WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Snohomish River Estuary
Total Maximum Daily Load

Submittal Report

August 1999
Publication No. 99-57-WQ
Printed on Recycled Paper

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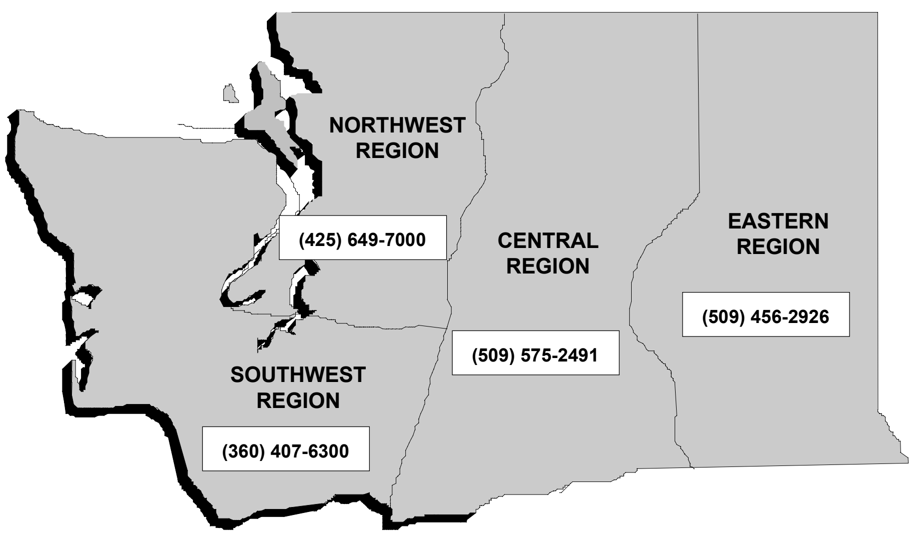

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Snohomish River Estuary Total Maximum Daily Load

Submittal Report

by
Steven R. Butkus
Robert F. Cusimano
David E. Wright

Washington State Department of Ecology
Water Quality Program
Post Office Box 47600
Olympia, Washington 98504-7600

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Introduction

Section 303(d) of the federal Clean Water Act mandates that the State establish Total Maximum Daily Loads (TMDLs) for surface waters that do not meet standards after application of technology-based pollution controls. The U.S. Environmental Protection Agency (EPA) has established regulations (40 CFR 130) and developed guidance (EPA, 1991) for establishing TMDLs.

Under the Clean Water Act, every state has its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses, such as cold water biota and drinking water supply, and criteria, both numeric and narrative criteria, to achieve those uses. When a lake, river or stream fails to meet water quality standards after application of required technology-based controls, the Clean Water Act requires that the state place the water body on a list of "impaired" water bodies and to prepare an analysis called a **Total Maximum Daily Load (TMDL)**.

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant which can be discharged to the water body and still meet standards, called the **loading capacity,** and allocates that load among the various sources. If the pollutant comes from a discrete source (referred to as a **point source**) such as an industrial facility's discharge pipe, that facility's share of the loading capacity is called a **wasteload allocation**. If it comes from a diffuse source (referred to as a **nonpoint source**) such as a farm, that facility's share is called a **load allocation**.

The TMDL must also consider seasonal variations and include a **margin of safety** that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. The sum of the individual allocations and the margin of safety must be equal to or less than the loading capacity.

The Washington State Department of Ecology (Ecology) is establishing a Total Maximum Daily Load (TMDL) for the Snohomish River Estuary for ammonia and biological oxygen demanding substances. This TMDL will address impairments due to low dissolved oxygen levels in three segments on the 1996 Section 303(d) list of impaired surface waters.

