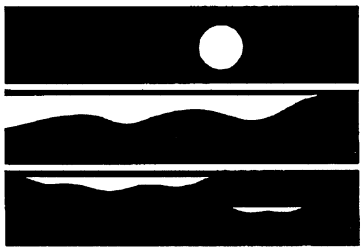


Watershed Briefing Paper for the Cedar/Green Water Quality Management Area

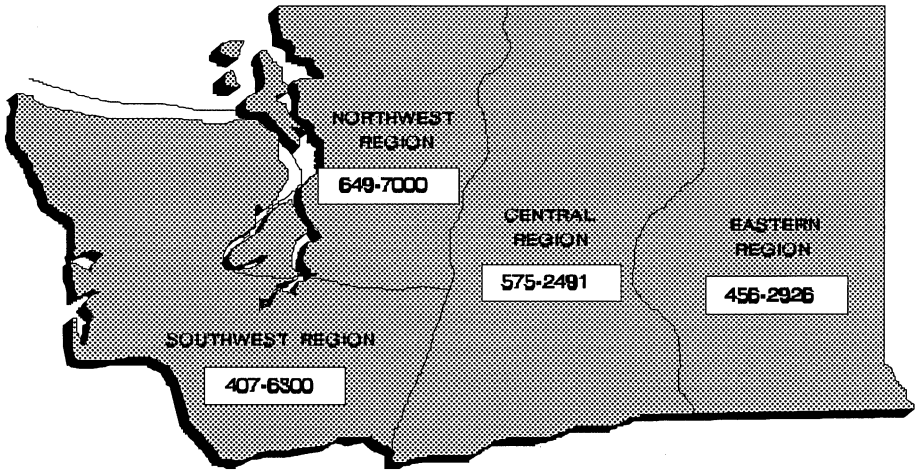
October 1997

Publication No. 97-335

Printed on Recycled Paper

For additional copies of this report, contact:

Department of Ecology
Publications
P.O. Box 47600
Olympia, WA 98504-7600
Telephone: (360) 407-7472



The Department of Ecology is an equal opportunity agency and does not discriminate on the basis of race, creed, color, disability, age, religion, national origin, sex, marital status, disabled veteran's status, Vietnam Era veteran's status, or sexual orientation.

For more information or if you have special accommodation needs, please contact Shirley Rollins at (360) 407-6696. Ecology Headquarters telecommunications device for the deaf (TDD) number is (360) 407-6006. Ecology Regional Office TDD numbers are as follows:

SWRO (TDD) (360) 407-6306
NWRO (TDD) (206) 649-4259
CRO (TDD) (509) 454-7673
ERO (TDD) (509) 458-2055

Watershed Briefing Paper for the Cedar/Green Water Quality Management Area

by
Karol Erickson
Dale Davis
Margaret Dutch
William Ehinger
Denis Erickson
Brad Hopkins
Guy Hoyle-Dodson
Jan Newton
Jenifer Parsons
Rob Plotnikoff
Kirk Smith

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Post Office Box 47600
Olympia, Washington 98504-7600

WRIAs 8 and 9
Waterbodies WA-08-0000, WA-09-0000

October 1997

Publication No. 97-335


Printed on Recycled Paper

This page is purposely blank for duplex printing

Table of Contents

Table of Contents (cont.)

Executive Summary

Purpose

This briefing paper summarizes the water quality studies conducted by the Department of Ecology Environmental Investigations and Laboratory Services Program (EILS) over the last ten years in the Cedar/Green Water Quality Management Area. The area includes Water Resource Inventory Areas 8 and 9, the Cedar and Green river watersheds, respectively.

The purpose of the review is to provide EILS' contribution to what is known about this region and identify water quality issues that may require monitoring or intensive studies over the next two years. This evaluation is part of an agency-wide scoping effort for Ecology's watershed approach to water quality management. The scoping process represents the first year of a five-year process, culminating in pollution prevention and control actions by year five.

Summary of Recommendations

River and Stream Ambient Monitoring

The following stations are recommended for future freshwater ambient monitoring (listed in order of priority):

Station Name	Rationale
1. Green River above Big Soos Creek	Dissolved oxygen, nutrients, fecal coliform bacteria.
2. Big Soos Creek near Auburn	Dissolved oxygen, nutrients, fecal coliform bacteria.
3. Mill Creek (Tributary to Green @ RM 22.2)	Dissolved oxygen, nutrients, fecal coliform bacteria.
4. Sammamish River at Bothell	Dissolved oxygen, nutrients, fecal coliform bacteria.
5. Cedar River at Maplewood	Fecal coliform bacteria.

Additional Parameters

Low level metals monitoring should be considered for the Cedar River at Logan Street Bridge in Renton. This station is a long-term core station and lacks baseline metals information.

Watershed Assessments and TMDLs

Ecology should investigate cooperative approaches and strategies with King County to address the numerous 303(d) listings in both the Cedar and Green watersheds. Potential approaches (not mutually exclusive) include watershed planning development and implementation, source assessment work, Total Maximum Daily Load (TMDL) studies, programmatic solutions, and grant funding. Given the high number of fecal coliform listings, special emphasis is warranted for bacteria contamination.

Toxics Investigations

Urban Nonpoint Contamination

Results from sampling by the Washington State Pesticide Monitoring Program (WSPMP) and U.S. Geological Survey (USGS) in this watershed answer some questions about the types and extent of contaminants in urban streams, but do little to identify specific sources. Information about how and where contaminants are getting into the streams is needed before steps can be taken to keep them out. For streams with high concentrations and/or numbers of contaminants identified by WSPMP and USGS results, more samples must be collected to identify specific sources.

Paine Field Drainage

This site has apparently been cleaned up by Boeing. However, there was never any follow-up sampling by Ecology to confirm that contaminants were completely removed. Due to the high concentrations of some contaminants found in 1987, particularly PCBs (20,500 µg/Kg in sediment), this area warrants confirmation sampling.

Compliance

Priorities for Class II inspections have been determined based on a number of factors, including last inspection, activity, permit expiration date, population served, discharge parameters, and receiving water status. Class II inspections are suggested for the following facilities:

Industrial Facilities

Cedar: Auburn Thoroughbred Racetrack, Birmingham Steel Corp, Jorgensen Forge Corp., Marco Seattle, Northlake Shipyard Inc, Pacific Coast Coal Co, Sea Tac Airport, and The Stroh Brewery

Green: Boeing Developmental Ctr, Cadman Seattle, Duwamish Shipyard, Texaco Kent, Texaco Harbor Island, Todd Pacific Shipyard, Tosco NW Co.

Municipal Facilities

Cedar: Edmonds STP, Lakota STP, Lynnwood STP, Metro West Point Wastewater Treatment Plant (WWTP), Miller Creek WWTP, Redondo STP

Green: Metro Alki Point, Metro Alki Point, Salmon Creek WWTP

Dischargers to National Pollution Discharge Elimination System (NPDES) Facilities

Pretreatment inspections in conjunction with Class II inspections are recommended for the following:

Cedar: Super Surface Tecna, Time Oil Company, Weyerhaeuser Technology Center

Green: Mobil Station 99D9T, Olympian Precast Inc., S & S Color Lab

Lake Ambient Monitoring

Both Snohomish County and King County have elaborate lake monitoring programs, although these programs have suffered from budget reductions in recent years. Due to the shortage of resources in Ecology, it is not recommended that Ecology expend any resources in this watershed for monitoring lake water quality since both Snohomish and King counties have existing lakes programs.

Aquatic Plants Ambient Monitoring

- Continue to monitor the *Hydrilla* population in Pipe and Lucerne lakes, and continue efforts to eradicate this plant.
- Continue to offer technical assistance to local government officials and citizens concerning the lakes with populations of noxious weeds.
- Continue monitoring lakes near waterbodies with noxious weeds to detect any new introductions of these plants at an early stage.
- Increase public education on the impacts of noxious aquatic weeds and how to prevent their spread.

Bioassessment Monitoring

The mountain regions of this Water Quality Management Area (WQMA) were the focus of the survey described in this briefing paper. Additional surveys of the lower watershed

need to be completed. The lower watersheds are influenced by suburban development and hobby farms.

Ground Water Investigations

The primary ground-water issue in the watersheds is related to the quantity of ground water available for water supply (personal communication with Dave Garland, NWRO, August 7, 1997). Regional staff did not identify any ground water quality issues. EILS has not done enough work in the area to make meaningful ground water quality recommendations.

Marine Water Quality Ambient Monitoring

Ecology should work with METRO-King County to identify where fecal coliform contamination is worst in Elliott Bay.

The somewhat frequent fecal coliform bacteria exceedences at station PSB003 near West Point is surprising given the well-mixed waters and the large basin that station represents. The source for the high concentration events in the Main Basin off West Point is not known and should be investigated.

Low dissolved oxygen (DO) may be of concern in Elliott Bay. The status of DO in Elliott Bay should be investigated from the METRO-King County database. Because of the extensive anthropogenic impact on the bay, it may be sensitive, though the concentration cited above poses no immediate cause for concern.

To assess eutrophication, it is recommended to assess nutrient trends in freshwater input where failing septics may occur, and where other exogenous point and non-point nutrient sources are significant. No current instances of eutrophication are evident in this WQMA though localized nearshore high ammonium values were observed (Kendra, 1989). Further investigation of nearshore nutrient conditions may be warranted.

Information is lacking on the degree that chemical contamination is historical (e.g., in sediments) or current (e.g., still mobile in water column and taken up by plankton, at the base of the pelagic food-web). In conjunction with METRO-King County, the degree of ongoing versus historical chemical contamination and its availability in the water column and to plankton should be assessed in specific areas of high concern.

Ecology should work with the Washington State Department of Health, University of Washington, National Marine Fisheries Service, and Pacific Coast Oyster Growers Association to develop a comprehensive monitoring and assessment program for harmful phytoplankton.

Abstract

This briefing paper summarizes the water quality studies conducted by the Department of Ecology Environmental Investigations and Laboratory Services Program (EILS) over the last ten years in the Cedar/Green Water Quality Management Area. The area includes Water Resource Inventory Areas 8 and 9, the Cedar and Green river watersheds, respectively. The purpose of the review is to provide EILS' contribution to what is known about this region and identify water quality issues that may require monitoring or intensive studies over the next two years.

Recommendations are given for adding five additional stations for freshwater ambient monitoring and for continued monitoring of lake aquatic plants. Follow-up source identification work, based on the Washington State Pesticide Monitoring Program and U.S. Geologic Survey sampling, is recommended for identifying how toxic contaminants are getting into streams. Cooperative approaches with King County are recommended for addressing the numerous section 303(d) listings in the management area for fecal coliform, dissolved oxygen, temperature and metals. Confirmation sampling is recommended for the Paine Field Drainage site to verify that toxic contaminants were completely removed. Numerous municipal and industrial wastewater treatment plants are recommended for inspections. Additional bioassessment surveys are recommended in the lower watershed.

Follow-up evaluation is recommended for fecal coliform contamination found in Elliott Bay near West Point. To address eutrophication, assessment of nutrient trends in freshwater input is recommended, especially where failing septics may occur and where other exogenous point and non-point nutrient sources are significant. The degree that chemical contamination is historical or current should be assessed in specific areas of high concern. Ecology should work with the Washington State Department of Health, University of Washington, National Marine Fisheries Service, and Pacific Coast Oyster Growers Association to develop a comprehensive monitoring and assessment program for harmful phytoplankton.

Acknowledgements

This report reflects work done by many EILS staff. Review comments by Larry Goldstein, Will Kendra, and Ken Dzinbal improved the report. Word processing by Joan LeTourneau was much appreciated.

River and Stream Ambient Monitoring

by
Brad Hopkins and William Ehinger

Water Quality

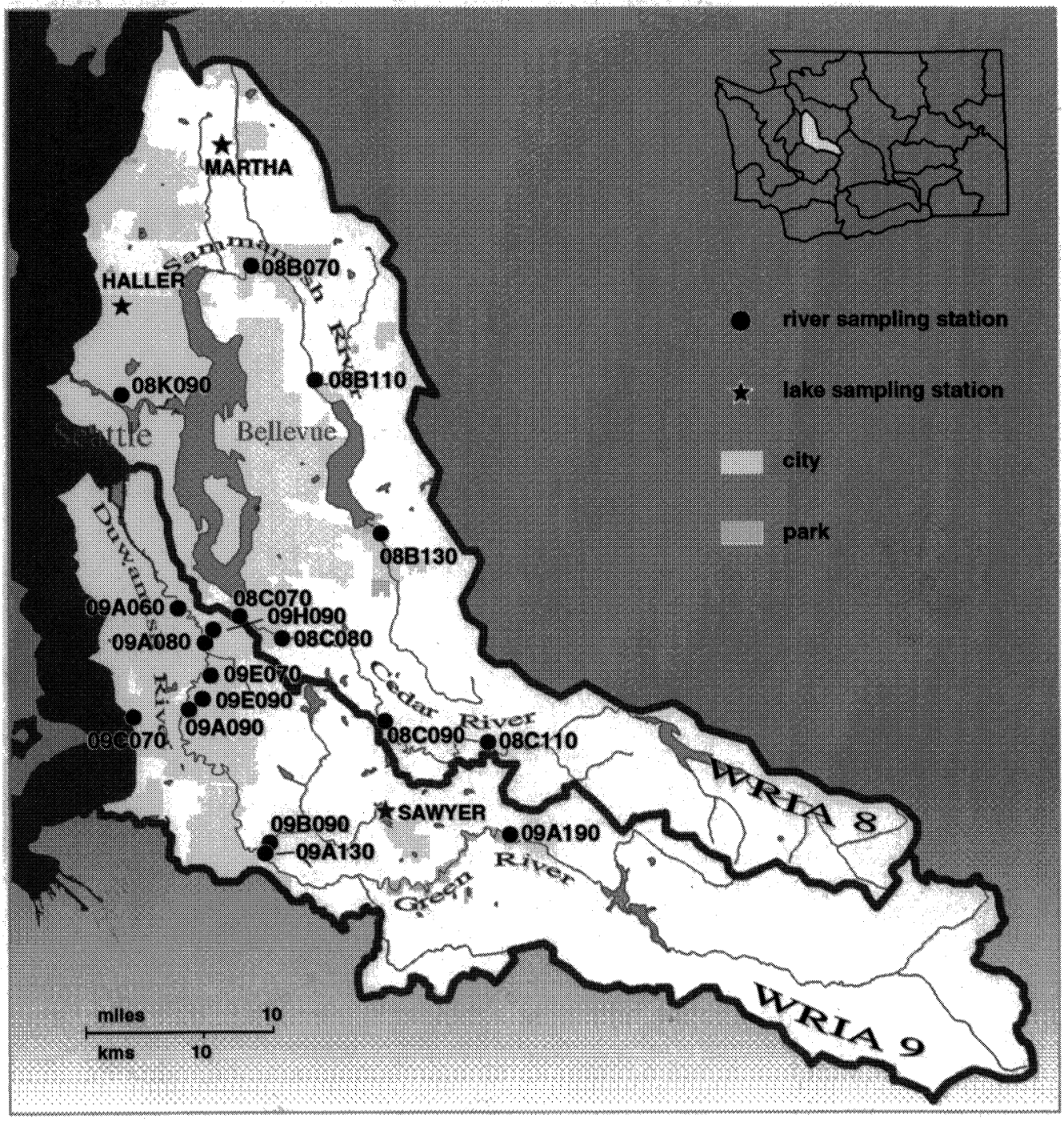
The Washington State Department of Ecology Ambient Monitoring Section (AMS) has collected monthly water quality information at 18 locations in the Cedar/Green WQMA since Water Year 1979 (October 1978- September 1979). Figure 1 shows the locations monitored and Table 1 the years they were sampled. Water quality samples were analyzed for most conventional parameters, including nutrients and instantaneous discharge (Hallock *et al.*, 1997).

