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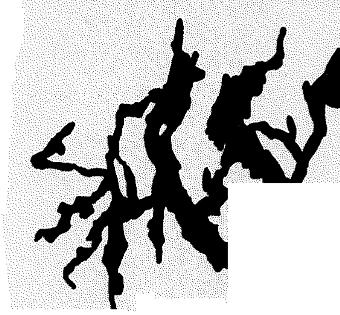
Washington State
Department of Ecology

Southern Puget Sound
Water Quality Assessment
Study

Part I Final Report

Discharge Zone Classification System

Southern Puget Sound



URS Company

WASHINGTON DEPARTMENT OF ECOLOGY

SOUTHERN PUGET SOUND WATER QUALITY ASSESSMENT STUDY

PART I FINAL REPORT

DISCHARGE ZONE CLASSIFICATION SYSTEM

FOR

SOUTHERN PUGET SOUND

July, 1985

URS CORPORATION

Fourth and Vine Building
Seattle, Washington 98121

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PREFACE

The Discharge Zone Classification System presented here was developed in response to community and Washington Department of Ecology needs. A mechanism was needed to help evaluate marine waters in Southern Puget Sound in terms of their acceptability as secondary wastewater discharge sites. The intent of this work is to provide a screening tool by which future National Pollutant Discharge Elimination System (NPDES) applicants, existing dischargers considering significant expansion, and regulatory agencies can evaluate possible planning and design options.

This document identifies marine areas where new or expanded discharges are unacceptable based on existing knowledge; e.g., water quality standards are currently not met, and impairment of existing uses may occur. It also provides a means for individual NPDES applicants to determine whether adequate initial dilution can be achieved at a given site. This method uses their projected wastewater flows, effluent quality, and diffuser design. Examples provided in this report necessarily make assumptions about these three variables. Alterations of any of these assumptions will affect the outcome of individual site-specific evaluations.

The Discharge Zone Classification System is not intended to replace site-specific evaluations required of NPDES applicants. Site-specific work is still needed to detail localized uses, water quality, dilution, and flushing constraints that may exist.

Flushing constraints within Southern Puget Sound are not detailed in this document. An initial data evaluation determined that development of basin-wide flushing estimates would not be possible with available information. With time, additional flushing data will be collected. However, until adequate data become available, individual applicants will have to address flushing during site-specific evaluations.

The first chapter of the report provides a discussion of the Discharge Zone Classification System developed in this study. Subsequent chapters document the approaches, methods, and results of the principal considerations used in developing the Discharge Zone Classification System: existing water quality, uses, and dilution.

This report is Part I of the Southern Puget Sound Water Quality Assessment Study prepared by URS Corporation under contract to the Washington State Department of Ecology. Evans-Hamilton, Inc., provided the historical water property data in the South Sound. Joy Michaud and Joe Joy of the WDOE Water Quality Investigation Section of the Office of Water Quality contributed the Existing Water Quality Evaluation and Dilution Requirements Analysis, respectively.

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DISCHARGE ZONE CLASSIFICATION SYSTEM

Introduction

Southern Puget Sound, consisting of the contiguous waters south of the Tacoma Narrows, is a resource of great importance to the State of Washington. In the past as today, the maintenance of excellent water quality and the preservation of uses have been subjects of much concern. Urban growth and development have placed great pressures on the water quality and the uses supported by the Southern Puget Sound system. As a result, future water quality-related planning efforts must carefully consider the protection of the Southern Puget Sound's water quality.

In response to this need and its mandated authorities, the Washington Department of Ecology (WDOE) in conjunction with URS has developed this Discharge Zone Classification System to identify areas in Southern Puget Sound where new or significantly expanded secondary wastewater discharges should be avoided to prevent degradation of existing water quality and harm to existing uses. This Discharge Zone Classification System is intended to be a screening tool for use by planners in siting future secondary wastewater discharges. Through using the Discharge Zone Classification map, planners can avoid proposing new discharge facilities in areas where historical water quality problems would be aggravated and where existing uses might be eliminated. In addition, the system provides guidance to assist NPDES applicants to determine whether adequate initial dilution can be achieved at a given site.

It should be noted that this Discharge Zone Classification System is intended to be a "first-cut" screening tool, and is not intended to replace the need to conduct site-specific studies to define specific impacts to water quality, uses, and other elements of the environment as required under the National Environmental Policy Act (NEPA), State Environmental Policy Act (SEPA), and other regulatory requirements. There is no intention to imply that secondary wastewater discharges in areas meeting the various criteria used in this study would not have adverse impacts on various environmental elements. The extent of impact would need to be evaluated in site-specific studies based on actual project specifications.

Use of this system does not eliminate the need to coordinate the site planning process with local jurisdictions, including Thurston, Pierce and Mason Counties and the Nisqually Indian and Squaxin Island Tribes, and to comply with relevant restrictions and conditions of these jurisdictions.

The Discharge Zone Classification System consists of two parts: (1) a Discharge Zone Classification map, and (2) dilution guidelines. The Discharge Zone Classification map represents a "first cut" screening tool to identify areas where existing water quality does not limit consideration of new or expanded secondary wastewater discharges, and where existing uses would not be eliminated by such discharges. The dilution guidelines provide guidance to assist a user of the system to determine if a particular site within the remaining area can meet the dilution requirement.

Discharge Zone Classification Map

In the Discharge Zone Classification map developed in this study, the waters of Southern Puget Sound have been classified into two categories: (1) areas presently considered not suitable for future secondary* wastewater discharges, and (2) areas where future secondary wastewater discharges will be considered.

Placement of areas into these categories has involved evaluations related to two principal considerations:

- historical water quality conditions
- existing uses

It should be noted that the locations of existing discharges have not been considered in developing this classification.

Screening criteria were developed for each of the principal considerations listed above. If an area failed the screening criterion for one or both of these considerations, the area was placed in the "not presently considered suitable for discharge" category. If it met these criteria, it was placed in the "will be considered" category.

The screening criteria used in developing the Discharge Zone Classification map are shown in Table 1. These were formulated on the basis of the present state of knowledge concerned with water quality management and available data. The technical discussions in this report provide rationale for these criteria.

Table 1. Screening criteria used in developing the discharge zone classification map.

Consideration	Screening criteria**
Water quality conditions	Areas characterized by frequent water quality violations
Existing uses	Areas where new discharge would preclude existing uses.

* Secondary treatment is defined in two ways: (1) as attaining an average effluent quality of 30 mg/l of five-day biochemical oxygen demand (BOD_5) and suspended solids (SS), (2) as equivalent to secondary treatment by trickling filter or waste stabilization pond as a minimum level of effluent quality not to exceed 45 mg/l for BOD_5 and SS.

** These areas not presently considered suitable for new secondary wastewater discharges. Other areas will be considered based on existing water quality and use considerations.

Figure 1 presents the Discharge Zone Classification map. This map shows areas (shaded) where applications for new or significantly expanded secondary wastewater discharges will be considered based on existing water quality and use considerations.

This map was prepared through integrating maps prepared for existing water quality conditions and uses. Detailed discussion in subsequent sections of this report describe the mapping processes for these individual considerations.

As can be seen in Figure 1, significant areas of Southern Puget Sound are presently considered not suitable for new secondary wastewater discharges. The basis for excluding such areas is one or more of the following:

- existing water quality problems
- potential elimination of existing uses

For example, Figure 1 indicates that the majority of Budd Inlet is not presently considered suitable. This evaluation is based on existing water quality problems (fecal coliform and dissolved oxygen violations); and the failure of use criteria (most of Budd Inlet is currently decertified for commercial shellfish operations by the Washington Department of Social and Health Services).

Dilution Guidelines

The Discharge Zone Classification System requires that, to be considered for new or significantly expanded secondary wastewater discharges, a site must meet the 100:1 initial dilution requirement set by the WDOE. Because the level of initial dilution that can be achieved is dependent upon the background concentrations in the receiving water, the prevailing current velocity and the selected diffuser design configuration, a generalized map cannot be developed showing areas of Southern Puget Sound where the dilution requirement can be met. Instead, the Discharge Zone Classification System presents a procedure to assist the user to determine whether adequate initial dilution can be achieved at a given site.

Based on a given diffuser design configuration, if site specific current information is not available the EPA "PLUME" model could be used to determine the discharge depth at which the required dilution can be attained. If site specific current information is available another accepted model could be used. It should be noted, however, that only the tenth percentile lowest velocities from the site specific current measurements should be used. As a general rule, diffuser design parameters, such as diffuser length, port spacing and diameter, can be scaled in proportion to the average design wastewater flows. The input to the model could be a set of generalized diffuser design parameters and the selected historical density profiles. A dilution map could be constructed from the model results to show the waters of Southern Puget Sound where required dilution can be

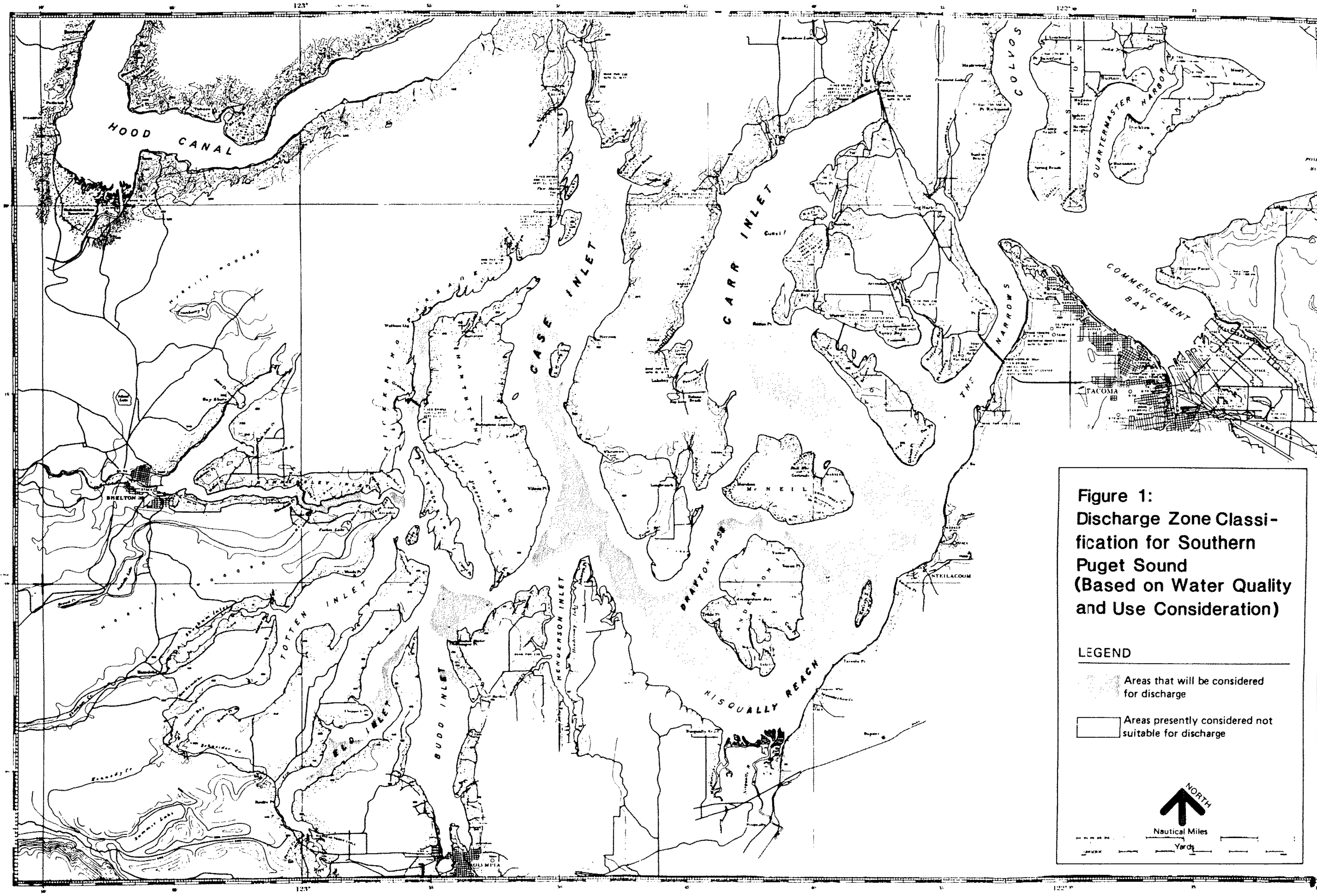


Figure 1: Discharge Zone Classification for Southern Puget Sound (Based on Water Quality and Use Consideration)

attained. An integrated map could be constructed by superimposing the dilution map on the Discharge Zone Classification map (Figure 1). For the purpose of demonstrating the evaluation process for the dilution consideration, sample dilution map and integrated Discharge Zone Classification map for the waters of the Southern Puget Sound were constructed in the subsequent "Dilution Guidelines" section of this report. Individual NPDES applicant may use this integrated map to screen the suitable areas for new or expanded wastewater discharges in relation to water quality, use and dilution considerations. In the case of specific diffuser design, individual NPDES applicant could use a plume model which is well-accepted by the modeling community to evaluate whether adequate dilution can be achieved at a given site. Site-specific studies should be conducted to determine the density and current data. It would be strongly recommended that preferred sites are at locations where stronger currents prevail.

EXISTING WATER QUALITY EVALUATION

This section describes the approach and results of the evaluation of existing water quality of Southern Puget Sound in relation to the consideration of new or significantly expanded secondary wastewater discharges. The results of this evaluation were integrated with those of the use evaluation in developing the Discharge Zone Classification map (Figure 1).

Class AA, A, and B waters in Southern Puget Sound were evaluated for consideration as future effluent discharge sites. Areas were classified as "not presently considered suitable" for future discharge according to the frequency of violations of their respective dissolved oxygen (D.O.), pH, and fecal coliform standards. These standards are shown in Table 2.

Table 2. WDOE classifications of waters and corresponding water quality criteria (WAC 173-201)

	Criteria		
Water Classification	Dissolved Oxygen (mg/l)	pH (S.U.)	Fecal Coliform (Orgs/100ml)
AA	7	7.0 - 8.5	14
A	6	7.0 - 8.5	14
B	5	7.0 - 8.5	100

Historical and current data (1973 to present) from the Department of Social and Health Services (DSHS) and the Washington Department of Ecology (WDOE) were used to make the evaluations (see Figure 2). Areas experiencing frequent or regular water quality standard violations are delineated in Figure 3, along with the DSHS and WDOE water quality monitoring stations. These areas are presently considered not suitable for future wastewater discharge sites.

The areas not presently considered suitable for future discharge include: the lower portion of Budd Inlet, all of Oakland Bay (including the westerly portion of Hammersley Inlet), the south end of Eld Inlet, Henderson Inlet, and the upper portion of both Case and Carr Inlets (Figure 3). The specific rationale used to delineate each zone is discussed below.

