Hood Canal Low Dissolved Oxygen

Preliminary Assessment and Corrective Action Plan

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The Preliminary Assessment and Corrective Action (PACA) Plan was developed through a collaborative and cooperative arrangement between the Puget Sound Action Team (Action Team), the state's partnership for Puget Sound, and the Hood Canal Coordinating Council (HCCC), the council of governments within the Hood Canal watershed. It identifies and quantifies major categories of nitrogen sources in to Hood Canal and suggests corrective actions to reduce these sources.

Acknowledgements

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Produced by Puget Sound Action Team and Hood Canal Coordinating Council

May 6, 2004

Executive Summary

The Preliminary Assessment and Corrective Action plan (PACA) strives to identify and quantify human-related sources of nitrogen that enter Hood Canal from land, surface, and groundwater. Human-related sources and activities supply nitrogen and organic material that stimulate prolific growth of plankton or algae, which initially oxygenates surface water, but the benefit only stays near the surface. Through eutrophication, excessive amounts of nutrients, such as nitrogen, enter water bodies and stimulate rapid algal growth. In a stratified water body, such as Hood Canal, the algae in the bloom can settle to deep waters where their decomposition by microorganisms can deplete the surrounding water of oxygen. This process plays a major role in the canal's hypoxic or low dissolved oxygen condition. The objective of the PACA plan is to reduce the human sources of nitrogen to help reverse the worsening hypoxic trend.

The Puget Sound Action Team (Action Team) and the Hood Canal Coordinating Council (HCCC) joined forces, in collaboration with technical experts from tribal and local governments, state and federal agencies, and interested and qualified local citizens, to: 1) develop a list of nitrogen sources from the best available information, 2) attempt to quantify and prioritize these sources, and 3) identify feasible corrective actions to keep pollution sources out of the Canal. The most feasible approaches were discussed with state agencies, local governments, tribes, and educators.

We identified six major categories of human-influenced nitrogen sources, which when combined, total between 86 and 319 tons per year:

- Human sewage (onsite systems) 39 – 241 tons
- Stormwater runoff 12– 24 tons, includes lawn fertilizers
- Chum salmon carcasses 16 – 24 tons
- Agriculture (animal) waste 18 – 22 tons
- Forestry 0.5 – 5 tons[1]
- Discharges from point sources 0.3 – 3 tons

[1] Based on 500 acres of fertilization in 2003.

These estimates were based on the best available data and the professional judgment of local and regional experts. Using adaptive management principles, we will update the PACA plan in later versions as new information becomes available.

Natural resource agencies, watershed and salmon restoration groups, the shellfish and timber industries, local and tribal governments, and environmental organizations have invested much effort and resources during the past twenty years to improve the quality of water in Hood Canal, to protect and restore fish habitat, and to restore areas to harvest shellfish. Corrective actions proposed in the PACA plan will build on, not replace, many of the useful and productive local, state, and tribal programs and activities already in place. Those include stormwater treatment, farm best management practices (BMPs), educational programs, water cleanup plans or total maximum daily loads (TMDL) and onsite sewage system permitting, monitoring, and maintenance.

Human-related sources and quantitative estimates of nitrogen inputs into Hood Canal may also need to be evaluated seasonally. Dissolved oxygen levels are lowest in late summer when recreational use and residential population peak and oceanographic conditions favor the creation of low levels of dissolved oxygen.

Reducing nitrogen inputs into the Canal is challenging because it requires separate attention, technology, and treatment practices in many cases. These approaches need to be systematic and strategic. More complex, technical solutions, public support and significant financial resources will be needed.

The PACA plan suggests actions that will help to reduce the overall nitrogen inputs into Hood Canal. Reducing the nitrogen loading from stormwater runoff and onsite sewage systems is particularly important in densely-developed areas such as Belfair, the Hoodsport area, and the north and south shores of lower Hood Canal. Nitrogen inputs from new development can be mitigated by innovative approaches such as low impact development.

Current appropriations to implement actions identified in the PACA plan total $600,000 from the state legislature, the governor, and Congress. While long-term water quality improvements will require additional funding, the current available funding should be viewed as a down-payment on a much larger investment.

The PACA plan is intended to be a living document, or blueprint, for corrective actions and communications. The recommended actions may be modified as additional information is obtained. We will work in conjunction with the larger and more comprehensive Hood Canal Dissolved Oxygen Program (HCDOP). The HCDOP is a private and public partnership that was created to aid the understanding of the Hood Canal marine and freshwater systems through monitoring and modeling of the Canal ecosystem. Working in concert with each other, the corrective actions that can be most effective will be incorporated into the broader HCDOP, so science helps to inform best management decisions, through an adaptive management approach.

I. Introduction

Oxygen is a basic biological need for aquatic life, just as it is for terrestrial life. Over the past several years data have indicated that hypoxia (low oxygen concentration of < 3ppm) in Hood Canal has become more severe. In the past two years, fish died during low oxygen conditions, and as a result, the Washington Department of Fish and Wildlife (Fish and Wildlife) enacted unprecedented fishing closures.

According to the Washington State Department of Ecology's (Ecology) evaluation of marine water quality monitoring indices, Hood Canal is considered to be of 'very high concern,' showing both high natural sensitivity to nutrient inputs and a strong probability that human activities are exacerbating water quality degradation (Ecology, 2001). Appendix A summarizes Ecology's marine water quality measures and their current and proposed water quality status listings under Section 303(d) of the Clean Water Act.

Evidence indicates that human-related sources of nutrient inputs are contributing to worsening hypoxia or low dissolved oxygen problems in the main body of Hood Canal. While further study and modeling is needed and anticipated, it is prudent to begin taking actions now to reduce nitrogen input into Hood Canal based on existing information.

Background

Hood Canal, located on the western side of the main Puget Sound basin, is an L-shaped fjord that is roughly 60 miles in length, and contains approximately 180 miles of shoreline (Figure 1). The last 15 miles of the Canal forms a bend to the east at the mouth of the Skokomish River. The Canal's width ranges from roughly one-half mile to four miles. Hood Canal lies in a furrow carved by past ice ages and is quite deep in the center reaching depths of 500 feet. A critical feature is the sill or shallow area at the north end that transects the Canal, east to west, south of the Hood Canal Bridge. This area is considerably shallower than areas just north or south of the sill. This sill tends to limit water exchange going into and out of the Canal.

The Canal is an estuary with five major rivers discharging to the Canal from the Olympic Mountains. Fresher water tends to layer on top of colder, more saline water, resulting in strong stratification during spring through fall especially. Fresh water on the surface influences circulation to the greatest degree, and surface waters generally flow northward. The water at depth has a higher salinity and is drawn southward into the Canal as the fresher water flows north. The dynamics of circulation and mixing of the canal's waters are complex, but definitely add to the conditions that naturally contribute to hypoxia. Although natural conditions play a significant role, so does the increasing human population that reside on the shores and surrounding hills of the canal.

For this plan, we reviewed 2000 census data (Figure 2). We estimated that nearly 54,000 people reside in the Hood Canal watershed. Because census data do not match up completely with the watershed boundary, estimates were made at the boundaries of the watershed. It is likely that the results slightly overestimate actual population within the Hood Canal watershed.

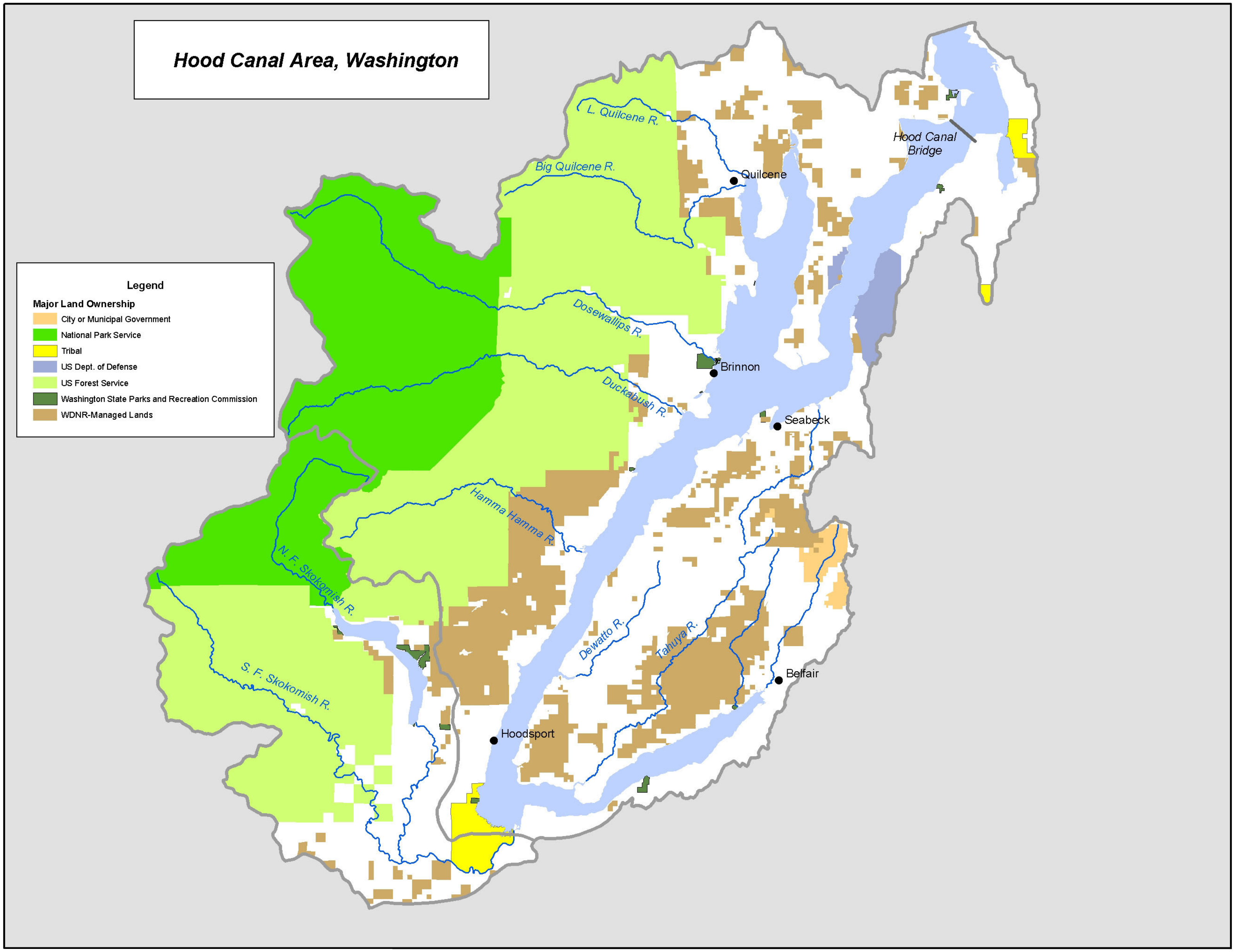

Figure 1. Hood Canal

Low dissolved oxygen concentrations in southern Hood Canal have been a problem for some time. The University of Washington (Collias, *et al.* 1974) recorded low dissolved oxygen as early as the 1950s. At that time the hypoxia was largely confined to Lynch Cove and southern Hood Canal and lasted for three to six months. In 1991, scientists from the NOAA/Pacific Marine Environmental Laboratory, noted that low oxygen concentrations in Lynch Cove appeared to be getting worse, and speculated that human-related or anthropogenic sources of nitrogen were likely to be a factor (Curl and Paulson, 1991).