Table 1. Freshwater Ambient Monitoring Locations in the Cedar/Green WQMA and the years they have been monitored.

	Station #	Station Name	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
1.	08B070	Sammamish R @ Bothell	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
2.	08B110	Sammamish R @ Redmond																	X			
3.	08B130	Issaquah Cr nr Issaquah																	X			
4.	08C070	Cedar R @ Logan St Bridge	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.	08C080	Cedar R @ Maplewood																	X			
6.	08C090	Cedar R @ Maple Valley																	X			
7.	08C110	Cedar R nr Landsburg	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X
8.	08K090	Ship Canal @ Freemont																	X			
9.	09A060	Duwamish R @ Allentown			X	X	X	X	X	X	X	X	X	X	X							
10.	09A080	Green R @ Tukwila															X	X	X	X	X	X
11.	09A090	Green R @ 212th St Bridge			X	X	X	X	X	X	X	X	X	X	X				X			
12.	09A130	Green R abv Big Soos Cr																	X			
13.	09A190	Green R @ Kanaskat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14.	09B090	Big Soos Cr nr Auburn																	X			
15.	09C070	Des Moines Cr nr Mouth																	X			
16.	09E070	Mill Cr @ Orillia								X	X	X	X	X	X				X			
17.	09E090	Mill Cr Kent on W Valley Hwy								X	X	X	X	X	X				X			
18.	09H090	Black R @ Renton																	X			

This page is purposely blank for duplex printing

Cedar/Green Water Quality Management Area



This page is purposely blank for duplex printing

Ship Canal

Ship Canal at Freemont

AMS collected information at the Freemont Bridge during Water Year 1994 (WY1994). There were no violations of Washington Water Quality Standards (WWQS) for those parameters monitored (Hallock and Ehinger, 1995) at this station.

Sammamish River

AMS has collected information at three locations on the Sammamish River: Sammamish R @ Bothell (River mile {RM} 20.4), Sammamish R @ Redmond (RM 28.65) and Issaquah Cr nr Issaquah (RM 33.6). The Sammamish River has continuing water quality problems with elevated temperatures, low dissolved oxygen and high fecal coliform bacteria concentrations.

Sammamish River at Bothell

This sampling location was monitored by Ecology from WY1978 to WY1994. Trend information on water quality data WY1987 to WY1994 is presented in Table 2.

Table 2. Trend Results for Sammamish River at Bothell from WY1987 to WY1994.

Parameter	Raw Data	Flow Adjusted
Temperature	NS	NA
Dissolved Oxygen	NS	NA
Percent Saturation	NS	NA
Specific Conductivity	D	D
Nitrate + Nitrite-N	NS	I
Ammonia -N	D	NA
Total Phosphorus	NS	NA
Soluble reactive Phosphorus	NA	NA
Total Suspended Solids	NS	NA
Fecal Coliform Bacteria	NS	NS
Flow	NS	

NS - Not Significant (P> 0.10)
NA - Not Applicable (data were inappropriate for analysis)
D - Decreasing
I - Increasing

Declining trends are present in the raw data for ammonia and specific conductivity. Flow adjusted trends for specific conductivity are also decreasing and flow adjusted nitrite + nitrite nitrogen levels are increasing. Review of WY1994 data shows continuing violation of WWQS for fecal coliform bacteria levels, temperature and dissolved oxygen. Temperatures for the months of June through September were in violation of standards. Elevated temperatures also contributed to 4 of the 6 dissolved oxygen violations (increased temperature reduces the amount of dissolved oxygen at 100 percent saturation). The percent saturation of dissolved oxygen at this location did not fall below 85 percent during WY1994 (Hallock and Ehinger, 1995). The Sammamish River serves as an outlet for Lake Sammamish, and the lake may be contributing a significant portion to the water quality problems.

Sammamish River at Redmond

This sampling location was only monitored for WY1994. Review of the data shows violation of WWQS for fecal coliform bacteria, temperature and dissolved oxygen. Fecal coliform bacterial violations were lower than those found at the Bothell station. Temperature violations from June through September were similar to those found at Bothell. Dissolved oxygen was violated on one occasion (July) and all saturation levels were above 85 percent (Hallock and Ehinger, 1995).

Issaquah Creek near Issaquah

This sampling location was only monitored for WY1994. Review of the data shows water quality within the expected range for similar streams in the basin with the exception of fecal coliform bacteria levels, which violated WWQS for July through September (Hallock and Ehinger, 1995).

Cedar River

AMS has monitored four locations on the Cedar River: Logan Street Bridge in Renton (RM 1.0), Maplewood (RM 4.1), Maple Valley (RM 14.5) and a site near Landburg (RM 25.1). Review of the WY1996 data shows the Cedar system as having good water quality, with only one violation of WWQS for fecal coliform bacteria. The WY1994 fecal coliform bacteria data show increasing counts as you move downstream.

Upstream/downstream comparisons between two long-term stations (Renton and near Landburg) from WY1987 to WY1996 indicate that, except for fecal coliform bacteria levels, the Cedar River does not change dramatically from the Cedar River Watershed (RM 25.1) to the City of Renton (RM 1.0).

Cedar River at Logan Street Bridge in Renton

This sampling location has been monitored by Ecology since WY1978 and is part of the ongoing monitoring program. Trend information on water quality data WY1987 to WY1996 is presented in Table 3.

Table 3. Trend Results for Cedar River at Logan Street Bridge in Renton from WY1987 to WY1996.

Parameter	Raw Data	Flow Adjusted
Temperature	D	NA
Dissolved Oxygen	D	NA
Percent Saturation	D	NA
Specific Conductivity	D	D
Nitrate + Nitrite-N	NS	NS
Ammonia -N	NA	NA
Total Phosphorus	NA	NA
Soluble reactive Phosphorus	NA	NA
Total Suspended Solids	NS	D
Fecal Coliform Bacteria	I	I
Flow	NS	

NS - Not Significant (P> 0.10)
NA - Not Applicable (data were inappropriate for analysis)
D - Decreasing
I - Increasing

The declining trends for dissolved oxygen/percent saturation and the increasing trend for fecal coliform bacteria are those of greatest concern. Declining trends are present for temperature, dissolved oxygen, percent saturation of dissolved oxygen and specific conductivity. Flow adjusted trends for specific conductivity and total suspended solids are also decreasing. Increasing trends are present in both the raw and flow adjusted fecal coliform data. The declining trend for dissolved oxygen/percent saturation, while present, is not having any in-stream impact. The median percent saturation level for WY1987 through WY1996 is 100.7 and the minimum was 95.5 percent. The increasing trend for fecal coliform could results in more violation in the future. Review of WY1996 data shows one violation for fecal coliform bacteria (Hallock *et al.*, 1997).

Cedar River at Maplewood

This sampling location was only monitored for WY1994. Review of the data shows no violations of WWQS and good water quality. The ten-mile reach between this station (RM 4.1) and the Maplewood location (RM 14.5) sees a substantial increase in fecal coliform bacteria concentrations (Hallock and Ehinger, 1995).

Cedar River at Maple Valley

This sampling location was only monitored for WY1994. Review of these data shows no violations of WWQS and good water quality (Hallock and Ehinger, 1995).

Cedar River near Landburg

This sampling location has been monitored by Ecology since WY1978, excluding WY1992 and WY1993, and is part of the ongoing monitoring program.

The Cedar River at Landburg has very good water quality. A declining trend for dissolved oxygen/percent saturation and an increasing trend for nitrate+nitrite-nitrogen are present in the raw data set from 1987-1996; however, their relative magnitudes are small. Data for WY1996 showed no violations of WWQS (Hallock *et al.*, 1997).

Green River

AMS has monitored nine locations on the Green River, five mainstream stations and four tributaries. The five mainstream stations are: Duwamish River at Allentown Bridge (RM 8.3), Green River at Tukwila (RM 12.4), Green River at 212th Street near Kent (RM 18.3), Green River above Big Soos Creek (RM 33.9) and Green River at Kanaskat (RM 57.6). The four Green River tributary stations are: Black River at Renton (RM 0.6), Big Soos Creek near Auburn (RM 1.6) and two on Mill Creek -- Mill Creek on West Valley Highway (RM 4.66) and Mill Creek at Orillia (RM 3.14). Upstream/downstream comparison between the two long-term stations at Tukwila and Kanaskat from WY1991 to WY1996 are presented in Table 4.

Table 4. Seasonal Wilcoxon-Mann-Whitney Upstream/Downstream Comparison for the Green River at Tukwila and Green River at Kanaskat from WY1991-WY1996.

Parameter	Difference *	Units
Temperature	2.0	°C
Dissolved Oxygen	-1.2	mg/L
Percent Saturation	-8.3	%
Specific Conductivity	43	µmhos/cm
Total Persulfate Nitrogen	0.381	mg/L
Nitrate + Nitrite Nitrogen	0.278	mg/L
Ammonia Nitrogen	0.015	mg/L
Total Phosphorus	0.031	mg/L
Soluble Reactive Phosphorus	0.008	mg/L
Total Suspended Solids	9.0	mg/L
Fecal Coliform Bacteria	82	#/100 ml
Flow	175	cfs

* median difference (downstream minus upstream, minus sign means decrease in variable value going downstream)

Almost all parameters monitored show a substantial change between RM 57.6 and RM 12.4. The WY1994 data between RM 33.9 to RM 18.3 show a significant degradation of water quality. Big Soos Creek (RM 33.8) and Mill Creek (RM 24.2) both enter the Green River in this river reach and might be impacting water quality (HHC, 1969).

Duwamish River at Allentown Bridge

This station has not been monitored since WY1990. The station was dropped because:

- the sample location is tidal influenced
- the Renton STP outfall was removed from the Green River (May 1987)

Green River at Tukwila

This station replaced the Allentown site and has been monitored since WY1992. Trend information on water quality data from WY1987 to WY1996 is presented in Table 5.

Table 5. Trend Results for the Green River at Tukwila from WY1992 to WY1996.

Parameter	Raw Data	Flow Adjusted
Temperature	D	NA
Dissolved Oxygen	NS	NA
Percent Saturation	D	NA
Specific Conductivity	NS	I
Nitrate + Nitrite-N	NS	I
Ammonia -N	NS	NA
Total Phosphorus	I	NS
Soluble reactive Phosphorus	NS	NA
Total Suspended Solids	NS	NS
Fecal Coliform Bacteria	NS	NA
Flow	NS	

NS - Not Significant (P> 0.10)
NA - Not Applicable (data were inappropriate for analysis)
D - Decreasing
I - Increasing

Decreasing trends are present for temperature and percent saturation. Increasing trends are apparent in total phosphorus and flow adjusted specific conductivity concentrations. Review of the WY1996 data shows the Tukwila site continuing to violate standards for temperature, dissolved oxygen and fecal coliform bacteria (Hallock, *et al.*, 1997).

Black River at Renton

This sampling location was only monitored for WY1994. WY1994 data showed violations for eight of the twelve months for dissolved oxygen and fecal coliform bacteria. The July 20 temperature of 20.6 also violated WWQS (Hallock and Ehinger, 1995). The Black River appears to have significant water quality problems.

Mill Creek at Orillia

This sampling location was monitored from WY1986 to WY1990 and again in WY1994. The station was established to track the clean-up activities of Western Processing near Orillia. Review of the WY1994 data shows chronic dissolved oxygen violations of WWQS. The station also had WWQS violations for fecal coliform bacteria and temperature (Hallock and Ehinger, 1995).

Mill Creek on West Valley Highway near Kent

This monitoring location was monitored from WY1986 to WY1990. The station was established as a control for ongoing clean-up activities at Western Processing near Orillia.

Green River at 212th Street near Kent

This sampling location was monitored by Ecology from WY1980 to WY1991 and again in WY1994.

Trend information from WY1987 to WY1994 shows decreasing specific conductivity and increasing fecal coliform bacteria and flow levels. The limited data set along with the two-year break in sampling may explain the difference between trend results at this location and those at Tukwila. Review of the WY1994 data shows violations of WWQS for temperature, dissolved oxygen and fecal coliform bacteria similar to those at the Tukwila site (Hallock and Ehinger, 1995).

Big Soos Creek near Auburn

This sampling location was only monitored for WY1994. Review of the WY1994 data shows WWQS were violated once for both temperature (August) and fecal coliform bacteria levels (February) (Hallock and Ehinger, 1995). Considering the limited data set, this stream appears to have only minor water quality problems.

Green River above Big Soos Creek

This monitoring location was only monitored for WY1994. Review of the WY1994 data shows only one temperature violation of WWQS (Hallock and Ehinger, 1995).

Green River at Kanaskat

This monitoring location was monitored by Ecology from WY1978 to WY1996 and is part of the ongoing monitoring efforts.

The Green River at Kanaskat has very good water quality. Water quality trends are present in the data set; however, their relative magnitudes are small. Data for WY1996 show no violations of WWQS (Hallock *et al.*, 1997).

Des Moines Creek

This sampling location was only monitored for WY1994. Review of the WY1994 data shows one fecal coliform bacteria violation of WWQS (Hallock and Ehinger, 1995).

Recommendations

Basin Station

The following are locations within the Cedar/Green WQMA that should be considered for future monitoring, listed in their order of priority.

Station Name	Rationale
1. Green River above Big Soos Creek	Dissolved oxygen, nutrients, fecal coliform bacteria.
2. Big Soos Creek near Auburn	Dissolved oxygen, nutrients, fecal coliform bacteria.
3. Mill Creek (Tributary to Green @ RM 22.2)	Dissolved oxygen, nutrients, fecal coliform bacteria.
4. Sammamish River at Bothell	Dissolved oxygen, nutrients, fecal coliform bacteria.
5. Cedar River at Maplewood	Fecal coliform bacteria.

Additional Parameters

Low level metals monitoring should be considered for the Cedar River at Logan Street Bridge in Renton. This station is a long-term core station and lacks baseline metals information.

References

HHC, 1969. River Mile Index - Deschutes, Nisqually, Puyallup, Green, Lake Washington and Snohomish Rivers. Northwest River Basin Commission, 53 pp.

Hallock, D., and B. Ehinger, 1995. River and Stream Ambient Monitoring Report for Wateryear 1994. Washington State Department of Ecology, Ambient Monitoring Section, Olympia, WA.

Hallock, D., B. Ehinger and B. Hopkins, 1997. Draft -River and Stream Ambient Monitoring Report for Wateryear 1996. Washington State Department of Ecology, Ambient Monitoring Section, Olympia, WA.

Watershed Assessments and TMDLs

by
Karol Erickson

Introduction

The Watershed Assessments Section has done limited work in the Cedar/Green WQMA. The largest project was a series of studies on Lake Sawyer and the Black Diamond Treatment Plant. In addition, studies have been conducted on the Washington Waste Hauling and Recycling facility and Fauntleroy Creek and Cove. Two fish hatcheries in the management area are included in a fish hatchery study, and Mill Creek and Newaukum Creek are included in a literature review for water quality impacts from dairies. The studies are summarized below.

