQA will include continuation of the contaminants of emerging concern (CEC) study in Elliott Bay. Three sampling events will occur at 3 stations.
- A special study will occur to compare FlowCam biovolume data to particulate organic carbon.

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Attachments that accompany this work plan include:

- Figures showing the locations of all the 2015 marine monitoring stations and moorings.
- Tables that include all parameters measured at monitoring stations.
- A table with all sampling station coordinates (Table 6)

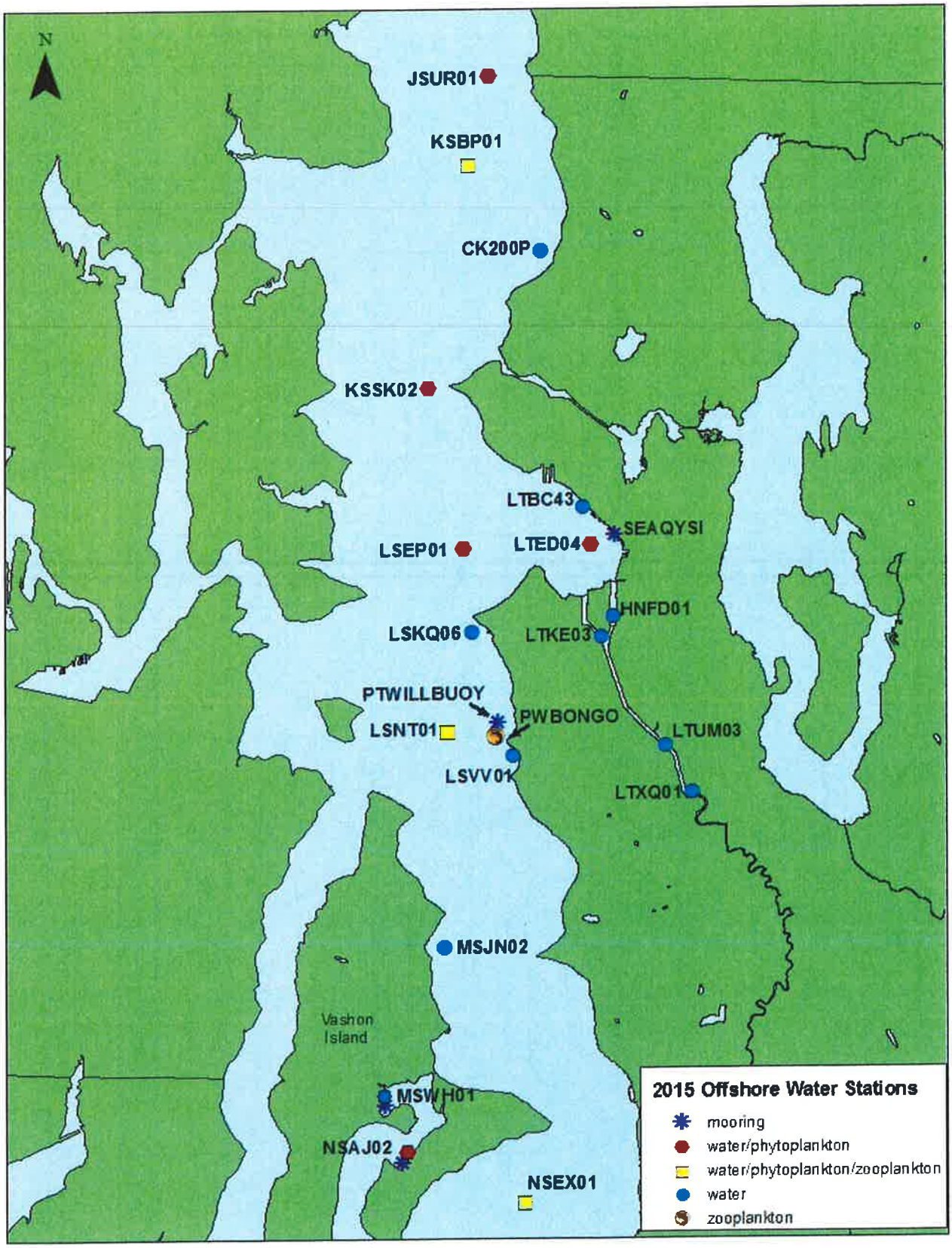

Figure 1. Offshore station locations for water, phytoplankton, and zooplankton

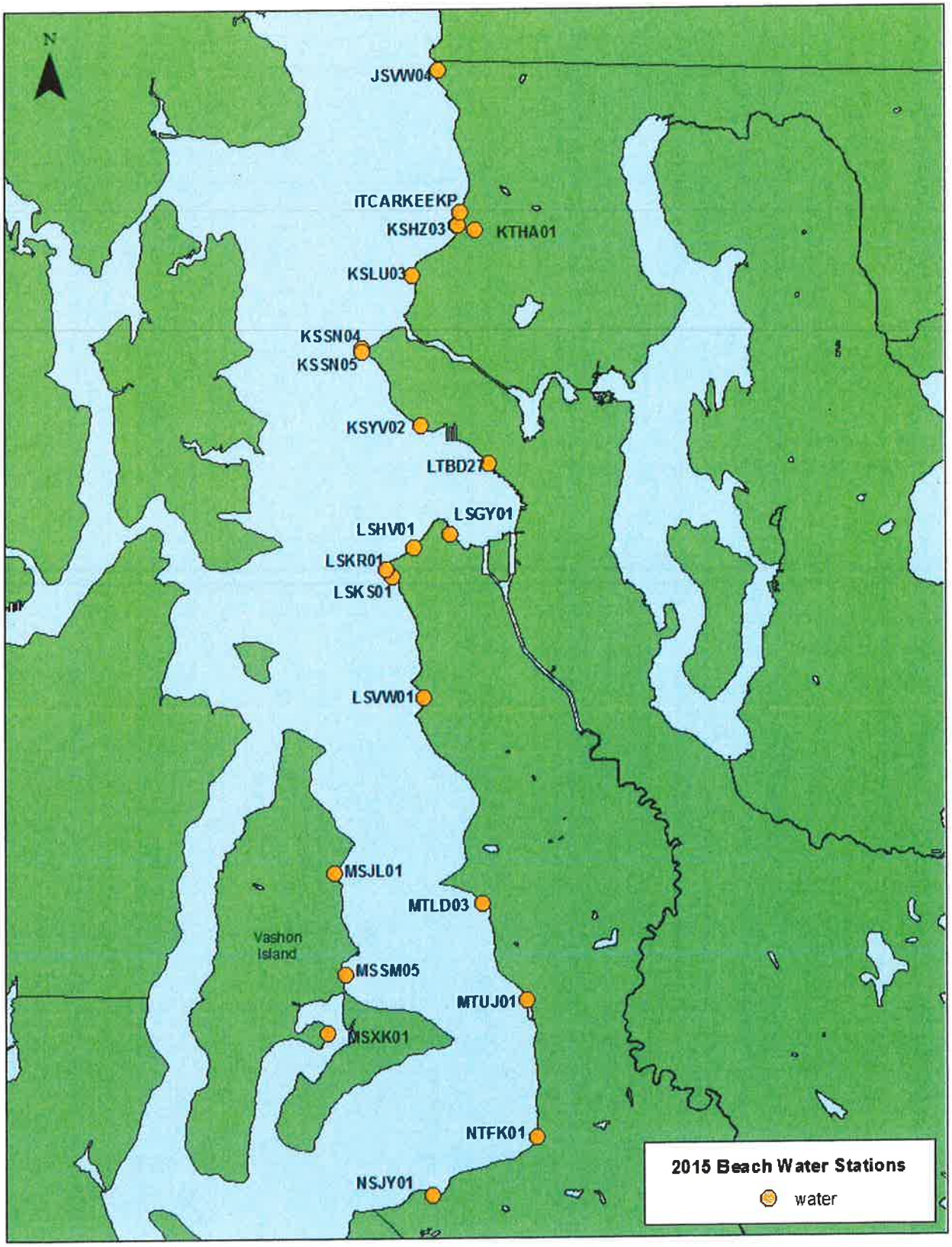

Figure 2. Beach water station locations

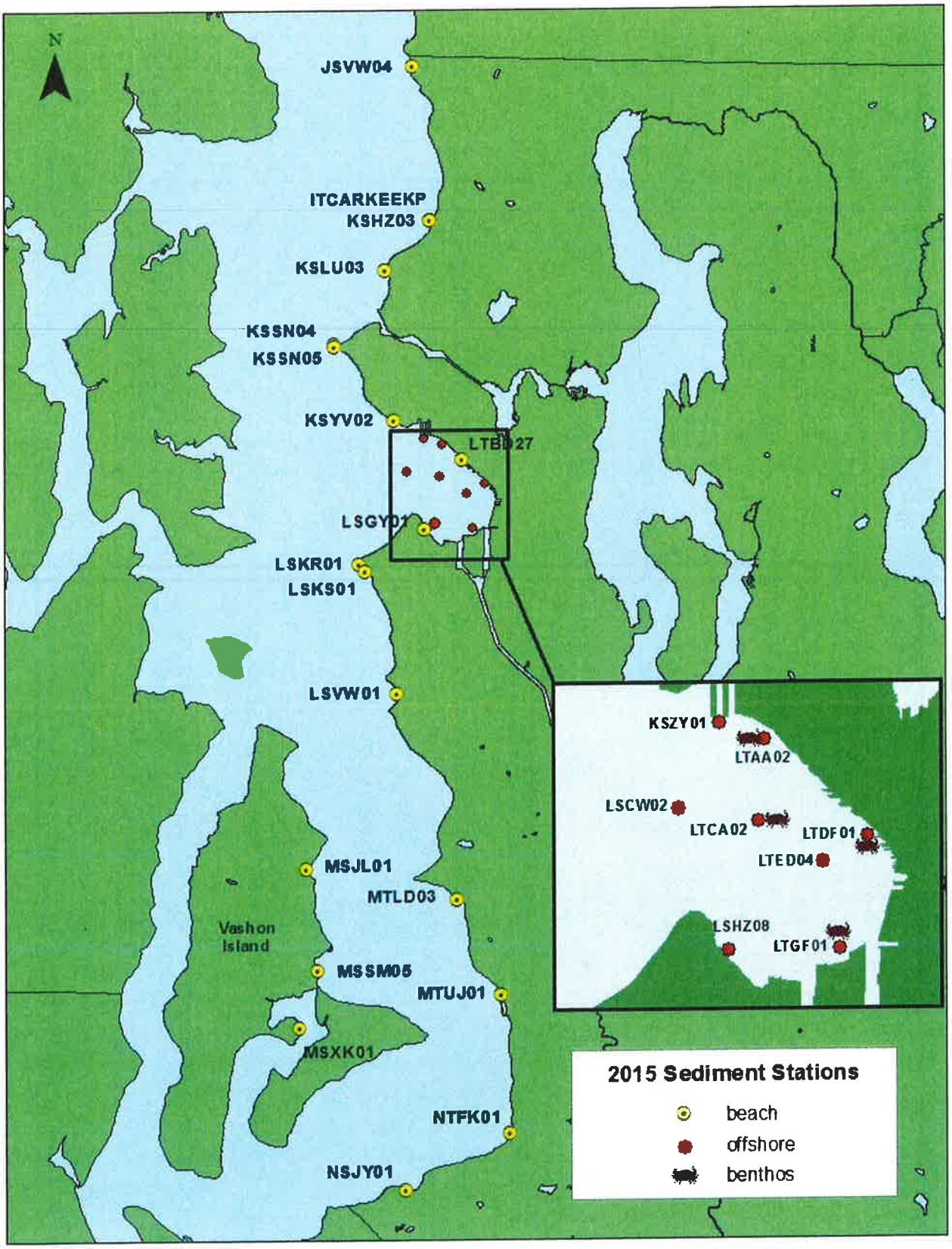

Figure 3. Sediment station locations

Table 1. 2015 Marine Offshore Monitoring Program

Semi-Monthly Water Column Sampling Matrix

		Bacteria		Laboratory									CTD								Field				Phyto	ZooPl	
Station	Depth (m)	Enterococcus	Fecal Coliform	Ammonia Nitrogen	Nitrite + Nitrate Nitrogen	Total Nitrogen	Orthophosphorus	Silica	Chlorophyll-a	Phaeophytin	Total Suspended Solids	Salinity	Chlorophyll, Field	Density, Field	Dissolved Oxygen, Field	Light Intensity (PAR), Field	Salinity, Field	Sample Temperature, Field	Surface Light Intensity (PAR), Field	Transmissivity, Field	Dissolved Oxygen, Field	Sample Depth	Sample Start Time	Secchi Transparency	Abundance, biovolume, & qual	Vertical Tow[3]	Oblique Tow[4]
JSUR01	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1		
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	100	1	1	1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	175	1	1	1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