Budd Inlet

According to 1981 DSHS data, the frequency and magnitude of fecal coliform violations are greatest at stations 33, 34, and 45 in the lower end of this inlet. At stations 35 and 36, the conditions are better, although the standard is still being violated about 30 percent of the time. WDOE data also indicate that there are frequent fecal coliform and D.O. violations. The WDOE data suggest that the fecal coliform levels may be declining since

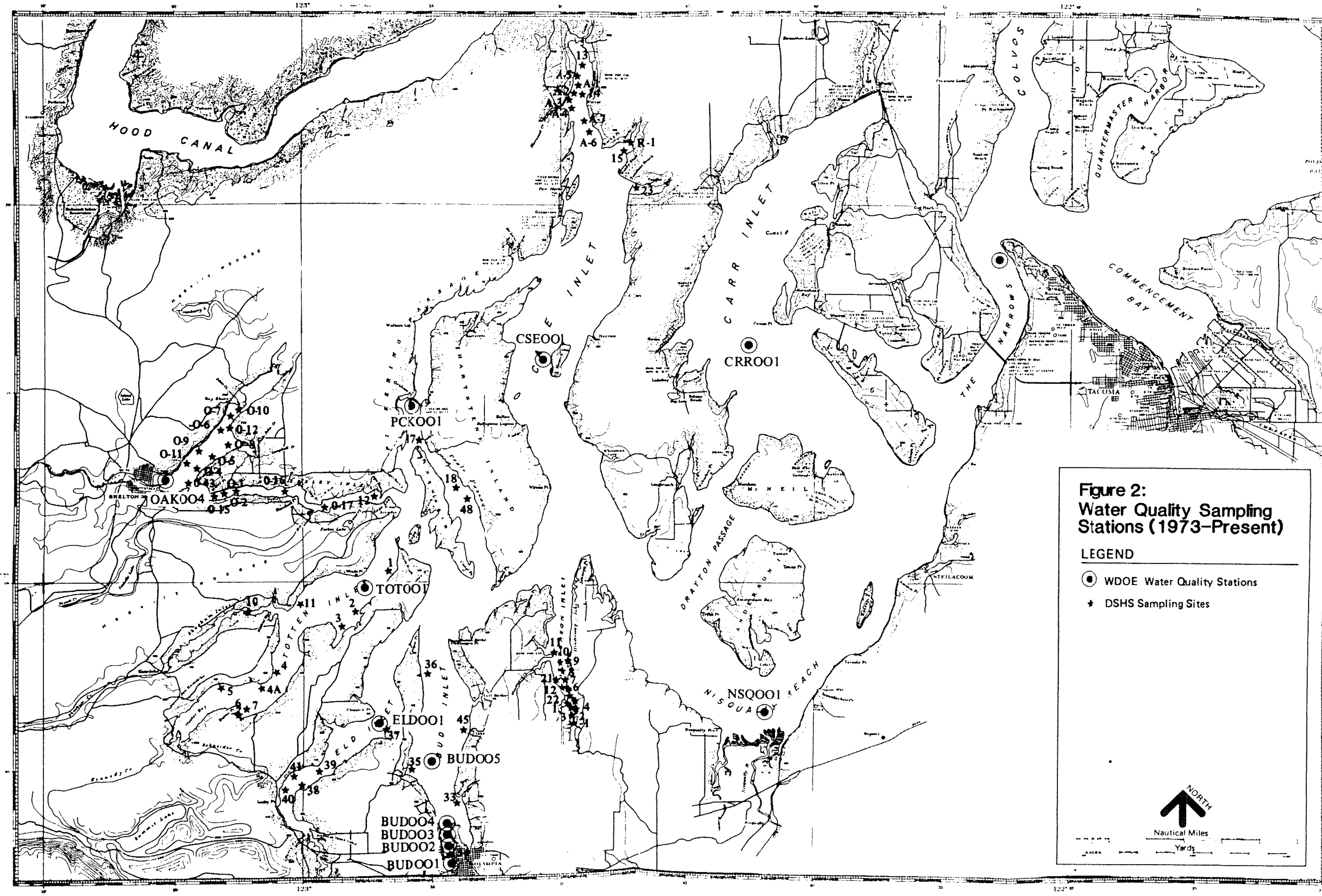


Figure 2:
Water Quality Sampling Stations (1973–Present)

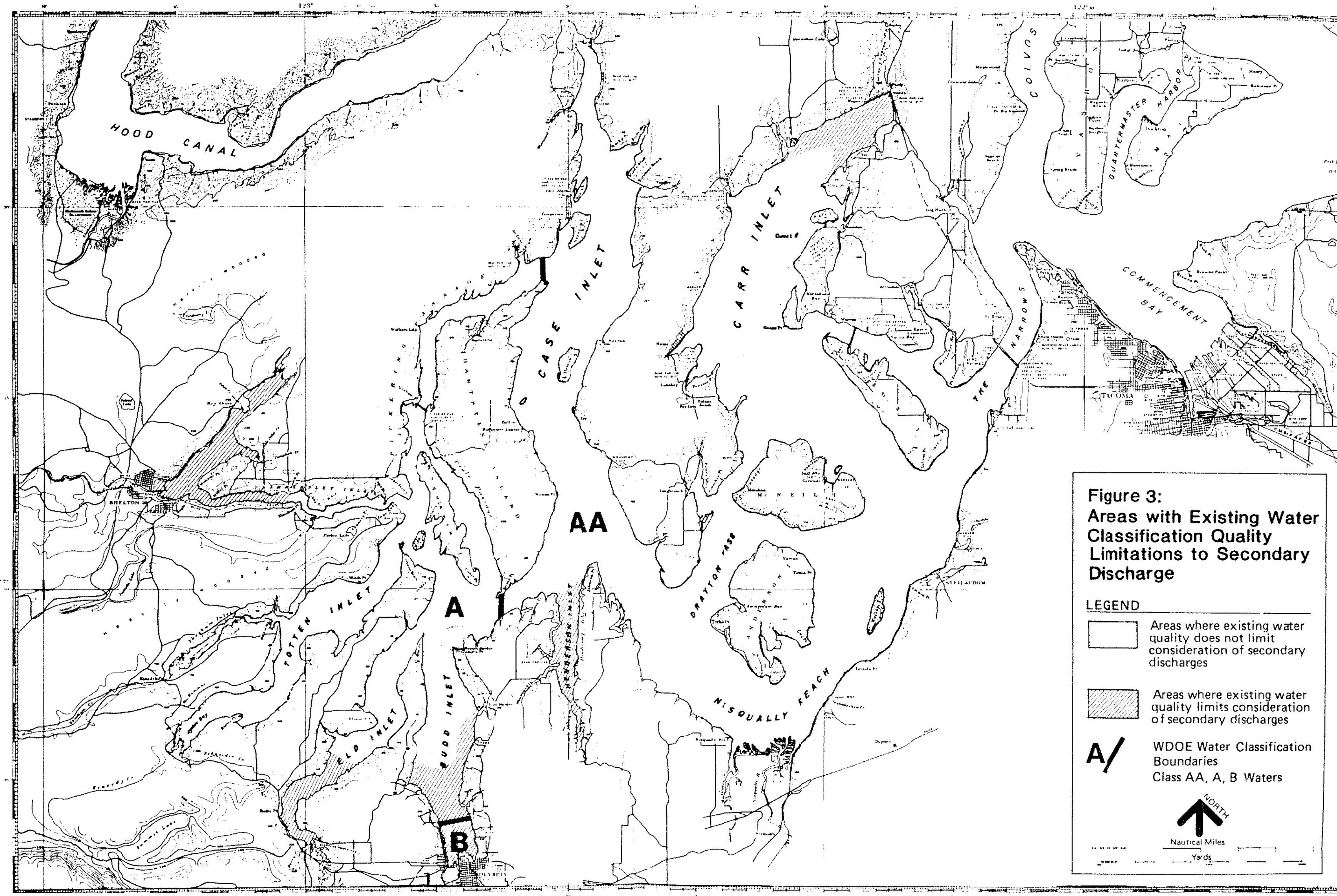


Figure 3: Areas with Existing Water Classification Quality Limitations to Secondary Discharge

there have been no fecal coliform violations for the last 30 months of data (through May 21, 1984). Dissolved oxygen, however, remains a problem in the lower end of the inlet. At station BUD005, D.O. appears to have shown recent improvements.

Oakland Bay

DSHS and WDOE data both show that there are frequent fecal coliform violations in this area, with the exception of DSHS stations 12, 16, and 17. Low D.O. levels have also been a problem in the past at WDOE station OAK004, although there have been no violations since November 1981.

Eld Inlet

The data sources used in the water quality analyses do not indicate that routine water quality violations are occurring in Eld Inlet. Recent preliminary data from an extensive bacteriological study of Eld Inlet (Taylor, 1983) indicate a fecal coliform problem exists in the lower inlet. This area has, therefore, been classified as "not presently considered suitable" for future secondary wastewater discharges.

Henderson Inlet

DSHS water quality stations in Henderson Inlet (see Figure 2) were sampled in May of 1981, August of 1982, and March of 1983. Only Sites 1 and 7 violated the fecal coliform standards during the May 1981 sampling trip. During the August 1982 trip, the southern and eastern sites were in violation. In March 1983, all sites were in violation. Whether this indicates a seasonal trend in water quality, or steadily worsening conditions, is difficult to determine. In either case, this inlet is considered to be "not presently considered suitable" for additional discharge sites.

Case Inlet

DSHS data indicate that there are many fecal coliform violations at the nearshore stations (Figure 2) during the winter (January 1981). In an extensive survey performed in July in Rocky Bay, over 30 percent of the samples taken violated the fecal coliform standard. Therefore, these areas are classified as "not presently considered suitable" for further discharge sites.

Carr Inlet

Although DSHS has no routine sampling stations in Carr Inlet, intensive fecal coliform surveys have been performed in the area. These surveys include eleven stations sampled in Minter Bay in June 1982, and a large survey completed in January 1982 that included forty-one stations throughout Henderson Bay. Each of the surveys indicated that the fecal coliform levels are above the Class AA standards.

Two of the major shellfish-growing sites, Burley Lagoon and Minter Bay, in the upper part of Carr Inlet have already been decertified due to fecal coliform contamination. The current plan is to restore these waters and eventually recertify the shellfish beds (Determan, et al., 1984). Restoration will include stringent control of discharges to the inlet, thus this area is "not presently considered suitable" for future discharge sites.

EVALUATION OF USES

This section describes the approach and results of the evaluation of existing uses of Southern Puget Sound in relation to the consideration of new or significantly expanded secondary wastewater discharges. The results of this evaluation were integrated with those of the existing water quality evaluation in developing the Discharge Zone Classification map (Figure 1).

Introduction

The concept of "beneficial uses" of water stems in part from federal clean water and pollution control legislation aimed at keeping the nation's waters "fishable" and "swimmable".[1] Washington State water quality standards are related to the beneficial uses of the waters of the state such that "existing beneficial uses shall be maintained and protected and no further degradation which would interfere with or become injurious to existing beneficial uses will be allowed" (WAC 173-201).

The Washington Water Resources Management Program (WAC 173-500-050) describes beneficial uses as "...uses of water for domestic, stock watering, industrial, commercial, agricultural, irrigation, hydroelectric power production, mining, fish and wildlife maintenance and enhancement, recreation, and thermal power production purposes, and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the state." For this study, several of these uses are especially relevant, including fish and wildlife maintenance and enhancement, recreation, and commercial uses of Southern Puget Sound. Others, such as hydroelectric power production, mining, and so on, are not relevant to this study.

Approach

A considerable data base describing uses in Southern Puget Sound exists in published reports and in unpublished information known to resource agency personnel. (See Appendix A for lists of documents and agencies consulted.) Various documents have been reviewed and agency personnel have been contacted in order to identify the uses of Southern Puget Sound and to identify policies or criteria related to conflicting uses of Southern Puget Sound waters.

In this study, considerations have emphasized uses that may conflict in a mutually exclusive way with wastewater discharge siting rather than on uses that can co-exist with such discharges (although some level of impact to the use may be anticipated). As such, the use portion of this study has not attempted to provide an exhaustive review or compilation of Southern Puget Sound uses. It has instead focused on those uses that may be

[1] 1972 Federal Water Pollution Control Act Amendment, Clean Water Act of 1977.

most influential in wastewater discharge siting. Effects on uses in an area that would result from a secondary wastewater discharge vary from no impact to elimination of the use. Within this range of effects, a discharge could have some degree of adverse impact that would need to be evaluated on a project-specific basis taking into account design and local environmental parameters. Exclusion of a use from an area might be outright, or it might occur only under some conditions. For example, within at least one-half mile of a wastewater discharge, DSHS typically does not allow commercial shellfish harvest.

With respect to water contact activities or personal use shellfishing, closure of a shoreline would probably occur only in the event that storm bypasses or equipment failure resulted in a significant discharge of untreated wastewater making swimming or shellfish consumption unsafe. Generally, such events would be temporary.

In screening the effects of secondary wastewater discharges on uses, four categories of effects were used. These categories include:

1. Minor or no effect on the use.

2. Localized adverse effects on the use. The degree of the effect needs to be evaluated in project-specific studies.

3. Localized adverse effects with the potential for elimination of the use under "worst-case" conditions anticipated to occur infrequently.

4. Elimination of a use due to regulatory policies or adverse effects.

In developing the Discharge Zone Classification map, category 3 and 4 effects were mapped. Table 3 shows the category of effect for each use considered and summarizes the rationale for how each use was treated in developing the Discharge Zone Classification. A more detailed discussion of this rationale is presented in the accompanying text.

A series of maps has been developed showing the locations of uses that are important in initial considerations of wastewater discharge siting. These maps have been integrated with the other elements of the study in developing the Discharge Zone Classification map.

<u>Criteria and Evaluation</u>

A strategy of the use portion of this study has been to evaluate which uses conflict in a mutually-exclusive way with wastewater discharge siting. For the purposes of delineating areas where additional wastewater discharges should not be considered, the question was asked whether or not the existing use may be precluded by locating a wastewater discharge at a particular

Table 3

Screening Evaluation of Southern Puget Sound Uses
Used to Develop the Discharge Zone Classification Map

Use	Is the use WQ Dependent?	Category of Effect on Use	Used to Develop Discharge Zones?	Comments
Commercial Shellfishing	Yes	4	Yes	The Washington DSHS typically does not permit commercial shellfish harvest within at least a one-half mile distance of a wastewater discharge. The actual distance closed depends on site-specific factors.
Personal Use Shellfishing	Yes	3	Yes	Although under normal operations coliform bacteria levels in effluent are very low, under conditions of STP failure or overflows, the coliform levels could increase, such that surrounding beaches could be closed by the local Health Department for personal use shellfishing. This condition would likely be temporary.
Water Contact Recreation (swimming, wading, scuba diving, water skiing)	Yes	3	Yes	Overflows of untreated wastewater resulting from storm bypass or system failure could result in closure of beaches by local health authorities. These events would be infrequent, and closures temporary. Locations of public parks and underwater diving areas, including artificial reefs used for fishing and scuba diving, are in the "not presently considered suitable" category.

Table 3 (Continued)

Use	Is the use WQ Dependent?	Category of Effect on Use	Used to Develop Discharge Zones?	Comments
Parks	Yes	4	Yes	Shoreline activities associated with parks include swimming, wading, shellfish gathering, and diving. Effects on these uses are presented under water contact recreation and personal use shellfishing.
Floating Aquaculture	Yes	4	Yes	Existing locations of floating aquaculture have been identified. Areas with the potential for floating aquaculture (mussels, nori) are not well known. Thus, only existing project locations have been placed in the "not presently considered suitable" category. A one-half mile zone surrounding them has been applied as for commercial shellfishing.
Fish				
- Salmonids (spawning, rearing, migration)	Yes	2	No	Assumes that achievement of water quality standards will protect marine life. Some temporary construction disturbance of nearshore habitat would be likely, but timing of construction to avoid principal migration periods would reduce impacts.
- Other Fish (spawning, rearing)	Yes	4	Yes	Pacific herring spawning habitat areas eliminated in areas of construction across beach spawning areas. Assumes that achievement of water quality standards will protect marine life.

Table 3 (Continued)

Use	Is the use WQ Dependent?	Category of Effect on Use	Used to Develop Discharge Zones?	Comments
Wildlife	Yes	2	Yes	Assuming that achievement of water quality standards protects wildlife, wildlife would not be eliminated from areas. As with fish, continued efforts to evaluate effects on wildlife from trace materials on wildlife area are encouraged. Critical areas such as the Nisqually Delta area and Gertrude Island are "not presently considered suitable" because of their importance to wildlife.
Sportfishing	Yes	2	No	Sportfishing for salmon and groundfish is a widespread activity in Southern Puget Sound. A secondary wastewater discharge is unlikely to significantly alter fishing patterns. Continued efforts to evaluate trace material effects on organisms and food webs in the vicinity of discharges (and away from them) are encouraged.
Commercial Fishing	Yes	2	No	Commercial fishing activities would not be eliminated in an area because of a new secondary discharge as long as water quality standards are met. Some interference with fishing gear (gill nets, trawl gear) could occur, depending on the depth of the outfall and its design.

Table 3 (Continued)

Use	Is the use WQ Dependent?	Category of Effect on Use	Used to Develop Discharge Zones?	Comments
Dredging Projects	No	4	Yes	An outfall structure is physically incompatible with dredging. Therefore areas that require frequent dredging are not considered acceptable sites.
Dredge Disposal	No	4	Yes	Open water disposal of dredge spoils would interfere with diffuser function. Therefore, open water disposal areas are not considered acceptable sites.
Aesthetics	Yes	1	No	A properly designed and sited secondary wastewater discharge would have little effect on aesthetic values of an area.
Boating (power boating, sailing, canoeing/row boating/ kayaking)	Yes	1	No	Boating is a widespread activity in Southern Puget Sound. Although it is to a degree water-quality dependent, it is unlikely that a secondary wastewater discharge would eliminate boating from any particular areas.
Commercial Navigation	No	1	No	Construction-related impacts of an outfall would be temporary. No long-term effects on commercial navigation would occur.

location. If the use and siting at that location were considered to conflict in a mutually-exclusive way at least under some circumstances, that location was classified in the "not presently considered suitable" category. If, based on the achievement of water quality standards compliance or based on other considerations, no clear incompatibility was identified, then such an area was maintained in the "will be considered" category.

It is not intended here to imply that uses in locations in the "will be considered" category may not be affected adversely to some extent by a nearby discharge location. The extent of degradation or effect would need to be evaluated in site-specific studies based on actual project specifications in order to comply with state and federal environmental policy acts (SEPA and NEPA, respectively).

Assumptions

This study has assumed that current water quality standards effectively operate to safeguard the health, viability, and reproductive success of organisms. As a result, if a discharge meets these water quality standards, then impacts to organisms should be negligible outside the immediate area of effect. It should be noted that this study has not considered the effects of minute quantities of toxic materials (metals, pesticides and other organic contaminants) that may occur in wastewater discharge streams. The effects of such materials on fish and wildlife and other uses are subtle; the degree of conflict needs to be evaluated on a site-specific basis during the SEPA and/or NEPA processes for particular locations.

Conflicting Uses

The focus of this part of the study has been to identify those uses that would be precluded near a wastewater discharge. Locations of such uses have been placed in a "not presently considered suitable" category based on the policy stated in the Washington State Water Quality Standards (WAC 173-201) that existing uses should be maintained and protected. The following discussion provides additional discussion related to uses occurring in Southern Puget Sound and presented in Table 3, and considers effects of siting a new wastewater discharge at or near the location of the use. Figures have been provided that indicate the locations of the uses that could be eliminated by a new wastewater discharge and that should be avoided in planning for future wastewater discharge points.