Summary of Studies

Lake Sawyer and Black Diamond Treatment Plant

Pelletier and Joy (1989) studied the influence of the Black Diamond Treatment Plant on nutrient balance in Lake Sawyer. They found that the treatment plant, which used a natural wetland component, was not effectively removing nutrients from the wastewater. Whole-lake total phosphorus increased by about 50% (from 20 to 31 ug P/L) following start-up of the plant. This corresponded to the estimated loading being discharged from the treatment plant. The authors recommended an in-lake total phosphorus criterion of 25 ug/L and recommended diversion of the Black Diamond wastewater treatment plant discharge from the lake.

Carroll and Pelletier (1991) published a diagnostic study of Lake Sawyer two years later. By this time, diversion of the treatment plant discharge was being planned, and the purpose of the study was to establish a comprehensive baseline water quality assessment. Recent housing development in the Rock Creek subbasin and along the shoreline, as well as suspected increases in the frequency of algae blooms, caused concern for the future water quality of the lake. The 1991 study confirmed phosphorus to be the limiting nutrient, and predicted the equilibrium trophic condition after treatment plant diversion. The report recommended an in-lake mean total phosphorus criterion of 16 ug/L. The study recommended nonpoint controls and cautioned that future development in the basin could counteract the positive influence of the treatment plant diversion.

See the Lake Ambient Monitoring section of this briefing paper for more recent water quality information on Lake Sawyer.

Washington Waste Hauling and Recycling

Sargeant (1996) performed some facility-drainage sampling for the Washington Waste Hauling and Recycling facility. Run-off from the facility eventually enters Mill Creek, a Class A stream. Sargeant found high turbidity in the facility's detention pond outlets, well in excess of the increases allowed by state water quality criteria. Fecal coliform bacteria levels also exceeded water quality criteria. The study recommended review of detention pond design and improved self-monitoring sampling methods.

Fauntleroy Creek and Cove

In 1988, Ecology coordinated a multi-agency attempt to study a recurrent odor problem at Fauntleroy Cove. Kendra (1989b) found that the source of the odor was a decaying algae mat 500 feet south of the ferry dock. Nitrogen from Fauntleroy Creek was found to be a likely contributor to the algae problem, with a loading of 1 to 2 pounds/day. Fauntleroy Creek also contributed significant bacteria to the cove, with frequent violations of state water quality criteria for fecal coliform. Both the nitrogen and bacteria were from nonpoint sources.

Fish Hatchery Study

Kendra (1989a) conducted a study of freshwater fish hatcheries during the 1988 summer low flow period. The Issaquah Creek and Tokul Creek hatcheries, located in the Cedar/Green WQMA, were included in the study. The Issaquah Creek component included sampling of the receiving water; at the Tokul Creek facility only influent and effluent were sampled. In Issaquah Creek, slight increases in suspended solids and nutrients were observed in the receiving water, but no water quality standards were violated. However, "this finding was expected in light of reduced fish loading at the hatchery during summer months." At Tokul Creek, the data were not characteristic of the entire effluent, but were included as representative of rearing ponds. The effluent showed slight increases in nutrients compared to influent water.

Water Quality Impacts from Dairies

Erickson (1995) conducted a literature review of surface water quality studies related to dairy waste practices. Three reports from the Cedar/Green WQMA were included, addressing Newaukum and Mill creeks.

The first report included in the survey was the Green-Duwamish Watershed Nonpoint Action Plan (King County, 1991). The plan states that the most significant nonpoint

pollution sources were believed to be agricultural sources from the Newaukum Creek area of the Enumclaw Plateau, one of the most intensive dairy areas in the state. "Fish production of Newaukum Creek and its tributaries is limited by deterioration of riparian habitat and by water quality. Erosion, increased by livestock with direct access to the stream banks, contributes to turbidity and sedimentation of fish breeding and feeding habitat downstream."

A second report also addresses Newaukum Creek. Fritz (1993) found that dairy wastes were directly entering the creek and its tributaries. Problems included elevated ammonia, fecal coliform bacteria, and nutrient levels. The Newaukum Creek study was initiated in 1990 to evaluate the effectiveness of BMP implementation in the Newaukum Creek Watershed. The study found additional water quality controls were needed.

In the Mill Creek Water Quality Management Plan (King County, 1993). In this report, Mill Creek was identified as being one of two streams in Metro's survey having the poorest water quality. The primary causes of water quality degradation were identified as livestock trampling streambanks and application of manure to pastures near streams and ditches in the winter. Water quality problems included very low dissolved oxygen (frequently below 3 mg/L), high turbidity, and elevated concentrations of fecal coliform bacteria, nutrients, and metals.

303(d) Listings

Tables 1 and 2 show the 303(d) listings for conventional parameters for streams in the Cedar and Green watersheds, respectively. The tables also show where watershed plans have been completed, or other efforts have been undertaken that could lead to delisting the waterbody.

The most common listed parameter is fecal coliform. One hundred percent of the waterbodies in the Cedar Watershed table and 76% of the waterbodies in the Green Watershed table are listed for fecal coliform. There are considerably fewer listings for dissolved oxygen, temperature, and metals.

In the Cedar Watershed, plans have been developed for Swamp Creek, North Creek, and the Cedar River Basin. However, the vast majority of listings do not show a watershed plan completed for that waterbody.

In the Green Watershed, the Longfellow Creek Watershed Plan and the Green/Duwamish Basin Plan address seven waterbody listings. A watershed analysis is scheduled for Smay Creek. A TMDL has been submitted for the Duwamish Waterway and River listings for dissolved oxygen; however it was determined to be incomplete by EPA in 1993. Seven waterbody listings have not been addressed with a watershed plan or other strategy that could lead to delisting, according to Ecology information.

Table 1. 303(d) listings for conventional parameters in the Cedar Watershed (does not include listings for toxic organic compounds and sediment bioassays)

Waterbody Segment Number	Waterbody Name	Fecal Coliform	Dissolved Oxygen	Temper-ature	Metals	Total Phosphorus	Completed Watershed Plans or Other Information
WA 08 1010	JUANITA CREEK	X					
WA 08 1012	FORBES CREEK	X					
WA 08 1014	YARROW BAY CREEK	X					
WA-08-1016	FAIRWEATHER BAY CREEK	X					
WA 08 1018	KELSEY CREEK	X					
WA 08 1020	THORNTON CREEK	X					
WA 08 1030	McALEER CREEK	X					
WA 08 1040	LYON CREEK	X					
WA-08-1050	SAMMAMISH RIVER	X					
WA 08 1060	SWAMP CREEK	X	X				Swamp Creek Watershed Plan
WA 08 1065	NORTH CREEK	X					North Creek Watershed Plan
WA-08-1070	SAMMAMISH RIVER	X	X	X			
WA-08-1080	SAMMAMISH RIVER	X	X				
WA-08-1085	LITTLE BEAR CREEK	X					
WA-08-1090	SAMMAMISH RIVER	X		X			
WA-08-1095	BEAR-EVANS CREEKS	X	X		X		
WA-08-1100	SAMMAMISH RIVER	X	X				
WA 08 1110	ISSAQUAH CREEK SYSTEM	X		X			
WA-08-1115	TIBBETS CREEK	X		X			
WA 08 1116	LAUGHING JACOB'S CREEK	X					
WA 08 1117	PINE LAKE CREEK	X					
WA 08 1118	ETON CREEK	X					
WA 08 1120	COAL CREEK	X					
WA 08 1130	MAY CREEK	X		X	X		
WA 08 1143	CEDAR RIVER	X					Cedar River Basin Plan
WA-08-1145	CEDAR RIVER	X					Cedar River Basin Plan
WA-08-2100	MERCER SLOUGH	X					
WA-08-9020	BEAVER LAKE					X	
WA-08-9070	COTTAGE LAKE					X	
WA-08-9090	DESIRE LAKE					X	
WA-08-9150	GREEN LAKE					X	
WA-08-9170	LARSEN LAKE					X	
WA-08-9190	MARTHA LAKE					X	
WA-08-9280	SCRIBER LAKE					X	
WA-08-9300	SILVER LAKE					X	
WA-08-9350	LAKE WASHINGTON	X					

Table 2. 303(d) listings for conventional parameters in the Green Watershed (does not include listings for toxic organic compounds and sediment bioassays)

Waterbody Segment Number	Waterbody Name	Fecal Coliform	Dissolved Oxygen	Temper-ature	Metals	Total Phosphorus	Other	Completed Watershed Plans or Other Information
WA 09 0010	ELLIOTT BAY	X			X			
WA-09-1000	LONGFELLOW CREEK	X						Longfellow Creek Watershed Plan
WA 09 1005	FAUNTLEROY CREEK	X						
WA-09-1010	DUWAMISH WATERWAY AND RIVER	X	X		X		X (pH)	TMDL based on relocation of the Renton wastewater discharge submitted on 3/9/92; EPA determined the TMDL was incomplete on 2/12/93
WA 09 1015	SPRINGBROOK (MILL) CREEK	X	X	X	X			Green/Duwamish Basin Plan
WA-09-1020	GREEN RIVER	X	X	X	X			
WA-09-1022	HILL (MILL) CREEK	X	X	X	X		X (NH3)	Green/Duwamish Basin Plan
WA-09-1026	SOOS CREEK	X	X	X	X			Green/Duwamish Basin Plan
WA-09-1028	NEWAUKUM CREEK	X	X					Newaukum Creek Watershed Porject, Green/Duwamish Basin Plan
WA-09-1030	GREEN RIVER			X				Green/Duwamish Basin Plan
WA-09-1040	GREEN RIVER	X						Green/Duwamish Basin Plan
WA-09-1041	GALE CREEK			X				
WA-09-1050	SMAY CREEK			X				DNR and Plum Creek have scheduled a TFW watershed analysis for watershed analysis units 090103 and 090105.
WA-09-2000	DES MOINES CREEK	X						
WA 09 2010	COLD SPRINGS CREEK	X						
WA 09 2020	REDONDO CREEK	X						
WA 09 2030	LAKOTA CREEK	X						
WA 09 2040	JOE'S CREEK	X						
WA-09-9120	LAKE HICKS (GARRETT LAKE)					X		
WA-09-9160	LAKE MERIDIAN					X		
WA-09-9210	LAKE NUMBER TWELVE						X	(Listed for exotic aquatic plants)

Recommendations

Ecology should investigate cooperative approaches and strategies with King County to address the numerous 303(d) listings in both the Cedar and Green watersheds. Potential approaches (not mutually exclusive) include watershed planning development and implementation, source assessment work, Total Maximum Daily Load (TMDL) studies, programmatic solutions, and grant funding. Given the high number of fecal coliform listings, special emphasis is warranted for bacteria contamination.

References

Carroll, J. and G. Pelletier, 1991. Diagnostic Study of Lake Sawyer, King County, Washington. February 1989 through March 1990. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

Erickson, K., 1995. Water Quality Impacts from Dairies in Washington State: A Literature Review. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

Fritz, R., 1993. Water Quality in the Newaukum Creek Watershed After the Implementation of Best Management Practices. Muckleshoot Indian Tribe, Fisheries Department, Auburn, Washington.

Kendra, W., 1989a. Quality and Fate of Fish Hatchery Effluents During the Summer Low Flow Season. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

Kendra, W., 1989b. Water Quality in Fauntleroy Creek and Cove During the Summer of 1988. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

King County, 1993. Mill Creek Water Quality Management Plan. King County Department of Public Works, Surface Water Management Division, Seattle, Washington.

King County, 1991. Green-Duwamish Watershed Nonpoint Action Plan, Final Plan. King County Environmental Division, Bellevue, Washington.

Pelletier, G. and J. Joy, 1989. Lake Sawyer - Black Diamond Waste Load Allocation Evaluation. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

Sargeant, D., 1996. Washington Waste Hauling and Recycling. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

Toxics Investigations

by
Dale Davis

Introduction

The Cedar/Green Watershed is the most heavily populated and industrialized area in the state. With this concentration of people and industries comes numerous problems related to toxic contaminants in surface waters. Many of these problems are associated with the industrial and commercial facilities that line the Elliott Bay waterfront, the Duwamish River, Salmon Bay, and Lake Union. Combined-sewer-overflows (CSO) that receive surface runoff from these areas are responsible for much of the contamination. Because of their magnitude, these problems have received much attention and are currently being addressed.

Several other areas in this watershed have been studied to evaluate toxic contamination in surface waters, but for most either there was no problem identified or the contamination has been addressed. Ongoing studies are assessing contaminants in nonpoint urban runoff.

Summary of Studies

Elliott Bay/Duwamish River

Several studies in Elliott Bay and the lower Duwamish River identified numerous heavily contaminated sites. Confirmed sources include storm drains, combined sewer overflows, historical spills, and waste handling practices, along with resuspensions and transport of contaminated sediments between areas. The data from these studies were summarized by Tetra Tech, Inc. (1986) to prioritize these sites for remedial action. However, shortly after this report the National Oceanic and Atmospheric Administration (NOAA) filed a natural resource damage lawsuit against the City of Seattle and METRO. As a result, the Elliott Bay/Duwamish River Restoration Panel was created, and is responsible for developing and implementing sediment cleanup and habitat restoration projects in Elliott Bay and the Duwamish River. The panel has identified a number of high priority cleanup sites in the area.

Prior to beginning the cleanup phase, a concern was raised that sediment remediation may not be successful due to continuing sources of contamination and migration of contaminated sediment from other parts of Elliott Bay and the Duwamish River. To address this concern a number of investigations were initiated as part of a recontamination

study (Norton and Michelsen, 1995). To aid in the design of these investigations, a comprehensive literature search was performed by Ecology (Johnson, 1993). Results from the recontamination study are currently being used to formulate a remedial design.

Salmon Bay/Lake Union

High concentrations of PCBs, PAHs, and metals have been identified in sediment samples collected from Salmon Bay and Lake Union (Hileman *et al.*, 1984; Yake *et al.*, 1986; Cubbage, 1992; Serdar and Cubbage, 1996). The objective of ongoing sediment sampling in Salmon Bay is to identify and prioritize the most heavily contaminated and toxic sites for remediation by Ecology's NWRO Toxics Cleanup Program (TCP) (Serdar and Cubbage, 1996, 1997).

Lake Washington

Sediment was sampled from sites throughout Lake Washington in a screening survey by Metro to assess contamination (Romberg *et al.*, 1984). The only area where significant toxic contaminants were identified was at the Quendall Terminals/J.H. Baxter Site on the southeast shore of Lake Washington, which is a historical refining and wood treatment facility. The extent of contamination and sediment toxicity at this site has been thoroughly evaluated (USEPA, 1984; Woodward-Clyde, 1989; Norton, 1991, 1992). A Remedial Investigation Feasibility Study is currently underway for this site through Ecology's NWRO TCP (Brian Sato, NWRO, personal communication, August 11, 1997).

Urban Nonpoint Contamination

Nonpoint stormwater runoff contamination from urban and suburban residential areas is an issue that has only recently been recognized as a significant problem. While contaminant concentrations in nonpoint runoff are typically lower than point source runoff, the problem is more wide-spread; there are often more contaminants, and the sources are more difficult to control. The objective of several ongoing studies in the Cedar/Green Watershed is to evaluate urban nonpoint runoff.