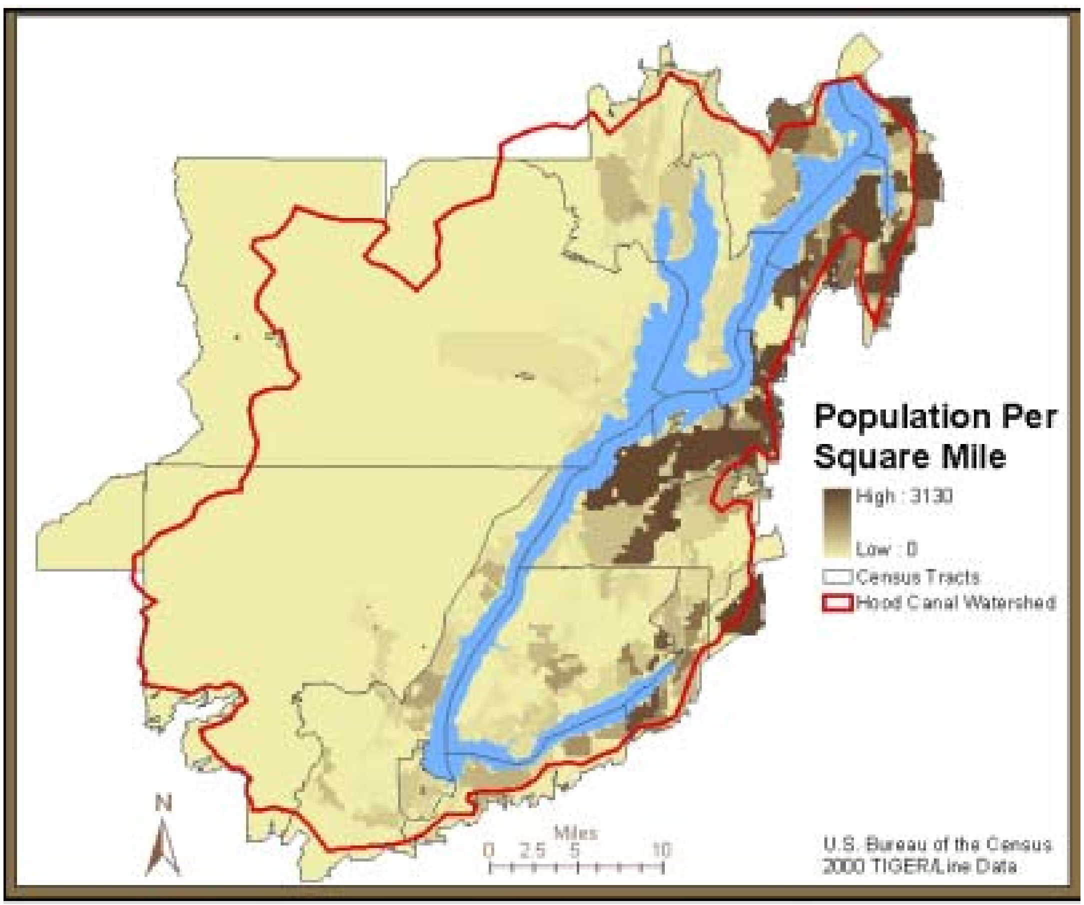

Figure 2. Population Density in the Hood Canal Watershed.

Reporting on results from the Puget Sound Ambient Monitoring Program (PSAMP), several reports from Ecology during the 1990s showed more months with dissolved oxygen below biologically relevant (safe) thresholds than were observed during the 1950s (Newton *et al.*, 1995, Newton *et al.*, 1998, Newton *et al*., 2002).[2] At Ecology's monitoring stations in both south (Sisters Point) and north (Bangor) Hood Canal, data showed that the south spent as many as 12 months in hypoxia, while the north--where hypoxia was relatively new on the scene--experienced as many as six months at biological stress levels. These observations led researchers to conclude that dissolved oxygen conditions may be deteriorating in southern Hood Canal; that low dissolved oxygen conditions may be spreading northwards; and that eutrophication (the accelerated production of marine plant matter) could be one of the processes contributing to this change (Newton *et al.,* 2002). A significant, extended hypoxia event in Hood Canal in 2002, followed by a rare spring fish kill in 2003 and a widespread kill in September 2003, increased the public and natural resource managers' concerns.

While all the information that is needed to quantitatively resolve which factors contribute to low oxygen in Hood Canal is not known, researchers observe:

1) Hypoxia is increasing in frequency and extent in Hood Canal.
2) Newton *et al.* (1995) conducted experiments that showed substantial enhancement of algal production by as much as 300 percent in Hood Canal when nitrogen was added. This indicates that increasing nitrogen could stimulate excess algal production and decrease deep-water oxygen concentrations when this biomass sinks to the bottom.
3) The factors controlling oxygen in Hood Canal include production of algal biomass (dependent on light and nutrient availability), ocean inputs, river inflow, the canal's flushing time, and the canal's "layering of water" or stratification.
4) Mobile marine life (e.g., fish, crab and shrimp) respond to hypoxia by trying to avoid the hypoxic zones, based on observations of numerous fish displacements in the water column and movement toward shore. Additionally, scientists have documented fish kills with organisms washing ashore, and over large areas of the seabed littered with dead organisms.
5) Oceanographers generally agree that the input of nitrogen from the incoming, deep ocean water exceeds the human-related nitrogen contribution. However, nitrogen from human sources is of a magnitude that could account for declines in oxygen, and definitely contributes to decreases in dissolved oxygen. Furthermore, existing data provide the basis for fairly simple calculations related to nitrogen that enters the canal via human sources which may be more significant when we factor in when (seasonally) and where (geographically, in the 60-mile range) nitrogen enter the system.
6) Data assembled by the HCDOP show that the winter 2004 oxygen levels in southern Hood Canal are the lowest on record (HCDOPa, 2004). While it is difficult to predict the full implications of these data, it does suggest that oxygen levels in Hood Canal are currently below an acceptable threshold and may reach lethal levels during the summer and fall of 2004.

[2] 5 mg/L = biological stress; 3 mg/L = hypoxia upper limit

Role of Nitrogen

While nitrogen is essential to living organisms and marine systems like Hood Canal, excess nitrogen can harm marine life by contributing to depletion of oxygen levels in some water bodies (Bricker, *et al.*, 1999; CENR, 2003; NRC, 2000). Through the process of eutrophication, excessive amounts of nutrients, such as nitrogen, enter aquatic environments and stimulate rapid algal growth. Initially, the algal blooms elevate surface water dissolved oxygen, but as they sink toward the deeper water and lose their ability to photosynthesize, they die and decompose, thereby using up oxygen at depth. The continuing inoculation of nitrogen in surface waters causes repeated blooms and die-offs that overall depress mid-and lower-depth waters' dissolved oxygen.

While there is uncertainty about the role of nitrogen loadings in the dissolved oxygen problems of the Hood Canal ecosystem, evidence from other areas suggest that human contributions to eutrophic conditions are substantial (Bricker, *et al.*, 1999). Other nutrients such as phosphorous, silicon, and iron, also may affect dissolved oxygen levels, but these are considered by many researchers to be secondary to the effects of nitrogen in marine environments (NRC, 2000). Experiments in Hood Canal have shown that algal production in the surface waters of the canal is stimulated by the introduction of increased nutrients (Newton, *et al*. 1995). This implies that excess nutrients that enter Hood Canal are increasing the growth of algae in the canal and contribute to depletion of oxygen in deeper waters by the process described above.

Purpose and Scope

The Hood Canal Low Dissolved Oxygen PACA Plan is part of a larger, more comprehensive effort known as the HCDOP (HCDOP). Details of the effort are found on the Internet at: **http://www.prism.washington.edu/hcdop/index.html**. A group of some 20 federal, tribal, state and local governmental agencies and non-profit organizations are involved with the HCDOP. The proposed three-year HCDOP will provide important new monitoring data, analysis, and modeling results that will increase our knowledge about human and natural cause-and-effect relationships for low dissolved oxygen in the Canal. Corrective actions proposed in this PACA plan will also be better informed and refined as HCDOP information becomes available.

We have taken the best available science and used it to define and quantify sources of nitrogen from anthropogenic sources into the Hood Canal. We prepared this plan with the full understanding that there is a great deal of uncertainty about the overall causes of low dissolved oxygen. Even so, we are committed to addressing the problem and taking actions now, simultaneously with the HCDOP monitoring and modeling work. We hypothesize through this plan that corrective actions can be identified and implemented to begin to address the most significant human-related contributions of nitrogen. From the research and experience from other estuaries with low dissolved oxygen, our working hypothesis is that that these actions will begin to reverse the worsening trend of low dissolved oxygen in Hood Canal.

While this plan identifies actions that can begin immediately, understanding the complex factors, particularly as they relate to the physical and oceanographic characteristics of Hood Canal, is critical. The plan will be revised as more information and greater understanding of complex processes operating in Hood Canal become available.

II. Monitoring

The following is a summary of the current marine water monitoring efforts in Hood Canal.

Washington Department of Ecology (Ecology) and the Puget Sound Ambient Monitoring Program (PSAMP)
Since 1975, Ecology has monitored two primary reference, or "core" stations monthly, and two rotational stations monthly in most years. In 1989 this Ecology effort became integrated with PSAMP, collecting data such as temperature, salinity, and oxygen at 0, 10, and 30 meters depth; in 1991, the team measured full depth profiles of these attributes from sea surface to the bottom.

Since the beginning of this monitoring, scientists have collected fecal coliform bacteria grab samples and Secchi readings (measuring water transparency), and, since 1991, the depth profiles have included temperature, salinity, density, pH, oxygen, light transmission, and fluorescence (measurement of this last attribute started in 2001). Also, scientists began gathering high-quality nutrient and chlorophyll data in the mid-1990s.

The testing stations are located at North Hood Canal, near Bangor (core); Central Hood Canal, near Hamma Hamma; Lower Hood Canal, near Sisters Point (core); and Lynch Cove. Since 1994, all four stations have been monitored monthly every year (Figure 3).

The Ecology-PSAMP Marine Waters Monitoring stations obtain their measurements using a seaplane in order to afford wide, statewide coverage. Navigating the plane necessitates good weather; therefore, during the winter months measurements are sometimes impossible to collect. Furthermore, civilian flights have been restricted near the Bangor Sub-base, which means these marine samples have not been collected regularly since the September 11 attacks on the World Trade Center. Samples can be collected only when Navy permission has been procured. In order to address the lack of winter measurements, Ecology has allocated funds to install moored profiling sensors that will allow scientists to obtain measurements without traveling to the stations.[3]

[3] Ecology Marine Waters Monitoring data can be downloaded and further details found at: http://www.ecy.wa.gov/programs/eap/mar_wat/mwm_intr.html
The most recent summary report of marine water quality conditions—including Hood Canal, (Newton et al., 2002)—can also be downloaded at that site.