Commercial Shellfish - Locating a wastewater discharge in or adjacent to commercial shellfish resources has important implications for harvest. Filter-feeding clams and oysters can potentially concentrate bacteria and viruses present in the water column and pass these on to human consumers creating a serious risk of disease. The Department of Social and Health Services is responsible for certifying that any area used for shellfish production is uncontaminated such that shellfish grown there are safe for human consumption. Until an area is surveyed and approved (certified), it is considered closed for commercial shellfish production. Areas may be decertified if they have once been certified and subsequently found to be contaminated. Some areas may be considered uncertifiable if they have not been previously used for commercial shellfish production, but where future certification would not be possible because of numerous sources of pollution. Others areas may be conditionally decertified or approved. For example, harvest may be prohibited in some areas for two weeks following some upper limit of rainfall occurring in a period of time (Saunders, 1984).

Typically areas within at least one-half mile of the discharge point are decertified by the Department of Social and Health Services (Jack Lilja, DSHS, personal communication, 1984). The actual extent of closed area depends on site specific characteristics including water quality and the risk of contamination from the failure of treatment systems or other proximate uncontrolled sources (Saunders, 1984). Thus, in order to avoid the loss of commercial shellfish beds (oysters, clams, mussels), wastewater discharge siting should be avoided within at least one-half mile of commercial and potentially commercial shellfish beds. Site-specific studies are necessary to determine the actually needed area of closure in a particular case. Figure 4 shows the Southern Puget Sound locations of existing commercial shellfish harvest and of potential harvest (Saunders, 1984; Mary Lou Mills, WDF, personal communication, 1984; Eric Hurlburt, WDF, personal communication, 1984). These areas and a one-half mile area surrounding them have been placed in the "not presently considered suitable" category.

This figure also indicates several areas that are currently uncertifiable or decertified by DSHS, or that are threatened. It is recommended that no additional wastewater discharges be made to these areas. Accordingly these areas have been placed in the "not presently considered suitable" category.

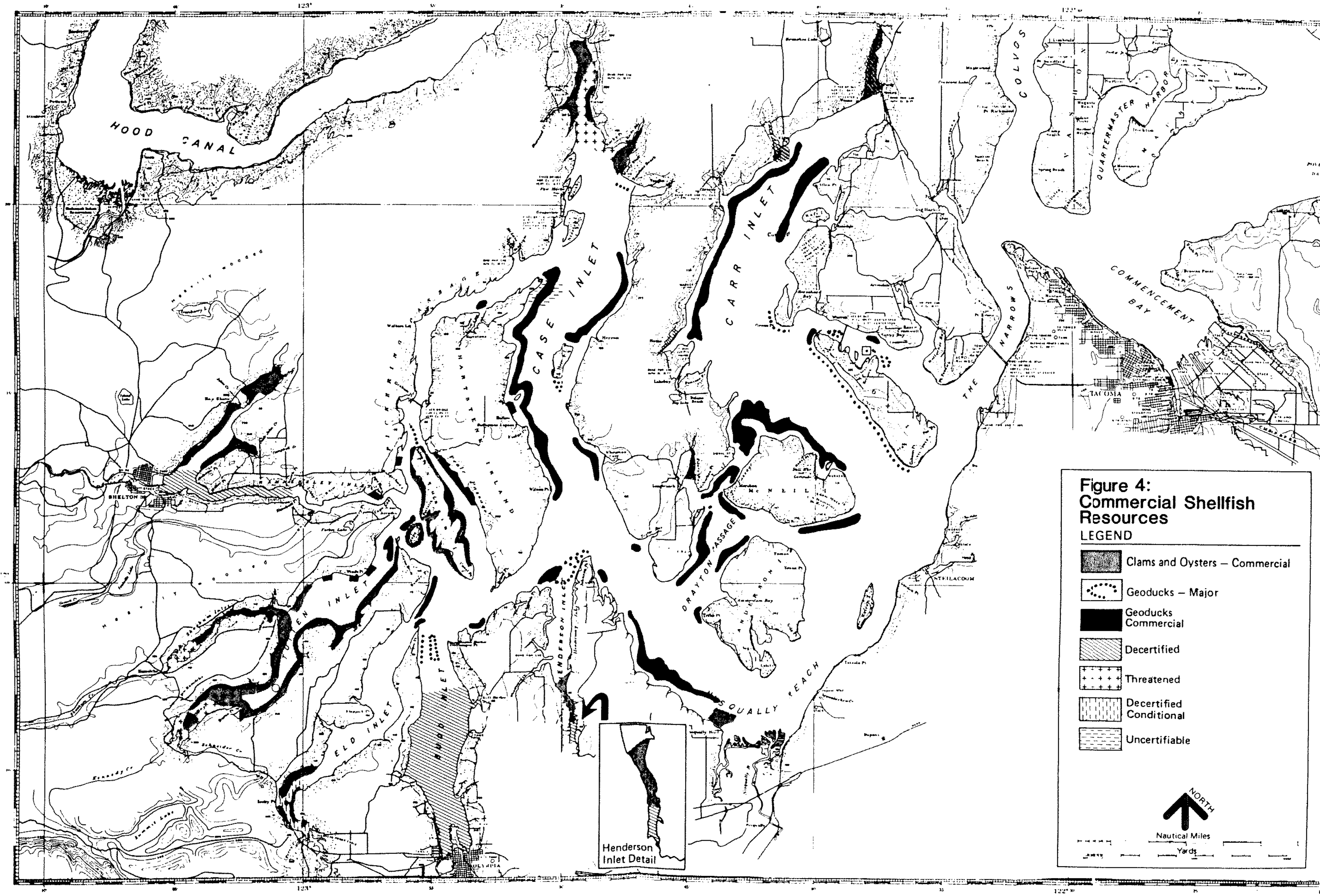
The areas shown in the map and causes for decertification according to Saunders (1984) include:

- Budd Inlet - Much of Budd Inlet has been decertified for commercial shellfish culture and harvest since the 1950s due to discharges to the inlet from the Deschutes River and the Olympia STP.

- Henderson Inlet - The upper end of the inlet was decertified in 1982 as a result of nonpoint pollution entering from adjacent upland areas. This condition is considered correctable.

- Eld Inlet - The upper end of the inlet has been conditionally decertified since 1983 as a result of nonpoint sources. The situation is considered correctable.

- Totten Inlet - The upper portion of Totten Inlet is currently considered threatened with respect to commercial shellfish culture. WDOE and WDNR have policies prohibiting sewage outfalls in Totten Inlet in order to protect the shellfish culture. Accordingly, Totten Inlet has been placed in the "not presently considered suitable" category.


HOOD CANAL
CASE INLET
CARR INLET
COLVOS
QUARTERMASTER HARBOR
COMMENCEMENT BAY
THE NARROWS
TACOMA
SHELTON
DRAYTON PASSAGE
ELD INLET
BUDD INLET
HENDERSON INLET
NISQUALLY REACH
STEILACOOM
OLYMPIA
Henderson Inlet Detail
Figure 4:
Commercial Shellfish Resources
LEGEND
Clams and Oysters – Commercial
Geoducks – Major
Geoducks Commercial
Decertified
Threatened
Decertified Conditional
Uncertifiable
NORTH
Nautical Miles
Yards

- Skookum Inlet - From its mouth, Skookum Inlet is considered threatened due to non-point sources from the surrounding land. A very highly developed clam and oyster resource exists in Skookum Inlet, representing a substantial part of Southern Puget Sound production. Because of these factors, Skookum Inlet has been placed in the "not presently considered suitable" category.

- Oakland Bay/Hammersley Inlet - Parts of Oakland Bay and Hammersley Inlet have been decertified since the 1950s because of mill and wastewater discharges in the Shelton area. The decertified area was reduced to the extent shown in Figure 4 in 1980 due to the installation of secondary treatment at the Shelton STP.

- Case Inlet - Near the north end of Hartstene Island, an area is shown in Figure 4 that is currently classified as uncertifiable due to the discharge of a private STP. A considerable geoduck resource exists in the uncertifiable area. In addition, the oyster resource at the upper end of Case Inlet (North Cove Inlet, Allyn) is designated as threatened due to septic drainfields, stormwater, and runoff from animal keeping activities.

- Carr Inlet - Decertification of culture areas in Burley Lagoon occurred in 1981 and in Minter Bay in 1982. The causes in both cases were related to non-point discharges to the water from surrounding lands. The situations at Minter Bay and Burley Lagoon are considered correctable.

Personal Use Shellfish Areas - As with commercial shellfish culture areas, recreational shellfish areas may be adversely affected by their proximity to wastewater sources. Filter-feeding clams and oysters can potentially concentrate bacteria and viruses present in the water column and pass these on to human consumers creating a serious risk of disease.

A number of personal use areas have been identified in Figure 5. These are areas where Department of Fisheries observers have consistently seen 10 or more people collecting shellfish during periods of low tide and include both privately and publicly owned lands (WDF, 1983a). In addition, Washington Department of Natural Resources public beaches are included in these personal use areas (WDF, 1983b; WDNR, 1978). Some level of personal use shellfishing, including use for recreation, subsistence, and dietary supplementation, also occurs in shoreline areas other than those indicated. For example, according to information provided by the Nisqually Indian Tribe, tribal members in small groups of two to five members, regularly use the shoreline areas throughout Southern Puget Sound for shellfish gathering. Squaxin tribal members also use the Squaxin Island shorelines and other shorelines of Southern Puget Sound in this way.

For the purposes of this evaluation, a one-half mile buffer has been applied on the same basis as for commercial shellfish areas. Thus areas including and within one-half mile of personal use areas shown in Figure 5 have been placed in the "not presently considered suitable" category.

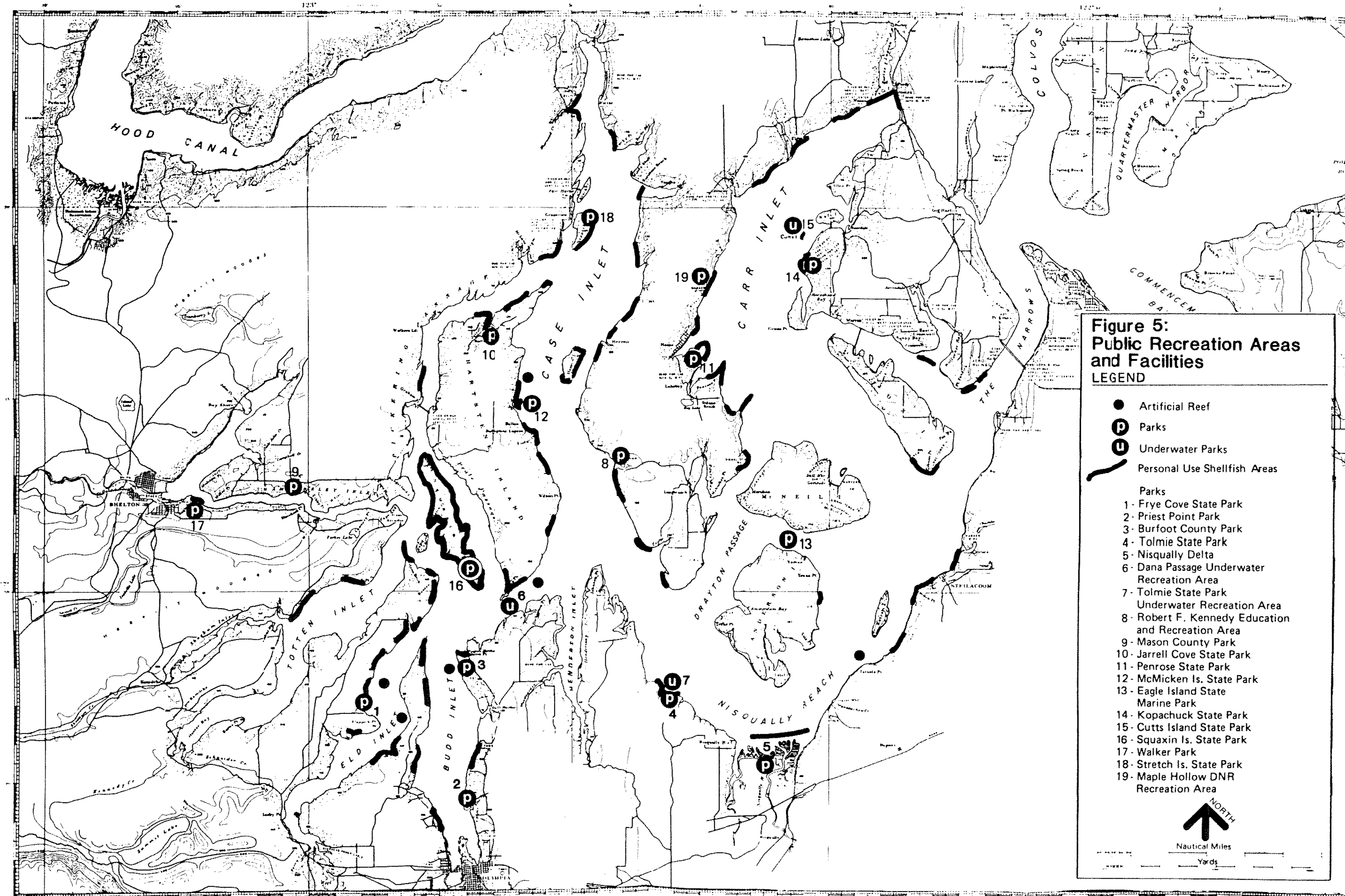


Figure 5:
Public Recreation Areas and Facilities
LEGEND
Artificial Reef
Parks
Underwater Parks
Personal Use Shellfish Areas
Parks
1 - Frye Cove State Park
2 - Priest Point Park
3 - Burfoot County Park
4 - Tolmie State Park
5 - Nisqually Delta
6 - Dana Passage Underwater Recreation Area
7 - Tolmie State Park Underwater Recreation Area
8 - Robert F. Kennedy Education and Recreation Area
9 - Mason County Park
10 - Jarrell Cove State Park
11 - Penrose State Park
12 - McMicken Is. State Park
13 - Eagle Island State Marine Park
14 - Kopachuck State Park
15 - Cutts Island State Park
16 - Squaxin Is. State Park
17 - Walker Park
18 - Stretch Is. State Park
19 - Maple Hollow DNR Recreation Area
NORTH
Nautical Miles
Yards
HOOD CANAL
CASE INLET
CARR INLET
COLVOS
QUARTERMASTER HARBOR
THE NARROWS
COMMENCEMENT BAY
DRAYTON PASSAGE
NISQUALLY REACH
MCNEIL
ANDERSON
TOTTEN INLET
ELD INLET
BUDD INLET
HENDERSON INLET
PICKERING
HARTSTENE ISLAND
SHELTON
STEILACOOM

Water Contact Recreation - Swimming beaches associated with parks and underwater recreation areas occur along the shoreline of Southern Puget Sound as shown in Figure 5. Artificial reefs used by divers are also shown in Figure 5. Criteria for closure of public swimming beaches are related to levels of coliform bacteria found in periodic tests by local health authorities. When STPs are working at their design levels, coliform outputs are not excessive and will not exceed water quality standards beyond the dilution zone. Problems arise, however, when the capacity of a system is exceeded as a result of excess storm water entering the system, or when equipment failure occurs and back-up systems prove to be inadequate (Saunders, 1984). EPA and WDOE requirements for treatment facilities, which include provisions for system redundancies and backup, make such events infrequent. However, in the event of such an occurrence, overflows can result in elevated coliform counts in the vicinity of the outfall and may result in the temporary closure of swimming beaches and other water contact activities.

No distance criteria for siting a wastewater discharge relative to a swimming beach are available; it is up to a proponent of a project to conduct site-specific studies to evaluate the effect of a proposed discharge on recreational uses (Darrel Cochran, Thurston County Health Department, personal communication, 1984).

Parks - Numerous parks and other recreational facilities occur along the Southern Puget Sound shoreline. These are shown in Figure 5. Shoreline activities associated with these parks include picnicking, shellfish gathering, swimming, diving, wading, and enjoyment of park aesthetics. The Nisqually Delta is used for hunting, fishing, shellfish gathering, and bird and other wildlife appreciation. Underwater recreation areas are found in Dana Passage, at Tolmie State Park along Nisqually Reach, at Cutts Island, and at Eagle Island State Park. In addition, artificial reefs are available at a number of locations for diving and spearfishing. These are shown in Figure 5.

Because public parks along the Southern Puget Sound shoreline support such activities as swimming and recreational shellfishing, these locations have been placed in the "not presently considered suitable" category. A one-half mile buffer has been included due to recreational shellfishing. Rationale for this classification is discussed in the water contact recreation and personal use shellfishing sections above.

Because of the risk of closure of beaches for swimming and other water contact recreation, the locations of existing swimming beaches associated with public parks and underwater recreation areas have been placed in the "not presently considered suitable" category.

Floating Aquaculture - Present floating aquaculture projects in Southern Puget Sound include algal (nori) and mussel culture. The Washington Department of Natural Resources (WDNR) has permits for nori culture projects at three sites in the study area (Figure 6). Currently, WDNR is operating only at the Wyckoff Shoal site. Floating shellfish (mussel) culture projects are shown by Saunders (1984) for Totten Inlet and upper Carr Inlet (see Figure 6).

A one-half mile buffer criterion can be applied to floating mussel culture locations for the same reasons as for commercial shellfishing. Thus, the existing locations and surrounding areas within one-half mile are "not presently considered suitable."

The same criterion has been applied here for nori culture. Although little is known about the effects of secondary effluent on algal species such as nori, evidence suggests that trace metals may be accumulated (Tom Mumford, WDNR, personal communication, 1984). The implications of such accumulation for human consumers are not presently known.