Several streams in the Cedar/Green Watershed have been sampled as part of the Ecology Washington State Pesticide Monitoring Program (WSPMP), and the U.S. Geological Survey's (USGS) Puget Sound National Water Quality Assessment Program (NAWQA). Some results for the WSPMP have been released in reports (Davis, 1993, 1996; Davis and Johnson, 1994a, 1994b). Results from sampling in 1996 are available for use in this scoping process, and additional sampling is in progress. The USGS has not released any data yet. The USEPA also sampled streams and Lake Washington as a part of two Puget Sound pesticide reconnaissance surveys (Crecelius *et al.*, 1989; PTI, 1991).

Most of the available data are for pesticides and PCBs only. The source of the pesticides is primarily from urban and suburban runoff, largely from residential use. These data indicate that there are typically a large number of different pesticides present in urban streams, but concentrations are usually low. Effects from the combination of multiple pesticides is poorly understood, but could be significant even when levels of individual compounds are low. Potential impacts from contaminants in urban runoff will be better understood when all data from the WSPMP and USGS have been evaluated.

Miscellaneous Studies

Paine Field Drainage Basins

Water and sediment samples were collected from six drainage basins below Paine Field in 1987 by Ecology at the request of the NWRO (Johnson and Norton, 1989). These samples were analyzed for the USEPA priority pollutants list and subjected to bioassays to assess toxicity. Very high concentrations of PCBs were found in sediments of a retention pond at a Boeing plant, and moderately elevated levels were detected at three other sites. In addition, high levels of arsenic, lead, mercury, zinc, and total cyanide were found in some samples. Laurence Ashley (Ecology NWRO) requested this study, and now reports that Boeing has cleaned up these contaminants (personal communication, August 6, 1997). There was no follow-up study to confirm the remedial action, but in a study of sediments along the Puget Sound shoreline where streams from the area discharge, levels of priority pollutants were low (Cubbage, 1995).

Lake Sammamish

Sediment and fish tissue from Lake Sammamish were collected and analyzed for a variety of toxic organic chemicals and priority pollutant metals by Ecology as part of a survey of chemical contaminants in ten Washington lakes (Serdar *et al.*, 1994). Arsenic concentrations exceeded sediment quality guidelines, and PCBs in whole fish were elevated. Levels of copper, chromium, and nickel were also high compared to the other lakes sampled. No additional sampling was recommended.

Duwamish and Green Rivers

Samples collected every other month for a year from the Duwamish River at Tukwila and the Green River at Kanaskat were analyzed for zinc, copper, lead, and cadmium as part of a study by Ecology to determine background metals concentrations in Washington rivers (Johnson, 1994). All metal concentrations in these two rivers were within state water quality standards for protecting aquatic life.

Queen City Farms

Queen City Farms is a Superfund site owned by Boeing near Maple Valley. The Cedar Hills Landfill, Stoneway Concrete gravel pit, and Cedar Grove Composting facility are also in this area. An unnamed creek that runs through or near these sites was sampled by Ecology in 1987 to screen for potential contaminants (Yake, 1988). No significant problems were identified.

The Queen City Farms site, managed by USEPA Region 10, has been cleaned up, and leachate from the land fill and composting facility has been diverted into King County's sanitary sewer system (Ron Devitt, NWRO, personal communication, August 11, 1997). However, soils in this area are very porous, and contaminants from these sites may have leached into the ground water prior to cleanup efforts.

Recommendations

Although there are a number of important issues related to toxic contaminants in the Cedar/Green Watershed, the importance of some has already resulted in actions to resolve the problems. Due to their magnitude, the Elliott Bay/Green River, Lake Union/Salmon Bay, and Lake Washington sites will require many more years of work before they are cleaned up or otherwise addressed, but are in various stages of remediation through cooperative efforts by city, county, state, and federal agencies. No recommendations are necessary.

Urban Nonpoint Contamination

Results from sampling by the WSPMP and USGS in this watershed will answer some questions about the types and extent of contaminants in urban streams, but will do little to identify specific sources. Information about how and where contaminants are getting into the streams is needed before steps can be taken to keep them out. For streams with high concentrations and/or numbers of contaminants identified by WSPMP and USGS results, samples should be collected throughout their lengths to identify specific sources.

Paine Field Drainage

This site has been cleaned up by Boeing. However, there was never any follow-up sampling by Ecology to confirm that MTCA numeric criteria were met. Due to the high concentrations of some contaminants found in 1987, particularly PCBs (20,500 µg/Kg in sediment), this area warrants confirmation sampling.

References

Crecelius, E., D. Woodruff, and M. Myers. 1989. 1988 Reconnaissance Survey of Environmental Conditions in 13 Puget Sound Locations. Puget Sound Estuary Program. U.S. Environmental Protection Agency, Region 10, Seattle, Washington. EPA 910/9-89-005.

Cubbage, J. 1992. Survey of Contaminants in Sediments in Lake Union and Adjoining Waters (Salmon Bay, Lake Washington Ship Canal, and Portage Bay). Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Toxics, Compliance, and Ground Water Investigations Section, Olympia, Washington.

Cubbage, J. 1995. Priority Pollutants in Nearshore Sediments in Port Gardner, Mukilteo and Everett, Washington. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Toxics Investigations Section, Olympia, Washington. Publication No. 95-301.

Davis, D. 1993. Washington State Pesticide Monitoring Program - Reconnaissance Sampling of Surface Water (1992). Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Toxics, Compliance, and Ground Water Investigations Section, Olympia, Washington.

Davis, D. 1996. Washington State Pesticide Monitoring Program - 1994 Surface Water Sampling Report. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington. Publication No. 96-305.

Davis, D. and A. Johnson. 1994a. Washington State Pesticide Monitoring Program - 1993 Surface Water Sampling Report. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington. Publication No. 94-164.

Davis, D. and A. Johnson. 1994b. Washington State Pesticide Monitoring Program - Reconnaissance Sampling of Fish Tissue and Sediments (1992). Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Toxics Investigations Section, Olympia, Washington. Publication No. 94-194.

Hileman, J., J. Yearsley, and J. Anderson. 1984. Lake Union Sediment Investigation. U.S. Environmental Protection Agency, Environmental Services Division, Region 10, Seattle, Washington.

Johnson, A. 1993. Elliott Bay Waterfront Recontamination Study - Literature Search. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

Johnson, A. 1994. Zinc, Copper, Lead, and Cadmium in Four Washington Rivers. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington. Publication No. 94-58.

Johnson, A. and D. Norton. 1989. Screening Survey for Chemical Contaminants and Toxicity in Drainage Basins at Paine Field, August 10-12, 1987. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Toxics Investigations/Ground Water Monitoring Section, Olympia, Washington.

Norton, D. 1991. Distribution and Significance of Polycyclic Aromatic Hydrocarbons in Lake Washington Sediments Adjacent to Quendall Terminals/J.H. Baxter Site. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Toxics Investigations/Ground Water Monitoring Section, Olympia, Washington.

Norton, D. 1992. Results of Sediment Sampling in the J.H. Baxter Cove, Lake Washington - June 1991. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Toxics, Compliance, and Ground Water Investigations Section, Olympia, Washington.

Norton, D. and T. Michelsen. 1995. Elliott Bay Waterfront Recontamination Study - Volume I: Field Investigation Report, Results of Monitoring Conducted along the Central Seattle Waterfront - October 1993 to October 1994. Elliott Bay/Duwamish Restoration Program, NOAA Restoration Program, National Marine Fisheries Service, Seattle, Washington. Panel Publication 9. Ecology Publication No. 95-335.

Romberg, G., S. Pavlou, R. Shokes, W. Horn, E. Crecelius, P. Hamilton, J. Gunn, R. Muench, and J. Vinelli. 1984. Toxicant Pretreatment Planning Study Technical Report: Presence, Distribution, and Fate of Toxicants in Puget Sound and Lake Washington. Metro, Seattle, Washington.

Serdar, D. and J. Cubbage. 1996. Chemical Contaminants in Salmon Bay Sediments - Results of Phase II Sampling. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington. Publication No. 96-343.

Serdar, D. and J. Cubbage. 1997 (in preparation). Chemical Contaminants in Salmon Bay Sediments - Results of Phase III Sampling. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington.

Serdar, D., A. Johnson, and D. Davis. 1994. Survey of Chemical Contaminants in Ten Washington Lakes. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Washington. Publication No. 94-154.

Tetra Tech, Inc. 1986. Elliott Bay Toxics Action Program: Initial Data Summaries and Problem Identification. Puget Sound Estuary Program. Prepared for U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, Washington. Final Report TC 3991-01.

USEPA. 1984. Port Quendall Offshore Sediment Investigation. U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

Woodward-Clyde. 1989. Technical Memorandum No.1 - Nearshore Sediment Sampling, J.H. Baxter Facility, Renton, Washington. Project No.86006S/0450. Prepared for the Washington State Department of Ecology, Northwest Regional Office, Bellevue, Washington.

Yake, B. 1988. Sampling Results for Unnamed Creek South of Queen City Farms (7/21/87). Washington State Department of Ecology, Water Quality Investigations Section, Olympia, Washington.

Yake, B., D. Norton, and M. Stinson. 1986. Application of the Triad Approach to Freshwater Sediment Assessment: An Initial Investigation of Sediment Quality Near Gas Works Park, Lake Union. Washington State Department of Ecology, Water Quality Investigations Section, Olympia, Washington.

This page is purposely blank for duplex printing

Compliance Monitoring

by
Guy Hoyle-Dodson

EILS Data and Reports

Cedar

In the Cedar Water Resources Inventory Area (WRIA) there are currently 24 dischargers that have permits under the National Pollution Discharge Elimination System (NPDES) and 74 dischargers that are permitted under the State Waste Discharge Permit Program (WAC 173-216). These include:

- NPDES Major Permits - 7 Municipal
- NPDES Minor Permit - 16 Industrial, 1 Municipal
- State Discharge to Publicly Owned Treatment Works (POTW) - 3 Industrial
- State Discharge to Ground Permits - 1 Industrial

Green

In the Green WRIA there are currently 13 dischargers that have permits under the NPDES and 26 dischargers that are permitted under the State Waste Discharge Permit Program (WAC 173-216). These include:

- NPDES Major Permits - 3 Municipal
- NPDES Minor Permit - 10 Industrial
- State Discharge to Publicly Owned Treatment Works (POTW) - 1 Industrial
- State Discharge to Ground Permits - 1 Industrial

Summary of Issues

There have been several facilities in the Cedar and Green WRIAs that have had EILS enhanced or limited Class II inspections over the last ten years. Data from studies more than ten years old are considered unrepresentative of current treatment facility effluent characteristics and these studies are not referenced. Data from Class II inspections more than five years old may also not be representative of current facility effluent discharge or operation.

Cedar

Major dischargers who have not received an enhanced Class II inspection during the last five years include:

Facility Name	Type	Facility Status	Permit Number	Effective Date	Expire Date	Permit Status	Last EILS Class II
EDMONDS STP	Municipal	Active	WA0024058	07/01/1997	06/26/2002	Active	April 17-19, 1989
LAKOTA STP	Municipal	Active	WA0022624	06/26/1997	06/26/2002	Active	None
LYNNWOOD STP	Municipal	Active	WA0024031	03/22/1993	12/31/1996	Extended	June 17-19, 1991.
METRO WEST POINT WWTP	Municipal	Active	WA0029181	01/01/1996	12/31/2000	Active	September 14, 1976.
MILLER CREEK WWTP	Municipal	Active	WA0022764	07/01/1997	06/23/2002	Active	April 22-24, 1991.
REDONDO STP	Municipal	Active	WA0023451	12/20/1988	12/18/1993	Extended	None

Minor industrial dischargers who have not received an enhanced Class II inspection during the last five years include:

Facility Name	Facility Status	Permit Number	Effective Date	Expire Date	Permit Status	Last EILS Class II
AUBURN THOROUGHBRED RACETRACK	Active	WA0031496	02/27/1996	02/27/2001	Active	None
CHEVRON POINT WELLS	Active	WA0003239	06/30/1997	06/30/2002	Active	None
DARIGOLD ISSAQUAH	Active	WA0021431	07/10/1997	06/30/2002	Active	None
FOSS MARITIME	Active	WA0031054	04/17/1997	04/17/2002	Active	None
HOLNAM INC	Active	WA0002232	06/16/1997	06/16/2002	Active	None
JORGENSEN FORGE CORP	Active	WA0030783	10/12/1993	10/12/1996	Extended	None
LAKE UNION DRYDOCK	Active	WA0030074	03/14/1997	03/14/2002	Active	None
MARCO SEATTLE	Active	WA0030881	03/02/1995	06/30/1997	Extended	None
NORTHLAKE SHIPYARD INC	Active	WA0030864	08/19/1994	06/30/1997	Extended	None
PACIFIC COAST COAL CO	Active	WA0030830	06/30/1992	06/30/1997	Extended	None
SEA TAC AIRPORT	Active	WA0024651	06/30/1994	06/30/1997	Extended	None
THE STROH BREWERY	Active	WA0031364	01/27/1995	06/30/1997	Extended	None
TRI STAR MARINE	Active	WA0030996	01/13/1993	12/13/1998	Active	None
WA UW MEDICAL CTR	Active	WA0030023	06/30/1997	06/30/2002	Active	None

Minor municipal dischargers who have not received an enhanced Class II inspection during the last five years:

Facility Name	Facility Status	Permit Number	Effective Date	Expire Date	Permit Status	Last EILS Class II
ALDERWOOD WTP	ACTIVE	WA0020826	06/21/1988	06/30/1993	EXTENDED	October 1992
SEATTLE WESTPOINT CSO	ACTIVE	WA0024503	04/18/1975	06/30/1977	EXTENDED	None

State to POTW or State to Ground dischargers who have not received an enhanced Class II inspection during the last five years include:

Facility Name	Facility Status	Type	Permit Number	Effective Date	Expire Date	Permit Status	Last EILS Class II
SUPER SURFACE TECNA	Active	State to POTW	ST0007317	02/21/1997	06/30/1999	Active	None
TIME OIL CO	Active	State to POTW	ST0007384	01/27/1997	01/27/2002	Active	None
WEYERHAEUSER TECH. CTR	Active	State to POTW	ST0007379	09/27/1996	07/15/2001	Active	None
BAKER COMMODITIES	Active	State to Ground	ST0007364	07/12/1994	07/12/1999	Active	None

Several receiving water bodies have known impairments of designated uses, caused mainly by fecal coliform. Facilities which discharge to impaired receiving waters (303d list) and their tributaries, and who are limited in their permit by one or more of the impairment parameters or whose discharge characteristics may potentially impact the receiving water, include:

Major Municipal Facilities

Puget Sound (Central) - WA-PS-0240 (Specific Impairment: Fecal coliform)

Edmonds STP (Municipal): (Discharge: Fecal coliform, BOD_5, NH_3-N, cyanide Cu, Hg, Ag, Pb, Zn)

Lakota STP (Municipal): (Discharge: Fecal coliform, BOD_5, NH_3-N)

Lynnwood STP (Municipal): (Discharge: Fecal coliform, BOD_5, NH_3-N, bioassay toxicity)

Metro Renton Wastewater Treatment Plant (WWTP) (Municipal): (Discharge: Fecal coliform, BOD_5, NH_3-N, bioassay toxicity)