The five elements of the Snohomish River Estuary TMDL as required by the Clean Water Act:

Loading Capacity

The loading capacity of the TMDL is based on the critical period from July through October when dissolved oxygen levels are the lowest. A water quality model was used to determine the amount of ammonia and oxygen demanding substances that could be discharged from point sources and meet the standard for dissolved oxygen. Existing loads from nonpoint sources were used in determining the loading capacity. The total loading capacities were set at 14,883 pounds per day of ultimate carbonaceous biochemical oxygen demand (UCBOD) and 2,724 pounds per day of ammonia nitrogen.

Wasteload Allocation

Wasteload allocations (WLAs)for point sources are set as allowable effluent limits for ultimate carbonaceous biochemical oxygen demand (UCBOD) and ammonia nitrogen. These represent reductions from 0% to 54% for ammonia and from 0% to 54% for UCBOD. The wasteload allocations will be implemented through issuance of discharge permits with effluent limitations.

Load Allocations

No reductions in existing loading are proposed for nonpoint sources. The load allocations (LAs) for nonpoint sources are equal to the existing human-caused loads during critical conditions minus estimates of background loads.

Margin of Safety

Several conservative assumptions were made in the model development and application that provide an inherent margin of safety. The model used critical low flows estimated to be the seven day low flow with a recurrence of once every 20 years. Extremes of either the 90th or 10th percentile values were used to estimate critical variables in the model application. Critical condition flows of the point sources were based on the 95th percentile of measured data. Effluent characteristics were set to the highest value measured during two surveys.

Seasonal Variation

Dissolved oxygen data collected from the Snohomish River show a definite pattern of seasonal variation. Based on a review of these and other data collected in the Snohomish Estuary, the critical period established for the TMDL was set as July through October.

Background

Geographic Setting

The study area is the lower part of the Skykomish River and all of the Snohomish River, Port Gardner, and the adjacent portion of Possession Sound (Figure 1). The Snohomish River drains 1,780 square miles, not including Quilceda Creek drainage area, and accounts for about 30 percent of the freshwater discharge to Whidbey Basin of the Puget Sound. The Snohomish River is formed by the junction of two major rivers--the Skykomish and Snoqualmie. The Snoqualmie drains 693 square miles and the Skykomish drains 844 square miles. Other sub-basins in the study area include the Pilchuck River, Woods Creek, and the Sultan River--plus Allen and Quilceda Creeks which enter Ebey Slough near Marysville. Within the study area there are also four drainage systems which are controlled by pumping stations: French Creek, the Marshland, Deadwater Slough, and Swan Trail Slough.

The Snohomish River enters inner Everett Harbor and then Possession Sound through several channels in the delta. These channels are known as Ebey Slough, which is cut along the north side of the delta; Steamboat Slough and Union Slough, through the center of the delta; and the main Snohomish River channel, which follows along the south side of the delta and the Everett Peninsula. By the deposition of alluvial material at its mouth, the Snohomish River has formed a tidal flat of about ten square miles in area. During extreme low tides, much of this area is exposed, and the river moves westward to Possession Sound through channels cut by the sloughs, and south to Port Gardner Bay through the dredged main channel. High flooding tides cause a strong upstream current that can push salt water more than six miles up the main river channel from its mouth at Preston Point.

The elevation of the Snohomish River at the confluence of the Snoqualmie and Skykomish Rivers (River Mile 20.5) is only 20 feet, which gives the lower river a slope of only about one foot per mile to the mouth. At Monroe (River Mile 25.0) and Sultan (River Mile 34.4) the Skykomish River elevations are 40 ft. and 90 ft., which provide river segment slopes of 4.4 and 5.3 ft per mile, respectively. From the confluence of the Snoqualmie and Skykomish Rivers to the mouth, the river channel is well-defined, consisting mainly of long, deep, slow-moving glides with a bottom substrate of sand or sand-mud. Along most of this segment the river is diked.

Soils along the flood plain of the river from the City of Snohomish to the mouth are mostly deep clay, sand, and silt loam with some very poorly drained areas. From the City of Snohomish to Monroe, the soils are moderately well-drained silt loam to excessively well-drained alluvium composed of sand, gravel, cobble, and stone. From Monroe to Sultan the flood plain soils are mostly well-drained river rock. The alluvium along the floodplain is reportedly deep, yielding large quantities of ground water. The ground water along the river, downstream of the Marshland, is brackish due to saltwater intrusion.