Saunders (1984) shows salmon pen operations in Peale Passage adjacent to Squaxin Island and in Hale Passage adjacent to Fox Island (see Figure 6). It is assumed here that achievement of water quality standards would protect water quality sufficiently, so that such operations would not be eliminated should a secondary wastewater discharge be sited nearby. Site-specific studies would need to be conducted for a particular project to determine the impact potential resulting from low levels of materials in secondary effluent.

Potential locations for floating aquaculture (nori, mussels) are not widely known (Saunders, 1984). It is likely that undeveloped areas occur in Southern Puget Sound where there exists a high potential for such activities. Wastewater discharge siting studies should consider the aquaculture potentials of alternative areas under consideration.

It should also be noted that the Mason County, Master Program designates certain areas for floating aquaculture. These areas include areas of Totten Inlet, all of Skookum Inlet, and Peale Passage between Squaxin and Hartstene Islands (Saunders, 1984).

Fish and Wildlife Resources - Southern Puget Sound supports a wide variety of fish and wildlife. No attempt here has been made to present distributions and abundances of species found in the area; however, discussions relevant to development of this discharge zone classification are presented. A variety of documents summarizing these resources are available. Several are listed in Appendix A.

- Nisqually Delta - The Nisqually Delta is one of the most significant areas of fish and wildlife habitat in the state. It is designated as a National Wildlife Refuge because of the many species of birds and mammals that utilize its relatively undisturbed estuarine and upland habitats. The Nisqually Delta is the major non-coastal nesting and feeding area for migrating waterfowl and shorebirds between the Skagit Flats and the Columbia River (U.S. Army Corps of Engineers, 1982). It provides critical

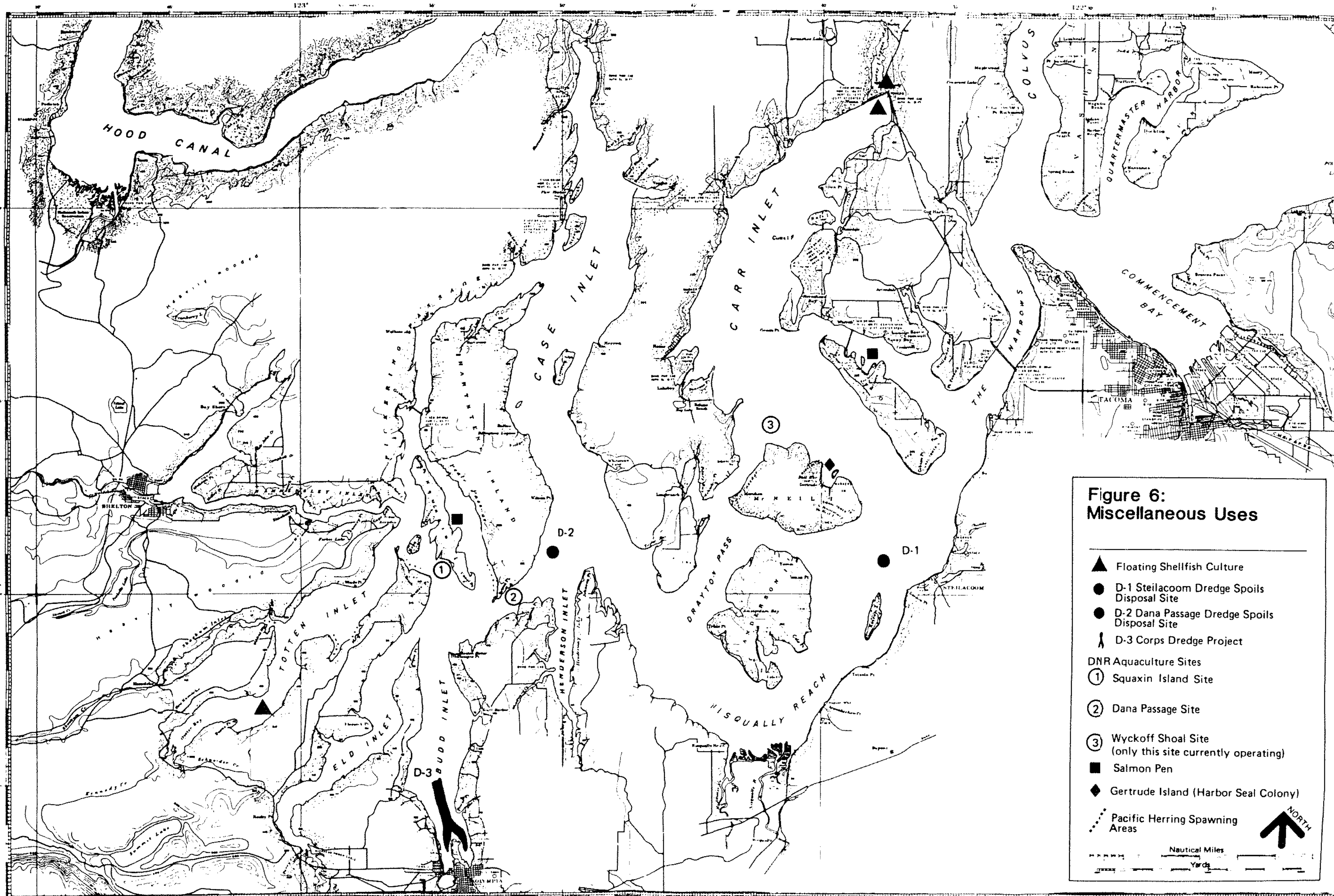


Figure 6:
Miscellaneous Uses
Floating Shellfish Culture
D-1 Steilacoom Dredge Spoils Disposal Site
D-2 Dana Passage Dredge Spoils Disposal Site
D-3 Corps Dredge Project
DNR Aquaculture Sites
1 Squaxin Island Site
2 Dana Passage Site
3 Wyckoff Shoal Site (only this site currently operating)
Salmon Pen
Gertrude Island (Harbor Seal Colony)
Pacific Herring Spawning Areas
NORTH
Nautical Miles
Yards
HOOD CANAL
CASE INLET
CARR INLET
COLVOS
QUARTERMASTER HARBOR
COMMENCEMENT BAY
THE NARROWS
TACOMA
SHELTON
TOTTEN INLET
ELD INLET
BUDD INLET
HENDERSON INLET
DRAYTON PASS
NISQUALLY REACH
HARTSTENE ISLAND
McNEIL
ANDERSON
D-1
D-2
D-3
1
2
3

habitat for mallard, pintail, American wigeon, and river otters (WDOE, 1977-1980). Its mudflats are also used by harbor seals as a haul-out area. The Nisqually River and estuary support important runs of anadromous fish.

Because of its exceptional importance to fish and wildlife, the Nisqually Delta has been included in the "not presently considered suitable" category. Any siting near the Nisqually Delta will no doubt be subject to a high degree of scrutiny by agencies and the public.

- <u>Fisheries Resources</u> - Important fisheries resources are found throughout Southern Puget Sound. These fisheries resources are important from a commercial fishing, sport fishing, as well as an ecological point-of-view. Salmon, steelhead, and sea run cutthroat trout use the rivers and streams entering the inlets and passages. The estuaries are important for spawning, passage and rearing of these anadromous fish. A variety of species of groundfish occur in the study area. A list of economically important species is presented in WDF, 1983a.

  The inlets (Henderson, Budd, Eld and Totten) all provide important surf smelt spawning areas along their shorelines. Spawning occurs primarily in the upper intertidal on these beaches. It is likely that with appropriate design, timing, and beach regrading, outfall construction across surf smelt spawning beaches would not permanently disrupt spawning habitat (Dan Penttila, WDF, personal communication 1984). Thus, because mitigation of impacts would likely be effective, surf spawning beaches have been placed in the "will be considered" category.

  Pacific herring spawning areas are located in parts of Totten and Skookum Inlets and in Squaxin Passage (Figure 6). Herring spawning occurs in the intertidal zone associated with particular vegetation requirements between the +3 foot to -15 foot zone. Because disturbance of herring spawning habitat may result in the loss of the habitat (due to the difficulty in restoring the appropriate conditions), outfall construction across herring spawning beaches is highly discouraged (Dan Penttila, WDF, personal communication, 1984). Thus, areas associated with herring spawning have been included in the "not presently considered suitable" category.

  Based on the intent that water quality standards are set to provide a measure of safety against adverse impacts to organisms, significant impacts to fisheries resources from a wastewater outfall are not expected. An issue that remains, however, and which would need to be evaluated for a specific project in light of then current understandings, is the problem of cumulative impacts to organisms and ecological systems of toxic contaminant accumulation in the environment. Considerable research is on-going relative to this issue and, at present, no clear-cut relationships are available to clarify the aims of this study.

o Wildlife - A wide variety of wildlife occurs in Southern Puget Sound. Shorebirds and waterfowl occur widely along Southern Puget Sound shorelines. Raptors, including peregrine falcons and bald eagles (species associated with special state and federal statutes), feed along the shorelines. Consultation with the U.S. Fish and Wildlife Service and Washington Department of Game Non-Game Program would be necessary in any siting proposal to avoid areas known to be used for nesting and/or roosting by bald eagles.

Other notable wildlife along these shorelines include harbor seals. Haul-out areas are documented in association with the Nisqually delta, each of the southern inlets (Henderson, Budd, Eld and Totten), and Carr and Case Inlets (Dexter et al, 1981). In some areas, harbor seals use log rafts as haul-out sites. An important harbor seal colony is located at Gertrude Island, adjacent to McNeil Island. Because of the importance of the Gertrude Island location to the Southern Puget Sound harbor seal population, this site has been placed in the "not presently considered suitable" category. Other seal haul-out locations should be considered in site-specific studies for particular proposals.

As discussed for fisheries resources, achievement of water quality standards is assumed to protect wildlife uses. Accordingly, wildlife use areas, other than those already noted, have not been limiting in developing this discharge zone classification. Shoreline construction activities would be disruptive of habitat and wildlife activities over the short-term. Such impacts would need to be evaluated on a specific project basis.

Sport Fishing - Sport fishing for salmon and groundfish occurs widely in Southern Puget Sound. Particular concentrations of sport salmon fishing have been noted at the entrances to Budd and Henderson Inlets and around Johnson Point in Nisqually Reach (Mary Lou Mills, WDF, personal communication, 1984). An important sport salmon fishing area has also been noted off the Nisqually Delta adjacent to Anderson Island. Additional areas occur in Carr and Case Inlets, and passages including Drayton, Balch, Hale, and Pickering. Sea run cutthroat are fished for along most shorelines of Thurston County (WDNR, 1972). Recreational groundfishing is commonly done with hook-and-line angling from boats and shore structures and underwater spearfishing.

It is uncertain what effect locating a wastewater discharge in the vicinity of these areas would have on the acceptability by sport fishermen of continued use of these areas. It is likely that considerable negative public concern would be generated by a proposal for an outfall in one of these areas. However, it is noted that sport fishing occurs in the vicinity of discharges in other areas, such as near West Point in the main basin of Puget Sound. In addition, for the purposes of this study it is assumed that impacts to the sport fishing resource would be negligible as long as water quality standards are met for the secondary effluent. Accordingly, these areas have not been excluded from consideration for secondary discharge siting. The impact of low levels of materials contained in secondary effluent on local fauna and food webs (including the sport fishing population) would need to be addressed in siting studies for any particular proposal.

Commercial Fishing - Locating a wastewater outfall in areas fished commercially raises two major concerns: (1) the effect of effluent on the health of the fish and the suitability of harvested fish for consumption, and (2) the potential for the outfall structure to interfere with fishing through snagging gear.

For the purposes of this study, the direct effects of effluent on fish and other organisms are assumed to be negligible as long as water quality standards are met. Within the initial dilution zone, impacts might be expected to be greater; however, the extent of such an area would be small. Thus, in this study no areas were excluded on the basis of harmful effects on fish species from contact with secondary effluent.

Physical interference of an outfall structure with commercial fishing gear could result in making a particular area unfishable. For example, placement of an outfall at depths less than about 20-30 feet could result in physical interference with gill nets, which typically operate to depths of about 30 feet (Mary Lou Mills, WDF, personal communication, 1984). An area of influence larger than the immediate outfall area could also be affected depending on local practices. Commercial salmon fishing areas have been placed in the "will be considered" category, but outfall design and siting should take into account the potential for interference with commercial salmon fishing gear. To avoid interference with gill nets, outfall structures should be buried to depths greater than 30 feet.

Areas of Southern Puget Sound are fished using trawling gear, which operates to greater depths than salmon gear. Various species of groundfish are taken using this gear, the most important species being Pacific cod, rockfish, English sole, starry flounder, and surf perch (WDF, 1983a). These species may occur over a broad range of depths, and trawling gear may be operated to near the bottom of these areas creating the potential for interference by an outfall at essentially any depth. Because the areas fished in this way are widespread and the potential area of impact is relatively small, it is not reasonable in this study to exclude areas from consideration on this basis. Site-specific studies should address such effects in the event that a project is proposed that might result in these impacts. Coordination with commercial fishing organizations, and tribal jurisdictions would be important in site-specific considerations.

Surf smelt are harvested commercially and recreationally. Harvest is typically by beach seine in waters 10-12 feet deep and out to 150-200 feet from shore depending on local conditions. To avoid interference with surf smelt harvest, outfall design should include burial across smelt beach areas out to depths of approximately 20 - 30 feet (Dan Penttila, WDF, personal communication, 1984).

A Pacific herring fishery occurs in Southern Puget Sound with most activity in the general areas of Fox, Anderson, and McNeil Islands. This fishery also extends into Carr and Case Inlets and to the Dana Passage/Hartstene Island area. It doesn't extend into the southern ends of the southern inlets. To avoid interference with herring nets, outfalls need to be placed at depths of approximately 80-100 feet (Dan Penttila, WDF, personal communication, 1984). Because of the widespread occurrence of the herring fishery, no specific areas have been placed in the "not presently considered suitable" category. However, siting and design should be coordinated with fisheries personnel.

Dredging Projects - Locating a wastewater outfall in the vicinity of an ongoing dredge project is of concern because an outfall structure in a dredged channel is physically incompatible with dredging activities (Alex Sumeri, Corps of Engineers, personal communication, 1984).

A review of Corps of Engineers dredging project permits identified that a number of dredging projects in the study area were permitted over the past several years. Some of these permits allow one-time dredging for construction projects; others allow maintenance dredging of channels and marina basins. The largest of these projects is the Corps of Engineers' channel maintenance program in the southern portion of Budd Inlet (Figure 6).

Because of the extent of the Budd Inlet channel maintenance program and its likely continuing need, the location of this project has been placed in the "not presently considered suitable" category. Other dredging project locations have not been so classified, because the extent of dredging is much smaller and their future dredging needs depend on site-specific conditions. It is likely also that additional dredging projects will be proposed for the study area which cannot now be anticipated.

Dredge Disposal - Two dredge spoils disposal sites are located in the study area. They include the Dana Passage site and the Steilacoom site (Figure 6). Because open-water dumping of dredge spoils and a wastewater outfall are incompatible, these dredge spoils sites have been placed in the "not presently considered suitable" category.

Use-Related Discharge Zones

Figure 7 represents an integration of the considerations described in the previous sections for individual uses. Areas of Southern Puget Sound where uses would very likely be precluded by a new secondary wastewater discharge are identified. These areas are "not presently considered suitable" for new secondary wastewater discharges.