Metro West Point WWTP (Municipal): (Discharge: Fecal coliform, BOD_5, NH_3-N)

Miller Creek WWTP (Municipal): (Discharge: Fecal coliform, BOD_5, NH_3-N, Cu, Ag, and Hg)

Redondo STP (Municipal): (Discharge: Fecal coliform, BOD_5, NH_3-N)

Minor Industrial Facilities

Puget Sound (Central) - WA-PS-0240 (Specific Impairment: Fecal coliform)

Auburn Thoroughbred Racetrack: (Discharge: Fecal coliform)

Birmingham Steel Corp: (Discharge: PCB, O&G, Cd, Cu, Pb, Ni, Zn)

Chevron Point Wells: (Discharge: BOD_5, Phnolics, O&G)

Foss Maritime: (Discharge: O&G, Cu, Pb, Zn)

Jorgensen Forge Corp: (Discharge: Pb, Zn)

Lake Union Drydock: (Discharge: Cu, Pb, Zn)

Marco Seattle: (Discharge: O&G)

Northlake Shipyard Inc: (Discharge: O&G, Cu, Pb, Hg, Zn)

Pacific Coast Coal Co: (Discharge: As, Cr, Pb, Fe, Hg)

Sea Tac Airport: (Discharge: O&G, BOD_5, NH_3-N, PAH, BTEX)

Tri Star Marine: (Discharge: O&G)

Lake Washington - WA-08-9350 (Impairment: Fecal coliform & Sediment Bioassay)

WA UW Medical Center: (Temp)

Minor Municipal Facilities

Puget Sound (Central) - WA-PS-0240 (Specific Impairment: Fecal coliform):

Alderwood WTP: (Discharge: Fecal coliform, BOD_5, NH_3-N)

Green

Major dischargers who have not received an enhanced Class II inspection during the last five years include:

Facility Name	Facility Status	Permit Number	Effective Date	Expire Date	Permit Status	Last EILS Class II
METRO ALKI POINT	Active	WA0029017	04/30/1993	12/31/1995	Extended	None
MIDWAY SEWER DISTRICT	Active	WA0020958	09/03/1992	08/01/1997	Extended	October 21-23, 1991
SALMON CREEK WWTP	Active	WA0022772	07/01/1997	06/23/2002	Active	June 4-6, 1991

Minor industrial dischargers who have not received an enhanced Class II inspection during the last five years include:

Facility Name	Facility Status	Permit Number	Effective Date	Expire Date	Permit Status	Last EILS Class II
BIRMINGHAM STEEL CORP	Active	WA0031305	08/25/1992	08/25/1997	Active	None
BOEING DEVELOPMENTAL CTR	Active	WA0031488	06/01/1995	06/30/1997	Active	January 1987
CADMAN SEATTLE	Active	WA0030945	10/01/1993	10/01/1998	Active	None
DUWAMISH SHIPYARD	Active	WA0030937	01/05/1996	01/05/2001	Active	None
SEATTLE STEAM	Active	WA0001503	02/11/1994	02/11/1999	Active	None
SEATTLE WESTPOINT CSO	Active	WA0024503	04/18/1975	06/30/1977	Extended	None
TEXACO 632320307 KENT	Active	WA0031518	06/13/1996	06/13/2001	Active	None
TEXACO HARBOR ISLAND	Active	WA0001791	04/08/1992	04/08/1997	Extended	None
TODD PACIFIC SHIPYARD	Active	WA0002615	10/07/1996	10/07/2001	Active	1973
TOSCO NW CO	Active	WA0001945	06/30/1997	06/30/2002	Active	None

State to POTW or State to Ground dischargers who have not received an enhanced Class II inspection during the last five years include:

Facility Name	Facility Status	Type	Permit Number	Effective Date	Expire Date	Permit Status	Last EILS Class II
MOBIL STATION 99D9T	Active	State To Ground	ST0007385	01/13/1997	01/13/2002	Active	None
OLYMPIAN PRECAST INC	Active	State To Ground	ST0007280	05/22/1996	05/22/2001	Active	None
S & S COLOR LAB	Active	State To POTW	ST0007294	07/01/1996	06/30/1999	Active	None

Several receiving water bodies have known impairments of designated uses. Causes were due to a number of different exceedences. Facilities which discharge to impaired receiving waters (303d list) and their tributaries, and who are limited in their permit by one or more of the impairment parameters or whose historic discharge characteristics may potentially impact the receiving water, include:

Major Municipal Facilities

Puget Sound (Central) - WA-PS-0240 (Specific Impairment: Fecal coliform)

Metro Alki Point WWTP (Municipal): (Fecal coliform, BOD_5, NH_3-N)

Midway Sewer District (Municipal): (Fecal coliform, BOD_5)

Salmon Creek WWTP (Municipal): (Fecal coliform, BOD_5, NH_3-N, Pb)

Minor Industrial Facilities

Puget Sound (Central) - WA-PS-0240 (Specific Impairment: Fecal coliform):

Duwamish Shipyard: (Fecal Coliform)

Duwamish Waterway And River - WA-09-1010

(Specific Impairments: Cu, Pb, Zn, PAHs, PCBs, D.O., pH, Fecal Coliform, Cd, Hg, As, Ag, Cr, Naphthalene, 2-Methylnaphthalene, Anthracene, 1,2,4-Trichlorobenzene, Chrysene, Pyrene, Benz(a)anthracene, Benzo(b,k)fluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,i)perylene, Hexachlorobenzene, DiethylPhthalate, N-Nitrosodiphenylamine, Fluorene, Fluoranthene, Phenanthene, Acenaphthene, Dimethyl Phthalate, Benzoic Acid, Butyl Benzyl Phthalate, 1,4-Dichlorobenzene, Dibenzofuran, Phenol, 4-Methylphenol, 2,4-Dimethylphenol, Benzyl Alcohol, Bis(2-ethylhexyl)phthalate, Sediment Bioassay):

Boeing Developmental Center: (pH, vinyl chloride, methylene chloride, trans-1,2-dichloroethene, cis-1,2-dichloroethene, trichloroethene, tetrachloroethene)

Cadman Seattle: (Oil&Grease, PBC, Cd, Cr, Cu, Ni, Pb, Zn)

Seattle Steam: (Temp, pH, Oil&Grease)

Seattle Westpoint CSO: (pH, temp, Fecal coliform, Total coliform, Fecal streptococci, BOD_5, COD, TOC, Cl, TSS, TS, TDS, NH_3-N, Kjeldahl-N, NO_2&NO_3, Total-P, D.O., Cyanide, Sulfide, Br, F, Al, Sb, As, Ba, B, Cd, Co, Cr, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, Ag, Tl, Ti, Zn, Algicides, Chlorinated organic compounds, Oil&Grease, Pesticides, Phenols, Surfactants, Radioactivity)

Texaco Harbor Island: (Oil&Grease, Benzene, Ethyl benzene, TSS)

Todd Pacific Shipyard: (Oil&Grease, Cu, Pb, Zn, Tributyltin)

Tosco NW Co.: (Oil&Grease, Benzene, BTEX, TPH-G, TPH-D)

Green River - WA-09-1020 (Specific Impairments: Hg, Cr, Temp, D.O., Fecal Coliform)

Texaco Kent: (pH, Benzene, BTEX, TPH-G)

Springbrook (Mill) Creek - WA-09-1015

(Specific Impairments: Fecal coliform, Temperature, D.O., Sediment Bioassay, Cd, Cu, Hg, Zn):

Texaco Kent: (pH, Benzene, BTEX, TPH-G)

Recommendations

Lack of data for a particular facility suggests that it should be inspected. Some results from previous Class II inspections indicate a need for follow-up or further study. Priorities have been determined from the number and severity of factors noted in the issues section (i.e. last inspection, activity, expiration date, population served, discharge parameters, receiving water status). Class II inspections are suggested for the facilities listed below. The highest priorities for Class II inspections for both the Cedar and Green watersheds should be developed cooperatively by Ecology's Northwest Regional Office, King County, and EILS.

Cedar

Industrial Facilities

Auburn Thoroughbred Racetrack, Birmingham Steel Corp, Jorgensen Forge Corp, Marco Seattle, Northlake Shipyard Inc, Pacific Coast Coal Co, Sea Tac Airport, & The Stroh Brewery

Municipal Facilities

Edmonds STP, Lakota STP, Lynnwood STP, Metro West Point WWTP, Miller Creek WWTP, Redondo STP

Dischargers to NPDES Facilities

Pretreatment inspections in conjunction with Class II inspections are recommended for the following: Super Surface Tecna, Time Oil Company, Weyerhaeuser Technology Center

Green

Industrial Facilities

Boeing Developmental Ctr, Cadman Seattle, Duwamish Shipyard, Texaco Kent, Texaco Harbor Island, Todd Pacific Shipyard, Tosco NW Co

Municipal Facilities

Metro Alki Point, Metro Alki Point, Salmon Creek WWTP

Dischargers to NPDES Facilities

Pretreatment inspections in conjunction with Class II inspections are recommended for the following: Mobil Station 99D9T, Olympian Precast Inc., S & S Color Lab

This page is purposely blank for duplex printing

Lake Ambient Monitoring

by
Kirk Smith

Water Quality

Lake Sawyer -- King County

Lake Sawyer is located two miles northwest of Black Diamond. It has four small islands. It is fed at the south end of the lake by Rock Creek, Ravensdale Creek, and an extensive wetland. The lake drains via Covington Creek to the Green River. Lake level is controlled by a concrete weir which was constructed in 1952.

Size (acres)	300
Maximum Depth (feet)	58
Mean Depth (feet)	26
Lake Volume (acre-feet)	7,700
Drainage Area (miles^2)	13.0
Altitude (feet)	512
Shoreline Length (miles)	7.0

Data from Bortleson *et al.* (1976)

Overall Assessment

The water quality of Lake Sawyer was fairly good in 1994. Secchi depths were deeper than they were in 1993. Also, concentrations of both total phosphorus and total nitrogen in the upper layer of water, during the August survey, were lower than all concentrations measured during 1992 and 1993.

Profile data from 1994 were similar to data collected during previous years. Dissolved oxygen concentrations were low throughout the lower layer of water during the August survey. As a result of these low oxygen concentrations, it is likely that phosphorus was recycled from sediments into the water column during late summer, resulting in the high concentration of total phosphorus in the hypolimnion during August.

Aquatic plants observed by Ecology during field visits include yellow-flowering water lily (*Nuphar polysepalum*), duckweed (*Lemna sp.*), cattails (*Typha sp.*), coontail (*Ceratophyllum demersum*), Eurasian milfoil (*Myriophyllum spicatum*), largeleaf pondweed (*Potamogeton amplifolius*), curlyleaf pondweed (*Potamogeton crispus*),

flatstem pondweed (*P. zosteriformis*), another pondweed (possibly *P. gramineas*), and white-flowering water lily (*Nymphaea odorata*).

Based on low hypolimnetic dissolved oxygen concentrations, recycling of phosphorus from sediments, and a moderately heavy population of aquatic plants, Lake Sawyer was classified as mesotrophic in 1994.

One of the major goals of diverting Black Diamond wastewater away from Lake Sawyer was to return the lake to a mesotrophic condition. Although it is still too soon to evaluate statistical trend in water quality, it does appear that there has been a short-term improvement. However, the Ecology report on the lake stipulated that stormwater and residential runoff must also be controlled in order to achieve long-term improvements in water quality. Continued education of homeowners, and cooperation with county regulations, should help Lake Sawyer. Long-term monitoring may be able to determine the long-term effectiveness of efforts to improve the quality of the lake.

Recommendations

Both Snohomish County and King County have elaborate lake monitoring programs, although these programs, like the Ecology LWQA program, have suffered from budget cutbacks in recent years. Due to the shortage of resources in Ecology, it is not recommended that Ecology expend resources in this watershed for monitoring lake water quality since both Snohomish and King counties have existing lakes programs.

Reference

Bortleson, G., N. Dion, J. McConnell, and L. Nelson, 1976. Reconnaissance Data on Lakes in Washington, Volume 2, King and Snohomish Counties. Water Supply Bulletin No. 43, Vol. 2. Washington State Department of Ecology, Olympia, WA.

Aquatic Plants Ambient Monitoring

by
Jenifer Parsons

Introduction

This chapter of the EILS Cedar/Green Basin Briefing Paper provides information on which waterbodies in the basin have been surveyed for aquatic plants, which waterbodies are known to have populations of noxious weeds or listed rare plants, and recommends future work to be done.

Historical Aquatic Plant Monitoring

Ecology's Ambient Monitoring Section (AMS) has monitored aquatic plants in lakes and rivers of the state since 1994. Table 1 provides the names of waterbodies included in this program within the Cedar/Green Basin. In addition, the Ecology Aquatic Weed Management Fund provided grant money to King County for aquatic plant mapping of 36 lakes (Table 2) (Walton, 1996).

Table 1: Waterbodies Monitored for Aquatic Plants by AMS

WRIA	County	Waterbody Name	Years Surveyed
9	King	Lucerne Lake	95, 96, 97
9	King	Meridian Lake	94, 97
9	King	Morton Lake	95, 97
9	King	Pipe Lake	95, 96, 97
9	King	Sawyer Lake	95, 97
9	King	Steel Lake	94
9	King	Wilderness Lake	95, 97

Table 2: Waterbodies Surveyed by King County, 1994 and 1995

WRIA	Waterbody Name	WRIA	Waterbody Name
8	Cottage Lake	9	Meridian Lake
8	Desire Lake	9	Morton Lake
8	Francis Lake	9	Neilson (Holm) Lake
8	Kathleen Lake	9	Panther Lake
8	McDonald Lake	9	Pipe Lake
8	Otter (Spring) Lake	9	Ravensdale Lake
8	Pine Lake	9	Retreat Lake
8	Welcome Lake	9	Sawyer Lake
9	Bass lake	9	Shadow Lake
9	Beaver Lake	9	Shady Lake
9	Deep Lake	9	Star Lake
9	Dolloff Lake	9	Walker lake
9	Lucerne Lake	9	Wilderness Lake

The waterbodies listed in Table 3 are those known to contain listed noxious weeds. For reference, the aquatic plants included on the state noxious weed list are:

Cabomba caroliniana (fanwort)
Egeria densa (Brazilian elodea)
Hydrilla verticillata (hydrilla)
Lysimachia vulgaris (garden loosestrife)
Lythrum salicaria (purple loosestrife)
Lythrum virgatum (wand loosestrife)
Myriophyllum aquaticum (parrot feather)
Myriophyllum spicatum (Eurasian milfoil)

Table 3: Waterbodies with listed noxious aquatic weeds

County	Waterbody Name	Noxious Aquatic Weed Present
King	Angle Lake	*Myriophyllum spicatum*
King	Bass Lake	*Myriophyllum spicatum*
King	Cottage Lake	*Lythrum salicaria*
King	Desire Lake	*Lythrum salicaria, Myriophyllum spicatum*
King	Dolloff Lake	*Lythrum salicaria, Myriophyllum spicatum*
King	Fenwick Lake	*Egeria densa*
King	Green Lake	*Myriophyllum spicatum*
King	Kathleen Lake	*Lythrum salicaria*
King	Lucerne Lake	*Hydrilla verticillata*
King	Meridian Lake	*Lythrum salicaria, Myriophyllum spicatum*
King	Neilson (Holm) Lake	*Myriophyllum spicatum*
King	Number Twelve Lake	*Myriophyllum spicatum*
King	Otter (Spring) Lake	*Lythrum salicaria, Myriophyllum spicatum*
King	Panther Lake	*Lythrum salicaria*
King	Phantom Lake	*Myriophyllum spicatum*
King	Pine Lake	*Lythrum salicaria*
King	Pipe Lake	*Hydrilla verticillata*
King	Sammamish Lake	*Myriophyllum spicatum*
King	Sawyer Lake	*Myriophyllum spicatum*
King	Shadow Lake	*Myriophyllum spicatum*
King	Shady Lake	*Myriophyllum spicatum*
King	Star Lake	*Myriophyllum spicatum*
King	Steel Lake	*Myriophyllum spicatum*
King	Union Lake	*Myriophyllum spicatum*
King	Unnamed Pond, Bellevue	*Myriophyllum aquaticum*
King	Washington Lake	*Myriophyllum spicatum*
King	Wilderness Lake	*Myriophyllum spicatum*
Snohomish	Silver Lake (28N-05E-30)	*Myriophyllum spicatum*

No locations of listed rare plants have been found by the aquatic plant monitoring program in the Cedar/Green Basin. However, comprehensive data on rare plants are not maintained by this program. The Natural Heritage Program at the Washington State Department of Natural Resources should be contacted for a complete review of rare plant locations.