KSBP01	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1		
	2.5, 3.5, 5.5, 8, 10[1]			1	1		1	1	1	1			1	1	1	1	1	1	1	1		1	1		1		
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	30																										
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	100			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	200			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1			1	
CK200P	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1			
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	35	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55	1	1	1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
KSSK02	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1		
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55	1	1	1	1	1	1	1			1		1	1	1	1	1	1	1	1		1	1				
LTBC43	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1			
	15	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
LTED04	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1		
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	75			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
LSEP01	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1		
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	100	1	1	1	1	1	1	1			1		1	1	1	1	1	1	1	1		1	1				
	180	1	1	1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
LSKQ06	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1			
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	35	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
LSNT01	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1		
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	30												1	1	1	1	1	1	1	1		1	1				1
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	100			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	180			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1			1	
LSVV01	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1			
	5	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
MSJN02	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1			
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55	1	1	1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
MSWH01[2]	1	1	1	1	1	1	1	1	1	1	1	1									1	1	1	1			
	variable[2]			1	1	1	1	1	1	1	1	1									1	1	1				
NSAJ02[2]	1	1	1	1	1	1	1	1	1	1	1	1									1	1	1	1	1		
	variable[2]			1	1	1	1	1	1	1	1	1									1	1	1				
NSEX01	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1	1		
	2.5, 3.5, 5.5, 8, 10[1]			1	1		1	1	1	1			1	1	1	1	1	1	1	1		1	1		1		
	15			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	25			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	30																										
	35			1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1				
	55			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
	100			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1			1	
	170			1	1		1	1			1		1	1	1	1	1	1	1	1		1	1				
Total # samples per month[5]		54	54	140	140	26	140	140	100	100	136	8	134	134	134	134	134	134	134	134	8	142	142	28	20	6	4
Total # Samples for 2015[5]		594	594	1540	1540	286	1540	1540	1100	1100	1496	88	1474	1474	1474	1474	1474	1474	1474	1474	88	1562	1562	308	220	66	40

[1] Sample will be analyzed on water collected from one of these depths, representing the "chlorophyll max".

[2] Sample collected 1m above the bottom (depth variable with tide height).

[3] Vertical tow (200 m) will be done twice monthly February through November, monthly January & December.