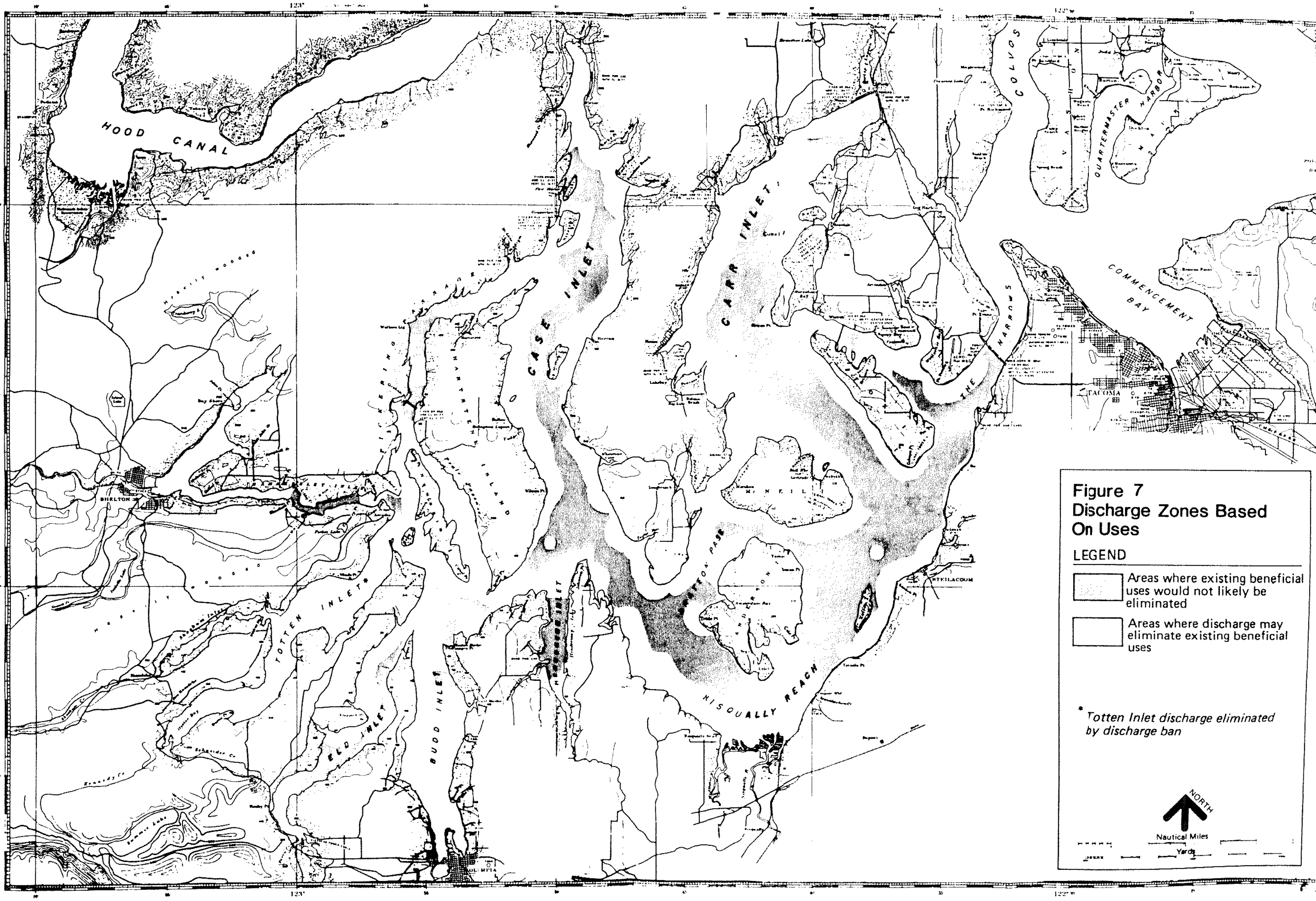


Figure 7
Discharge Zones Based On Uses

DILUTION GUIDELINES

Introduction

An important consideration for siting wastewater discharge facilities is the availability of sufficient water depth at a prospective outfall site to achieve suitable initial dilution of the effluent. This section describes the approach and presents a sample procedure for the evaluation of the initial dilution potential at potential sites within Southern Puget Sound. The procedure described here as part of the Discharge Zone Classification System can be used in conjunction with the Discharge Zone Classification Map (Figure 1) in evaluating the siting potential of locations not eliminated from consideration based on existing water quality and use conflicts.

Modeling Approach

The EPA PLUME Model (EPA, 1979), assumes zero current, or a model of similar characteristics but incorporates current, is recommended to model the initial dilution of secondary effluent. The EPA model is well documented and has been used frequently in Puget Sound studies, including outfall studies in the Central Kitsap and Seahurst areas, and a number of 301(h) waiver applications.

The PLUME model considers a buoyant plume issuing from the outfall ports at an arbitrary angle into a stagnant, stratified environment. Another plume model may be used when site specific current information is available. In this case, the tenth percentile* lowest current velocities should be used. Input to either type of model typically includes: depth-density profiles, discharge density, diffuser depth, flow rate, and diffuser characteristics.

The primary data needed for model dilution calculations presented here were water density profiles. These were available in water property data collected by the University of Washington during an intensive sampling survey conducted in 1957-1958 (Olcay, 1959). This is regarded as the most intensive water property survey in Southern Puget Sound. For Southern Puget Sound, 52 stations were identified (Figure 8). Density profiles at these stations were considered to be representative of the surrounding waters to approximately the midpoint between adjacent stations. Boundaries for each station are shown in Figure 8. Density profiles of these stations can be found in Appendix B.

In this study, the discharge density of the secondary effluent was assumed to be 1.000. Because the specific gravity of sewage typically ranges between 0.990 and 1.000, this assumption is conservative.

* on a representative cumulative frequency distribution of current data

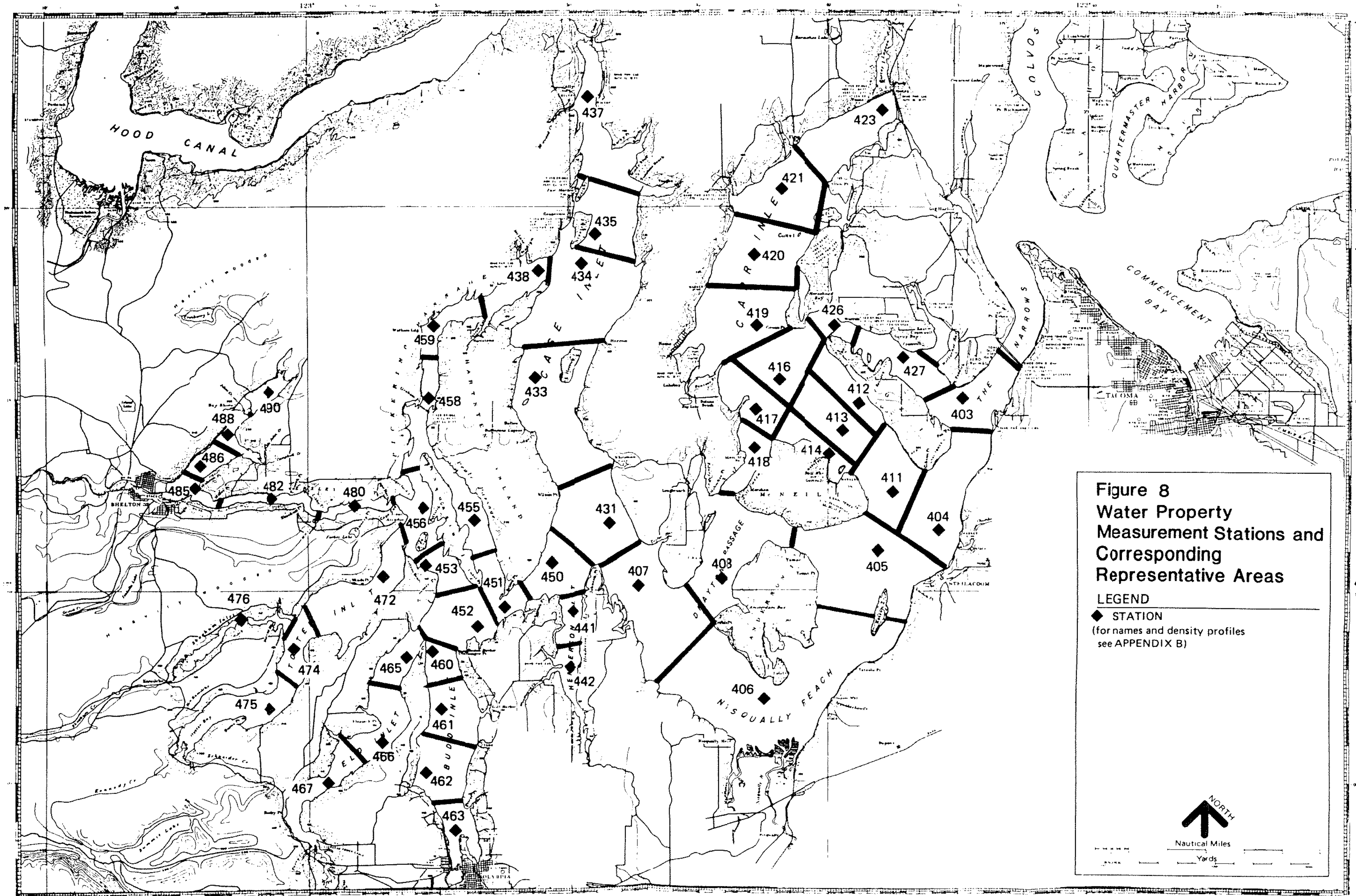


Figure 8
Water Property Measurement Stations and Corresponding Representative Areas

Factors typically considered in the design of a diffuser are the topography of the proposed diffuser site, the diameter and length of the diffuser, the depth of discharge, and the port size, spacing and diameter. Table 4 gives a range of parameters for diffuser design, compiled from design features of recent major Pacific Ocean outfalls (Fischer, et al., 1979). The number and diameter of diffuser ports need to be determined for specific projects. Port diameters are determined by selecting an acceptable port velocity and calculating the necessary area for the velocity. Selection of port diameters is based on design considerations to keep all ports flowing full at all times and to allow for sufficient velocity to prevent deposition within the pipe.

Table 4

A Range of Parameters for Diffuser Design
(Fischer, et al., 1979)

Design Parameter	Range of Specifications
Diffuser length	10 to 15 feet/mgd of average design flow
Port spacing	8 to 15 feet on centers with an average of about 10 feet
Jet velocity	5 to 13 feet/sec for average flow
Area factor (total port area/pipe area)	0.39 to 0.63

The depth of discharge depends on the slope of the bottom along the proposed outfall line and the length of outfall required to obtain satisfactory dilution. Because of the complex hydraulics of the diffuser section, the topography of the proposed diffuser site should be as level as possible.

Criteria and Evaluation

In order to determine whether or not sufficient dilution is achievable in areas represented by each station, it was necessary to identify an acceptable initial dilution. In an estuary, the amount of initial dilution is determined by the volume within the Zone of Initial Dilution (ZID) at low slack tide. The size of the ZID is determined by water depth and the diffuser's length. The location must be 100 feet from the shore measured at the mean lower low water line, one foot above the bottom, and one foot below the water's surface. The initial dilution requirement must be met at the edge of the ZID (WDOE, 1978).

The dilution required for any new wastewater discharge depends on the quality of the effluent to be discharged. Adequate diluting water is required within the ZID to ensure water quality criteria are met.

Water quality criteria can be placed into two general categories; each individual category relates to acute and chronic toxicities, respectively. Acute criteria are based on protection of the biota from immediate mortalities or lethal toxicity occurring at any time. Chronic criteria are based on protection of the biota from subtle, longer term (i.e., 24-hour to 30-day) effects. Because wastewater discharges are present all of the time, water quality at the edge of the ZID should be maintained at or below chronic criteria.

For the screening purposes of the Discharge Zone Classification System, a general idea of effluent quality is needed to determine an acceptable initial dilution requirement for estuarine receiving waters. Analysis of the information presented in Appendix C indicates a dilution requirement of 100:1 should protect the receiving environment against worst-case conditions arising from secondary and tertiary wastewater treatment plant effluent discharges. It also appears protective in consideration of observed background concentrations in Southern Puget Sound and non-urban Central Basin embayments (Table C-2 in Appendix C).

In evaluating the dilution potential for the potential outfall site, the maximum and minimum stratification reflected in the available density profiles for each site need to be considered in the modeling analysis. The highest and lowest stratification profiles likely represent the worst and best dilution conditions, respectively. For each potential outfall site, an accepted plume model should be used to test the discharge depth at which the 100:1 dilution criteria will be met.

A Sample Case of Dilution Evaluation

As a general rule, diffuser design parameters such as diffuser length, port spacing and diameter, can be scaled in proportion to the average design flows (Table 4). For the purpose of illustration, the following design specifications are selected from Table 4 for a case discharge of an average flow of 1 MGD and pipe diameter of 12 inches.

diffuser length	=	15 feet/MGD
port spacing	=	8 feet on center
jet velocity	=	5 feet/second
area factor	=	0.39

Other input parameters to the plume model can be derived from the above data, which are:

number of ports	=	3
port diameter	=	4 inches

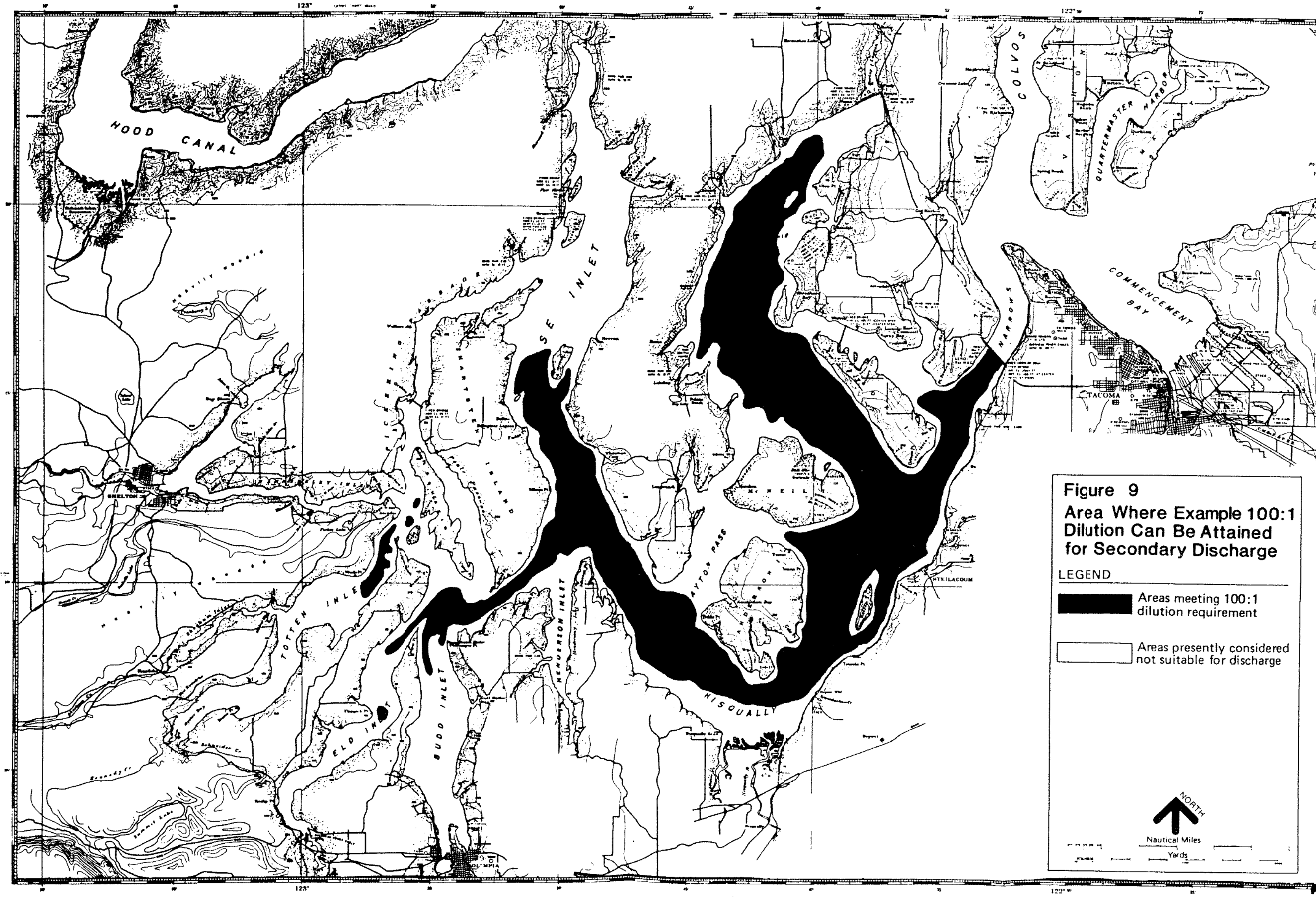


Figure 9
Area Where Example 100:1 Dilution Can Be Attained for Secondary Discharge

The results of applying the EPA Plume Model to identify the waters of Southern Puget Sound where 100:1 dilution could be achieved using the example design condition are shown in Figure 9. All 52 stations (Figure 8) were tested for passage of the 100:1 dilution criteria under the conditions of maximum diffuser depth. Stations of non-compliance with the 100:1 dilution criteria under the conditions of maximum diffuser depth were excluded from further testing. The second part of this task involved further testing of the stations which passed this "first cut". The stations were tested for compliance at a range of diffuser depths separated by 5 meter increments. A sample dilution model run can be found in Appendix D.

This map (Figure 9) is valid for all design flows, but only for the cases where the diffuser design parameters were derived from the same aforementioned scaling factors. Figure 10 shows an integrated map which superimposes the dilution map (Figure 9) on the Discharge Zone Classification Map (Figure 1).

Individual NPDES applicants may use this map (Figure 10) for a quick evaluation of a given site in relation to water quality, use, and dilution considerations. In the case of specific diffuser design, individual NPDES applicants could use an accepted plume model (incorporating with or without current) to evaluate whether adequate dilution can be achieved at a given site.

Figures 9 and 10 are intended to be a "first-cut" screening tool, and are not intended to replace the need to conduct site-specific studies to determine the density and current data in the vicinity of the potential discharge sites. It would be strongly recommended that preferred sites are at locations where stronger currents prevail.

