

EXECUTIVE SUMMARY

The King County Department of Natural Resources operates and maintains three wastewater treatment plants (West Point, South Plant, and Vashon Island) and two combined sewer overflow treatment plants (Alki and Carkeek) that discharge treated effluent into the Central Puget Sound Basin. One of King County's responsibilities is to conduct monitoring in marine waters to verify that these discharges are not degrading water quality within the vicinity of the treatment plants. The routine marine monitoring program has two components; point source monitoring which focuses on areas near treatment plant discharges and ambient monitoring which focuses on areas outside the immediate vicinity of known discharges. It is important to monitor areas outside the influence of point source discharges in order to assess background conditions in central Puget Sound.

King County is planning a new regional wastewater treatment plant in northern King County or southern Snohomish County that will discharge treated effluent through a marine outfall. An intensive marine monitoring program, the Marine Outfall Siting Study (MOSS), was initiated in late 1998 in support of siting a suitable outfall location. This program continued throughout 1999 and 2000.

In 1999, 5 offshore/nearshore and 6 beach water stations, 37 offshore/nearshore and 4 beach sediment stations, 4 shellfish stations, and 4 macroalgae stations were sampled for the point source program. For the point source monitoring program in 2000, 6 offshore/nearshore and 6 beach water stations, 20 offshore/nearshore and 3 beach sediment stations, 4 shellfish stations, and 4 macroalgae stations were sampled. For the 1999 ambient program, 6 offshore/nearshore and 15 beach water stations, 5 beach sediment stations, 6 shellfish stations, and 5 macroalgae stations were sampled. Six offshore/nearshore and 15 beach water stations, 6 offshore/nearshore and 3 beach sediment stations, 6 shellfish stations, and 4 macroalgae stations were sampled for the ambient program in 2000. Water samples were analyzed for bacteria, nutrients, dissolved oxygen, chlorophyll, and physical parameters. Sediment samples were analyzed for organic compounds, metals, and conventional parameters. Sediments around the two main wastewater treatment plants were also sampled for benthic infauna. Shellfish samples were analyzed for organics, metals, and bacteria. Macroalgae were analyzed for metals.

A total of 10 offshore stations (8 in 1999 and 10 in 2000) were sampled for physical properties, nutrients, dissolved oxygen, chlorophyll, and bacteria for the MOSS project. In addition, organics (including polynuclear aromatic hydrocarbons, pesticides, polychlorinated biphenyls, and chlorinated herbicides) and total and dissolved metals were sampled at eight offshore stations in both 1999 and 2000 for the MOSS project. Five of the ten stations are also part of the ambient and point source monitoring programs, however, additional parameters that are not part of the routine sampling program were analyzed.

Eleven beach stations located from Picnic Point (southern Snohomish County) to Shilshole Bay (King County) were sampled for the MOSS project in 2000. Three stations are also part of the ambient monitoring program but had additional parameters analyzed that are not part

of the routine sampling program, such as *E. coli*. Other parameters monitored included physical properties, nutrients, bacteria, organics (including polynuclear aromatic hydrocarbons, chlorinated and organophosphorus pesticides, polychlorinated biphenyls, and chlorinated herbicides), and metals.

Water quality data were also collected for the MOSS project in a series of transects at six locations in the Central Basin. Each transect consisted of either five or six stations spaced equidistant across the length of the transect. Measurements were recorded monthly for a minimum of 15 months starting in 1999. Data collected included physical properties, dissolved oxygen, and chlorophyll.

MONITORING RESULTS

Water

All offshore/nearshore stations met the Washington State Class AA marine surface water standards for fecal coliform bacteria with the exception of two stations located in inner Elliott Bay. Levels at these stations met the geometric mean standard of 14 colonies/100 ml but exceeded the peak standard of 43 colonies/100 ml. The highest values for the Elliott Bay stations occurred during periods of high rainfall and these sites receive higher freshwater input than other stations due to their proximity to the Duwamish River. Fecal coliform bacteria in the water column near the County's treatment plant discharges were found at low levels (usually less than 5 colonies/100 ml), if detected at all.