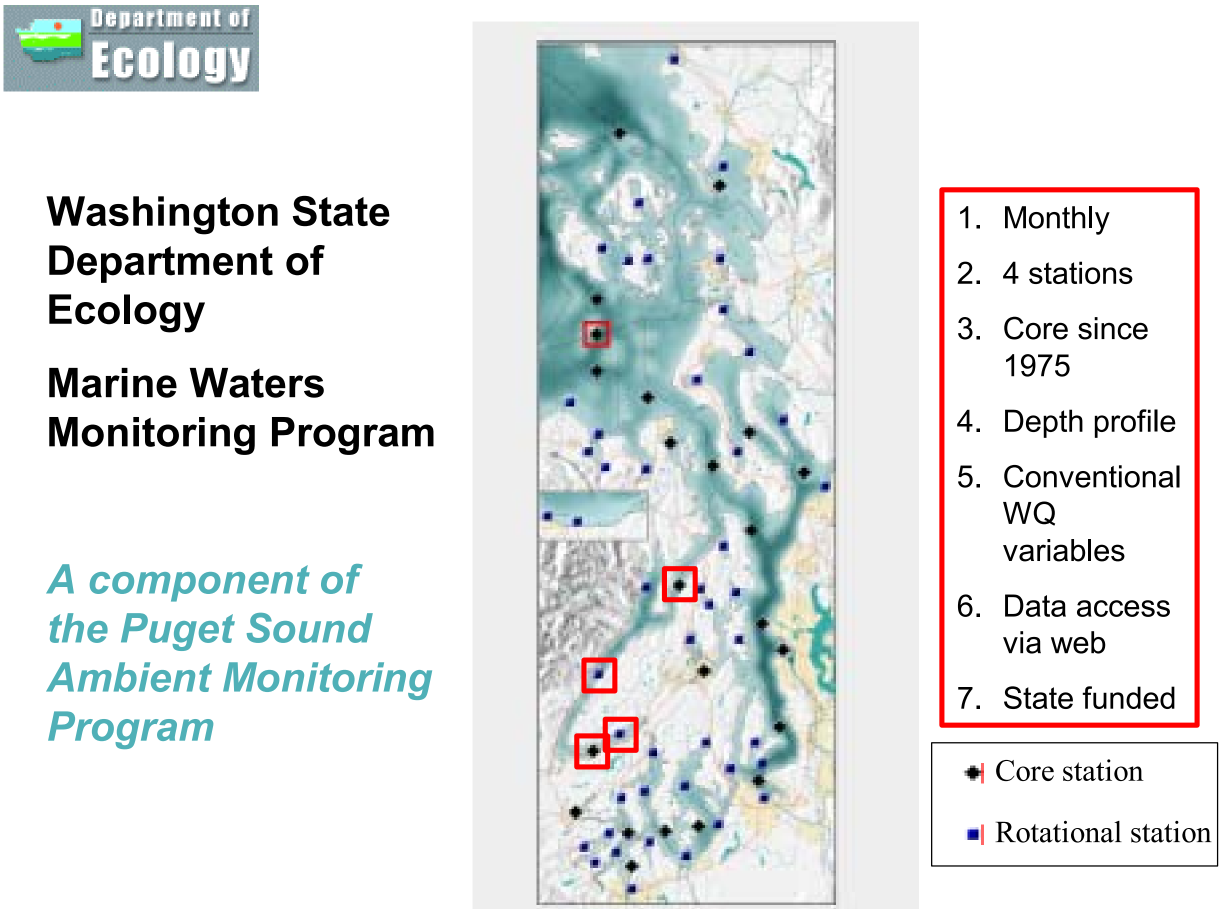

Figure 3. Puget Sound Ambient Monitoring Program (PSAMP) Ambient Monitoring Stations.

<u>Puget Sound Regional Synthesis Model (PRISM)</u>
Since 1998, the PRISM program of the University of Washington, partnered with Ecology and others, has conducted bi-annual cruises in greater Puget Sound, including Hood Canal. Typically the cruises are conducted in June and December. Each cruise analyzes 11 stations in Hood Canal, obtaining full-depth profiles of temperature, salinity, oxygen, fluorescence, and light transmission. The cruises also collect 8-12 discrete samples for nutrients, oxygen, chlorophyll composition, and Secchi depths. Methods are identical to those used by Ecology-PSAMP monitoring. The 11 stations evenly span the length of Hood Canal from its Admiralty Inlet entrance to the Great Bend. Summary plots of the data can be viewed at:
http://www.psmem.org/data/uwhydrographicsurvey.html

University of Washington PRISM investigators have also developed a profiling mooring ("ORCA"), operating currently in Puget Sound near Point Wells, which could be re-deployed to Hood Canal in late summer 2004 (http://www.ocean.washington.edu/research/orca/).

University of Washington

Puget Sound Regional Synthesis Model (PRISM)

A University Initiative Fund sponsored program

1. 2x per year
2. 11 stations
3. Since 1998
4. Depth profile
5. Conventional WQ variables
6. Data viewing via web
7. UW funded

Figure 4. Prism Monitoring Stations.

<u>HCDOP Citizen Monitoring</u>
Since August 2003, the HCDOP has deployed a team of trained citizen monitors who have collected discrete samples for oxygen analysis weekly from six transects (Figure 4).

The Hood Canal Salmon Enhancement Group (HCSEG) coordinates the sampling work done by the citizen volunteers, and a HCSEG analyst runs the oxygen titration analysis. Ecology staff trained all personnel, including the titration analyst, using the same techniques as Ecology-PSAMP and PRISM monitoring. PRISM paid for the analytical and sampling equipment to establish the lab at HCSEG.

Sampling points along each transect include three stations: one near each shore and one mid-channel. Discrete samples for oxygen are obtained at each mid-channel station at three depths (surface, middle, and bottom) and at the nearshore stations at two depths (surface and bottom). Transects are located at Lynch Cove (Ecology station), Sisters Point (Ecology station), Potlatch (PRISM station), Bambans Cove, Hamma Hamma (Ecology station), and Bangor (Ecology station) and a single nearshore station at the Sund Rocks Marine Preserve (Figure 4).

The weekly data from August 15, 2003 to the present are posted on the HCDOP Web site: http://www.prism.washington.edu/hcdop/index.html

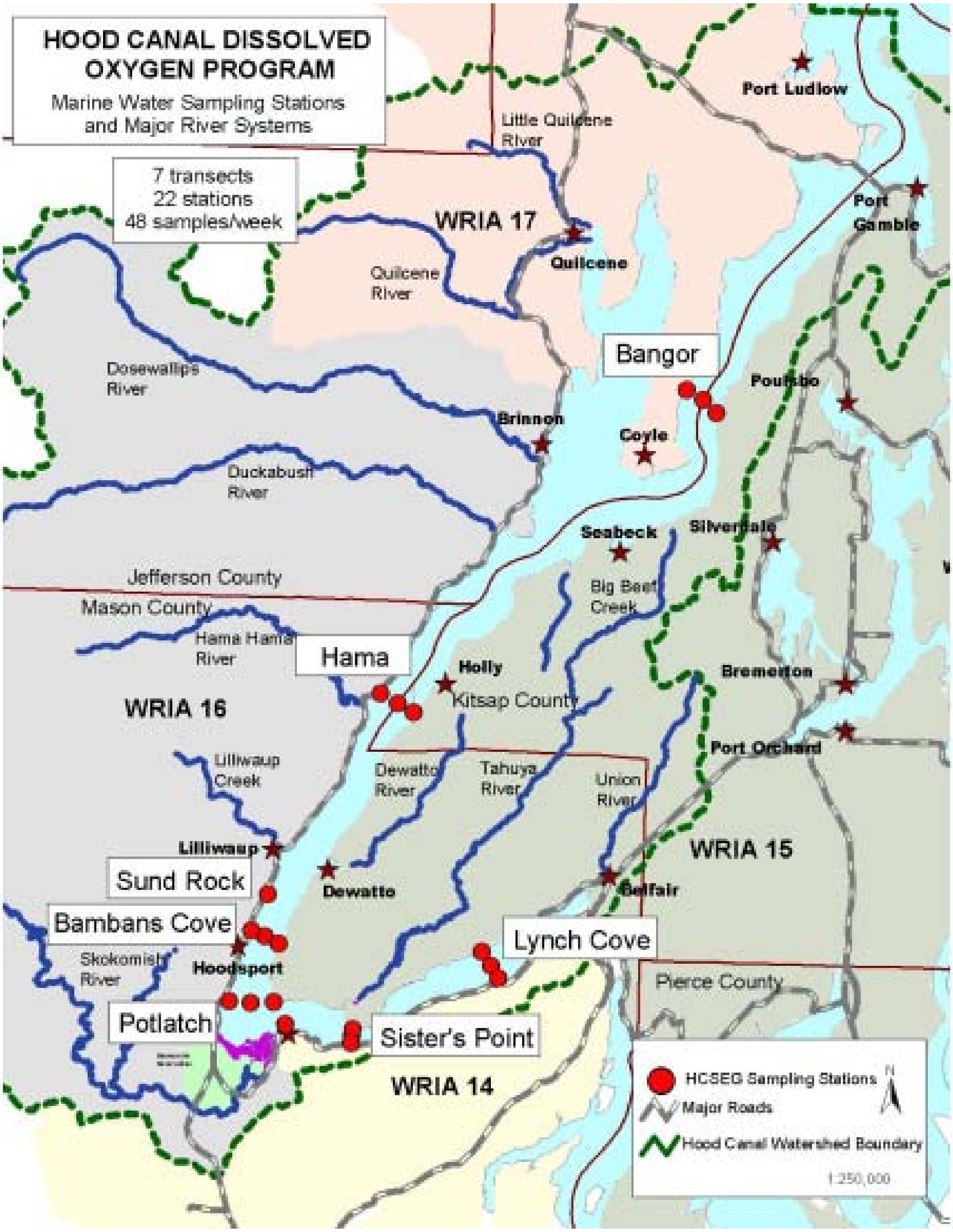

Figure 5. Hood Canal Salmon Enhancement Group Monitoring Stations.

Kitsap County Health District (KCHD) SSWM Monitoring Program
KCHD has been conducting water quality trend monitoring of marine and freshwaters in the Kitsap County portion of Hood Canal since 1996. Seventeen stream stations and

21 marine water stations are regularly sampled for fecal coliform bacteria, temperature, turbidity, pH, and dissolved oxygen. Samples are collected from a 12-inch depth below the surface. (Note, as of October 2003, KCHD suspended its marine monitoring program in Hood Canal and began using marine fecal coliform data collected by the Washington State Department of Health.)

The purpose of KCHD's SSWM monitoring is threefold: to assess water quality data and trends with respect to water quality and public health standards and criteria; to enable early detection of water pollution problem areas for prioritization and cleanup; and to verify that cleanup efforts have been successful. Monitoring results are shared with the state departments of Health and Ecology with respect to their shellfish and ambient monitoring programs.

U.S. Geological Survey (USGS) Studies

In 2003, Congress appropriated $350,000 to the USGS Water Resources Division in Tacoma. The USGS office, in collaboration with the HCDOP advisory group, developed a work plan and designed studies that will: (1) assess sources of nitrogen from surface and groundwater in the major sub-basins of the canal; and (2) conduct focus studies along smaller streams and shoreline sections to better understand how nitrogen from sources such as onsite sewage systems is transferred through ground and surface water to marine waters. Details for this work can be found on USGS's Web site: http://wa.water.usgs.gov/projects/hoodcanal/publications.htm

From spring to early fall of 2004, USGS will conduct field studies, analyze existing data from other sources, attempt to fill data gaps, and produce a report later this year. We will use this information to alter the PACA loading estimates as needed.

Other monitoring efforts and water quality improvement efforts underway in Hood Canal

Hood Canal contains watershed areas primarily within three counties, comprising portions of four Water Resource Inventory Areas (WRIAs). Because many efforts have been ongoing for some time (some more than 10 years), we intend to work closely with all of the partners in Hood Canal, including federal, state, tribal and local governments and agencies, nonprofit entities, and other public groups.