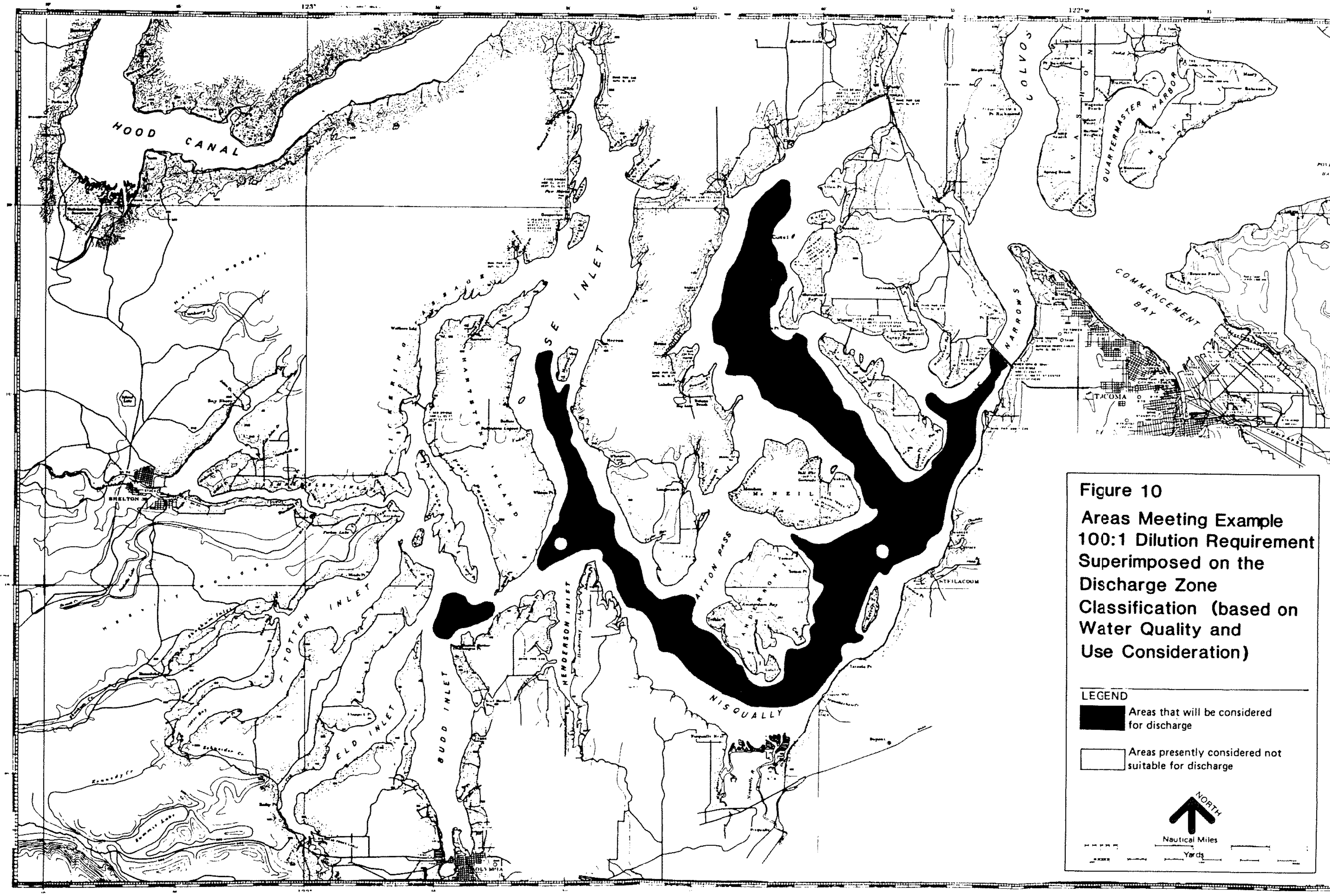


Figure 10
Areas Meeting Example 100:1 Dilution Requirement Superimposed on the Discharge Zone Classification (based on Water Quality and Use Consideration)

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Appendices

APPENDIX A

INFORMATION DATA BASE ON USES

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INFORMATION DATA BASE ON USES

Southern Puget Sound supports a wide variety of uses, including commercial and recreational shellfish and fishing activities, swimming and diving, boating, and aesthetic enjoyment. In addition, the region provides fish and wildlife habitat for an array of species. Except in limited areas, the existing water quality classifications (see Table 2) support these characteristic uses. The following sections present lists of references reviewed and agency personnel contacted in preparing the use study.

References

A great deal of documentation exists describing the various uses of Southern Puget Sound. Some of this is published in scientific papers; other information is available from federal, state and local resource and planning agencies. Several convenient summaries of information are, however, available for the purposes of this study and planning-level studies can provide a suitable level of detail concerning the types and distributions of uses in Southern Puget Sound. The following list presents several of these sources. Many of these references provide detailed reference lists that identify other sources of detailed information. This annotated listing is not exhaustive. It does, however, provide access to a considerable amount of information available describing the uses of Southern Puget Sound.

(1) Saunders, Robert S. 1984. Shellfish Protection Strategy. Shorelands Division, Washington State Department of Ecology, Olympia, Washington.

This report describes management strategies to protect shellfish resources in Puget Sound. It provides maps showing existing areas of commercial shellfish culture. In addition, these maps show areas that are currently decertified, uncertifiable and threatened; commercial harvest of shellfish is disallowed in the former two areas.

(2) Washington State Department of Fisheries. 1983a. Salmon, marine fish, and shellfish resources and associated fisheries in Washington's coastal and inland marine waters. Technical Report No. 79. Compiled and edited by Mary Lou Mills, Frances Solomon, and Wendy Shaul (illustrator and cartographer), Olympia, Washington.

This report provides maps showing the distributions of salmon baitfish, groundfish, and shellfish resources and associated fisheries in Puget Sound, the Strait of Juan de Fuca and the Washington Coast.

(3) Washington State Department of Fisheries. 1983b. Puget Sound Public Shellfish sites. Revised by Eric Hurlburt and Albert Scholz, Olympia, Washington.

This document contains maps of Puget Sound showing the locations of public shellfish sites. In addition, the locations of boat launches are shown.

(4) Dexter, R. N. et al. 1981. A Summary of Knowledge of Puget Sound related to chemical contaminants. NOAA Technical Memorandum OMPA-13. National Oceanic and Atmospheric Administration, Office of Marine Pollution Assessment, Boulder, Colorado.

This report presents a summary of available physical, chemical and biological information about Puget Sound. In addition to fish, birds and mammals, it provides information about plankton and invertebrates. Discussions of circulation, sedimentation, and water chemistry are provided. Each section is followed by an extensive reference list.

(5) Washington Department of Ecology. 1977-1980. Coastal Zone Atlas of Washington, Vol. 7, Pierce Co.; Vol. 8, Thurston Co.; Vol. 9, Mason Co. Olympia, Washington.

This atlas presents information in a series of maps that show the locations of critical habitats in Washington coastal areas for fish, birds and mammals. In addition these maps show various geological, geohydrological and land use patterns along the coastlines of the state. Volumes 7-9 are relevant to Southern Puget Sound areas.

(6) Washington Department of Ecology. 1977. Washington Coastal Areas of Major Biological Significance, Olympia, Washington.

This report and its accompanying maps describe the distributions, life histories, and habitat requirements of a broad range of mammal, bird, fish, and invertebrate species that occur in Puget Sound and other coastal areas of Washington. Critical habitat areas are identified.

(7) Washington Department of Natural Resources. 1978. Your Public Beaches - South Puget Sound, Olympia, Washington.

This set of maps shows the locations of and lists the shellfish species associated with the public beaches in Southern Puget Sound.

(8) U.S. Army Corps of Engineers. 1982. Final Environmental Impact Statement for Weyerhaeuser Export Facility at Dupont. Seattle District.

This FEIS summarizes the biological resources of the Nisqually Delta area. It identifies other references that provide more detail about the species of the delta area and Nisqually Reach.

(9) JRB Associates. 1984. Water Quality Dependent Water Uses in Puget Sound and Identification of Existing Water Quality Data. Prepared for U.S. EPA. EPA 910/9-83-118a.

This report (in two volumes) identifies the uses of Puget Sound subregions including Southern Puget Sound. It contains information describing the productivity of commercial resources by species and subregion. It further identifies individuals associated with agencies and other organizations with knowledge relevant to the various resources. The second volume of the report identifies organizations, agencies, and individuals who have water quality-related information.

(10) U.S. Army Corps of Engineers. 1975. Washington Environmental Atlas, Seattle District.

This atlas identifies a wide range of environmental features of Washington State. Some information is relevant to the Southern Puget Sound area.

(11) Washington Department of Fisheries/Department of Natural Resources. 1981. Management Plan for the Puget Sound Commercial Geoduck Fishery. Olympia.

This plan contains maps showing the locations of geoduck beds allocated by WDNR for commercial harvest. Goals and management procedures and policies are presented.

List of Contacts

The following list is comprised of individuals who were contacted during the development of the use portion of this study.

Name	Agency
Eric Hurlburt	Washington Department of Fisheries
Greg Bargmann	Washington Department of Fisheries
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Name	Agency
Dan Penttila	Washington Department of Fisheries

Tom Mumford	Washington Department of Natural Resources
Jack Lilja	Washington Department of Social and Health Services
Gary Fraser	Washington Department of Social and Health Services
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Darrel Cochran	Thurston County Health Department
Steve Martin	U.S. Army Corps of Engineers
Alex Sumeri	U.S. Army Corps of Engineers
Tom Mueller	U.S. Army Corps of Engineers

APPENDIX B

HISTORICAL DENSITY PROFILES IN SOUTHERN PUGET SOUND

(Olcay, 1959)

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1956

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 488 CHAPMAN	0.0	1.01289	0.0	1.01704
	1.0	1.01567	1.0	1.01727
	2.0	1.01657	2.0	1.01737
	3.0	1.01747	3.0	1.01747
STATION 490 OAKLAND	0.0	1.01444	0.0	1.01884
	1.0	1.01585	1.0	1.01676
	2.0	1.01641	2.0	1.01876
	4.0	1.01647	4.0	1.01879
	7.0	1.01658	7.0	1.01888
	10.	1.01669	10.	1.01897
STATION 406 NISQUALLY	0.0	1.013070	0.0	1.022160
	5.0	1.021836	10.0	1.022160
	10.	1.021872	20.	1.022160
	20.	1.022035	40.	1.022150
	60.0	1.022174	60.0	1.022170
	123.	1.022594	123.	1.022230
STATION 407 DEVIL'S	0.0	1.020051	0.0	1.02190
	5.0	1.021662	5.0	1.02190
	10.	1.021758	10.	1.02193
	20.	1.021949	20.	1.02195
	30.	1.021997	30.	1.02205
	50.	1.022004	50.	1.02214
	75.	1.022066	75.	1.02222
	104.	1.022138	104.	1.02230
STATION 431 JOHNSON	0.0	1.02209	0.0	1.02146
	5.0	1.02211	5.0	1.02157
	10.	1.02218	10.	1.02164
	20.	1.02230	20.	1.02189
	30.	1.02249	30.	1.02191
	50.	1.02263	50.	1.02194
	70.	1.02263	70.	1.02193
	110.	1.02263	110.	1.02195
STATION 441 HENDERSON	0.0	1.02081	0.0	1.02128
	2.0	1.02153	2.0	1.02142
	4.	1.02156	4.	1.02143
	7.	1.02172	7.	1.02147
	10.	1.02183	10.	1.02148
	13.	1.02192	13.	1.02153
	17.	1.02204	17.0	1.02160

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 442 WOODWARD	0.0	1.02121	0.0	1.02121
	1.0	1.02122	1.0	1.02122
	2.	1.02183	2.	1.02183
	5.	1.02276	5.	1.02276
STATION 450 DICKERSON	0.0	1.02225	0.0	1.02147
	5.0	1.02228	5.0	1.02148
	10.	1.02233	10.	1.02153
	20.	1.02254	20.	1.02156
	30.	1.02256	30.	1.02260
	44.	1.02258	44.	1.02266
STATION 451 BRISCO	0.0	1.02181	0.0	1.02181
	5.0	1.02182	5.0	1.02182
	10.	1.02183	10.	1.02183
	20.	1.02186	20.	1.02186
	30.	1.02207	30.	1.02207
	37.	1.02222	37.	1.02222
STATION 452 DOVER	0.0	1.02023	0.0	1.02171
	5.0	1.02169	5.0	1.02170
	10.	1.02185	10.	1.02171
	20.	1.02190	20.	1.02173
	30.	1.02192	30.	1.02174
	50.	1.02190	50.	1.02173
	57.	1.02192	57.	1.02173
STATION 453 HUNTER	0.0	1.02171	0.0	1.02185
	2.0	1.02191	2.0	1.02184
	5.	1.02205	5.	1.02184
	10.	1.02260	10.	1.02185
	15.	1.02257	15.	1.02184
STATION 456 ARCADIA	0.0	1.01932	0.0	1.02179
	2.0	1.01977		
	5.	1.02003	5.	1.02180
	10.	1.02061	10.	1.02179
	15.	1.02119	15.	1.02179

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 460 DOFFLEMYER	0.0	1.02120	0.0	1.02120
	2.0	1.02152	2.0	1.02152
	5.	1.02154	5.	1.02154
	10.	1.02154	10.	1.02154
	15.	1.02155	15.	1.02155
	20.	1.02156	20.	1.02156
	29.	1.02158	29.	1.02157
STATION 461 GULL	0.0	1.01784	0.0	1.02128
	2.0	1.02134	2.0	1.02149
	5.	1.02165	5.	1.02165
	10.	1.02169	10.	1.02174
	15.	1.02169	15.	1.02179
STATION 462 OLYMPIA	0.0	1.01825	0.0	1.02096
	2.0	1.02131	2.0	1.02141
	4.	1.02155	5.	1.02174
	8.	1.02167	10.	1.02200
	13.	1.02168	13.	1.02205
STATION 463 BUDD BOUY-12	0.0	1.01468	0.0	1.01940
	2.0	1.02046	2.0	1.02141
	4.	1.02144	4.	1.02150
	7.	1.02151	7.	1.02154
	10.	1.02155	10.	1.02151
STATION 465 COOPER	0.0	1.02081	0.0	1.02124
	5.0	1.02156	5.0	1.02130
	10.	1.02175	10.	1.02136
	15.	1.02186	15.	1.02136
	25.	1.02192	25.	1.02144
STATION 466 FLAPJACK	0.0	1.01971	0.0	1.02195
	2.0	1.02112	2.0	1.02195
	4.	1.02131	4.	1.02196
	7.	1.02165	7.	1.02195
	12.	1.02185	12.	1.02196
	15.	1.02197	15.	1.02197

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 472 WINDY	0.0	1.01998	0.0	1.02079
	2.0	1.02045	2.0	1.02082
	5.	1.02082	5.	1.02084
	10.	1.02110	10	1.02084
	20.	1.02128	20.	1.02086
	30.	1.02130	30.	1.02085
STATION 474 KAMILCHE	0.0	1.01822	0.0	1.02086
	2.0	1.02014	2.0	1.02089
	4.	1.02053	4.	1.02092
	7.	1.02118	7.	1.02100
	12.	1.02124	10.	1.02105
	18.	1.02130	15.	1.02111
			18.	1.02113
STATION 475 BURNS	0.0	1.01807	0.0	1.02016
	1.0	1.01980	1.0	1.02016
	2.0	1.02090	2.0	1.02020
	4.	1.02147	4.	1.02039
	15.	1.02460	15.	1.02144
STATION 476 SKOOKUM	0.0	1.01825	0.0	1.02152
	1.0	1.01858	1.0	1.02152
	2.0	1.01856	2.0	1.02152
	3.	1.01950	3.	1.02152
STATION 467 ELD	0.0	1.02177	0.0	1.02177
	1.0	1.02177	1.0	1.02177
	2.0	1.02180	2.0	1.02180
	4.0	1.02184	4.0	1.02184
	7.0	1.02188	7.0	1.02188
	10.0	1.02188	10.0	1.02188
	14.0	1.02188	14.0	1.02188

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 401 DEFIANCE	10.	1.02228		
	20.	1.02239		
	30.	1.02241	30.	1.02373
	50.	1.02241		
	60.	1.02266		
	73.	1.02298	73.	1.02374
STATION 402 EVANS	10.	1.02230	NA	NA
	20.	1.02231		
	29.	1.02236		
	49.	1.02242		
	60.	1.02245		
STATION 403 DAYS	0.0	1.02220	1.0	1.02256
	10.	1.02238	10.	1.02251
	20.	1.02251	25.	1.02252
	30.	1.02258		
	55.	1.02266	55.	1.02251
STATION 404 TOLIVA	0.0	1.02126	0.0	1.02262
	5.0	1.02144	5.0	1.02260
	10.	1.02172	10.	1.02261
	20.	1.02190	20.	1.02264
	30.	1.02206	30.	1.02265
	49.	1.02227	50.	1.02265
	74.	1.02230	75.	1.02267
	98.	1.02238	100.	1.02273
	128.	1.02246	128.	1.02272
STATION 405 GORDON	0.0	1.01961	1.0	1.02317
	5.0	1.02189		
	10.	1.02200	10.	1.02315
	20.	1.02208		
	30.	1.02220	25.	1.02313
	49.	1.02237	50.	1.02315
	73.	1.02241	75.	1.02321
	97.	1.02245	100.	1.02320
	127.	1.02247	130.	1.02223
	165.	1.02247	165.	1.02322

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 408 DRAYTON	NA	NA	0.0	1.02350
			10.	1.02351
			20.	1.02355
			30.	1.02356
			59.	1.02356
STATION 411 GIBSON	0.0	1.02163	0.0	1.02267
	5.0	1.02165	5.0	1.02267
	10.	1.02185	10.	1.02267
	20.	1.02197	20.	1.02268
	30.	1.02204	30.	1.02267
	50.	1.02210	50.	1.02266
	75.	1.02215	75.	1.02268
	100.	1.02220	100.	1.02268
	130.	1.02227	130.	1.02266
	163.	1.02233	163.	1.02266
STATION 412 STILL1	0.0	1.02174	0.0	1.02249
	5.0	1.02173	5.0	1.02249
	10.	1.02198	10.	1.02256
	20.	1.02207	20.	1.02251
	30.	1.02214	30.	1.02252
	50.	1.02217	50.	1.02253
	75.	1.02219	75.	1.02254
	100.	1.02231	100.	1.02256
	125.	1.02232	125.	1.02261
STATION 413 STILL2	0.0	1.02224	0.0	1.02267
	5.0	1.02255	5.0	1.02266
	10.	1.02266	10.	1.02267
	20.	1.02275	20.	1.02267
	30.	1.02279	30.	1.02267
	60.	1.02286	50.	1.02267
			75.	1.02268
	90.	1.02290	100.	1.02267
	125.	1.02291	125.	1.02268
STATION 414 STILL3	0.0	1.02210	0.0	1.02267
	5.0	1.02224	5.0	1.02267
	10.	1.02234	10.	1.02267
	20.	1.02241	20.	1.02267
	30.	1.02248	30.	1.02266
	40.	1.02267	40.	1.02267
	50.	1.02267	50.	1.02267