Fecal coliform counts at intertidal beaches are influenced by freshwater runoff from the surrounding watersheds. As a result, the number of stations exceeding the Class AA marine standards increased in the high rainfall months and at stations closer to freshwater sources. Ten beaches exceeded both the geometric mean and peak standards; four met the geometric mean but not the peak standard; four had variable results between years; and twelve passed both standards. Beaches with the lowest bacteria counts were located near Boeing Creek, Seacrest Park and around the Duwamish Head area.

Enterococcus bacteria levels in the offshore/nearshore water column were low, if detected at all. Enterococcus bacteria counts at beach stations varied between stations and months and did not correlate with fecal coliform bacteria counts. *E. coli* was monitored at the MOSS stations only and showed the same pattern as enterococcus bacteria, in that *E. coli* was seldom detected in offshore waters and varied between stations and months.

Temperature, salinity, and density values indicated a well-mixed water column throughout most of the year, although seasonal thermal stratification was evident in summer for offshore/nearshore stations. A time-lag of about one month was noted in the peak water temperatures between the beach and offshore stations with temperatures peaking in August at beach stations and in September for offshore stations.

In 1999 and 2000, all dissolved oxygen (DO) values were above 5.0 mg/L, the level at which potential problems could occur, at all but three stations. The stations where DO levels were measured as low as 4.5 mg/L were located in Possession Sound, mid-channel of the main basin, and inner Elliott Bay. All DO levels below 5.0 mg/L were measured at the deepest sampling depth for each station.

Nutrients, such as ammonia and nitrate+nitrite, exhibited trends similar to previous years. Ammonia was highest in the summer and nitrate+nitrite was most abundant in winter when not being taken up by phytoplankton. All ammonia concentrations for beach and offshore stations, including those located near the treatment plant outfalls, were well below the Washington State ammonia criterion for marine surface waters. Phytoplankton blooms (indicated by chlorophyll-*a* concentrations) in 1999 and 2000 were not as consistent in terms of occurring at similar times of the year as seen in previous years. The May and June blooms appeared to be consistent in both 1999 and 2000, however, the timing of the late summer/early fall bloom was variable. The three northernmost stations (located in Admiralty Inlet, Possession Sound, and mid-basin south of Richmond Beach) had chlorophyll-*a* peaks occurring earlier (in April) than the other stations.

Fourteen total metals were analyzed at the MOSS offshore stations of which 12 were detected in over 90% of the samples. For dissolved metals, 9 of the 14 metals were detected in over 90% of the samples. Metal concentrations for all offshore samples were well below the associated Washington State acute and chronic marine water quality criteria. For beach samples, 11 of the 14 total metals analyzed were detected in over 97% of the samples and 10 of the 14 dissolved metals were detected in over 90% of the samples. Metal concentrations at all beach stations were below Washington State acute and chronic marine water quality criteria.

Twenty different organic compounds were detected in offshore water column MOSS stations. Most compounds were polynuclear aromatic hydrocarbons and phthalates. Twenty-one different organic compounds were detected in samples at MOSS beach stations. Again, most compounds were polynuclear aromatic hydrocarbons and phthalates. Washington State has not promulgated water quality criteria for any of the compounds detected.

Sediment

Sediments around the South Plant, Vashon Island, and Alki treatment plant outfalls were sampled in 1999 and around the West Point and Carkeek outfalls in 2000. Additional samples, including beach sediments, were collected from other areas as well.

Sixteen metals were analyzed and several were either not detected (antimony, selenium and thallium) or seldom detected (cadmium and silver). Arsenic was only detected in one sample in 1999 but was detected in all but one offshore sample in 2000. Beryllium, chromium, copper, lead, nickel, and zinc were detected in most samples, however, no concentrations exceeded Washington State Sediment Quality Standards (SQS) guidelines. Mercury was

detected in the majority of offshore samples and mercury concentrations at the stations along the Seattle waterfront in Elliott Bay exceeded the SQS. Similar results have been seen in previous sampling events for this station, where there is known mercury contamination. For the outfall stations, a concentration gradient was not evident for any of the sites with respect to distance away from the outfall pipe.