Work that is being conducted in WRIAs 14 and 16 are especially pertinent to the overall HCDOP monitoring. Individuals working in the WRIA planning groups are overseeing monitoring in small streams over an 18-month period, installing temporary stream gauges to determine the overall freshwater flow entering Hood Canal from small streams, and assessing overall contribution of pollutants entering the Canal. This work will help to better quantify nitrogen inputs that have been unknown.

Through the HCDOP process, we intend to work with all agencies and entities involved, which includes: USGS; WRIA 14, 15, 16 and 17 Watershed Management Act planning efforts; Ecology; Fish and Wildlife; the Skokomish Tribe; Mason Conservation District; Mason and other counties involved in TMDL or water cleanup plans in the Skokomish and Union rivers; the Port Gamble S'Klallam Tribe; U.S. Navy; HCSEG; Washington

Sea Grant Program, and Washington State Cooperative Extension. As better information becomes available, we will modify the PACA, as needed.

III. Role of Public Involvement and Education

We convened a group of environmental educators to provide the current and best thinking about the role that education and public involvement would play in improving dissolved oxygen conditions in Hood Canal.

Public education fills an important need to inform residents and visitors about human-related nutrient sources and what they can do to help the situation. Specific strategies are discussed in the following sections, and the education and public involvement team will continue to meet to develop materials and carry out an effective strategy. Hood Canal residents have an ongoing need for education about low dissolved oxygen, what is being done, what more needs to be done, and what they can do to help. This overall, broad scope education effort needs to provide additional support to specific programs and plans to reduce human influences on low dissolved oxygen.

In addition to support for specific actions to reduce nitrogen input, resources are needed to build and maintain an educational network that works together to protect Hood Canal. Public agencies, including Washington State University Extension, Washington Sea Grant, or the Action Team may best fill this role. Alternatively, private non-profit organizations, including The Hood Canal Watershed Project, the Mary E. Theler Organization, the Lower Hood Canal Watershed Implementation Committee, the HCSEG or the HCCC could also potentially coordinate this broad education effort. Coordination may require additional funding. Research conducted in the Chesapeake Bay watershed has indicated that using such media as newspaper or television would assist in reaching a broad audience and may improve effectiveness of the education and outreach (CWP, 1999).

Enhancing existing environmental education programs with advertising will improve the effectiveness of those programs.

An education and outreach strategy could use the following communications channels:

- Newspapers and newsletters
- Web sites
- Presentations and information sharing at public meetings
- Civic and volunteer activities
- Cable TV and/or radio advertisements or programming (such as public access)
- Festivals and other public events
- Intensive door-to-door leafleting, surveying and education

<u>Involving local citizens in monitoring:</u> The HCSEG works with volunteers, Ecology, and the University of Washington to monitor dissolved oxygen levels at several sites in Hood Canal. Citizen volunteers in this program play a key role in tracking oxygen levels in Hood Canal and provide valuable data for scientific analysis. The Action Team has

provided funds to help the monitoring project continue through the fall of 2004. This action provides both public education and outreach functions to citizens in the Hood Canal watershed.

There is a long-standing educational program in the Canal that encourages citizens to monitor water quality in oysters along many shoreline sections of the canal; water quality field agents from Washington Sea Grant Program and Washington State University Extension play a significant role in helping residents observe changes in marine life or structure of their beaches, provide useful tools for onsite operation and maintenance by homeowners, and promote "shoreline stewardship" programs.

IV. Human Contribution to Low Dissolved Oxygen and Potential Corrective Actions

Ecology staff has established though experimentation that nitrogen limits algal growth in Hood Canal (Newton *et al.* 1995). Therefore, the emphasis for this plan is primarily focused on nitrogen loading. This section summarizes existing information on the major human-influenced sources of nitrogen and, using existing data estimates the amount of nitrogen entering Hood Canal. Potential corrective actions that should be implemented immediately are also described in this section. Detailed information regarding the nitrogen loading calculations, including data sources, data quality, assumptions and limitations are in Appendix B of this plan.

We approached developing the PACA by first gathering existing studies and data, and convening a group of local scientists and technicians who work in the Hood Canal watershed. These experts, collectively, have the best working knowledge of the local conditions, and helped to refine and validate the process to develop the preliminary assessment. The full details of the two work sessions, each lasting more than five hours, are in Appendix C. Results from these work sessions were invaluable in developing our assumptions and approach. In some cases, we modified the approaches suggested by the work sessions for the drafting of the plan.

The nitrogen sources and loading estimates, (*i.e.,* how much nitrogen from each source), entering into Hood Canal are shown in Figure 6. All of the estimates are presented as potential ranges of loading, instead of single value estimates, due to inherent uncertainty or differing numbers based on alternative assumptions and calculations.

Overall, from the available data, we calculate that nitrogen leached from onsite sewage systems is clearly the largest source entering Hood Canal. Although not precise, we estimate that sewage contributes between 33% and 84% of all anthropogenic nitrogen entering Hood Canal. The exact figure is likely to be in the middle of the range, and will be improved as more data are gathered through the USGS focus studies and HCDOP.

We estimate that stormwater runoff, chum salmon carcasses and agricultural practices have a smaller, but important contribution to the anthropogenic nitrogen budget.

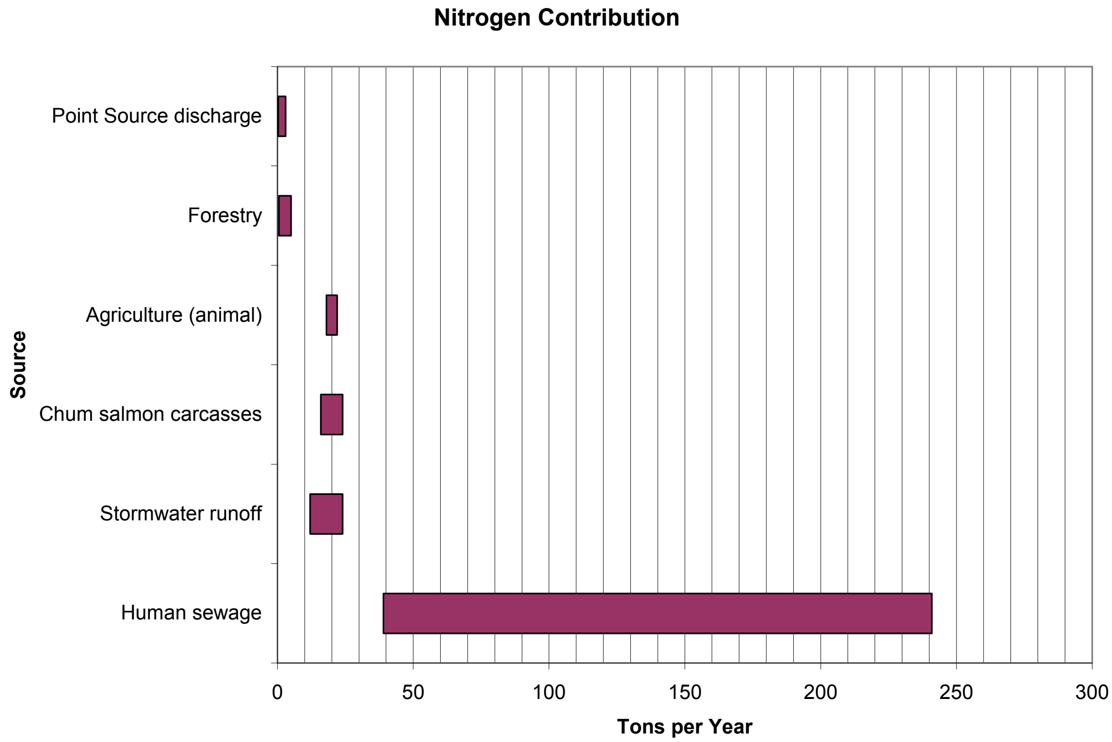

Figure 6. Estimated Range of Nitrogen Contributions into Hood Canal.

Seasonal Differences

Each of the nitrogen sources and human impacts can also be assessed in the context of the time of year that the impact occurs. For instance, stormwater runoff occurs primarily in the winter months, while the nitrogen from onsite sewage systems are leached to groundwater year round. With the higher population of seasonal residents and vacationers in the Hood Canal watershed, onsite sewage systems may discharge higher amounts of nitrogen during the summer months. Figure 7 shows seasonal projections for nitrogen sources analyzed in the PACA plan.

Researchers involved with the HCDOP are creating a model and are conducting monitoring studies to calibrate and validate the model. Understanding how seasonal differences in nitrogen loading affect the dynamics of plankton growth and low dissolved oxygen will be an important facet of the modeling exercise. Until the model is complete, we assumed that algae could use all nitrogen entering Hood Canal, and that seasonal differences need to be taken into account qualitatively when considering corrective actions.

We identified corrective actions in several ways. First, we used information gathered from scientists working in Hood Canal and in "broader" areas, such as Chesapeake Bay, who have been working to reduce nutrients and improve low dissolved oxygen conditions for many years.

Second, we used experts' knowledge of the Hood Canal watershed, including activities and actions that have been taken previously to address the low dissolved oxygen problems. We identified actions that have been successful in the past, and did not consider recommendations that have not been successful in other water quality planning efforts.

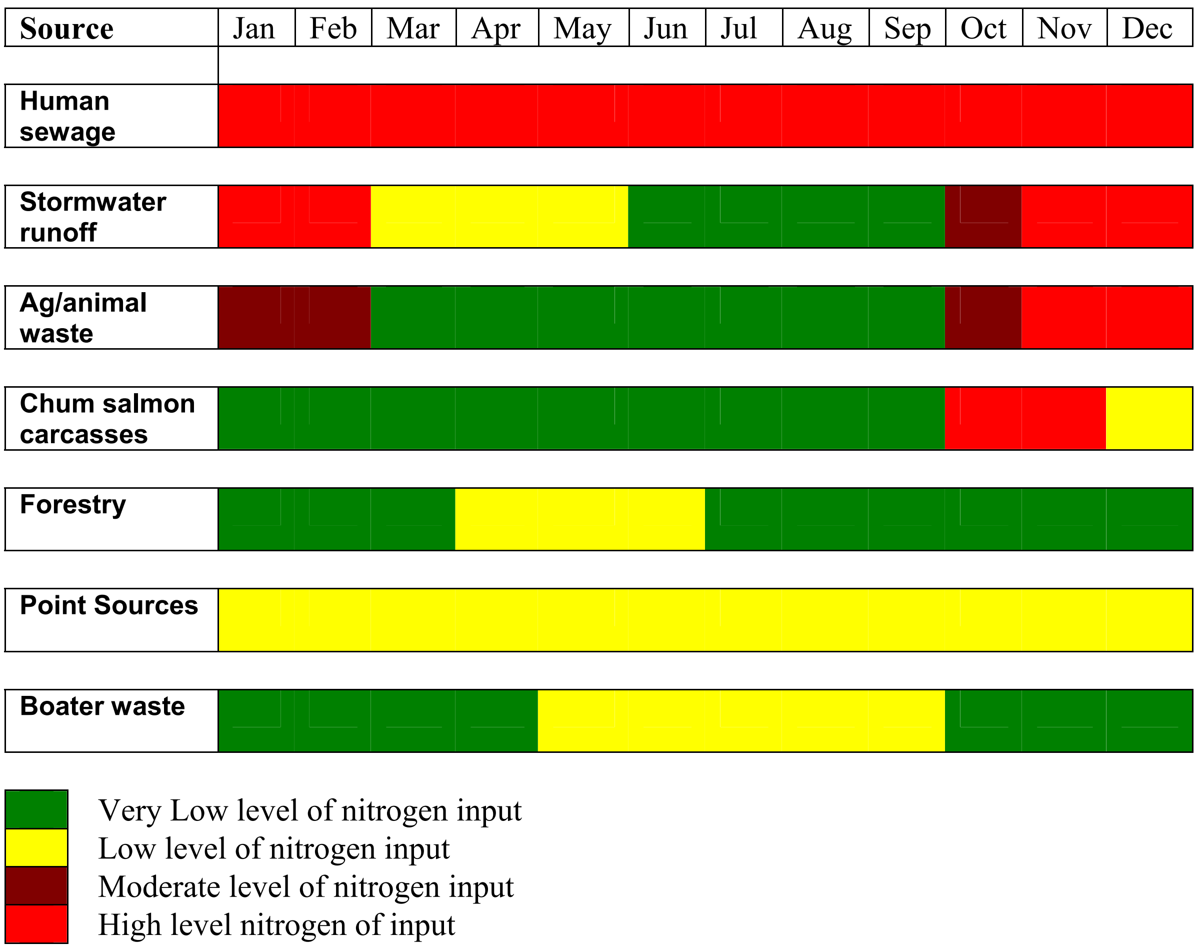

Figure 7. Timing of Nitrogen Inputs into Hood Canal.