[4] Oblique tow (to 30 m) will be done twice monthly February through November (2 different depth contours).

[5] Total number of samples per month/year assumes monthly sampling at all stations in January and December.

Table 2. 2015 Marine Offshore Monitoring Program--Lower Duwamish River

Monthly Water Column Sampling Matrix

		Bacteria		Laboratory									CTD								Field		
Station	Depth (m)	Enterococcus	Fecal Coliform	Ammonia Nitrogen	Nitrite + Nitrate Nitrogen	Orthophosphorus	Silica	Total Suspended Solids	Dissolved Organic Carbon	Total Organic Carbon	Dissolved Oxygen - Winkler	Salinity	Chlorophyll, Field	Density, Field	Dissolved Oxygen, Field	Light Intensity (PAR), Field	Salinity, Field	Sample Temperature, Field	Surface Light Intensity (PAR), Field	Transmissivity, Field	Dissolved Oxygen, Field	Sample Depth	Sample Start Time
LTKE03	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	variable[1]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
LTUM03	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	variable[1]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
HNFD01	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	variable[1]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
GTPP01[2]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
	variable[1]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1
LTXQ01[3]	1	1	1	1	1	1		1				1									1	1	1
Total # Samples per Month:		9	9	9	9	9	8	9	8	8	8	9	8	8	8	8	8	8	8	8	1	9	9
Total # Samples for 2015:		104	104	104	104	104	92	104	92	92	92	104	92	92	92	92	92	92	92	92	8	104	104

[1] Sample collected one meter above the bottom (depth variable with tidal height).

[2] Sample location is tentative and sampling will not start until March at the earliest.

[3] This station is sampled from land.