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 415 HEAD1	0.0	1.02156	0.0	1.02268
	5.0	1.02179	5.0	1.02268
	10.	1.02188	10.	1.02267
	20.	1.02194	20.	1.02269
	30.	1.02200	30.	1.02266
	40.	1.02214	40.	1.02267
	60.	1.02219	60.	1.02266
	80.	1.02223	80.	1.02266
STATION 416 HEAD2	0.0	1.02196	0.0	1.02254
	5.0	1.02242	5.0	1.02255
	10.	1.02260	10.	1.02256
	20.	1.02274	20.	1.02257
	30.	1.02278	30.	1.02257
	40.	1.02280	40.	1.02258
	60.	1.02286	60.	1.02257
	85.	1.02289	85.	1.02257
STATION 417 HEAD3	0.0	1.02205	0.0	1.02248
	5.0	1.02224	5.0	1.02249
	10.	1.02230	10.	1.02250
	15.	1.02234	15.	1.02249
	20.	1.02244	20.	1.02247
STATION 418 HEAD4	0.0	1.02254	0.0	1.02205
	5.0	1.02255	5.0	1.02205
	10.	1.02260	10.	1.02204
	15.	1.02265	15.	1.02204
STATION 419 GREEN	0.0	1.02323	0.0	1.02253
	5.0	1.02349	5.0	1.02253
	10.	1.02359	10.	1.02254
	20.	1.02362	20.	1.02255
	30.	1.02362	30.	1.02255
	40.	1.02364	40.	1.02257
	60.	1.02363	50.	1.02257
			70.	1.02258
	85.	1.02367	85.	1.02257
	99.	1.02371	99.	1.02257

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 420 CUTTS	0.0	1.02062	0.0	1.02252
	5.0	1.02189	5.0	1.02253
	10.	1.02208	10.	1.02254
	20.	1.02218	20.	1.02254
	30.	1.02226	30.	1.02255
	40.	1.02230	40.	1.02256
	50.	1.02233	50.	1.02255
	62.	1.02235	62.	1.02257
STATION 421 GLEN	0.0	1.02149	0.0	1.02197
	5.0	1.02225	5.0	1.02198
	10.	1.02247	10.	1.02199
	20.	1.02249	20.	1.02199
	30.	1.02252	30.	1.02200
	40.	1.02253		
	50.	1.02254	50.	1.02200
STATION 422 ELGIN	0.0	1.02004	0.0	1.02230
	5.0	1.02200	5.0	1.02231
	10.	1.02216	10.	1.02232
	15.	1.02219	15.	1.02235
	20.	1.02221	20.	1.02236
	25.	1.02225	25.	1.02240
	27.	1.02226	27.	1.02241
STATION 423 WAUNA	0.0	1.02007		
	4.0	1.02209	3.0	1.02231
	8.0	1.02242	6.0	1.02235
	10.	1.02246	10.	1.02237
STATION 426 WARREN	0.0	1.02164	0.0	1.02190
	5.0	1.02177	5.0	1.02189
	10.	1.02184	10.	1.02188
	15.	1.02197	15.	1.02191
	20.	1.02224		
	22.	1.02235	22.	1.02189
STATION 427 CROMWELL	NA	NA		
			5.0	1.02364
			10.	1.02364
			20.	1.02364
			30.	1.02364

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 432 WHITEMAN	0.0	1.02190	0.0	1.02260
			3.0	1.02260
	5.0	1.02196	5.0	1.02261
	10.	1.02210	10.	1.02261
	20.	1.02211	20.	1.02266
			30.	1.02272
	30.	1.02229	40.	1.02272
	54.	1.02245	50.	1.02273
	64.	1.02252	64.	1.02274
STATION 433 HERRON	0.0	1.02061	0.0	1.02279
	5.0	1.02214	5.0	1.02276
	10.	1.02213	10.	1.02283
	20.	1.02219	20.	1.02277
	30.	1.02217	30.	1.02282
	54.	1.02212	50.	1.02286
			54.	1.02287
STATION 434 ROCKY	0.0	1.01867	0.0	1.02269
	2.0	1.02118	2.0	1.02270
	5.0	1.02171	5.0	1.02275
	10.	1.02183	10.	1.02282
	15.	1.02189		
	18.	1.02193	18.	1.02283
STATION 436 DUTCHESS	0.0	1.01961	0.0	1.02248
			2.0	1.02249
	5.0	1.02182	5.0	1.02249
	10.	1.02199	10.	1.02252
			15.	1.02260
			20.	1.02260
	25.	1.02207	25.	1.02261
STATION 437 ALLYN	0.0	1.01169	0.0	1.02149
			1.0	1.02148
	2.0	1.02138	2.0	1.02149
	4.0	1.02199	4.0	1.02149
STATION 438 DOUGALL	0.0	1.02000	0.0	1.02213
	5.0	1.02158	5.0	1.02213
	10.	1.02177	10.	1.02214
	15.	1.02197	15.	1.02214
	25.	1.02202		
	29.	1.02204	29.	1.02218

SOUTH PUGET SOUND
HISTORICAL DENSITY DATA
1957 TO 1958

	MAXIMUM STRATIFICATION		MINIMUM STRATIFICATION	
	METERS	SPECIFIC GRAVITY	METERS	SPECIFIC GRAVITY
STATION 455 PEARCE	NA	NA	0.0	1.02063
			2.0	1.02094
			4.0	1.02115
			8.0	1.02128
			13.	1.02144
STATION 458 GRAHAM	0.0	1.02045	0.0	1.02186
	5.0	1.02077	5.0	1.02186
	10.	1.02126	10.	1.02186
	15.	1.02133		
	18.	1.02137	18.	1.02185
STATION 459 GRANT	0.0	1.02136	0.0	1.02164
	5.0	1.02154	5.0	1.02164
	10.	1.02203	10.	1.02165
	15.	1.02228	15.	1.02166
	20.	1.02253	20.	1.02166
STATION 480 CANNERY	0.0	1.02179	0.0	1.02195
	2.0	1.02187	2.0	1.02196
	5.0	1.02186	5.0	1.02195
STATION 482 CHURCH	0.0	1.01618	0.0	1.02186
	2.0	1.01828	2.0	1.02185
	4.0	1.01848	4.0	1.02184
	7.0	1.01868	7.0	1.02183
	10.	1.01880	10.	1.02186
	16.	1.01904	16.	1.02185
STATION 485 SHELTON	0.0	1.01281	0.0	1.02000
	2.0	1.01723	2.0	1.02001
	4.0	1.01758	4.0	1.02003
	7.0	1.01894	7.0	1.02002
	10.	1.01918		
	15.	1.01955		
	22.	1.02007	22.	1.02002
STATION 486 OAKLAND	NA	NA	0.0	1.01917
			1.0	1.01947
			2.0	1.01978

APPENDIX C

DILUTION REQUIREMENT ANALYSIS

APPENDIX C

DILUTION REQUIREMENT ANALYSIS

Table C-1 was constructed to show EPA priority pollutants, their saltwater aquatic life criteria, concentrations in secondary and tertiary effluents, and dilution required to meet aquatic life criteria at maximum and most common concentrations.

EPA priority pollutant saltwater criteria were taken from the Federal Registers of: Nov. 28, 1980; Aug. 13, 1981; and February 7, 1984 (FR 1980; FR 1981; FR 1984).

The concentrations of priority pollutants in municipal wastewater are listed from a variety of sources:

- EPA maximum value: The maximum value detected in treated effluent from fifty publicly owned treatment works (POTWs). THe POTWs included both secondary and tertiary plants. Each was sampled 60 to 303 times for priority pollutants (Burns and Roe Industrial Services Corp., 1982).

- EPA median values: Values represent the median influent concentration multiplied by the median removal efficiency reported for activated sludge (A.S.) and trickling filter (T.F.) plants (Burns and Roe Industrial Services Corp., 1982).

- Los Angeles POTWs: Mean secondary municipal effluent concentration from Los Angeles County Joint Water Pollution Control Plants (JWPCP)(Mills, Dean and Porcella, et al., 1982).

- WDOE records: Geometric means or the range of metal concentrations in secondary treatment plant effluents summarized from 14 to 19 samples (Heffner, 1982).

- Orange County: Geometric mean concentrations from a trickling filter (T.F.) and an activated sludge (A.S.) POTW in Orange County (McCarty and Reinhard, 1980).

- EPATOX: Values represent the range of concentrations in nine samples from five municipal effluents in EPA Region 10. Samples were taken in 1978 and 1980 (EPATOX, 1981).

- Other: Concentrations of individual pollutants from various journal articles.

- Most Common: Concentrations picked as the most representative of secondary municipal effluents, based on concentrations, or ranges of concentrations, listed in Table C-1.

Table C-1. EPA priority pollutants, their: saltwater aquatic life criteria, concentrations in secondary and tertiary municipal effluents, and dilution required to meet aquatic life criteria at maximum and most common concentrations. All concentrations are in ug/L.

POLLUTANT	SALTWATER CRITERIA				MUNICIPAL EFFLUENTS										DILUTION REQUIREMENTS			
	ACUTE	CHRONIC	24HR.	ANYTIME	EPA 1/ maximum value	EPA 2/ median values AS	EPA 2/ median values TF	Los 3/ Angeles POTWs	WDOE 4/ records	Orange 5/ County TF	Orange 5/ County AS	EPATOX 6/	OTHER	MOST COMMON	ACUTE Most Common	ACUTE Maximum	CHRONIC Most Common	CHRONIC Maximum
Acenaphthene	970	710	-	-	25							<0.1		<0.1	0	0	0	0
Acrolein	55	-	-	-								<0.01						
Acrylonitrile	-	-	-	-								<0.01						
Dieldrin	-	-	0.0019	0.71	0.1							<0.001-0.004		0.001	0	0	0	52
Aldrin	-	-	-	1.3	6.0							<0.001-0.2		0.001	0	4		
Antimony	-	-	-	-	69			3.0				<0.1-1.2		0.1				
Arsenic			7/															
__Arsenic (+3)	508	-	(63)	(120)	122			4.0				<0.1-4.3		5	0	0 (0)	(0)	(1)
__Arsenic(+5)	23.9	-	-	-														
__Monosodium methanearsenate	-	-	-	-														
Asbestos	-	-	-	-														
Benzene	5100	700	-	-	72	0.5	0.4	22				<0.01-0.1		10	0	0	0	0
Benzidine	-	-	-	-								<0.01						
Beryllium	-	-	-	-	12			0.2				<0.01-1.3						
Cadmium	-	-	4.5(12)	59(38)	199	0.5	3.0	8.0	<1-20			<0.01-1.2		10	0 (0)	2 (4)	1 (0)	43 (16)
Carbon Tetrachloride	50,000	-	-	-	67			16			<0.1	<0.01		5	0	0		
Chlordane	-	-	0.004	0.09	0.2							<0.001		0.001	0	1	0	49
Chlorinated Benzenes	160	129	-	-	330*									5*	0*	1*	0*	2*
__Hexachlorobenzene	-	-	-	-	10							<0.01						
__1,2,4,5-tetrachlorobenzene	-	-	-	-														
__Pentachlorobenzene	-	-	-	-														
__Trichlorobenzene	-	-	-	-	310					0.46	0.18	<0.01		0.2				
__Monochlorobenzene	-	-	-	-	9			3		2.5	0.11	<0.01		2				
Chlorinated Ethanes	-	-	-	-														
__Monochloroethane	-	-	-	-	960							<0.01						
__1,1-dichloroethane	-	-	-	-	6							<0.01						
__1,2-dichloroethane	13,000	-	-	-	13,000			11				<0.01		1	0	0		
__1,1,1-trichloroethane	31,200	-	-	-	3500	4	2	180		4.7	2.9	<0.01-0.5		25	0	0		
__1,1,2-trichloroethane	-	-	-	-	6							<0.01						
__1,1,1,2-tetrachloroethane	-	-	-	-														
__1,1,2,2-tetrachloroethane	9020	-	-	-	5							<0.01-1		0.01	0	0		
__Pentachloroethane	390	281	-	-											0	0	0	0
__Hexachloroethane	940	-	-	-								<0.01		<0.01	0	0		
Chlorinated Naphthalenes	7.5	-	-	-								<0.01		<0.01	0	0		

All footnotes on last page.

Table C-1. continued. EPA priority pollutants, their: saltwater aquatic life criteria, concentrations in secondary and tertiary municipal effluents, and dilution required to meet aquatic life criteria at maximum and most common concentrations. All concentrations are in ug/L.

POLLUTANT	SALTWATER CRITERIA ACUTE	CHRONIC	24HR.	ANYTIME	MUNICIPAL EFFLUENTS EPA 1/ maximum value	EPA 2/ median values AS	TF	Los Angeles 3/ POTWs	WDOE 4/ records	Orange County 5/ TF	AS	EPATOX 6/	OTHER	MOST COMMON	DILUTION REQUIREMENTS ACUTE Most Common	Maximum	CHRONIC Most Common	Maximum
Chlorinated Phenols	-	-	-	-														
__4-chloro-3-methylphenol	-	-	-	-	4													
__2,4,6-trichlorophenol	-	-	-	-	3							<0.01-0.4		0.1				
__2,3,5,6-tetrachlorophenol	440	-	-	-											0	0		
__4-chlorophenol	29,700	-	-	-											0	0		
__3-chlorophenol	-	-	-	-														
__2,3-dichlorophenol	-	-	-	-														
__2,5-dichlorophenol	-	-	-	-														
__2,6-dichlorophenol	-	-	-	-														
__3,4-dichlorophenol	-	-	-	-														
__2,3,4,6-tetrachlorophenol	-	-	-	-														
__2,4,5-trichlorophenol	-	-	-	-								<0.01						
__2-methyl-4-chlorophenol	-	-	-	-														
__3-methyl-6-chlorophenol	-	-	-	-														
Chloroalkyl Ethers	-	-	-	-								<0.01						
__bis(chloromethyl)ether	-	-	-	-								<0.01						
__bis(2-chloroethyl)ether	-	-	-	-								<0.01						
__bis(2-chloroisopropyl)ether	-	-	-	-								<0.01						
Chloroform	-	-	-	-	106	3	2	30		1.6	2.9	0.5-3		5				
2-chlorophenol	-	-	-	-	5							<0.01						
Chromium																		
__Chromium(+6)	-	-	10(54)	1260(1200)											0	0	0	0
__Chromium(+3)	10,300	-	-	-	890	17	55	90	<2-30			1-8		50	0	0		
Copper	-	-	4(2)	23(3.2)	255	21	67	50	20			7-83		30	0 (0)	10 (79)	7 (14)	63 (127)
Cyanide(free-HCN+,CN-)	30	2	(0.57)	(1)	2140	95	107					<0.001-0.04		0.01	0 (0)	70(2139)	0 (0)	1069 (3754)
DDT & metabolites	-	-	0.001	0.13	0.5							<0.001-0.04		0.005	0	3	4	499
__DDD(TDE)	3.6	-	-	-	0.3							<0.001-0.12		0.005	0	0		
__DDE	14	-	-	-								<0.001-0.009		0.005	0	0		
Dichlorobenzenes	1970	-	-	-	40*					2.4	0.67	<0.01-0.1		1.0*	0*	0*		
Dichlorobenzidines	-	-	-	-	5							<0.01						
Dichloroethylenes	224,000	-	-	-	17	0.1	0.1					<0.01-3.0		0.1	0	0		
__1,1-dichloroethylene	224,000	-	-	-	11							<0.01		<0.01	0	0		
2,4-dichlorophenol	-	-	-	-	470							<0.01-1						
Dichloropropanes	10,300	3040	-	-	8							<0.01-0.3		0.01	0	0	0	0
Dichloropropenes	790	-	-	-								<0.01		<0.01	0	0		

All footnotes on last page.

Table C-1. continued. EPA priority pollutants, their: saltwater aquatic life criteria, concentrations in secondary and tertiary municipal effluents, and dilution required to meet aquatic life criteria at maximum and most common concentrations. All concentrations are in ug/L.