The lower Snohomish River and its sloughs are an important habitat for acclimating adult and juvenile salmon to salt/fresh water before they migrate from one environment to the other. In addition to these waters providing a migration route to and from spawning grounds, the lower parts of the river, sloughs, and near shore estuary are important juvenile rearing areas. Portions of the Skykomish and Snoqualmie river systems provide excellent spawning habitat for chinook, coho, pink, and chum salmon both in the main channels and tributaries.

Historically, land-use in the area has mostly been agriculture and forest, but it is rapidly becoming more urban. In the 1980's, Snohomish County was the fastest growing county in the state. Population increased by 38 percent in this decade, and much of the growth took place in municipalities in the Snohomish River drainage. Increased urbanization is likely having a direct impact on water quality through alteration of stream banks, riparian vegetation, and near stream forest. The growing urbanization also translates to increased loading from wastewater treatment plants, with potential adverse effects on water quality.

Description of Pollutant Sources

Four wastewater treatment plants (WWTPs) discharge treated wastewater within the TMDL study area: The City of Snohomish WWTP discharges to the mainstem at river mile 12, Lake Stevens Sewer District WWTP discharges to Ebey Slough at river mile 6.5, the City of Marysville WWTP discharges to Steamboat Slough at river mile 3.5, and the City of Everett WWTP discharges at two locations to the mainstem at RM 2.5 and RM 3.5. Although the major focus of the TMDL study is on point sources of pollution, nonpoint sources are considered, but only as loads from tributaries entering the Snohomish River or sloughs. Ecology has conducted a more detailed water quality assessment of the tributaries and their drainage's to the Snohomish River (Cusimano and Coots, 1997).

Applicable Criteria

Within the state of Washington, water quality standards are published pursuant to Chapter 90.48 of the Revised Code of Washington (RCW). Authority to adopt rules, regulations, and standards as are necessary to protect the environment is vested with the Department of Ecology. Under the federal Clean Water Act, the EPA Regional Administrator must approve the water quality standards adopted by the State (Section 303(c)(3)). Through adoption of these water quality standards, Washington has designated certain characteristic uses to be protected and the criteria necessary to protect these uses [Washington Administrative Code (WAC), Chapter 173-201A). These standards were last adopted in November 1997.

This TMDL is designed to address impairments of characteristic uses caused by low dissolved oxygen. The characteristic uses designated for protection in Snohomish River Estuary are as follows:

"Characteristic uses. Characteristic uses shall include, but not be limited to, the following:

(i) Water supply (domestic, industrial, agricultural).

(ii) Stock watering.

(iii) Fish and shellfish:

Salmonid migration, rearing, spawning and harvesting.

Other fish migration, rearing, spawning, and harvesting.

Clam, oyster and mussel rearing, spawning, and harvesting

Crustaceans and other shellfish rearing, spawning, and harvesting.

(iv) Wildlife habitat.

(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).

(vi) Commerce and navigation."

[WAC 173-201A-030(2)]

The TMDL applies to waters of the Snohomish River Basin downstream of the confluence of the Snoqualmie and Skykomish Rivers, and includes Possession Sound and Inner Everett Harbor. These waters are designated as Class A with the exception of the Inner Everett Harbor which is Class B. The water quality standards describe criteria for dissolved oxygen. Different criteria apply to fresh and marine water.

For Class A freshwaters:

"Freshwater - dissolved oxygen shall exceed 8.0 mg/L."

[WAC 173-201A-030(2)(c)(ii)(A)]

For Class A marine waters:

"Marine Water - dissolved oxygen shall exceed 6.0 mg/L. When natural conditions, such as upwelling, occur, causing the dissolved oxygen to be depressed near or below 6.0 mg/L, natural dissolved oxygen levels may be degraded by up to 0.2 mg/L by human-caused activities."