Table 3. 2015 Marine Beaches Monitoring Program

Monthly Water and Annual Sediment Sampling Matrix

		Water								Sediment									
		Bacteria		Laboratory conventionals					Field	Laboratory					Field				
Locator	Station Description	Enterococcus	Fecal Coliform	Ammonia Nitrogen	Nitrite + Nitrate Nitrogen	Total Nitrogen	Orthophosphorus	Salinity	Sample Temperature, Field	BNAs	PCBs/PBDEs	Total Metals	Total Organic Carbon	Total Solids/Grain Size	Sample Start Time	Sediment Sampling Range	SampcoordX	SampcoordY	Sediment Description
JSVW04	Richmond Beach	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ITCARKEEKP	Carkeek Park - North	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
KSHZ03	Carkeek Park - Piper's Creek Mouth	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
KTHA01	Carkeek Park - Piper's Creek Upstream	1	1	1	1		1		1										
KSLU03	Golden Gardens	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
KSSN04	West Point - North	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
KSSN05	West Point - South	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
KSYV02	South Magnolia CSO	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
LTBD27	SAM Sculpture Park Beach	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
LSGY01	Seacrest Park	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
LSHV01	Alki Beach	1	1	1	1		1	1	1										
LSKR01	Alki Beach - Alki Plant	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
LSKS01	Richey Viewpoint	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
LSVW01	Fauntleroy Cove	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MTLD03	Normandy Park	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
MTUJ01	Des Moines Creek Park	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
NTFK01	Redondo Beach	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
NSJY01	Dumas Bay Park	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MSJL01	Vashon Island - Gorsuch Road	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
MSSM05	Vashon Island - Tramp Harbor	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
MSXK01	Vashon Island - Burton Acres Park	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Total # samples per month:	**21**	**21**	**21**	**21**	**6**	**21**	**20**	**21**	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**19**
	Total # samples for 2015:	**252**	**252**	**252**	**252**	**72**	**252**	**240**	**252**	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**19**	**19**

Table 4. 2015 Mooring Program Quality Control/Calibration Samples

		Lab						Field	
Station	Depth (m)	Dissolved inorganic carbon / Total alkalinity[3]	Nitrate Nitrogen	Orthophospahte phosphorus	Silica	Dissolved Oxygen	Salinity	Turbidity	Sample Temperature
PTWILLBUOY	1	1	1	1	1	1	1	1	1
	25	1		1	1		1		1
MSWH01[1]	1	1		*a*	*a*	1	*a*		1
	variable[2]	1		*a*	*a*		*a*		1
NSAJ02	variable[2]					1	*a*	1	1
SEAQYSI	1					1	1	1	1
	10					1	1	1	1
Total # samples per month		**6**	**1**	**6**	**6**	**5**	**8**	**4**	**8**
Total # samples for 2015		**72**	**12**	**72**	**72**	**60**	**96**	**48**	**96**

[1] Samples for DIC, TA, temperature, salinity, orthophosphate, and silica collected twice monthly.

[2] Variable - Sample collected one meter above the bottom (depth variable with tidal height).

[3] DIC and total alkalinity will be analyzed at PMEL.

[a] Samples collected as part of routine sampling program (see Table 1).

Table 5. 2015 Marine Offshore Monitoring Program

Elliott Bay Subtidal Sediment Sampling Matrix

		Laboratory											Field						
Locator	Station Description	BNAs (incl. 4-nonylphenol & coprostanol)	Chlorinated Pest/PCBs	PBDEs	Tributyltin	Total Metals	Total Solids	Total Organic Carbon	PSD	Ammonia	Total Sulfide	Benthic infauna	Sample Start Time	Sample Depth	Sediment Sampling Depth	Sediment Sampling Range	SampcoordX	SampcoordY	Sediment Description
KSZY01	Elliott Bay - Pier 90/91	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1
LTAA02	Elliott Bay - Grain Terminal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LSCW02	Elliott Bay - Outer	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1
LTCA02	Elliott Bay - North Central	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1
LTDF01	Elliott Bay - Central Waterfront	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LTED04	Elliott Bay - South Central	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LSHZ08	Elliott Bay - Cove 2	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1
LTGF01	Elliott Bay - Harbor Island	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Total # samples for 2015:	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**4**	**8**	**8**	**8**	**8**	**8**	**8**	**8**

Notes

Samples will be collected from the 0 to 2 cm depth stratum.

Metals will include Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Se, Ag, Sn, and Zn.

All analyses will be performed following QA1 guidance.