Additional details - Waterbodies with Noxious Weeds

The lakes of greatest concern for noxious aquatic weeds are Pipe and Lucerne Lakes. *Hydrilla verticillata* (hydrilla) was discovered here by King County and Ecology in 1995. *Hydrilla* is a class A noxious weed, which means control is required by law. So far this lake system is the only known *Hydrilla* location in the state. During the summers of 1995,

1996 and 1997 the lakes were treated with the systemic herbicide Sonar® to attempt eradication. Since 1995 the population has been reduced by approximately 95% (Sytsma 1996). However, *Hydrilla* has dormant tubers in the lake sediment which are unaffected by the herbicide until they sprout. Therefore, control efforts must continue until the tuber bank is exhausted.

Myriophyllum spicatum (Eurasian milfoil) is a widespread problem in this basin. Most lakes that receive high levels of public use contain this plant. Several lakes have been the subject of control efforts, and two lake groups in this basin have received money from Ecology's Aquatic Weed Management Fund for planning or control projects (Lake Wilderness, Lake Number Twelve). King County has also received funding for volunteer training in aquatic plant identification to assist with monitoring the spread of this plant.

Both *Egeria densa* (Brazilian elodea) and *Myriophyllum aquaticum* (parrot feather) are known from one location each in this basin. The *M. aquaticum* is located in a private pond near Lake Sammamish. The pond owner has been conducting some hand pulling to try to control the plant's growth and spread (Kenney, 1996). The *E. densa* in Lake Fenwick is spreading throughout the lake (Chase, 1995). So far, no publicly funded control efforts have been made targeting these plant populations.

The distribution of *Lythrum salicaria* (purple loosestrife) is probably much more widespread in this basin than indicated by Table 3. This plant grows in wetlands and riparian areas which are not surveyed by this program. The King and Snohomish County Noxious Weed Control Boards should have more information on the distribution of this and the other listed wetland weeds (*Lythrum virgatum* and *Lysimachia vulgaris*)

Recommendations

- Continue to monitor the *Hydrilla* population in Pipe and Lucerne lakes, and continue efforts to eradicate this plant.

- Continue to offer technical assistance to local government officials and citizens concerning the lakes with populations of noxious weeds.

- Continue monitoring lakes near waterbodies with noxious weeds to detect any new introductions of these plants at an early stage.

- Increase public education on the impacts of noxious aquatic weeds and how to prevent their spread.

References

Chase, R. 1995. City of Kent. Personal Communication.

Kenney, J. 1996. Private land owner. Personal Communication.

Sytsma, M. 1996. Portland State University. Personal Communication.

Walton, S. 1996. Aquatic Plant Mapping for 36 King County Lakes. King County Surface Water Management Division, Seattle, WA.

This page is purposely blank for duplex printing

Bioassessment Monitoring

by
Rob Plotnikoff

Introduction

Water quality conditions defined by chemical analysis can fail to protect stream biota from physical changes in the environment or from 'slugs' of pollutants that are missed in regular sampling routines. The purpose of the biological monitoring program is to screen sites for various stream quality impacts (Plotnikoff and Ehinger 1997). Collection and analysis of benthic macroinvertebrate (biological) information was completed at six sites in the Cedar/Green WQMA (Figure 1).

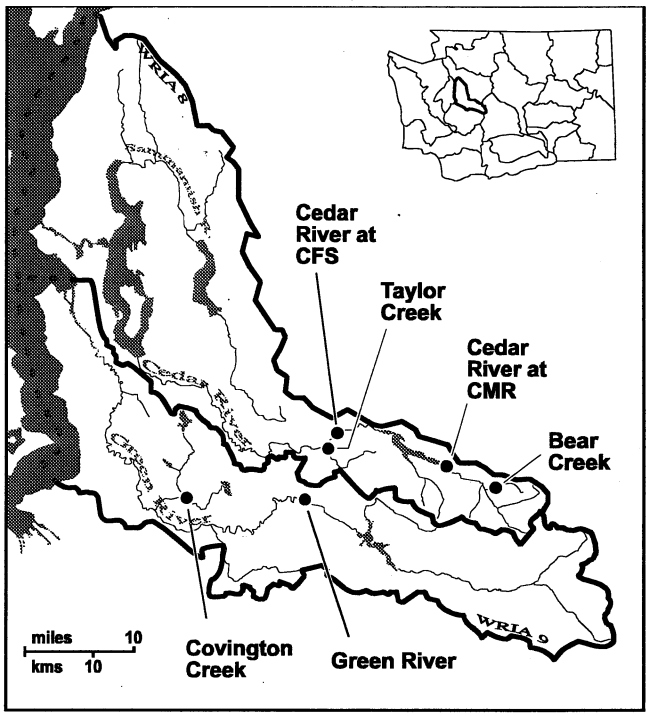


Figure 1. Cedar/Green Water Quality Management Area. Summer 1994 biological monitoring sites.

Site Locations

Most of the sites surveyed were situated within the boundary of the Seattle City water supply reservoir. These sites had been subjected to potential impacts from past logging activity. In one case, a recent debris torrent scoured the stream channel and piled sediment on both banks. The following table lists the sites surveyed and the surrounding land use impacts.

Site	Surrounding Land Use
Cedar River abv Cedar Falls	flow regulation/logging (historic)
Cedar River abv Chester Morse Reservoir	historic logging
Bear Creek	debris torrent
Taylor Creek	historic logging
Green River at Kanasket	logging/suburban
Covington Creek	suburban/least disturbed

Condition of Streams

Biological conditions in two settings were considered least disturbed: the Green River at Kanasket (mountain stream), and Covington Creek (suburban stream). A large number of species were collected at each of these locations. Location and access to these stream reaches was limited by private property and may contribute, in part, to the healthy biological conditions.

Taylor Creek and Cedar River below Cedar Falls maintained biological communities that indicated presence of suspended organic particulates and prolific algal communities used as a food source. Transport of organics in dissolved and particulate form was likely through overland runoff. Both sites also contained species that were tolerant to presence of fine sediment.

Cedar River above Chester Morse Reservoir was influenced by large quantities of sediment transport. Braiding channels and woody debris physically indicated the changing channel condition. Only a small number of species was collected at this site.

Bear Creek was visually degraded from a large debris torrent (landslide of sediments). Even though the riparian area was mostly buried beneath sediments, this stream contained a very large number of species. A rare species of stonefly was present that indicated a recovering channel. The resulting sediment matrix following this slide formed a hardened mass that bordered the stream. Sediment transport through this reach appears to originate from above the slide area. The sediments must contain an organic food source that sustained the appearance of this rare species. Availability of the organic food source underscores the importance of riparian vegetation to recovery of degraded streams in this watershed.

Conclusions and Recommendations

- Changes in riparian vegetation and frequency of forest harvest influence streams in the mountainous areas of the Cedar/Green WQMA. The large amount of precipitation in this area transports dissolved and particulate organics into streams. The quantity of organic matter transport may be an early indicator of more detrimental future impacts from sediment transport.

- The mountain regions of this WQMA were the focus of this survey. Additional surveys of the lower watershed need to be completed. The lower watersheds are influenced by suburban development and hobby farms.

Reference

Plotnikoff, R. and S. Ehinger, 1997. Using Invertebrates to Assess the Quality of Washington Streams and to Describe Biological Expectations. Washington State Department of Ecology, Olympia, WA.

This page is purposely blank for duplex printing

Ground Water Investigations

by
Denis Erickson

EILS Studies

Projects conducted by EILS ground-water staff in the Cedar/Green Water Quality Management Area are summarized below.

Monterey Apartments Monitoring Well Sampling

In 1995 and 1997 EILS sampled monitoring wells at the Monterey and Del Roy Apartments site located in the Queen Anne District of northwest Seattle (Marti, 1997). Past releases from a gas station contaminated ground water at the site. Remedial actions consisting of the removal of all underground tanks and the installation of a spray aeration vapor extraction system have been implemented. EILS sampled wells for benzene, toluene, ethylbenzene, xylene, total petroleum hydrocarbons as gasoline, and total recoverable lead in October 1995, January 1997 and April 1997. The purpose of the sampling was to define the current distribution and concentrations of the petroleum plume and to document the effectiveness of the remedial actions. Based on the results of the last sampling event in April 1997 high concentrations of hydrocarbons are still present in the ground water.

Quarterly Review of Ground Water Monitoring Results at Ravensdale Pit

Ravensdale Pit, located about one mile south of Ravensdale, Washington, was a depression formed by earlier coal mining. The pit received about 268,000 tons of cement kiln dust between 1979 and 1989 from the Ideal Basic Industries' Seattle Plant. Cement kiln dust is generated during the manufacture of cement. Ground water monitoring, initiated in 1985, was required as a condition of Ideal Basic's exemption of cement kiln dust from Washington State's Dangerous Waste Regulations. Ideal Basic was purchased by Holnam Inc., in 1990. Four monitoring wells and a mine portal are sampled quarterly at the pit and EILS reviews the monitoring results for the Hazardous Waste and Toxics Reduction Program. The most recent review is described in Erickson (1997). Monitoring results have shown that soluble constituents including calcium, magnesium, chloride, sulfate, and bicarbonate have migrated to ground water and the mine portal discharge. Trace metals are sampled annually. To date, trace metals have not been detected consistently above ambient concentrations.

Recommendations

The primary ground-water issue in the watersheds is related to the quantity of ground water available for water supply (personal communication with Dave Garland, NWRO, August 7, 1997). Regional staff did not identify any ground water quality issues. EILS has not done enough work in the area to make meaningful ground water quality recommendations.

References

Erickson, D.R., 1997. Ravensdale Pit Groundwater Monitoring Results, March 1997. Memorandum to Bob Stone, Hazardous Waste and Toxics Reduction Program, May 20, 1997. 7 p.

Marti, P.B., 1997. Monterey Apartments Monitoring Well Sampling - January 12-14, 1997. Memorandum to Brian Sato, March 20, 1997. 5 p.

Marine Water Quality Ambient Monitoring

by
Jan Newton

Introduction

The Cedar/Green basin (WRIAs #8 and 9) includes Elliott Bay and a major portion of the Main Basin of Puget Sound. State WRIA boundaries divide several major Puget Sound basins between two or more watershed basins. For example, the Main Basin is shared by both Cedar/Green, Kitsap and other watersheds. The watershed approach makes sense for freshwater systems or for semi-enclosed marine bays receiving river water from a single watershed (e.g., Elliott Bay); however, it is difficult to apply to the Puget Sound marine basins, which are commonly divided into Puget Sound Main Basin, Hood Canal, South Puget Sound, Whidbey Basin, San Juan/Strait of Georgia, and Strait of Juan de Fuca. Because contamination can come from either shoreline (or any watershed) of a subdivided waterbody, it is difficult to evaluate these waterbodies using the watershed approach. In this report, all adjoining waterbodies to the Cedar/Green shoreline were considered part of that WQMA, not just those listed for the specified WRIAs. This means the addition of areas with "WA-PS-xxxx" designations. The waterbody segments considered for Cedar/Green WQMA and the Marine Waters Monitoring stations located within these segments are listed in Table 1.

The Marine Waters Monitoring (MWM) program of the Ambient Monitoring Section is responsible for monitoring the marine waters of Puget Sound and the coastal estuaries Grays Harbor and Willapa Bay. The data record for MWM stations located within the Cedar/Green WQMA and its adjoining waterbody segments is shown in Table 2. There are few marine stations in this WQMA. Two of the monitoring stations represent well-mixed, open basins whereas others represent small, enclosed bays. Stations are typically located in the central portion of the basin or bay, away from the nearshore or known point sources (Figure 1). Water quality samples were analyzed for most conventional parameters, including nutrients and bacteria (Newton *et al.*, 1997).

Two primary factors causing poor water quality are: 1) the existence of anthropogenic inputs/alterations to the environment (e.g., point and non-point contamination, nutrient loading, alteration of habitat, freshwater diversion); and 2) a long residence time (poor flushing of water). Residence times are influenced by natural bathymetry, tidal forcing and circulation. Simply stated, water quality problems become notable when input sources are significant or when removal mechanisms are slow. However, in evaluating water quality, the natural water quality for that area must be considered. Natural water quality does not

always follow the WAC (1992) criteria; thus, knowledge of the environmental mechanisms affecting the various parameters is required. Because information on pre-anthropogenic influence on water quality can be limited to non-existent, this evaluation can be difficult.

Marine Water Quality

Known water quality problems and concerns for the Cedar/Green WQMA are listed in Table 3. Some of the Section 303(d) listings were for metals or toxics and were based on data not collected by MWM.

With the exception of Elliott Bay, the marine areas covered by the Cedar/Green WQMA primarily are well-flushed, deep basins. Relative to other WQMAs in the state, this area presents less risk for marine water quality problems to develop because of its hydrodynamic characteristics.

Fecal Coliform Bacteria

Based on data from the one Ecology MWM station (ELB015), fecal coliform contamination is chronically evident in Elliott Bay. The Department of Natural Resources of Metropolitan King County conducts extensive monitoring of marine waters in Elliott Bay and the Main Basin. Contact Dr. Randy Shuman of the Marine Water Monitoring and Assessment program of METRO-King County for details. Ecology should work with METRO-King County to identify where fecal coliform contamination is worst in Elliott Bay.

The somewhat frequent fecal coliform bacteria exceedences at station PSB003 is surprising given the well-mixed waters and the large basin that station represents. The source for the high concentration events in the Main Basin off West Point is not known and should be investigated. Possibilities are 1) advection from Elliott Bay (correlate with Salinity-Temperature data to trace water masses), 2) WWTP events (correlate with records from METRO West Point outfall), or 3) runoff from land and beaches (correlate with rain events). These sources are not mutually exclusive, but some attempt should be made to elucidate the source for this contamination.