[WAC 173-201A-030(2)(c)(ii)(B)]

For Class B marine waters:

> *"Marine Water - dissolved oxygen shall exceed 5.0 mg/L. When natural conditions, such as upwelling, occur, causing the dissolved oxygen to be depressed near or below 5.0 mg/L, natural dissolved oxygen levels may be degraded by up to 0.2 mg/L by human-caused activities."*

[WAC 173-201A-030(3)(c)(ii)(B)]

The water quality standards describe how to apply the different criteria of dissolved oxygen in an estuary.

> *In brackish waters of estuaries, where the fresh and marine water quality criteria differ within the same classification, the criteria shall be interpolated on the basis of salinity; except that the marine water quality criteria shall apply for dissolved oxygen when salinity is one part per thousand or greater and for fecal coliform organisms when salinity is ten parts per thousand (o/oo) or greater.*

[WAC 173-201A-060(2)]

Water Quality Impairments

As a result of dissolved oxygen measurements that show criteria are exceeded, waters in the Snohomish River Estuary are included on Washington's 1996 Section 303(d) list.

Table 1. Snohomish Estuary 1996 Section 303(d) Listed Waters for Dissolved Oxygen

Water Body Name	Segment Description	Segment Identification Number
Port Gardner and Inner Everett Harbor	Northeast of a line bearing 121 true from approximately 47°59'5"N and 122°13' 44"W (southwest corner of the pier)	WA-07-0010
Snohomish River	Mouth at Port Gardner (east of Longitude 122°13' 40"W) to Snohomish River Mile 8.1 (southern tip of Ebey Island)	WA-07-1010
Snohomish River	Pilchuck (River Mile 13.4) to the confluence of the Snoqualmie River and the Skykomish River (River Mile 20.5).	WA-07-1050
Allen Creek*	Mouth at Ebey Slough River Mile 2.9 to headwaters	WA-07-1012
Quilceda Creek*	Mouth at Ebey Slough River Mile 0.4 to headwaters	WA-07-1015
Wood Creek (Marshlands)*	Mouth at Snohomish River Mile 7.7, including the ditch system draining from the southeast	WA-07-1019
French Creek*	Mouth at Snohomish River Mile 14.7 to headwaters	WA-07-1052

* Dissolved Oxygen in tributary streams is not addressed in this TMDL.

Seasonal Variation

Dissolved oxygen data collected from the Snohomish River show a definite pattern of seasonal variation. Data collected by Ecology's Ambient Monitoring Program were compiled for two stations on the Snohomish River and descriptive statistics were generated for the period of record. Based on a review of these and other data collected in the Snohomish Estuary (Ehinger, 1993), the critical period established for the TMDL was set to July through October.

Table 2. Statistics of Dissolved Oxygen Concentrations in the Snohomish River

Month	**Ecology Station 07A090 (Snohomish River at Snohomish)**			**Ecology Station PSS015 (Snohomish River at Highway 99)**		
	Number of Samples	Median Dissolved Oxygen (mg/L)	Minimum Dissolved Oxygen (mg/L)	Number of Samples	Median Dissolved Oxygen (mg/L)	Minimum Dissolved Oxygen (mg/L)
January	7	12.3	11.7	0	-	-
February	8	12.3	11.8	0	-	-
March	8	12.0	11.6	0	-	-
April	8	11.6	11.0	10	12.3	10.0
May	8	11.1	10.3	10	12.3	11.3
June	8	10.4	9.6	10	11.6	9.9
July	8	9.5	8.4	10	10.6	7.2
August	7	9.2	8.7	10	9.4	8.3
September	7	9.4	9.0	10	9.4	6.5
October	8	10.8	10.1	10	8.6	7.2
November	8	11.6	11.4	10	11.2	7.4
December	8	12.2	11.8	1	11.7	11.7