Third, we spoke with relevant agency staff in work sessions to find out what challenges they were facing, and how specific recommended actions would be received. The goal was not to recommend actions or activities that cannot be implemented effectively by the agency or organization that has jurisdiction or responsibility for that activity.

Therefore, the list of recommended corrective actions represents what is believed to be realistic in terms of achieving near-term agency or organizational support. With funding, we hypothesize that these actions will collectively begin to improve dissolved oxygen conditions in Hood Canal.

Human Sewage

Human sewage is primarily composed of the elements oxygen, hydrogen, carbon and nitrogen incorporated into living and non-living solid and liquid material. Sewage will naturally decompose on the ground surface, in the soil, or in a water body. Historically, disease was spread through contact with sewage. The desire to reduce the risk of disease transmission led to the development of sewage treatment systems.

Sewage is treated with community sewage treatment plants and individual onsite sewage systems (often called "septic systems"). Onsite sewage systems predominate in the Hood Canal watershed. The potential contribution by the few community sewage treatment plants is addressed in the "Point Source" section of this plan. In this section, we will consider the oxygen demand from sewage treated in onsite sewage systems.

Because of the widespread use of onsite sewage systems in rural areas around the country, there has been a great deal of research to determine how these systems affect the environment. From this research, scientists have found that through the use of a well-maintained onsite sewage system biochemical oxygen demand (BOD)[4], bacteria, and pathogens are effectively reduced. However, conventional onsite sewage systems do not effectively reduce nitrogen (EPA, 2002).

Hood Canal's nearly 54,000 residents live in an estimated 24,800 housing units. Sewage from nearly all of those units is discharged to onsite sewage systems. In addition, an unknown number of onsite sewage systems serving commercial and public facilities receive sewage during their use by residents and transient visitors.

These systems are designed to settle solids, process oxygen-demanding material, and distribute treated effluent below the soil surface. When functioning properly, such systems are able to significantly reduce BOD, bacteria, and most pathogens. While recent developments in treatment technology have produced system components with good nitrogen removal capability, most systems currently in use in the Hood Canal watershed were not designed to do so. Based on the computations detailed in Appendix B, it is estimated that the residential onsite sewage systems alone annually contribute between 39 and 241 tons of nitrogen to Hood Canal.

[4] Biochemical Oxygen Demand (BOD) refers to the amount of oxygen used by microorganisms in an aquatic environment to decompose organic material such as dead plants, leaves, grass clippings, manure, or sewage during a 5-day test. As the amount of organic material increases in a body of water, the number of microorganisms and their requirement for oxygen also increases.

Corrective Actions

The siting, design, construction, and operation of onsite sewage systems are regulated by local public health agencies in accordance with local codes that are consistent with the Washington Administrative Code (WAC) 246-272. Four agencies hold jurisdiction within the Hood Canal watershed for permitting onsite sewage systems: Jefferson County Health & Human Services Department, KCHD, and Mason County Department of Health Services. Washington Department of Health has jurisdiction for larger onsite and community systems.

Counties' programs to manage onsite sewage systems are based on the needs and issues identified in each county. They are also tailored to work within local funding, political, and geographic constraints. That amounts to different local programs throughout Hood Canal to address onsite sewage systems.

The regulatory objective of these agencies is to protect the public health. Traditionally, the indicators for public health protection have been the incidence of waterborne disease and risk factors associated with the spread of pathogens (e.g., sewage on the ground). Except in limited areas where soil conditions allow rapid penetration to groundwater, the presence of elevated nitrogen concentrations signaled neither. Thus, nitrogen reduction for ecosystem protection has not been a regulatory target in the health onsite sewage rules.

However, state and local rules allow local jurisdictions to delineate geographic areas as "Areas of Special Concern" under WAC 246-272-21501 within which more stringent regulatory requirements are be imposed. This mechanism has been used by the Jefferson County Health & Human Services Department to require nitrogen reduction by onsite sewage systems, but for the purpose of protecting drinking water supplies and preventing nitrate contamination of aquifers. Designation of Hood Canal as an "Area of Special Concern" has not been discussed by any of the regulatory bodies overseeing onsite sewage system permitting as of the date of the PACA publication.

The technical advisory committee to the PACA concluded that human sewage effluent from onsite sewage systems is a significant anthropogenic nitrogen input to Hood Canal. The analysis conducted in this Plan, based on available data, confirms that onsite sewage is likely the single largest source of anthropogenic nitrogen inputs into Hood Canal.

To reduce nitrogen from onsite sewage systems, the following actions are recommended:

1) Assessment and facility construction
   Development in the Hood Canal watershed occurs on isolated individual sites, in residential clusters, and in small communities. The individual onsite sewage systems serving these developments vary in age and treatment capacity. Where clusters of high-density development is present and the treatment efficiency of the existing individual systems is poor, effort should be initiated to develop small community collection and treatment facilities with effective nitrogen removal. Where possible, subsurface dispersal of treated effluent should be installed at the greatest possible

distance from the marine shoreline. Often, community systems include the purchase of land at a distance "upland" for the drainfield disposal site to allow for greater treatment opportunity than individual onsite sewage systems on the marine shorelines. A model for such efforts is the Madrona Beach community near Union, where a community system was recently built to serve about 30 homes.

Support for larger community collection and treatment facilities to serve Belfair, the Skokomish Indian Nation, and Hoodsport needs to be continued and enhanced. In addition, continued efforts should be supported to identify candidate sites for community sewage solutions. Any public sewer system constructed to serve residences outside of designated Urban Growth Areas may have restrictions associated with compliance with the Growth Management Act. Currently, the only designated Urban Growth Area in the Hood Canal watershed is in the community of Belfair.

2) <u>Application of state-of-the-art technology</u>
Recent developments in onsite treatment technology have produced several types of equipment, as well as innovative construction techniques that produce treated sewage effluent with low-nitrogen concentrations. Local health jurisdictions are not necessarily confident that the new technology provides consistent nitrogen reduction when employed in residential situations. In addition, the technologically advanced systems require a higher level of maintenance and monitoring once they are installed.

Promoting basic research and testing of onsite sewage systems in use in the watershed would improve the confidence that state agencies and local health jurisdictions have for the capabilities of these various technologies to treat nitrogen. Professional staff at the local health jurisdictions need to be confident in the capability and reliability of the technology so that there is local support to amend regulations and utilize advanced sewage treatment technology. Successful education and promotion of the use of nitrogen reducing technology would likely result in each health jurisdiction choosing to designate its portion of the Hood Canal watershed as an area of special concern and adopting standards to implement the designation.

One recent study conducted by Jefferson County Environmental Health Division showed promising results with sand filters and other technologies to reduce nitrogen (Jefferson County Health & Human Services 1999). The study was not broad enough to make overall conclusions about the performance of these systems elsewhere. However, Jefferson County did adopt standards for nitrogen reduction by onsite sewage systems, but for the purpose of protecting drinking water supplies and preventing nitrate contamination of aquifers.

Specific projects to promote the use of advanced nitrogen treatment technology for onsite sewage systems in the Hood Canal watershed include:

- Monitoring projects to evaluate nitrogen treatment effectiveness of various technologies "in the ground" will improve local health jurisdictions' confidence in onsite sewage systems' nitrogen reduction capabilities.

- Projects to assist public agencies and private organizations in developing remote monitoring systems to improve regulatory and Operations and Maintenance programs' efficiency, monitoring capacity and reporting.
- An inventory of onsite sewage systems operating in the Hood Canal watershed would be beneficial when coupled with specific monitoring actions.
- Programs to determine efficiency-of-scale possibilities, market-based tools or other incentives that can be used to voluntarily increase the use of onsite sewage systems that have been shown to reduce nitrogen in laboratory studies.
- Focused workshops for the health jurisdictions in the Hood Canal watershed, potentially in partnership with the Washington Onsite Sewage System Association (WOSSA), to conduct training related to the current available technology to reduce nitrogen.

3) Education and motivation
   - A survey of onsite system owners should be conducted to assess their knowledge about system management needs, and their attitudes about sewage system management services. If changes are to be made in Hood Canal, local health staff need to better understand citizen motivations, environmental awareness, and support for environmental actions. This will allow the development of more effective and targeted educational programs and more supportable regulations. Such tools as workshops and surveys provide for this type of interaction and information sharing.
   - A coordinated public education and social marketing effort should be initiated to clearly convey the relationship between onsite sewage disposal, the potential for damage to the Hood Canal environment when sewage is inadequately treated, the economic impacts of degraded water quality, and the action owners can take to ensure proper system function.
   - All the effected Boards of Health permitting onsite sewage systems in the Hood Canal watershed should be asked by the State Board of Health and/or Ecology to hold a joint session to be briefed on the PACA. Topics should include the role of onsite sewage to nitrogen loading, technical issues and limitations, and regulatory issues and limitations. Although not likely to be a high cost, existing funds for onsite sewage programs are focused on efficient permitting. Providing staffing support or a small amount of funding to one or more local jurisdiction would help ensure that a joint meeting would occur.

Stormwater Runoff

Prior to property development, coniferous forests primarily covered the landscape in the Hood Canal watershed. Under these conditions, there was very little (less than 1 percent) overland flow or stormwater runoff. Even during large storms, the vast majority of rainfall in forested watersheds infiltrated, was taken up by plants or evaporated.

Stormwater runoff is associated with development and impervious surfaces such as roads, rooftops, and parking lots. Even lawns, if the soil is compacted, are considered largely impervious. The volume and quality of stormwater runoff from developed lands are related to the amount and intensity of rainfall, the amount, location, and connectivity of impervious surfaces in the watershed, and the land use practices occurring in the developed area. Other factors include soil type and infiltration rates, topography and vegetated cover. Research is also pointing to the importance of road networks, associated roadside drainage infrastructure and stream crossings in a watershed as being important to the transmittal of stormwater runoff.

Stormwater treatment and flow attenuation are achieved through the use of BMPs. These BMPs include grassy swales, detention/retention ponds, infiltration basins, constructed wetlands, and engineered structures such as vaults and oil/water separators. These stormwater BMPs have generally been designed to reduce chemical pollutants, sediment, peak flows and flow durations during and immediately after rain events. Stormwater BMPs do not necessarily address or reduce nitrogen concentrations in stormwater effectively and consistently (EPA, 1999; CWP, 2004).