Dissolved Oxygen

Although the DO standard for class AA waters is set at 7.0 mg/L, respectively, (WAC, 1992) the natural DO concentrations of many Puget Sound waters will be lower. This is because the oceanic waters flowing into the region through the Strait of Juan de Fuca are upwelled Pacific Ocean waters that can have naturally low (i.e. between 5 and 7 mg/L) DO concentrations, primarily in late summer. Thus, DO excursions below 7 mg/L but above 5 mg/L are to be expected.

None of the open basins in this WQMA has problems stemming from low DO. The well-mixed nature of these deep tidally mixed basins prevents low DO concentrations from occurring. Natural phytoplankton production can cause low DO concentrations in near-bottom waters, because of the oxidation of sunken organic material. However, near-bottom DO concentrations are increased when mixed with oxygenated surface waters. Strong density stratification (e.g., in areas with freshwater input) inhibits mixing and results in maintaining low DO in near-bottom waters. Thus, areas in Puget Sound with high production and strong density stratification can naturally have DO concentrations less than 5 mg/L in late summer. In order to assess eutrophication and its impact on low DO concentrations, it is important to consider historical data since Puget Sound has naturally low DO in some places at certain times of year.

Refer to Newton *et al.* (1997) for a more thorough assessment of DO concentrations and historical values.

Low DO may be of concern in Elliott Bay. Since June 1992, when MWM was conducted to the sea-bed instead of just to 30 m, there was one observation of DO below 5 mg/L at station ELB015. In August 1995 the concentration at 86 m was 4.95 mg/L (Newton et al., 1997). The status of DO in Elliott Bay should be investigated from the METRO-King County database. Because of the extensive anthropogenic impact on the Bay, it may be sensitive, though the concentration cited above poses no immediate cause for concern.

Nutrients

Eutrophication will have serious impacts in areas where flushing is low and where phytoplankton growth is nutrient limited. In well-mixed areas, phytoplankton are more typically light-limited since they are mixed below the euphotic zone. Most of the marine waters in this WQMA fall into this category. The outfall at West Point is a classic example of where nutrient input did not disrupt the primary production of the basin. However, there are areas, particularly in the nearshore regions, where effects may be stimulated (e.g., species shifts) though this has not been documented in this region. It is important to assess suspected nutrient sources and to compare with historical levels. Comparing nutrient concentrations in the water column is not conclusive, since algal uptake is rapid; however, analysis of nutrient ratios can be insightful since ammonium-N, in short supply naturally (0.03 mg/L in Admiralty Inlet), often is indicative of anthropogenic input.

To assess eutrophication, it is recommended to assess nutrient trends in freshwater input, where failing septics may occur, and where other exogenous point and non-point nutrient sources are significant. Water column measurements such as DO, nutrient concentrations, stratification intensity, phytoplankton community abundance and composition, and the sensitivity of primary production to added nutrients are useful, as is comparison with historical values. No current instances of eutrophication are evident in this WQMA though localized nearshore high ammonium values were observed (Kendra, 1989). Based

on this study it is evident that significant loading may occur from relatively small creeks. Further investigations of nearshore nutrient conditions may be warranted.

Toxics/Metals

As is shown in Table 3, many of the 303(d) listings for marine areas in the Cedar/Green WQMA are from exceedances in toxics and metals in Elliott Bay. The Department of Natural Resources of Metropolitan King County conducts significant assessment of metals and organic compounds in Elliott Bay and the Duwamish River. Ecology should contact Dr. Randy Shuman of the Marine Water Monitoring and Assessment program of METRO-King County.

Lacking is information on the degree that chemical contamination is historical (e.g., in sediments) or current (e.g., still mobile in water column and taken up by plankton, at the base of the pelagic food-web). New technology (semi-permeable membrane devices) and/or mussel cages with tissue analysis would yield contamination levels in the water.

In conjunction with METRO-King County, the degree of ongoing versus historical chemical contamination and its availability in the water column and to plankton should be assessed in specific areas of high concern.

Harmful Phytoplankton Species

The occurrence of harmful or toxic phytoplankton in these waters is not well documented, though outbreaks have occurred. To some extent the lack of data on harmful phytoplankton occurrence indicates a lack of outbreaks, but it also indicates a lack of monitoring.

Observations of harmful phytoplankton in the Cedar/Green Basin include the diatom species (*Pseudonitzschia* spp.) that causes Amnesiac Shellfish Poisoning, the dinoflagellate (*Alexandrium* spp.) that causes Paralytic Shellfish Poisoning, a flagellate species (*Heterosigma carterae*) that can cause fish kills, and a dinoflagellate (*Dinophysis* sp.) that can cause diarrhea in humans. No outbreaks have caused human death, but significant loss of resources have occurred through fish kills. The stimuli for blooms of harmful phytoplankton are not understood. Monitoring of phytoplankton species, to be effective, must be done frequently and accompanied by other environmental variables.

Ecology should work with the Washington State Department of Health, University of Washington, National Marine Fisheries Service, and Pacific Coast Oyster Growers Association to develop a comprehensive monitoring and assessment program for harmful phytoplankton. This work could be conducted under the auspices of the Puget Sound Ambient Monitoring Program (PSAMP).

Recommendations

- Ecology should work with METRO-King County to identify where fecal coliform contamination is worst in Elliott Bay.

- The source for the high concentration events in the Main Basin off West Point is not known and should be investigated.

- Low DO may be of concern in Elliott Bay. The status of DO in Elliott Bay should be investigated from the METRO-King County database. Because of the extensive anthropogenic impact on the bay, it may be sensitive, though the concentration cited above poses no immediate cause for concern.

- To assess eutrophication, it is recommended to assess nutrient trends in freshwater input, where failing septics may occur, and where other exogenous point and non-point nutrient sources are significant.

- In conjunction with METRO-King County, the degree of ongoing versus historical chemical contamination and its availability in the water column and to plankton should be assessed in specific areas of high concern.

- Ecology should work with the Washington State Department of Health, University of Washington, National Marine Fisheries Service, and Pacific Coast Oyster Growers Association to develop a comprehensive monitoring and assessment program for harmful phytoplankton.

References

Kendra, W. 1989. Water Quality in Fauntleroy Creek and Cove during the Summer of 1988. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, May 1989, Olympia, WA.

Newton, J.A., S.L. Albertson and A.L. Thomson. 1997. Washington State Marine Water Quality in 1994 and 1995. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Publication #97- 316, Olympia, WA.

WAC (Washington Administrative Code), 1992. Chapter 173-210A WAC: Water Quality Standards for Surface Waters of the State of Washington. Olympia, WA.

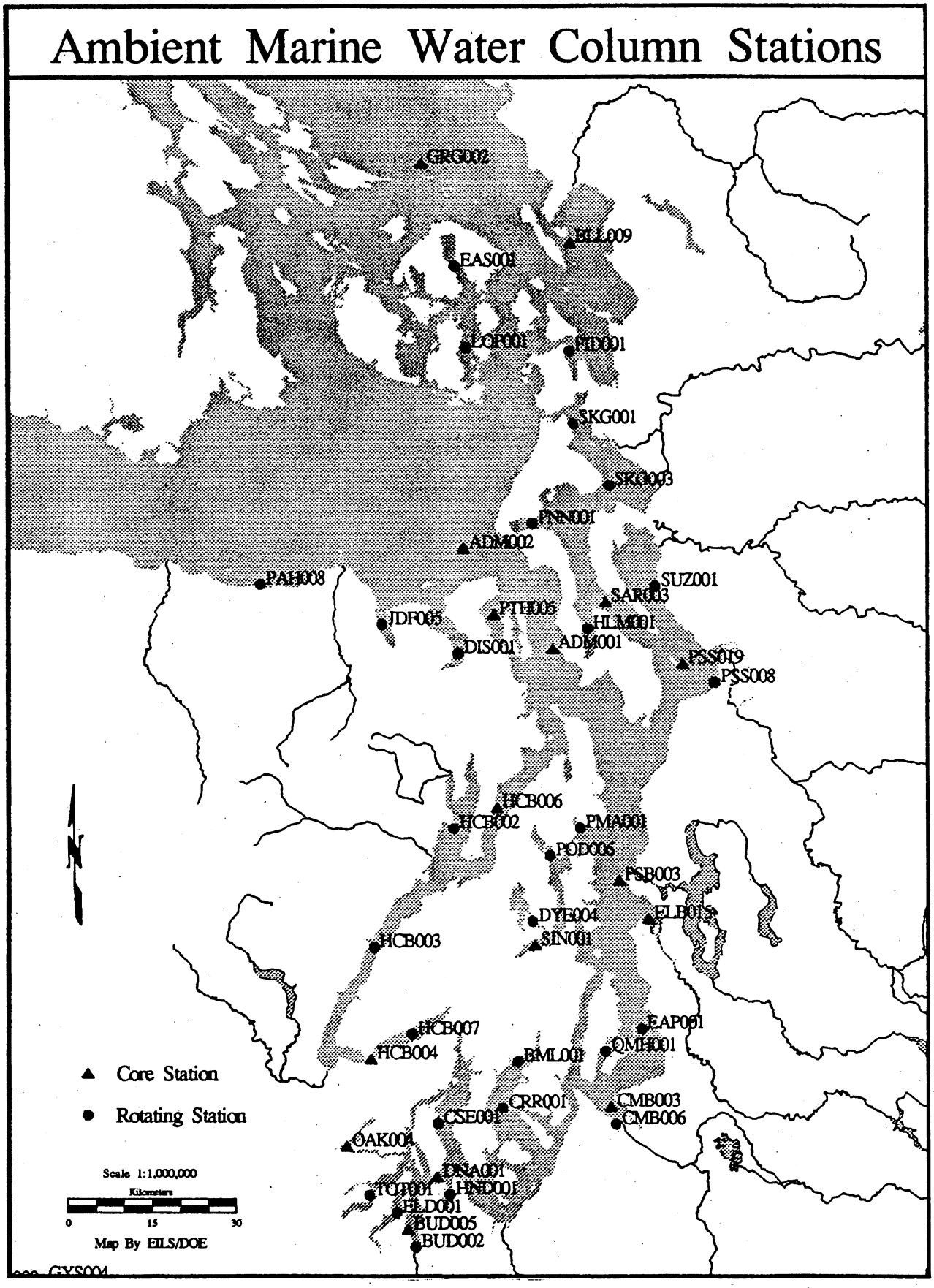


Figure 1. Core and rotational stations occupied by Marine Waters Monitoring for long-term ambient monitoring in Puget Sound.

Table 1. Waterbodies relevant to the Cedar/Green WQMA. Also shown are the Marine Waters Monitoring stations located within the waterbody.

Segment #	Waterbody Name	Class	MWM Station (current)	MWM Station (historical)
WA-09-	Elliott Bay	B	ELB015	[1]ELB005, and 9 older[2] stns
WA-PS-	Possession Sound (South)	AA	*none in WQMA*	
WA-PS-	Puget Sound (N. Central and	AA	*none in WQMA*	
WA-PS-	Puget Sound (Central)	AA	PSB003	4 older[2] stns
WA-PS-	Puget Sound (S. Central) and East	AA	EAP001	
WA-PS-	Dalco Passage/Poverty Bay	AA	*none in WQMA*	

[1]data record WY1980-88
[2]data record WY1973-76

Table 2. Marine Waters Monitoring data availability for Cedar/Green WQMA. Station data available for current and historical stations. An "X" denotes monthly data in Ecology's Ambient Monitoring database and in US EPA Storet for the listed wateryear (WY). Wateryears begin in October and end in September of the year named. Some wateryear records are incomplete due to missed surveys or isolated sampling events; sampling during winter months did not commence until WY 1989. Core stations as of WY 1997 indicated by "C".

Station Number	Station Name	Core	Latitude (deg min N)	Longitude (deg min W)	WY: 73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
East Passage																													
EAP001	SW of Three Tree Point		47 25.65	122 23.25																X	X	X	X				X		
Elliott Bay																													
ELB001	Pier 91		47 37.56	122 22.53	X	X	X																						
ELB002	Pier 66		47 36.66	122 20.96	X	X	X																						
ELB003	Pier 51		47 36.11	122 20.36	X	X	X																						
ELB004	East WW Mouth		47 35.38	122 20.58	X	X	X																						
ELB005	Near Harbor Island		47 35.35	122 21.11								X	X	X	X	X	X	X	X	X									
ELB006	West WW Mouth		47 35.41	122 21.53	X	X	X																						
ELB008	Duwamish Head		47 36.05	122 23.16	X	X	X																						
ELB009	Duw. WW Spok. St. Br.		47 34.28	122 21.16	X	X	X																						
ELB010	Duw. WW 16th St. Br.		47 31.25	122 18.78	X	X	X					X	X	X	X	X	X	X	X	X									
ELB012	Duw. R. Marg. Way		47 30.05	122 17.33	X	X	X																						
ELB015	E. of Duwamish Head	C	47 35.47	122 22.10																				X	X	X	X	X	x
Puget Sound Main Basin / Lk Wash. Ship Canal																													
PSB002	Alki Point		47 34.60	122 25.40	X	X	X																						
PSB003	West Point	C	47 39.60	122 26.50					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	x
PSB006	Ballard Bridge		47 39.55	122 22.50	X	X	X	X																					
PSB007	Lake Union/Gas Works		47 38.63	122 19.90	X	X	X	X																					
PSB008	Fremont Bridge		47 38.88	122 20.90	X	X	X	X																					

Table 3. Summary of marine water quality issues in Cedar/Green WQMA. Includes WRIA #09 and relevant PS segments.

Segment #	Area Name	Water Quality Issues	
		1996 Section 303 (d) listing	Other water quality concerns/observations
WA-09-0010	Elliott Bay	Fecal Coliform Sediment Bioassay Metals (8 listed) Organics (38 listed)	Fecal coliform bacteria levels are elevated in Elliott Bay. At **Stn ELB015** there were 8 occurrences of >14 org./mL, just between WY 1992-96. Four of these were >50 org./mL. In WY 1995 there was one occurrence of DO concentration below 5 mg/L. The concentration was 4.95 mg/L and does not represent cause for concern; however, due to the heavy use of this bay, conditions should be monitored closely. Ecology should consult METRO-King County data for a better assessment of the Bay's low DO status.
WA-PS-0230	Puget Sound (N. Central and Useless Bay)	PCBs	No monitoring station.
WA-PS-0240	Puget Sound (Central)	Fecal Coliform	Unlike other stations in the well-mixed Main Basin of Puget Sound, **Stn PSB003** has fairly frequent exceedences of 14 org./mL fecal coliform. Between WY 1977 and 1996 there were 10 such occurrences. Five of these were >50 org./mL. The source of the contamination could be from Elliott Bay, METRO WWTP, or land runoff. Comparison with rain, sewer and salinity data should be made to determine which vector is most likely.
WA-PS-0270	Puget Sound (S. Central and East Passage	Fecal Coliform Ammonium-N (Kendra, 1989)	For the period monitored (WY 1988-91 and 1995) there was only one exceedence of fecal coliform at >14 org./mL at **Stn EAP001.** This station represents well-mixed, deep basin with relatively few point sources in the vicinity.