POLLUTANT	SALTWATER CRITERIA				MUNICIPAL EFFLUENTS									DILUTION REQUIREMENTS			
														ACUTE		CHRONIC	
	ACUTE	CHRONIC	24HR.	ANYTIME	EPA 1/ maximum value	EPA 2/ median values AS	TF	Los 3/ Angeles POTWs	WDOE 4/ records	Orange 5/ County TF	AS	EPATOX 6/	OTHER MOST COMMON	Most Common	Maximum	Most Common	Maximum
2,4-dimethylphenol	-	-	-	-	10							<0.01					
2,4-dinitrotoluene	590	-	-	-	2							<0.01	<0.01	0	0		
1,2-diphenylhydrazine	-	-	-	-	2							<0.01					
Endosulfan	-	-	0.0087	0.034	2*							<0.001	0.001	0*	58*	0*	229*
Endrin	-	-	0.0023	0.037								<0.001	0.001	0		0	
Ethylbenzene	430	-	-	-	120	0.8	0.8	18		1.4	0.04	<0.01	1	0	0		
Fluoroanthene	40	16	-	-	33							<0.01	<0.01	0	0	0	1
Haloethers	-	-	-	-	6							<0.01					
__2-chloroethyl vinyl ether	-	-	-	-													
__4-bromophenyl phenyl ether	-	-	-	-													
__4-chlorophenyl phenyl ether	-	-	-	-													
__bis(2-chloroethoxy)methane	-	-	-	-													
Halomethanes	12,000	6400	-	-	62,000*	20*	9*	10*				<0.01-9*	10*	0*	4*	0*	9*
__Bromomethane	-	-	-	-													
__Chloromethane	-	-	-	-													
__Chlorodibromomethane	-	-	-	-													
__Dichloromethane	-	-	-	-													
__Dichlorobromomethane	-	-	-	-													
__Dichlorodifluoromethane	-	-	-	-													
__Trichlorofluoromethane	-	-	-	-													
Heptachlor	-	-	0.0036	0.053	2*							<0.001	0.001	0*	37*	0*	555*
Hexachlorobutadiene	32	-	-	-								<0.001					
Hexachlorocyclohexanes	-	-	-	-													
__Lindane (gamma BHC)	0.16	-	-	-	1.4					0.19	0.15	<0.001-0.09	0.005	0	8		
__BHC isomer mixtures	0.34	-	-	-	3.8*							<0.001-0.2*	0.01*	0*	10*		
____alpha BHC	-	-	-	-	0.7							<0.001-0.23	0.001				
____beta BHC	-	-	-	-	1.7							<0.001	<0.00				
____delta BHC	-	-	-	-								<0.001-0.004					
Hexachlorocyclopentadiene	7	-	-	-								<0.001	<0.001	0	0		
Isophorone	12,900	-	-	-	12							<0.01-0.3	0.1	0	0		
Lead	688	25	(8.6)	(220)	400	10	42	3	<3-200			2-14	30	0 (0)	0 (1)	0 (2)	15 (46)
Mercury	-	-	0.1(0.1)	3.7(1.9	2	0.1	0.2	0.1				<0.01-0.2	0.2	0 (0)	0 (0)	1 (1)	19 (19)
Naphthalene	2350	-	-	-	24	0.2				0.57	0.06	<0.01-0.2	0.2	0	0		
Nickel	-	-	7.1	140	679	37	27	220	<3-50			5-50	30	0	4	3	95
Nitrobenzene	6680	-	-	-	4							<0.01		0	0		

All footnotes on last page.

Table C-1. continued. EPA priority pollutants, their: saltwater aquatic life criteria, concentrations in secondary and tertiary municipal effluents, and dilution required to meet aquatic life criteria at maximum and most common concentrations. All concentrations are in ug/L.

POLLUTANT	SALTWATER CRITERIA				MUNICIPAL EFFLUENTS										DILUTION REQUIREMENTS			
															ACUTE		CHRONIC	
	ACUTE	CHRONIC	24HR.	ANYTIME	EPA 1/ maximum value	EPA 2/ median values AS	TF	Los Angeles 3/ POTWs	WDOE 4/ records	Orange County 5/ TF	AS	EPATOX 6/	OTHER	MOST COMMON	Most Common	Maximum	Most Common	Maximum
Nitrophenols	4850	-	-	-	240*										0*	0*		
__2,4-dinitro-o-cresol	-	-	-	-								<0.01						
__Dinitrophenols	-	-	-	-								<0.01						
__Mononitrophenols	-	-	-	-	235*							<0.01						
__Trinitrophenols	-	-	-	-	4							<0.01						
Nitrosamines	33	-	-	-								<0.01			0	0		
__Dimethylnitrosamine	-	-	-	-														
__Diphenylnitrosamine	-	-	-	-														
__Di-n-propylnitrosamine	-	-	-	-														
Pentachlorophenol	53	34	-	-	440							<0.01-2	2 †	2	0	7	0	12
Phenol	5800	-	-	-	89	0.8		14				<0.01-24		10	0	0		
Phthalate Esters	2944	-	-	-	2750*										0*	0*		
__bis(2-ethylhexyl)phthalate	-	-	-	-	418	10	21	4		20	9.3	<0.01-20		10				
__Diethyl phthalate	-	-	-	-	32	0.3	-	<10				<0.01-3						
__Dimethyl phthalate	-	-	-	-	5			<10		16	5.4	<0.01-2						
__Di-n-butyl phthalate	-	-	-	-	138	1	2	90		2.9	4.4	<0.01-6						
__Di-n-octyl phthalate	-	-	-	-	12							0.1-1.1						
__n-butylbenzyl phthalate	-	-	-	-	2200	0.2	0.9					<0.01						
Polychlorinated Biphenyls	10	-	0.03	-	3.1*					3.3	0.47	<0.005	0.06 ††	0.05	0*	0*	1*	102*
Polynuclear Aromatic Hydrocarbons	300	-	-	-	100*									0.1*	0*	0*		
__Acenaphthylene	-	-	-	-	5							<0.01						
__Anthracene	-	-	-	-	32							<0.01						
__Benzo(a)anthracene	-	-	-	-	11							<0.01						
__Benzo(b)fluoranthene	-	-	-	-								<0.01						
__Benzo(k)fluoranthene	-	-	-	-								<0.01						
__Benzo(g,h,i)perylene	-	-	-	-	4							<0.01						
__Benzo(a)pyrene	-	-	-	-								<0.01						
__Chrysene	-	-	-	-	11							<0.01						
__Dibenzo(a,h)anthracene	-	-	-	-	5							<0.01						
__Fluorene	-	-	-	-	5							<0.01						
__Indeno(1,2,3-c,d)pyrene	-	-	-	-	42							<0.01						
__Phenanthrene	-	-	-	-	32							<0.01						
__Pyrene	-	-	-	-	11							<0.01-0.5						

All footnotes on last page.

Table C-1. continued. EPA priority pollutants, their: saltwater aquatic life criteria, concentrations in secondary and tertiary municipal effluents, and dilution required to meet aquatic life criteria at maximum and most common concentrations. All concentrations are in ug/L.

POLLUTANT	SALTWATER CRITERIA				MUNICIPAL EFFLUENTS										DILUTION REQUIREMENTS			
	ACUTE	CHRONIC	24HR.	ANYTIME	EPA 1/ maximum value	EPA 2/ median values AS	EPA 2/ median values TF	Los Angeles 3/ POTWs	WDOE 4/ records	Orange County 5/ TF	Orange County 5/ AS	EPATOX 6/	OTHER	MOST COMMON	ACUTE Most Common	ACUTE Maximum	CHRONIC Most Common	CHRONIC Maximum
Selenium	-	-	-	-	1045			7				<0.01-0.8						
__Selenite	-	-	54	410														
__Selenate	-	-	-	-														
Silver	-	-	-	2.3	44	1	1	2	<1-3			<0.01-7		5	1	18		
Tetrachloroethylene	10,200	450	-	-	1200	4	1	160		0.6	1.5	<0.01-7		10	0	0	0	2
Thallium	2130	-	-	-	2			1				<0.01-5		1	0	0		
Toluene	6300	5000	-	-	1100	2	3	24				<0.01-240		10	0	0	0	0
Toxaphene	-	-	-	0.07								<0.02		<0.02	0	0		
Trichloroethylene	2000	-	-	-	630	3	1	12		0.9	-	<0.01-8		3	0	0		
Vinyl Chloride (Chloroethylene)	-	-	-	-	5800							<0.01						
Zinc	-	-	58	170	3800	52	156	260	72			40-310		100	0	21	1	65

1/EPA maximum value from Burns and Roe Industrial Services Corp., 1982, Tables 4 and 7.
2/EPA median influent concentrations times percent removal for activated sludge (AS) and trickling filter (TF) plants. Data from Burns and Roe Industrial Services Corp., 1982, Tables 9 and 11.
3/Secondary effluent values for Los Angeles County publicly owned treatment works (POTWs). Data are as presented in Table III-55 of Mills, Dean and Porcella, et al., 1982.
4/Geometric mean or range of concentration(s) from secondary treatment plants as presented in Heffner, 1982.
5/Orange County Sanitation District trickling filter (TF) and activated sludge (AS) effluent values in Table IX(QI) of McCarty and Reinhard, 1980.
6/EPATOX STORET file treatment plant effluent values from EPA, 1981.
7/( ) = Proposed criterion promulgated by EPA:FR, 1984.
†Data from Buhler, Rasmusson and Nakaue, 1973.
††Data from Table IX-5 of Dexter, Anderson, Quinlan, et al., 1981.
*Summation of concentrations of chemicals in group.
TF = trickling filter
AS = activated sludge
< = less than

It is important to note that metals and cyanide effluent concentrations listed in Table C-1 are for total fraction. As a generalization, criteria were applied to these data even if the criteria specified a particular fraction or ionic state; e.g., arsenic +3, active copper, and free cyanide, etc.

The simple dilution requirements have been calculated for both the maximum and the most common effluent considerations to meet EPA marine acute and chronic toxicity criteria. For our purposes, a generalization has been made concerning the aquatic criteria:

- acute = anytime
- chronic = 24-hour or 30-day

Although this is not strictly correct, the generalization provides a reasonable method to evaluate all the various criteria. For more information on the difference between these terms, please see the November 28, 1980, Federal Registers. The dilution factor does not consider individual pollutant's chemical interactions, fate, transport mechanisms; e.g., bioaccumulation potentials, synergistic effects, speciation in marine water, volitilization, etc. It also does not consider the background concentrations of pollutants in the receiving water.

Table C-2 lists background concentrations of some metals, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons (PNA) in Puget Sound. The data are taken from several references, and include only concentrations of these pollutants in Budd Inlet or outside the industrialized urban embayments of Puget Sound; e.g., Commencement Bay, Elliott Bay, etc.

Table C-2. Concentrations of selected priority pollutants in Puget Sound waters. All concentrations in ug/L unless otherwise noted.

	Central Puget Sound[a]		Budd Inlet[b]	Point No Point[c]	
	Total	Dissolved	Converted Particulate	Soluble	Total
Metals					
Arsenic	1.5-2.0	1.4-1.8	<0.19	--	--
Cadmium	0.3	0.3	--	0.3	0.3
Chromium	--	--	0.21	--	--
Copper	0.5	0.3-0.4	0.40	0.15	0.17
Lead	2.8	--	0.22	4.2	4.4
Nickel	1.3	0.3-0.4	0.10	0.30	0.40
Selenium	--	--	0.01		
Zinc	1.9	--	1.55	1.1-2.0	1.3-2.3

	Water	Suspended Particulates (ug/g)	Surface Film
PCB[d]	0.004	0.100	0.012

Polynuclear Aromatic Hydrocarbons[b]	Budd Inlet Converted Particulate	Budd Inlet Dissolved
Naphthalene	0.0002	0.021
Fluorene	0.0004	<0.001
Phenanthrene	0.0010	0.005
Anthracene	0.0008	<0.001
Fluoranthene	0.0007	0.025
Pyrene	0.0018	0.003
Benzo(a)anthracene	<0.0001	<0.001
Chrysene	<0.0001	<0.001
Benzo(a)pyrene	<0.0001	<0.001

[a]Arsenic values from Carpenter, Peterson, and Jahnke, 1978-(Figure 1). Dissolved cadmium, copper, and nickel values from Curl, 1982-(Table 5.6). Total cadmium, copper, lead, nickel, and zinc from Schell, et al., 1977-(Table 6.1).

[b]Metal values converted from Table 2 of Riley, et al., 1980 using Olympia suspended matter concentrations (ppm, dry weight) and applying 8.6 mg/L dry weight suspended load (Table 1) value for Olympia. Dissolved polynuclear aromatic hydrocarbon (PNA) from Table 11, and suspended matter PNA values from Table 15.

[c]Values taken from Schell, et al., 1977-(Table 4.1).

[d]Values from Pavlou and Dexter, 1979-(Table 1, Main Basin).

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APPENDIX D

SAMPLE DILUTION MODEL RUN

APPENDIX D

SAMPLE DILUTION MODEL* RUN

The sample model output shown in this Appendix is for the Station #406, Nisqually Reach. Figure 8 in the main report shows its location. The Density Profile is the case of maximum stratification for the period of record. The flowrate is 1.0 MGD with the diffuser at maximum depth of 123 meters. The units are in meters and m/s. Other input parameters are: port angle (zero degrees), discharge density (1.0), number of ports or diffuser size (3 ports), and port diameter (.112 meters or .367 ft). Port velocity is calculated from port flowrate and diameter. Table D-1 shows the output results.

The printout interval was selected at 5 meters; however, a smaller interval could be selected if finer resolution is needed. The output variables trace the plume and its characteristics along its trajectory. T is a time based on the centerline velocity. S is the distance along the centerline. X and Z are distances measured horizontally in the direction of the discharge and vertically from the water's surface to the center of the plume, respectively. Elevation is the vertical distance to the centerline of the plume from the level of the discharge. D is the diameter of the plume and DILN is the centerline dilution. The dilution and height of rise to the trapping level are also given.

In the example shown, the centerline of the plume rose 19.2 percent of the total depth, which was to 99.4 meters, and attained a centerline dilution of 176.3 to 1. In the terminology of the problem, the plume was "trapped" at this level. This means that the buoyancy of the plume equalled the buoyancy of the ambient water at this point. Since the plume attained a 176:1 dilution ratio, it passed the 100:1 dilution criteria originally set forth.

* EPA PLUME model (A. Teeter and D. Baumgartner. 1979) was used for the sample initial dilution calculation.

```
053 PLUME VERSION 2.3 9/12/77
0*********A BUOYANT PLUME IN A DENSITY STRATIFIED MEDIA*********
0NISQUALLY REACH PLUME DATA 5/54 MAXIMUM
-CASE NO.    1 INITIAL CONDITIONS .....
0     UNITS: MKS
-    PORT ANGLE . . . . . . . . . . . . . .      0.0
0     FROUDE NUMBER . . . . . . . . . . . .     89.3
      LENGHT FOR FLOW ESTABLISHMENT . .          .63
     INTEGRATION STEP LENGTH .. . . . . .        .117
     PRINTOUT INTERVAL   . . . . . . . .        5.00
     X0 .. . . . . . . . . . . . . . . .         .62
     Z0   . . . . . . . . . . . . . . . .     122.94
     DISCHARGE DENSITY  . . . . . . . . .       1.00000
     PORT DEPTH    . . . . . . . . . . . .    123.00
     FLOWRATE . . . . . . . . . . . . . .         .44000E-01
     NUMBER OF PORTS  . . . . . . . . . .      3.
     DISCHARGE VELOCITY . . . . . . . . .       1.49
     PORT DIAMETER   . . . . . . . . . . .       .11200E+00
  DENSITY STRATIFICATION DEPTH RHO

                                 0.00      1.01307
                                 5.00      1.02184
                                10.00      1.02187
                                20.00      1.02204
                                60.00      1.02217
                               123.00      1.02259

         T          S          X         Z          D        ELEV       THETA      DILN
       9.85       5.55       3.73     119.57      1.71       3.43       73.5     16.2492
      25.27      10.60       4.64     114.62      3.26       8.38       83.1     47.7143
      43.66      15.64       5.12     109.60      4.82      13.40       85.7     89.1494
      64.95      20.69       5.44     104.56      6.37      18.44       86.7    134.8856
      89.78      25.73       5.72      99.53      7.92      23.47       87.0    176.3410
     120.18      30.77       5.99      94.49      9.48      28.51       86.6
     166.21      35.82       6.45      89.47     11.03      33.53       78.4
     180.54      36.52       6.73      88.86     11.25      34.14        0.0
-LAST LINE ABOVE IS FOR MAXIMUM HEIGHT OF RISE.
ATRAPPING LEVEL IS       99.4 WITH DILUTION OF   177.0285
 HEIGHT OF RISE= 19.2 PERCENT OF DEPTH
    0.114 CP SECONDS EXECUTION TIME.
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Table D-1
Sample Output for a Dilution Model Run

APPENDIX E

LIST OF INDIVIDUALS
WHOSE WRITTEN COMMENTS ON THE DRAFT REPORT
WERE RECEIVED

APPENDIX E

LIST OF INDIVIDUALS WHOSE WRITTEN COMMENTS ON THE DRAFT REPORT WERE RECEIVED

Written comments were received on the draft report of Discharge Zone Classification System for Southern Puget Sound were received from following individuals:

Lacey, Olympia, Tumwater, Thurston County (LOTT) STP Phase II Project
- Gene Asselstine

Thurston County Commissioners
- George Barner
- Karen Fraser
- Les Eldridge

The Citizens Advisory Committee of LOTT II
- Charles Woelke

City of Lacey
- Mark Brown

The Advisory Committee of LOTT II
- Dave Skramstad

City of Tumwater
- Leonard Smith

Washington State Department of Fisheries
- Ronald Westley

Washington State Department of Natural Resources
- Dave Jamison

Washington State Department of Ecology
- Bob Saunders
- Tom Eaton

Nisqually Indian Tribe
- Richard Wells

Squaxin Island Tribe
- David Whitener
- Brian Wood

Parametrix, Inc.
- Waite Dalrymple

Citizen
- Nancy Kroening