As detailed in Appendix B, stormwater runoff is estimated to contribute between 12 and 24 tons of nitrogen per year to Hood Canal. Additionally, stormwater contributes BOD and other chemicals that may secondarily contribute to low dissolved oxygen problems.

Each county develops stormwater regulations based on state guidance documents from Ecology. Two main components direct stormwater regulation— one is to reduce erosion from construction sites and the other treats and manages stormwater runoff from impervious surfaces. Stormwater standards include temporary erosion control, design standards for stormwater retention/detention ponds and treatment BMPs to improve water quality. Kitsap and Mason counties use the *Stormwater Program Guidance Manual for the Puget Sound Basin* (Ecology, 1992) as the technical guidance document for their stormwater management programs, although both counties plan to update their stormwater regulations to be technically equivalent to more current Ecology guidelines. Jefferson County has already adopted the *2001 Stormwater Management Manual for Western Washington* to base stormwater runoff protection standards.

At the time of the PACA plan, no city or county-managed stormwater collection and treatment systems were in the Hood Canal watershed, except at Bangor Sub-base. One is being planned for the Belfair urban growth area. Kitsap County collects a fee to fund its comprehensive surface water management program to run its stormwater program, identify pollution sources, and protect and restore shellfish growing areas, among other activities. Neither Jefferson nor Mason counties have a stormwater fee; both fund their stormwater and water quality protection programs from other revenue sources. Jefferson County is developing a surface water management plan with grant funding assistance from Ecology.

Corrective Actions

The following corrective actions are recommended to address impacts from stormwater runoff:

1) <u>Programmatic improvements to manage stormwater more effectively</u>
   A stormwater collection and treatment system is being planned for the community of Belfair. For this specific area, or other areas where larger stormwater runoff systems are being planned, corrective actions would include:
   - Development of an operations and maintenance plan (O & M Plan), including a funding mechanism for ongoing costs (both capital and non-capital) that would improve the likelihood of federal and state funding for the project.
   - Provided that the O & M Plan is completed, activities that increase the speed or cost effectiveness in which the Belfair stormwater system is planned and constructed.
   - Provided that the O & M Plan is completed, activities that improve the efficiency of nitrogen reduction from the planned Belfair stormwater system.
   - Education and public involvement programs that improve the likelihood of community support for the development and costs of a stormwater system in Belfair.
   - Counties should be provided with funding to study and identify where programmatic improvements would decrease nitrogen loading from stormwater runoff, through such activities as increased inspections, modifications to standards, and development of public-private partnerships to increase program effectiveness.

2) <u>Educational and incentive programs targeted at residents to reduce the input of nitrogen from landscaping practices and pet waste</u>
   A large portion of the nutrient and contaminant inputs into Hood Canal that come from stormwater occur from activities that are legal and common practice, such as lawn application of fertilizers and other landscaping practices. The contribution from individual landscaping practices is one component of the overall stormwater source calculation that is best addressed through effective public education.

   Many successful educational programs already exist, and are detailed in the PACA Educational Work Session notes found in Appendix C. However, providing additional funding for agencies and organizations that have successfully conducted stormwater education to expand education and outreach activities will create additional capacity.

   The following types of actions are educational or outreach activities that are stormwater-related, and have been undertaken, could be undertaken, or could be expanded with additional funding:
   - Create education materials and workshops that instruct and motivate shoreline property owners to reduce fertilizers, establish native plant buffers, properly dispose of pet waste, maintain onsite sewage systems, and reduce runoff from their property.
   - Work with people who own waterfront property and provide them with training and incentives to maintain or plant buffers.
   - Offer incentives and guidance for property owners to protect and restore buffers along Hood Canal streams and shorelines.

- Instruct property owners about good ways to dispose of yard waste and composting options to keep nitrogen out of streams and Hood Canal.
- Educate property owners to reduce stormwater runoff through landscaping.
- Offer Master Gardener programs for landscaping practices to reduce nitrogen.
- Provide training for realtors and other professionals to prepare them with information about wetlands, onsite sewage systems, shoreline development issues, and a variety of other topics to educate clients who are seeking to buy or build a house in the Hood Canal watershed.
- Promote incentives for conservation/land trust options.
- Develop and implement an education strategy to reach new and part-time residents.
- Explore the possibility of using market-based incentives for alternatives to nitrogen containing materials at the retailer or wholesaler level.

3) Implementation of low impact development practices

Studies show that undisturbed land and planted areas provide natural infiltration and treatment of contaminants in stormwater runoff. Low impact development is an ecological approach to site development that uses the natural features of a piece of property and special management practices to reduce and treat stormwater runoff.

Because each county in the Hood Canal watershed currently allows low impact development to occur, there are other social and economic barriers that may be preventing these practices from being implemented. Counties and state agencies must assess and develop appropriate incentives to encourage low impact development. The following types of projects to encourage low impact development could be undertaken, or could be expanded with additional funding:

- Because of the lack of designated Urban Growth Areas and large subdivisions in the Hood Canal, many of the tools associated with low impact development need to be modified if they are to be successfully employed. Local jurisdictions would benefit from the creation of a "handbook" for the Hood Canal Watershed that details specific low impact development practices that could occur within the context and scope of development occurring within the Canal. The handbook would also review each county's existing regulations and include recommendations for changes to county regulations that would promote low impact development practices. This could be implemented by one or more of the governmental agencies, or a private organization.
- Offer developers and county staff low impact development training and design assistance and create demonstration projects.
- Offset costs of low impact development in a pilot program combined with marketing the project to improve public acceptance of the practice.
- Systematically analyze current regulatory hurdles or constraints limiting low impact development.
- General strategies for public education to provide public information about low impact development.
- Include training for low impact development techniques such as rain gardens, green roofs, and other methods to infiltrate stormwater runoff.

- Develop a homeowner's booklet tailored to Hood Canal residents that describes the myriad of practices that can be undertaken on individual residential home sites to reduce stormwater runoff and nitrogen contamination to Hood Canal.

Commercial Fishing Practices

Geoduck Fishery

The process of harvesting geoduck clams temporarily disturbs and suspends sediment. Water jets scour sediment and uncover buried organisms during the process of underwater harvest of geoduck clams. This activity has the potential to release nitrogen that had been bound to sediment. According to Washington Department of Natural Resources the following significance for substrate in harvest areas were noted:

> "Geoduck harvest has limited impacts on substrate. Clams are removed individually, so only the immediate area around the clam is affected and only small amount of sediment leaves the hole. The biggest impact to substrate is the creation of harvest holes. These holes are temporary, refilling within several days to seven months depending on substrate composition and strength of the local water currents. The water-jet (harvesters) introduces well-oxygenated water into the substrate. In substrates that are devoid of oxygen, the oxygenated water can temporarily oxygenate the reduced substrate within the harvest holes" (DNR & DFW, 2001).

We conclude the practice is not a major contributor to nitrogen because the disturbance is localized and short term. Furthermore, most of the commercial tribal and non-tribal harvest occurs in northern Hood Canal, away from the severely oxygen depleted area. (Morris Barker, personal communication, 2004).

Corrective Actions

No corrective actions are proposed at this time.

Disposal of Chum Salmon Carcasses in Marine Waters

Five species of Pacific salmon return to Hood Canal rivers and streams. One species, fall chum salmon, *Oncorhynchus keta*, return in huge numbers as a result of hatchery programs at local salmon hatcheries. These fish return between October 1 and November 30. Skokomish Tribal fishermen harvest the returning adult chum salmon in beach seine and gillnet fisheries (David Herrera, personal communication, 2004).

In recent years, salmon markets have been severely depressed. However, the demand for salmon eggs (for caviar) has been strong and supports a strong commercial fishery for the Tribe. So the chum salmon are now caught for their eggs and there is no market for the fish itself. As the fish return, tribal fishermen strip eggs from the female chum salmon and discard the carcasses into the marine waters along with most male chum salmon. The Tribal commercial fishery harvests about 250,000 chum salmon each year, on average. About two-thirds of the carcasses are discarded in marine nearshore areas, where the protein and oil in their flesh demands oxygen for decomposition. Although these dead fish undoubtedly use up oxygen as they rot, the exact amount of nitrogen leached into the Hood Canal and the BOD equivalent is difficult to compute, since much of the fish's flesh is converted into other living biomass by detritus feeders, such as crab and shrimp. We estimate that the nitrogen equivalent for 250,000 chum carcasses disposed in deep water is between 16 tons and 24 tons (Appendix B).

Corrective Actions

The Skokomish Tribe is an active participant in the HCDOP and important partner in the PACA plan development. Tribal staff explain that the tribe wants to find or develop commercial markets for salmon carcasses and have explored several alternatives for turning the waste product into a viable business opportunity. One challenge that keeps tribal fishermen from better disposing of carcasses is that the economics of the fisheries has kept them fishing with gill nets and small boats, leaving little room to safely hold large quantities of fish (Guy Miller, personal communication, 2004).

The Skokomish Tribe has proposed, and we recommend several ideas for using the chum carcasses, including: (1) finding buyers to purchase the early-returning brighter fish for human consumption, perhaps as canned or smoked product; (2) bulk composting and mixing with wood chips for plant fertilizer; (3) selling to a pet food manufacturer; (4) freezing carcasses for later land application in the upper watershed, where nitrogen is needed to support wild salmonid production in freshwater systems.

No matter what the end product or fate, the tribal resource managers emphasize that the way to stop overboard fish-disposal is to develop markets for the whole fish and to find a safe, easy way to handle large quantities of fish (especially at peak season catch) (Keith Dublanica and David Herrera, personal communication, 2004). Some possible solutions include:

- Lease "tender" boats for tribal fishermen so they can gain easy access and offload large quantities of fish in the 250,000 to 750,000 pound range during a month's time.
- Provide a quick way for fishermen to unload their catch and get back to fishing.
- Find the labor force and equipment to move/transport/suction fish in an efficient manner on the water and on shore.
- Provide an incentive, such as a price per fish or per pound, to get fishermen to participate.
- Purchase or lease on-land storage freezer or refrigeration facilities, or direct bulk sale for large quantities of fish (depending on their ultimate use).
- Develop a land-based composting facility in a large area that's removed from residences and other concentrated or sensitive land development. Additional equipment for moving and chopping carcasses and chipping wood would be needed to assist the composing process. Regulatory restrictions for the use of salmon carcasses in compost would have to be addressed. The end products, market demand for those products, and ultimate economic viability would have to be pursued, perhaps with assistance from the Mason County Economic Development Council and Washington Sea Grant Program.

Agricultural Waste and Practices

Nationally, agriculture is the largest source of nitrogen pollution to coastal waters (*Bricker et al*., 2003). The main sources of nitrogen from agricultural lands are leaching and runoff from fertilized lands and animal waste (NOAA, 2003; Carpenter *et al.*, 1998). Total new nitrogen sources to agricultural fields in the United Stated have doubled from eight million metric tons per year in 1961 to 17 million metric tons per year in 1997 (Howarth *et al.* 2002 as cited in CENR, 2003).

Although runoff and leaching from agricultural lands is highly variable, researchers have estimated that approximately 20 percent of the nitrogen applied to agricultural fields in the United States leaches into surface or groundwater (NRC, 1993 and Howarth *et al* 1996, 2002 as cited in CENR 2003). Runoff and leaching may be as little as three percent from grasslands with clay-loam soils or as high as 80 percent for some row-crop fields on sandy soils (Howarth *et al.* 1996 as cited in CENR, 2003). Nitrogen losses are even greater in areas of high rainfall and during wet years (CENR, 2003).