Technical Analysis

An EPA-supported model, WASP5, was used to simulate the hydrodynamics and water quality of the estuary system (EPA 1993). The WASP5 system is composed of two independent computer programs, DYNHYD5 and WASP5. DYNHYD5 simulates water movement or hydrodynamics while the water quality program, WASP5, simulates the movement and interactions of chemical constituents within the water. WASP5 is composed of two sub-programs, EUTRO5 and TOXI5 which simulate conventional pollutants (involving dissolved oxygen, biochemical oxygen demand, nutrients and eutrophication), and toxic pollutants (involving organic chemicals and metals), respectively. The Snohomish River Estuary WASP5 model network extends from an upstream boundary just below the confluence of the Skykomish and Snoqualmie Rivers, to six seaward boundaries in Possession Sound.

An existing calibrated and verified hydrodynamic model (previous version DYNHYD4) of Everett Harbor and the lower Snohomish River was updated to DYNHYD5. The DYNHYD5 program was used to simulate segment hydrodynamics (e.g., velocities, volumes, depths, etc.) under changing tidal conditions and steady state river flow. In addition, the WASP5 kinetic sub-program EUTRO5 was linked to DYNHYD5 to simulate water quality variables such as dissolved oxygen and ammonia under steady state loading conditions. The resulting combined model portrays psuedo-dynamic conditions in the estuary (*i.e.*, steady state pollutant loading and river flow with changing tides, resulting in changing velocities, volumes, and depths).

Although the lower Skykomish River was also in the study area, it was not included in the WASP5 model network. Extending the model upstream to include the City of Monroe and Sultan WWTPs was not considered necessary because water quality in the Skykomish River is good and the dischargers are very small, relative to river flow.

Loading Capacity

Identification of the loading capacity is an important step in developing TMDLs. The loading capacity is the amount of pollutant a water body can receive and still meet water quality standards. By definition, a TMDL is the sum of the allocations. An allocation is defined as the portion of a receiving water's loading capacity that is assigned to a particular source. EPA defines the loading capacity as "the greatest amount of loading that a water can receive without violating water quality standards."

The loading capacity is often figured based on critical conditions. Critical conditions were evaluated in the model to estimate the potential effects of current and future waste loading to the estuary. Critical conditions are those possible physical, chemical, and biological characteristics of the receiving water and pollutant loading sources that can increase the adverse effects of a pollutant of concern (e.g., low river flow and increased temperature would increase the effect of a given biochemical oxygen demand load). For the Snohomish River Estuary, the critical period was July through October. The ambient data showed that the probable combined occurrence of high water temperature, low dissolved oxygen, and low river flow would be restricted to these months. Critical condition values for river flow (and tides), boundary and tributary concentrations, effluent discharge characteristics, and model segment characteristics were used to determine the loading capacity and subsequent allocations.

To estimate allowable biochemical oxygen demand (BOD) loading, the water quality standard was assumed to be met if the model predicted dissolved oxygen to be greater than the criteria, or if the human-caused depletion was less than 0.2 mg/L when dissolved oxygen was predicted to be below the criteria. The critical time, when dissolved oxygen concentrations are the lowest, is around high slack tide. The dissolved oxygen profiles for the mainstem and sloughs show that the predicted minimum dissolved oxygen values without loading are below the marine criteria for part of the modeled system. At high tide the marine dissolved oxygen criterion of 6.0 mg/L would apply to all of the segments in the lower river and sloughs. In order to compare the magnitude of the difference between both high and low dissolved oxygen concentrations with and without loading, the difference between the maximum dissolved oxygen concentrations with and without loading sources, and the difference between the minimum dissolved oxygen concentrations with and without loading sources, were calculated as the predicted dissolved oxygen deficits for each model segment.