Of the 98 organic compounds analyzed, 11 were detected in offshore/nearshore samples and 6 were detected in beach samples in 1999. In 2000, 23 compounds were detected in offshore/nearshore samples and 1 was detected in a beach sample. Most of these compounds were polynuclear aromatic hydrocarbons (PAHs). Three PCB Aroclors were detected at all stations around the South Plant TP outfall (Aroclor 1254 and 1260 were detected in all samples and 1248 was detected in two samples). Sampling generally showed the highest levels of organic compounds in the nearshore area of Elliott Bay. No organic compounds exceeded SQS criteria for any stations (both offshore/nearshore and beach) in either 1999 or 2000.

Biological monitoring (benthic community analysis) was conducted at six stations in 1999 around the South Plant TP outfall and at six stations around the West Point TP outfall in 2000. Diversity indices and total species abundances were generally higher at the West Point stations than at the South Plant stations, due to the sandier sediments at West Point. Sediment grain size is a major factor in determining the total number of species, dominant species, and total biomass. The benthic communities at both sites are typical of sediments with similar physical characteristics and of sediments at similar depths.

Shellfish

Shellfish (butter clams) tissues from four point source and two ambient stations were analyzed for metals and organic compounds. Ten of the 11 metals analyzed were detected in 1999 and 13 of the 14 metals analyzed in 2000 were detected. Concentrations varied only slightly between stations. There was no correlation between metal concentrations and lipid content. State and federal criteria do not exist for acceptable levels of metals in shellfish tissues, however, the Food and Drug Administration (FDA) has established an Action Level in fish and shellfish tissues of 1.0 mg/kg for mercury. When this value is exceeded, the food product cannot be commercially traded. Mercury concentrations in shellfish tissues were well below this Action Level. The FDA has also established guidance values termed "Levels of Concern" for mollusks for five metals: arsenic, cadmium, chromium, lead, and nickel. Shellfish results were below these Levels of Concern.

Of all the organic compounds analyzed, only benzoic acid was detected. Benzoic acid is a degradation product produced by metabolic processes and has always been detected in shellfish samples.

Fecal coliform concentrations varied from station to station and from month to month. Generally, stations near Seahurst, West Point, and Normandy Park had the lowest values and

the station at Tramp Harbor had the highest values. The association between fecal coliform concentrations measured in shellfish and concentrations detected in water was examined and a consistent relationship was not evident. Enterococcus concentrations also varied from station to station and month to month and stations near Seahurst, West Point, and Normandy Park had consistently low values.

Macroalgae

Algae samples were collected from nine stations in 1999 and eight stations in 2000 for analysis of metals. Four metals were not detected in any of the samples and lead was seldom detected. Copper and zinc were detected in all samples. Arsenic, cadmium, chromium, and nickel were detected in most samples. Concentrations varied between stations and did not show a consistent pattern when compared with previous results. In the past few years, chromium, nickel, and zinc values were found to be higher at the West Point stations, however, results in 1999 and 2000 did not indicate higher concentrations at the West Point stations.

CTD Transect Data

Conductivity, temperature, depth (CTD) transects were conducted monthly at three locations in 1999 and 2000 for the MOSS project. Three additional sites were sampled in 2000. Data collected included physical properties, dissolved oxygen, and chlorophyll-*a*. Temperature, salinity, and density data indicated typical seasonal patterns, with the water column warming in June. Salinities near the surface of the Possession Sound transect were lower than other areas due to the freshwater input of the Snohomish River. Chlorophyll-*a* concentrations showed patterns similar to the northern ambient stations monitored, with higher values detected in May, July, and October. Dissolved oxygen concentrations were below 5.0 mg/L for 11 of the 70 transects. The majority of low values were recorded in Possession Sound, which has historically low DO concentrations. Overall, transect data indicated patterns consistent with observed and suspected circulation patterns of the Central Basin and Possession Sound.