Hood Canal agricultural land use comprises approximately 3,000 acres, while forestry lands comprise more than 200,000 acres. Yet despite the Canal's comparatively small-scale agriculture, agriculture is still one of the top anthropogenic nitrogen sources entering Hood Canal. According to our calculations, agricultural inputs contribute 18 to 22 tons of nitrogen per year to the Hood Canal. Refer to Appendix B for a full detailed methodology.

Corrective Actions

Due to the great variability in the amount of nitrogen entering into Hood Canal waters from different farms, corrective actions should focus on those farms that may have the highest potential to negatively impact water quality (*e.g.,* farms that are adjacent to the water). By reducing inputs from the highest contributing farms, the overall input of nitrogen into Hood Canal would be reduced significantly.

Many recommendations already exist on how to reduce nitrogen runoff from farms entering into waterways. Ecology provides several recommendations in the Skokomish River Detailed Implementation Plan for Fecal Coliform Bacteria to reduce agricultural waste runoff:

- Construct fences to exclude animals from waterways,
- Maintain streamside vegetation,
- Apply manure at times and rates that prevent excess from being carried into waterways,
- Store and cover manure so that it is not accessible to rain or flood waters, and
- Maintain pastures and animal-keeping areas to minimize run-off.

Horses for Clean Water, a non-profit organization that works to help horse owners manage their land in the best way possible for horse health and the environment, has similar recommendations for managing horse waste. They provide detailed information in their guidebook, *Healthy Horses Clean Water: a guide to environmentally friendly horsekeeping* (http://www.psat.wa.gov/Publications/HORSE_MAN.pdf), on to how to implement these preferred practices to manage waste.

While much work has been done in this area, existing recommendations need to be implemented as quickly as possible. Additional education, training, and incentives are needed to remove barriers and encourage landowners to adopt these preferred management practices.

Specific recommendations include:

- Provide manure and nitrogen management information, training, and incentives,
- Promote incentives for farmers to maintain or restore streamside and shoreline buffers to prevent agricultural runoff, and
- Provide incentives for farmers to protect and restore wetlands.

Available Resources

Conservation districts provide local landowners with technical, financial, and educational assistance for implementing BMPs on-the-ground to improve natural resources. Conservation districts in Mason, Kitsap, and Jefferson counties work with landowners to develop and implement farm plans to manage animal wastes, apply fertilizers, and prevent nitrogen pollution through protecting and restoring riparian areas. The districts offer cost-share opportunities to help qualifying property owners implement BMPs to protect water quality. The Mason Conservation District uses a geographic information system (GIS) to map BMPs throughout Mason County.

In 2003, Ecology awarded a Centennial Clean Water Fund grant to the Mason Conservation District to identify and correct bacterial pollution in the lower Union River watershed and the Skokomish River watershed. With this funding, the Mason Conservation District, together with the Mason County Department of Health Services and the HCSEG, will work with property owners to correct failing sewage systems, manage animal waste, and establish a stewardship program in the community. Ecology provided funding for the KCHD Upper Union River Restoration Project. During this project, KCHD performed a sanitary survey of onsite sewage systems and animal waste management practices bordering the river. The Kitsap Conservation District performed farm planning as part of this effort. The USDA Natural Resources Conservation Service (NRCS) also provides technical and financial assistance to landowners developing and implementing conservation plans.

Forest Practices

Much of the area surrounding Hood Canal is forested. Approximately 92,000 acres in the West Shore Hood Canal watershed are forested occupying 89 percent of the west shore area (PSCRBT, 1995). In the Upper Hood Canal watershed there are approximately 51,000 forested acres covering 88 percent of the watershed (PSCRBT, 1993) and in the lower Hood Canal watershed approximately 90,000 acres are forested covering 88 percent of the watershed (LHCWMC, 1992).

Maintaining the Hood Canal watershed in forestry land use can provide many benefits to water quality and can result in low amounts of nitrogen input. When the watershed is forested, there is very little (less than 1 percent) overland flow or stormwater runoff. Even during large storms, the vast majority of rainfall in forested watersheds infiltrates is taken up by plants or evaporates.

However, some forestry activities can contribute nitrogen and BOD to Hood Canal. When forests are harvested, the loss of vegetation allows for surface water runoff and conveyance of materials and nitrogen to surface waters, and subsequently to Hood Canal. In addition, the alteration of forests from coniferous-dominated to mixed alder and coniferous forests increases the amount of atmospheric nitrogen that is converted into nitrates and potentially conveyed to Hood Canal. A more comprehensive assessment is needed to document these potential sources.

Forest fertilization is also a potential contributor to elevated amounts of nitrogen in Hood Canal. Nitrogen from fertilizers, usually applied as urea, can move off-site via groundwater and surface runoff.

A Bureau of Land Management study conducted in the Western Cascades showed that applied nitrogen losses to streams in the western Cascades is generally less than 10 percent, and can be greater depending on soil and moisture conditions (Anderson, 2002). Fertilizer applications can result in immediate and relatively high-concentration of nitrogen to streams (Anderson, 2002). Longer-term nitrogen losses to streams can continue during subsequent rainstorms as nitrification proceeds (Anderson, 2002). A 1973 study about forest fertilization conducted on the Tahuya River on the Kitsap Peninsula, showed a 0.45 to 1 percent loss of ammonia to downstream sites (Cline, 1973). Forest practice regulations have increased water quality protections in recent years with the implementation of the Washington forest practices rules.

Precisely how much nitrogen from forest fertilization reaches the Hood Canal waters is not known. Some monitoring is currently being conducted through a partnership between the Mason Conservation District and The Evergreen State College. Preliminary monitoring results show low levels of nitrates in forest streams. Further research and monitoring would be needed to fully understand the implications of forest fertilization as it relates to low dissolved oxygen levels in Hood Canal.

Depending on how many acres are fertilized in a particular year and the stream protection practices that are followed, there can be substantial variation in the potential nitrogen contribution from forest fertilization. We estimate that if 500 acres are fertilized there is a potential nitrogen input to Hood Canal between approximately 0.5 and 5 tons (Appendix B).

Biosolids, another type of fertilization, are applied primarily at one location in the Hood Canal watershed, in private forestlands managed by Olympic Resource Management near the Hood Canal Bridge. In 2003, there was approximately 103 tons of biosolids applied to forest lands. The nitrogen content of biosolids varies, but averaged 3% of the total mass of biosolids from the data analyzed for this plan. Therefore, total nitrogen added to forest lands from biosolids is roughly 3 tons. Assuming the same range of nitrogen loss from application as with other forest fertilizations equals between 62 and 620 pounds of nitrogen per year from this source.

The actual nitrogen input from forestry fertilization is likely to be at the lower end of the range for several reasons. Foresters must now comply with more stringent state regulated forest and fish rules. In addition, if upland forests are fertilized in upland forests as they were in 2003, nitrogen entering upland forest streams can be relatively undetectable downstream if the stream is productive and if the rate of transport is slow enough to allow for the nitrogen to be absorbed by aquatic plants (Cline, 1973). Also many foresters, including Simpson, now employ more advanced technologies, such as Global Positioning Systems (GPS) to more accurately locate areas to be fertilized and to maintain required stream buffers during fertilization.

Corrective Actions

The state of Washington forest practices rules (WAC 222-38-030) apply to both state and private forest lands with respect to fertilizer application.

These rules include a mechanism to provide greater protection to waters where nutrient sensitive conditions in downstream waters exist. This regulation is as follows:

> WAC 222-38-030(3)(f) Where the department [department of natural resources] has been provided information by the department of ecology indicating that water quality in downstream waters is likely to be impaired by entry of fertilizer into waters, such waters shall be protected by site specific conditioning.

This regulation was used in the Mason County area of the Hood Canal in the 1990's for protection of Hood Canal water quality at the request of Ecology (Joanne Schuett-Hames, personal communication, 2004).

Based on the current sensitivity to anthropogenic nutrients being added to the marine waters of Hood Canal, we recommend that the Department of Natural Resources and Ecology use this forest practices regulation provision, and provide site specific conditioning for forest fertilization applications within Hood Canal basins.

Hydraulic and Hydrological Modification

This section describes modifications, which range from alterations in freshwater flow and mixing regimes to those that indirectly impact natural nitrogen cycling in the Canal.

It is difficult to determine and quantify specific effects on dissolved oxygen levels in Hood Canal from hydraulic and hydrological modifications. Impacts from these modifications can only be understood through extensive modeling and monitoring. An accurate assessment of the impacts of these modifications must wait for HCDOP scientists to construct a calibrated model of Hood Canal. A model will allow creation of contingency scenarios that can test various hypotheses related to hydraulic and hydrological modifications on low dissolved oxygen.

The PACA plan will only address hydraulic and hydrological modifications qualitatively, and suggest how these factors might exacerbate sensitivity to low dissolved oxygen conditions. Where restoration activities are ongoing, this plan highlights and identifies the possible contributions those activities have on low dissolved oxygen.

River Inputs to the Canal

Human activities, such as roads, dams, bridges and home building, have changed the flow of several major rivers that run into Hood Canal. The primary alteration that has occurred in the Skokomish River is the dewatering of the North Fork Skokomish River by dams owned by Tacoma Public Utilities. The Skokomish River is the largest contributor of freshwater to Hood Canal, which influences surface salinity; temperature and surface flow in the canal. The modification of the flow regime over the past century, caused by the construction and operation of the Lake Cushman Dams, has changed the timing of peak flows and the discharge of freshwater from the Skokomish River into Hood Canal.

The potential impact to dissolved oxygen includes changes to the surface flushing from the south end of Hood Canal during spring freshets, diminished summer freshwater flow, and possibility that these changes have created changes to stratification in the south end of Hood Canal.

Note: An ongoing lawsuit between the Skokomish Tribe and the Tacoma Public Utilities over various aspects of the dam and release of water to the river, could affect dissolved oxygen by changing the water storage, river flow and mixing regimes of the lower Hood Canal.

Corrective Actions

The primary corrective action is to complete a calibrated model of Hood Canal. If modeling determines that flow modifications to the Skokomish River contribute to the low dissolved oxygen, then a corrective action would be to restore flows back into the north fork of the Skokomish River so that the flow regime can begin to return to its natural function.

Estuarine Diking and Filling

During the early 1900s and through the middle of the 20th century, farmers diked much of the lower Quilcene and Skokomish rivers to create additional agricultural lands. Many of these diked areas are no longer useful for agricultural purposes, and the altered natural estuarine wetlands and tidal channels that existed historically impede salmon migration and acclimation to seawater, as well as limit the natural capture of carbon and nitrogen in wetlands and side channels. Diking along river banks and building levees has also changed side channels of the river, scoured banks, and even changed the river channel in some cases.

Corrective Actions

Fishery biologists and engineers have proposed multiple projects to restore salmon habitat and natural estuarine functions recently on many of the river systems in the Hood Canal. For example, the Skokomish Tribe, the HCCC, Tacoma Power, and the U.S. Army Corps of Engineers have begun studying feasible options to restore these historic functions and processes of the lower Skokomish River. The multi-organizational collaborative team has completed engineering and design studies to remove dikes, fill borrow pits, and allow wetlands and side channels to reestablish, and adding both complexity and diversity to these altered areas. This will help with salmon recovery for endangered stocks in particular, as well as trapping nutrients that now flow directly to the canal (Richard Brocksmith, personal communication, 2004; Keith Dublanica, personal communication 2004; Bernie Hargrave, personal communication, 2004; Kathy Kutz, personal communication, 2004).