In order to establish the loading capacity, the model was run with reduced BOD and ammonia loads until all segments below the marine criterion met the 6.0 mg/L criterion at high tide, or caused no more than a 0.2 mg/L deficit. The segment located near the midpoint of Steamboat Slough, at the junction with upper Ebey Slough was found to be the “critical” model segment in the system, or the segment which requires the most load reduction to meet the criteria. The minimum dissolved oxygen concentration in this model segment, with and without BOD loading, was predicted to be 5.79 and 6.01 mg/L, respectively. The allowable 0.2 mg/L deficit was applied to the predicted deficit for this segment such that the final dissolved oxygen with treatment was 5.81 mg/L, which is 0.19 mg/L below the marine criterion. A stricter interpretation of the marine dissolved oxygen criteria would be to allow only a 0.01 mg/L deficit at this location. However, the 0.2 mg/L deficit was allowed because the water quality standards state that natural oxygen levels ***near*** or below 6.0 mg/L may be degraded by up to 0.2 mg/L. Based on these criteria, the total loading capacities were derived to be 14,883 pounds per day of ultimate carbonaceous biochemical oxygen demand (UCBOD) and 2,724 pound per day of ammonia nitrogen.

Load and Waste Load Allocations

Three critical areas were used to set allocation: in the mainstem river by the Everett discharge, in lower Steamboat Slough by the Marysville discharge, and in upper Steamboat Slough. The point source loads were adjusted in the model to meet the water quality criteria in the estuary at these model segments (i.e., human caused dissolved oxygen deficit not to exceed 0.2 mg/L when either the marine or fresh water criteria would apply). Allocations were established based on these model results. Since no reductions are proposed for nonpoint sources, the load allocations (LAs) for nonpoint sources are equal to the human-caused loads minus estimates of background loads (Table 3). Wasteload allocations (WLAs)for point sources are set as allowable effluent limits for ultimate carbonaceous biochemical oxygen demand (UCBOD) and ammonia nitrogen (Table 4). No allocation has been made for future growth (e.g., new discharges, or increased WWTP capacity) and the downstream or seaward loading is not included.

Table 3. Load Allocations for Nonpoint Sources

Loading Source	**Ammonia-N (lbs/day)**		**UCBOD (lbs/day)**	
	Background	**LA**	**Background**	**LA**
Upstream Boundary (Snohomish RM 20.5)	283	0	6798	0
French Creek	0.4	18.8	105	419
Pilchuck River	1.5	7.52	361	0
Wood Creek (Marshland)	0.4	19.8	105	367
Deadwater Slough	0.1	22.1	35.6	285.4
Swan Trail Slough	0.04	33.36	10.4	131.6
Quilceda Creek	0.12	0.44	29.1	36.5

Table 4. Wasteload Allocations for Point Sources

Loading Source	**Ammonia-N**			**UCBOD**		
	Existing Load (lbs/day)	WLA (lbs/day)	Reduction Needed (%)	Existing Load (lbs/day)	WLA (lbs/day)	Reduction Needed (%)
Tulalip Landfill	8.14	8.14	0%	0	0	0%
Snohomish WWTP	99	99	0%	186	186	0%
Lake Stevens WWTP	396	283	29%	347	347	0%
Marysville WWTP	403	403	0%	2891	1344	54%
Everett WWTP North	1904	876	54%	3336	3336	0%
Everett WWTP South	1041	667	36%	988	988	0%

Margin of Safety

The statute requires that a margin of safety be identified to account for uncertainty when establishing a TMDL. The margin of safety can be explicit in the form of an allocation, or implicit in the use of conservative assumptions in the analysis. Several assumptions and critical conditions used in the modeling analysis of the Snohomish River Estuary TMDL provide an inherent margin of safety as required by the statute. These conservative assumptions and critical conditions are listed below:

- Critical river flows for the period were estimated as the 7-day average low flow with a recurrence interval of once every 20 years (7Q20). Since these are applied to the seasonal period from July to October, the flows are equivalent to the annual 7Q10 specified in the water quality standards (Ecology, 1991).