Table 6. Marine Monitoring Program

Sampling Stations, Matrices Sampled, and Station Coordinates

Locator	Description	Stratum	Matrices	Northing[1]	Easting[1]
JSVW04	Richmond Beach/Point Wells	Beach	Water/Sediment	286171	1257194
ITCARKEEKP	Carkeek Park	Beach	Water/Sediment	263756	1259915
KSHZ03	Piper's Creek Mouth	Beach	Water/Sediment	263736	1259784
KTHA01	Piper's Creek	Stream	Water	262962	1262305
KSLU03	Golden Gardens	Beach	Water/Sediment	256354	1253305
KSSN04	West Point North	Beach	Water/Sediment	245729	1246032
KSSN05	West Point South	Beach	Water/Sediment	245272	1245980
KSYV02	Magnolia CSO	Beach	Water/Sediment	234547	1254488
LTBD27	SAM Sculpture Park	Beach	Water/Sediment	228851	1264297
LSGY01	Seacrest Park	Beach	Water/Sediment	218711	1258776
LSHV01	Alki Beach	Beach	Water	216852	1253532
LSKR01	Alki North	Beach	Water/Sediment	213666	1249416
LSKS01	Richey Viewpoint	Beach	Water/Sediment	212668	1250283
LSVW01	Fauntleroy Cove	Beach	Water/Sediment	194969	1254846
MTLD03	Normandy Park	Beach	Water/Sediment	165142	1263285
MTUJ01	Des Moines Creek Park	Beach	Water/Sediment	151129	1269533
NTFK01	Redondo Beach	Beach	Water/Sediment	131067	1270899
NSJY01	Dumas Bay Park	Beach	Water/Sediment	122831	1255835
MSJL01	Vashon - Gorsuch Creek	Beach	Water/Sediment	169666	1241897
MSSM05	Vashon - Tramp Harbor	Beach	Water/Sediment	154908	1243459
MSXK01	Vashon - Burton Acres Park	Beach	Water/Sediment	146481	1240772
JSUR01	Brightwater TP outfall	Offshore	Water/Phyto	287580	1250910
KSBP01	Jefferson Head	Offshore	Water/Phyto/Zoo	275439	1248062
CK200P	Carkeek CSO TP Outfall	Offshore	Water	263819	1257728
KSSK02	West Point TP Outfall	Offshore	Water/Phyto	245121	1242740
LTBC43	Elliott West CSO TP Outfall	Offshore	Water	228985	1263430
SEAQYSI	Seattle Aquarium	Offshore	Mooring	225168	1267840
LTED04	Elliott Bay	Offshore	Water/Phyto/Sediment/Benthos	223909	1264675
HNFD01	East Waterway	Offshore	Water	214139	1267488
LTKE03	Duwamish River	Offshore	Water	211418	1265871
LTUM03	Duwamish River	Offshore	Water	196629	1274591
LTXQ01	Henderson/MLK CSO TP Outfall	Offshore	Water	190313	1278053
LSEP01	South TP Outfall	Offshore	Water/Phyto	223360	1247399
LSKQ06	Alki CSO TP Outfall	Offshore	Water	212065	1248334
PTWILLBUOY	Point Williams	Offshore	Mooring/Zoo	205989	1252069
LSNT01	Fauntleroy/Vashon	Offshore	Water/Phyto	198653	1245194
LSVV01	Barton CSO Outfall	Offshore	Water	195347	1253935
MSJN02	Vashon TP Outfall	Offshore	Water	169328	1244585
NSEX01	East Passage	Offshore	Water/Phyto/Zoo	134701	1255331
MSWH01	Quartermaster Harbor	Offshore	Water/Mooring	147976	1236667
NSAJ02	Quartermaster Harbor	Offshore	Water/Mooring/Phyto	140223	1239011
KSZY01	Elliott Bay: Pier 90/91	Offshore	Sediment	231983	1258639
LTAA02	Elliott Bay: grain terminal	Offshore	Sediment/Benthos	231054	1261260
LSCW02	Elliott Bay: outer	Offshore	Sediment	227106	1256271
LTCA02	Elliott Bay: north central	Offshore	Sediment	226303	1260915
LTDF01	Elliott Bay: central waterfront	Offshore	Sediment/Benthos	225367	1267270
LTGF01	Elliott Bay: Harbor Island	Offshore	Sediment/Benthos	218854	1265592
LSHZ08	Elliott Bay: Cove 2	Offshore	Sediment	218767	1259170

[1]North American Datum 1983 (NAD83) - State Plane Coordinate System - Washington North 4601