This page is purposely blank for duplex printing

Marine Sediment Quality Ambient Monitoring

by
Maggie Dutch

Introduction

The Ecology Marine Sediment Monitoring Team has conducted the Sediment Monitoring Component of the Puget Sound Ambient Monitoring Program (PSAMP) since 1989. Through 1995 this program consisted of a three-part study of Puget Sound's benthic environment: conducting sediment analysis for contamination by organic compounds and metals; sediment toxicity testing using bioassay procedures; and benthic invertebrate community analysis. Seventy-five PSAMP stations were sampled throughout Puget Sound, Hood Canal, the Strait of Georgia, and the Strait of Juan de Fuca (Figures 1A, B). Sediment chemistry analyses indicated that overall, contaminants were undetected in 70 percent of all analyses. Compounds that were detected generally occurred at stations located in urban or industrial centers. Toxicity tests were inconclusive, showing no consistent patterns of amphipod mortality (Llansó, *et al.*; in review). Multivariate analysis techniques suggest that infaunal assemblages are structured in part by sediment composition, water depth, and geographical location (Llansó; in review).

Eleven of the PSAMP stations are located within the Cedar/Green WQMA, and were sampled with varying frequency over seven years (Table 1). Table 2 summarizes the chemistry data from those stations within the Cedar/Green WQMA which were in exceedence of Washington State Sediment Management Standards Chemical Criteria (Chapter 173-204 WAC). Four of the 56 samples analyzed were found to exceed these criteria for 21 organic compounds and summed compound values. Nineteen of these exceedences were from the April 1992 and April 1993 samples taken at Station 33 (Elliott Bay), and consisted primarily of high molecular weight polynuclear aromatic hydrocarbons (HPAH). The sediment sample taken at Station 22 (Mukilteo) in April 1990 had a measured concentration of Bis (2-ethylhexyl) phthalate which exceeded both Lowest Apparent Effects Threshold (LAET) and Minimum Cleanup Levels (MCUL) values. The sample taken at Station 23R (East Central Basin) in April 1995 displayed a LPAH criterion in exceedence of the LAET value.

Recommendations

Of the eleven PSAMP stations in the Cedar/Green WQMA, Station 22, located in Elliott Bay, displayed the greatest degree of chemical contamination of sediments, primarily containing HPAH compounds. The PSAMP Sediment Monitoring Component was designed to provide long-term, baseline data regarding the sediment conditions in different locations rather than to address specific contamination issues. The data generated through this effort can be provided to local monitoring entities (METRO, Port of Seattle, etc.) to enhance knowledge of sediment conditions at the location sampled and facilitate existing or future coordinated pollution prevention or clean-up efforts. No further management recommendations are provided.

References

Llansó, R.J. *et al.* In review. Marine Sediment Monitoring Program: Summary Report for 1989-1995. Washington State Department of Ecology. Olympia, WA.

Llansó, R.J. In review. Benthic Community Structure at PSAMP Monitoring Stations. Washington State Department of Ecology. Olympia, WA.

Figure 1A. Northern Puget Sound stations monitored by the MSMP.

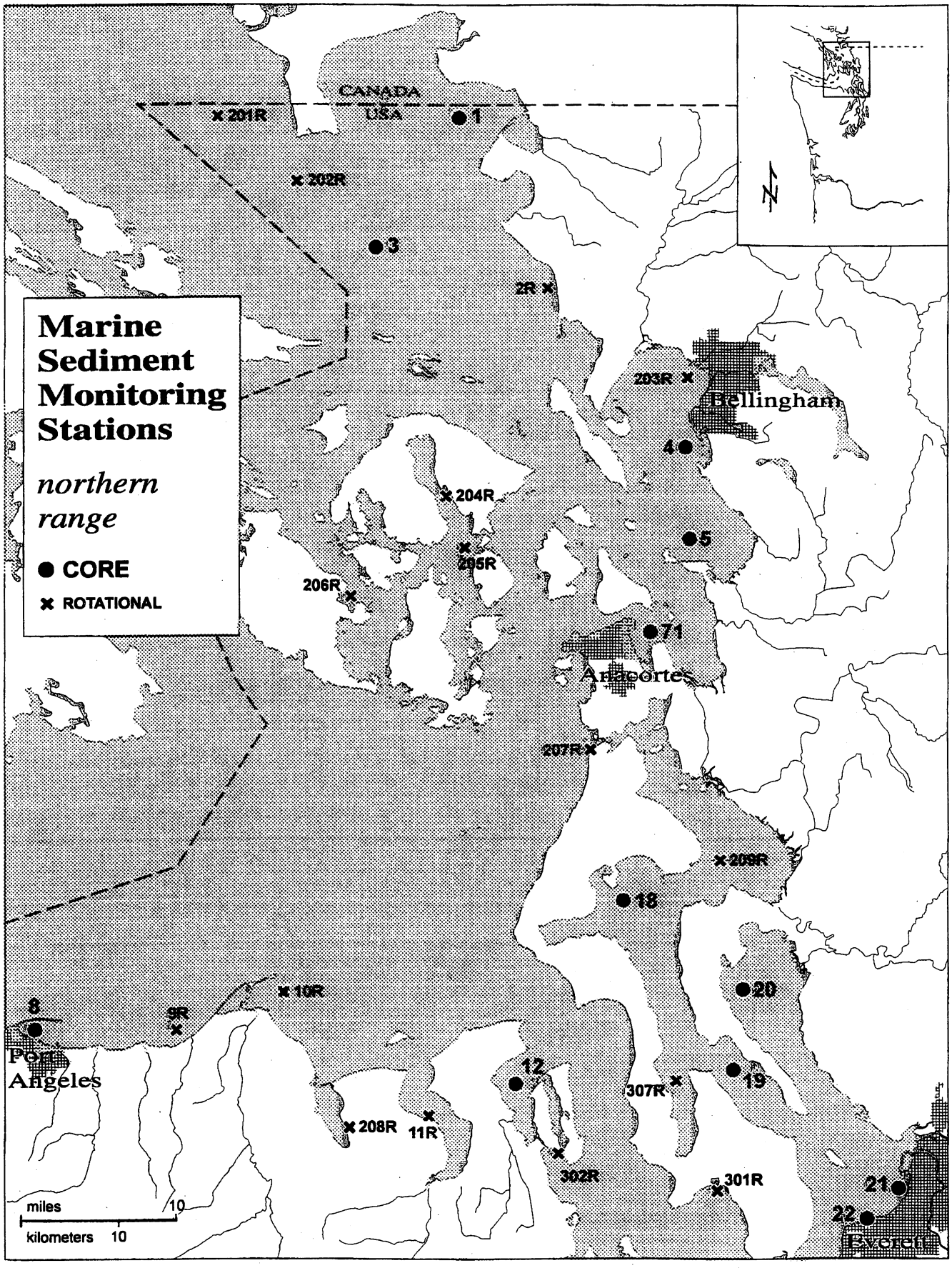


Figure 1B. Southern Puget Sound stations monitored by the MSMP.

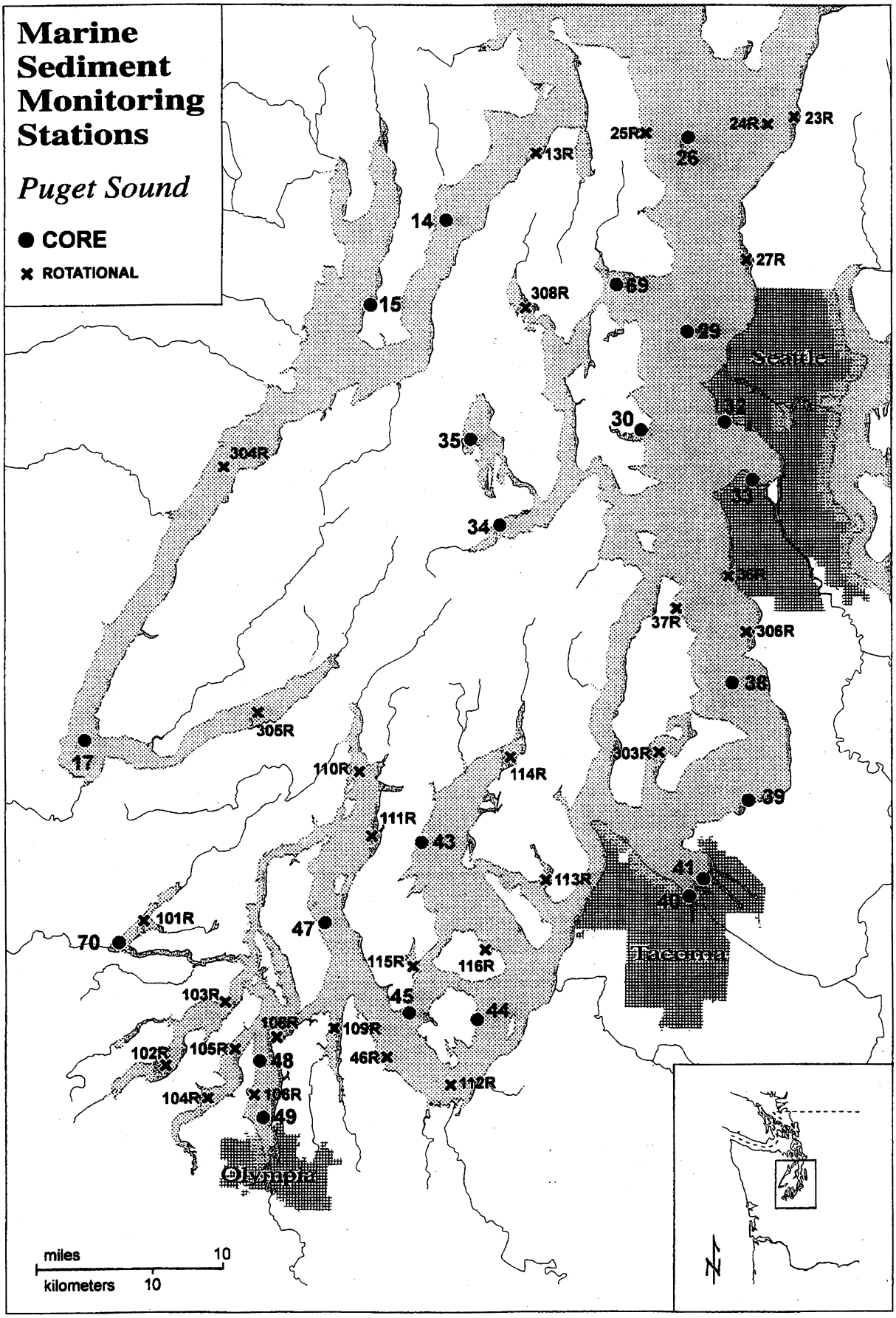


Table 1. Designation, location and sampling schedule of Puget Sound Ambient Monitoring Program sediment monitoring stations within the Cedar/Green WQMA. An "X" denotes year sampled.

Station Number	Station Name	Latitude (deg min N)	Longitude (deg min W)	Approx. Water Depth (Meters)	Year 89	90	91	92	93	94	95
22	Mukilteo	47 57.330	122 17.180	20.5	X	X	X	X	X	X	X
23R	East Central Basin (South of Picnic Point)	47 52.235	122 20.067	20	X			X			X
24R	East Central Basin (West of Norman Beach)	47 51.860	122 21.930	182	X			X			X
27R	Richmond Beach	47 45.565	122 23.180	21	X			X			X
29	Shilshole	47 42.045	122 27.242	199	X	X	X	X	X	X	X
32	Magnolia Bluff	47 37.905	122 24.515	21	X	X	X	X	X	X	X
33	Elliot Bay (SE of Duwamish Head)	47 35.230	122 22.545	20	X	X	X	X	X	X	X
36R	Brace Point	47 30.810	122 23.845	15	X			X			X
38	Point Pully (3-Tree Point)	47 25.700	122 23.618	199	X	X	X	X	X	X	X
39	Dash Point (East of Dumas Bay)	47 20.225	122 22.315	14.5	X	X	X	X	X	X	X
306R	Seahurst East Passage	47 28.225	122 22.555	75				X			X

Table 2. Puget Sound Ambient Monitoring Program sediment monitoring stations within the Cedar/Green WQMA in exceedence of Sediment Management Standards Chemical Criteria.

Station Number	Station Name	Date Sampled	Chemical Criteria*	Chemical Parameter	Parameter Type	Measured Concentration (ppm)	Sediment Quality Standards (SQS) Concentration (ppm carbon**)	Exceedence Quotient***	Chemical Analysis Qualifier Code****
22	Mukilteo	4/1/90	LAET	Bis(2-ethylhexyl) phthalate	Phthalate Ester	95	47	2.021	E
		4/1/90	MCUL	Bis(2-ethylhexyl) phthalate	Phthalate Ester	95	78	1.217	E
23R	East Central Basin	4/1/95	LAET	Low Molecular Weight PAH	LPAH (summed value)	420	370	1.135	
33	Elliot Bay	4/1/92	LAET	Benzo(a)anthracene	HPAH	130	110	1.181	
		4/1/92	LAET	Benzo(a)pyrene	HPAH	170	99	1.717	
		4/1/92	LAET	Benzo(g,h,i)perylene	HPAH	68	31	2.193	E
		4/1/92	LAET	Chrysene	HPAH	170	110	1.545	
		4/1/92	LAET	Dibenz(a,h)anthracene	HPAH	32	12	2.666	
		4/1/92	LAET	Dibenzofuran	Miscellaneous Extractable	16	15	1.066	
		4/1/92	LAET	Fluoranthene	HPAH	230	160	1.437	
		4/1/92	LAET	Fluorene	LPAH	32	23	1.391	
		4/1/92	LAET	High Molecular Weight PAH	HPAH (summed value)	1500	960	1.562	
		4/1/92	LAET	Indeno(1,2,3-cd)pyrene	HPAH	94	34	2.764	
		4/1/92	MCUL	Indeno(1,2,3-cd)pyrene	HPAH	94	88	1.068	
		4/1/92	LAET	Phenanthrene	LPAH	180	100	1.8	
		4/1/92	LAET	Total benzofluoranthenes (b+k (+j))	HPAH (summed value)	330	230	1.434	
		4/1/92	LAET	Total Polychlorinated Biphenyls	PCB	14	12	1.166	E
		4/1/93	LAET	Benzo(a)pyrene	HPAH	140	99	1.414	
		4/1/93	LAET	Benzo(g,h,i)perylene	HPAH	81	31	2.612	
		4/1/93	MCUL	Benzo(g,h,i)perylene	HPAH	81	78	1.038	
		4/1/93	LAET	Dibenz(a,h)anthracene	HPAH	36	12	3	
		4/1/93	MCUL	Dibenz(a,h)anthracene	HPAH	36	33	1.09	
		4/1/93	LAET	High Molecular Weight PAH	HPAH (summed value)	1000	960	1.041	
		4/1/93	LAET	Indeno(1,2,3-cd)pyrene	HPAH	93	34	2.735	
		4/1/93	MCUL	Indeno(1,2,3-cd)pyrene	HPAH	93	88	1.056	
		4/1/93	LAET	Total benzofluoranthenes (b+k (+j))	HPAH (summed value)	230	230	1	

*Chemical Criteria taken from Chapter 173-204 WAC - Sediment Management Standards:
LAET - Lowest Apparent Effects Threshold (Table I. Marine Sediment Quality Standards)
MCUL - Minimum Cleanup Levels (Table III. Puget Sound Marine Sediment Cleanup Screening Levels and Minimun Cleanup Levels
**ppm carbon - the listed chemical parameter criteria represent concentrations in parts per million, "normalized," or expressed, on a total organic carbon basis
***Exceedence Quotient = Measured Concentration/SQS Concentration
****Chemical Analysis Qualifier Code: E=Estimated value