- Although no discharge was observed from the "pumped" tributaries (*i.e.*, French Creek, the Marshland, Deadwater Slough, and Swan Trail Slough) during the August 1993 and 1996 surveys, an estimated discharge was included for the critical condition scenario.

- For most water quality variables, critical conditions for the upstream and downstream were based on the 90th percentile (or 10th for chlorophyll) of data from Ecology's Ambient Monitoring Program.

- The critical condition flows for the WWTP discharges were based on the 95^{th} percentile of effluent concentrations measured between August and September 1998 (see Technical Addendum 2 in Appendix C). All other effluent characteristics were set to the highest value measured during the August 1993 Class II inspections and the August 1996 effluent sampling survey.

Summary Implementation Strategy

The success of the TMDL relies upon the eventual diversion of most of the City of Everett discharge to deepwater in Port Gardner and upgrades in the level of treatment at the City of Marysville and the Lake Stevens Sewer District. Effluent limits and compliance schedules in the NPDES permits for the municipalities should result in the achievement of the requisite water quality standards.

Overview

The municipal entities with WWTP discharges into the Lower Snohomish River Estuary have been actively involved in the development process, forming the Snohomish River Water Quality Association following the publication of the Phase II Report (Cusimano, 1997). Designation of Chinook salmon in the Snohomish River system as threatened specie has created a heightened awareness of possible corrective and mitigative measures necessary to improve water quality. Continuing engineering evaluation of each facility is on-going.

Implementation Plan Development and Activities

The City of Everett and the Kimberly Clark Tissue Company have entered into a contractual agreement governing the joint use of a deepwater outfall into Port Gardner Bay. This will allow the eventual diversion of up to 32 million gallons per day of treated effluent from the Everett Water Pollution Control Facility. The outfall facility is currently scheduled for completion in June 2004. The Lake Stevens Sewer District has already retained consulting services to design interim WWTP improvements to meet the WLA requirements by 2002. The City of Marysville has recently completed an update of its Comprehensive Plan and is now beginning to evaluate phased improvements to their WWTP facility. A compliance schedule requiring upgraded discharges by 2003 has been incorporated into the draft NPDES permits. The City of Snohomish has recently completed an upgrade of their facility and should be able to comply with TMDL requirements. Real time monitoring of the USGS gauging station at Monroe via the internet should allow the facilities to take interim storage measures during critical tide sequences should the Snohomish River begin to approach the critical flows until treatment upgrades are completed.

Monitoring Strategy

Because completion of the upgrades or diversion will not be completed until the summer of 2004 it may be possible to place one of the rotating ambient water quality monitoring stations in the basin to evaluate compliance with water quality standards. This is in keeping with the Department's basin approach and will correspond to the Scoping year for the Snohomish Basin.

Interim compliance targets and WWTP effluents will be monitored through the monthly submittal of Discharge Monitoring Reports (DMRs). The City of Everett has an on-going receiving water sampling program in the vicinity of their two outfalls. This could be expanded to include measurements of the dissolved oxygen during the critical tides of the low flow period.

Funding Sources

Funding to comply with the requirements of the TMDL are available from the Centennial Clean Water Fund (CCWF), the State Revolving Fund (SRF), and local financing which can be either general obligation bonds or revenue bonds.

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Figures

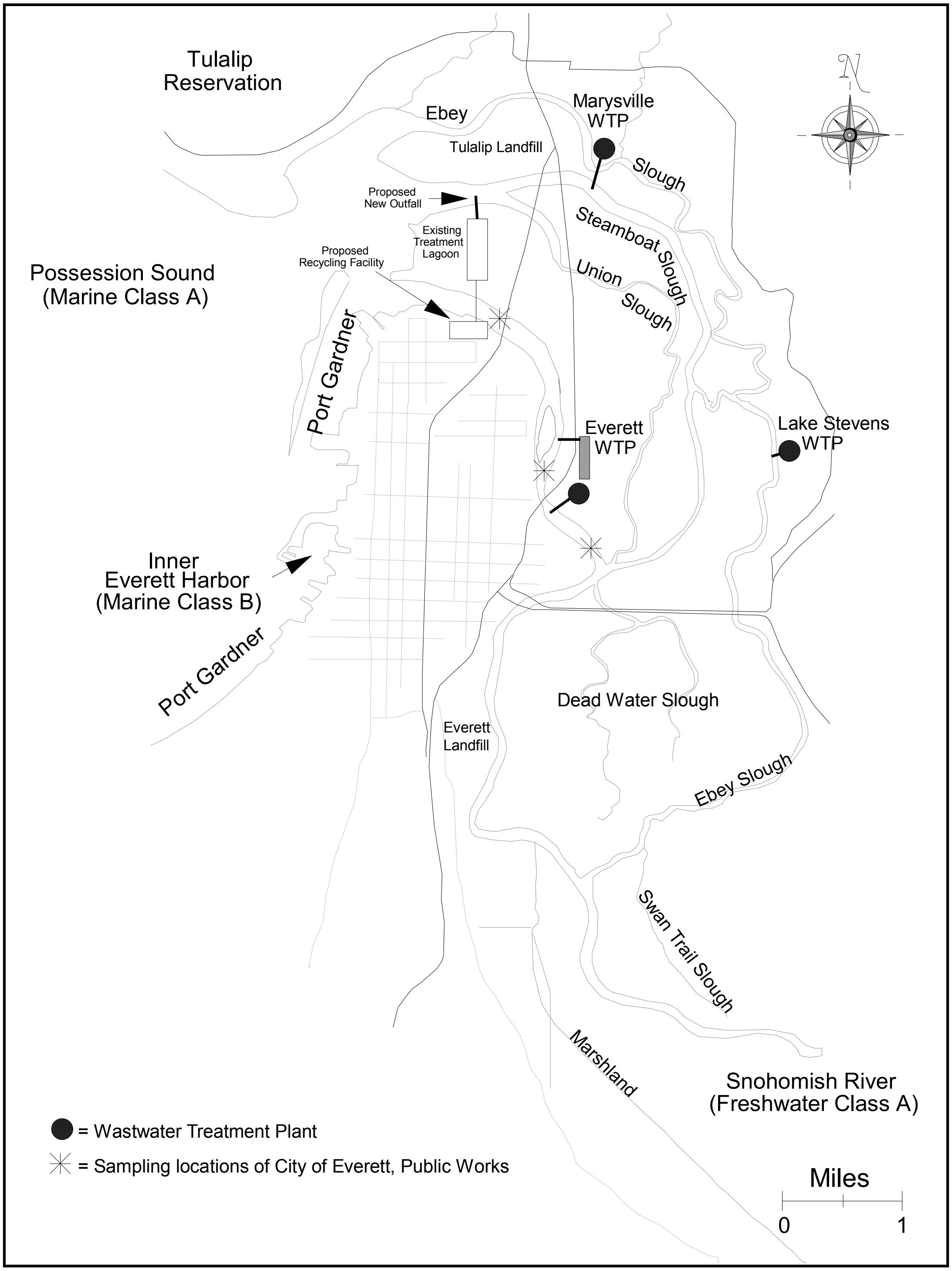

Figure 1. Snohomish River Estuary Map

Appendix A

<u>Public Participation Materials</u>

Appendix B

Summary of Public Process
and
<u>Responses to Comments Received</u>

Appendix C

Technical Reports

Bound Separately as Ecology Publication Number 95-338 - "Snohomish River Estuary Dry Season TMDL Study - Phase I - Water Quality Model Calibration."

Bound Separately as Ecology Publication Number 97-325 - "Snohomish River Estuary Dry Season TMDL Study - Phase II - Water Quality Model Confirmation and Pollutant Loading Capacity Recommendations."

Snohomish River Estuary Dry Season TMDL Study - Phase II - Technical Addendum Number 1

Snohomish River Estuary Dry Season TMDL Study - Phase II - Technical Addendum Number 2