Similar work is being done in the Quilcene River estuary, although the project is moving more slowly. Jefferson County has acquired lands from frequently flooded areas in the lower river and estuary, with the overall goal of restoring natural estuary processes and improving salmon habitat. When completed, actions will have similar, but smaller scale improvements as the Skokomish River project.

Flooding on the Skokomish River

Flooding on the Skokomish River has become a regular seasonal event. Predictably on a seasonal cycle, the first major rainstorms in October or November create widespread flooding in the Skokomish River valley. When sediment and gravel deposits in the lower river and essentially raises the river bed, a process known as "aggradation" occurs. With the aggradation, the river bed is higher than the surrounding floodplain in many areas. As a result, the depth within the channel is insufficient to handle increased flows of the river and it floods.

Flooding in this valley is a cumulative effect of several additive processes. The Cushman hydroelectric project and its two dams regulate and divert flows that historically moved sediment down-river to the delta area and minimized the process of aggradation. Flow diversion combined with past, poor logging practices, inadequate road maintenance in the upper watershed and diking in the lower watershed, contribute to a river system that fails to move gravel and sediment to the lower river and delta areas, and ultimately to increased flooding.

Corrective Actions

Similar problems on a smaller scale are being addressed in the Lower Big Quilcene River through limited dredging of gravel traps, property buyouts, dike setback and/or removal which allows for improved floodplain connectivity.

The overall harm from the frequent flooding is that the water transports a great deal of sediment and nutrients from the floodplain to the Hood Canal. Animal wastes, onsite sewage effluent and other nitrogen sources have a direct conduit into the Canal via surface water.

Hood Canal Floating Bridge

Near the north end of the canal, a highway floating bridge operated by the Washington State Department of Transportation, traverses the approximately 1.5 mile width of the canal near Lofall (Figure 1). Near the bridge, a fairly shallow "sill," or change in bottom topography, decreases the canal's depth from approximately 500 feet south of the bridge to approximately 150 feet deep near the bridge. Some residents claim that the bridge impedes surface flow, thereby reducing flushing of the canal.

A cursory analysis indicates that the bridge may have little or no effect. Researchers and engineers will analyze the bridge once a Hood Canal model is developed as an outcome of the HCDOP. The net estuarine flow is driven by the amount of freshwater runoff from major rivers and streams. During an ebbing tide, the water is higher on the canal south side of the bridge and will flow around or under the bridge. Rate of flow is self-correcting, in that if the flow is too slow, the water on the canal side will pile up, causing a greater height difference and increasing the flow around or under the bridge. The bridge may act as a wave break, possibly reducing surface aeration from wave action, but the net effect is believed to be minimal (John Dohrmann, personal communication, 2004).

Point Sources

Wastewater and stormwater discharges are regulated primarily by discharge permits, which stipulate specific limits and conditions of allowable discharge. A waste discharge permit is required for disposal of waste material into "waters of the state," which include rivers, lakes, streams, and all underground waters and aquifers. A waste discharge permit is also required for certain industrial users that discharge industrial waste into sanitary sewer systems. The ***general permit*** approach produces a permit for a group of similar discharges at diverse locations. A general permit is appropriate when the characteristics of the discharge *[and receiving waters]* are similar and a standard set of permit requirements can effectively provide environmental protection. ***Individual permits*** are written for a specific discharge at a specific locations. The individual permit is highly tailored to regulate the pollutants in a discharge into a particular receiving water. Figure 8 shows the various permitted discharges to Hood Canal.

Unlike many other urbanizing areas of Puget Sound, few municipal wastewater treatment plants exist on the 180 miles of shoreline of Hood Canal. Human sewage is treated almost exclusively by onsite sewage systems, which are detailed in the Human Sewage Section, above.

In Hood Canal, there are three or four NPDES Individual Permits for sewage treatment plant discharges to Hood Canal (Figure 8):

- Pope Resources Inc., which discharges into Port Gamble Bay at the north end of Hood Canal. It serves the community of Port Gamble.
- Alderbrook Inn Resort, which discharges near Union in the South end of Hood Canal.

- One permit, for Troutdale Lodge near Hoodsport, was not found although EPA documents indicate that there might be an operational facility there.
- One permit, for the Port Gamble S'Klallam Tribe, which discharges into the Hood Canal near the Hood Canal Bridge, was not found although Tribal staff indicate there is a permitted facility operating there.

Sewage from Sub-base Bangor is piped outside of the Hood Canal watershed for discharge elsewhere.

The Alderbrook NPDES permit, recently issued by Ecology, does not set limits for nitrogen in the effluent, but agency engineers estimate this type of system and use would produce effluent with total nitrogen levels in a range of 2-10 pounds per day, which is very low (David Dougherty, personal communication, 2004). Additionally, the permit allows for similar maximum load of up to 10 pounds BOD in the effluent. Past measurements of amounts of nutrients show lower actual levels of discharge for nitrogen and BOD, on the order of 0.5 to 4 pounds per day and 1 pound per day, respectively.

Based on these numbers, a range for discharge from the Alderbrook Resort would be about 365 to 3,650 pounds (0.18 – 1.83 tons) of nitrogen annually, and about the same for BOD, estimated total is 0.36 to 3.66 tons.

There are also fish hatcheries operating under NPDES General and NPDES Discharge permits. These hatcheries are located on the Skokomish River and tributaries, Hoodsport, and the Quilcene River (Figure 8). Discharges from these facilities were not calculated for this plan because nitrogen data were not available.

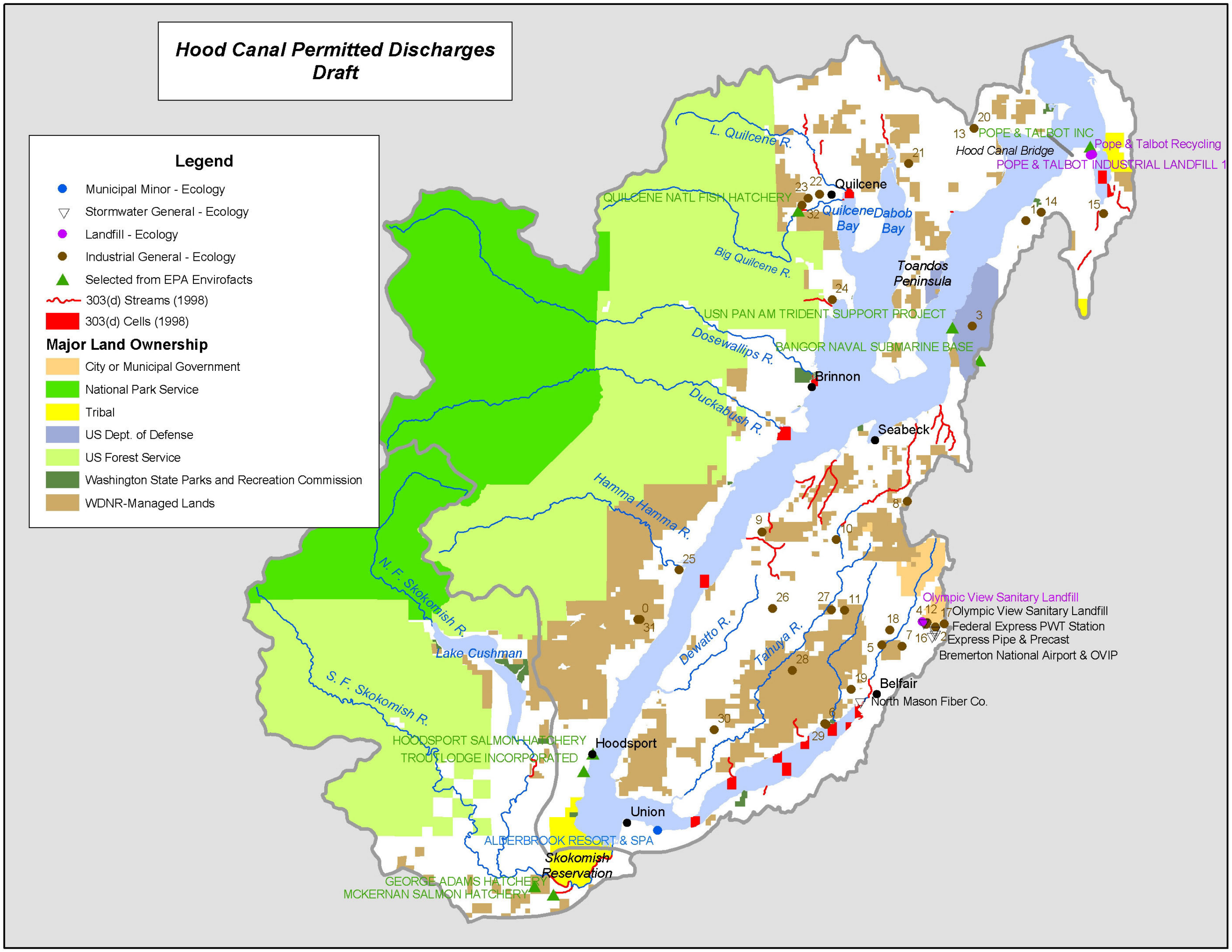

Figure 8. Location of NPDES Permitted Discharges in Hood Canal

Corrective Actions

1) Permit Renewal and Data Tracking
   Point sources are permitted by the Ecology on a cyclical basis. Each permit being renewed in Hood Canal should be assessed for the contribution to nutrient loading and impacts to low dissolved oxygen, including:
   - Conduct a systematic review of existing permitted facilities, which could be done either by Ecology staff or another entity involved with the HCDOP. The review should also include assessing whether there are unpermitted facilities discharging into Hood Canal.
   - Condition discharge permits with required nitrogen, phosphorus and BOD monitoring.
   - Potentially, if a particular permit were determined to be problematic, Ecology could limit nitrogen inputs, could change the depth of the permitted outfall, or could require land application of treated effluent instead of marine discharge.

2) Actions for Facilities to Take
   Hatcheries are run by State, Tribal and Federal agencies and private industry. Hatchery managers should explore improved sediment capture of waste and unused food. State of Washington hatcheries, operated by the Fish and Wildlife include the George Adams Hatchery on the Skokomish River and the Hoodsport Hatchery. Facilities that discharge directly to Hood Canal either have a waste capture pond or intend to design and install such a system soon (Mary Lou Mills, personal communication 2004). In addition, low nitrogen food could be used if hatchery personnel determine that it would reduce nitrogen inputs to Hood Canal and not impact fish health.

Atmospheric Deposition

Nitrogen deposited from the atmosphere can cause eutrophication in water bodies just as nitrogen sources from the ground. Atmospheric deposition of nitrogen can enter water bodies through wet deposition (rain, snow, or fog) or as dry deposition (dust particles or gases). Nitrogen compounds may travel great distances through air currents and disperse to areas far from the originating source.

Nationally, the largest sources of ammonia (NH3) emissions are fertilizers and domesticated animals such as hogs, chickens, and cows (EPA, 2004a). The combustion of fossil fuels (coal, oil, gas) is a major source of nitrogen oxide (NOx) pollution in the air (EPA, 2004b). Nitrogen oxides are the only major pollutant regulated under the Clean Air Act of 1970 that has not declined significantly although the rate of emissions may have stabilized since regulation (NRC, 2000).

In many areas of the U.S. and internationally, atmospheric deposition of nitrogen is significant. In the Chesapeake Bay, for example, 21 percent of the total nitrogen pollution entering the Bay comes from the air (EPA, 2000). Because atmospheric deposition may be a significant source of nitrogen to Hood Canal, further research and monitoring should be conducted to better define potential nitrogen contributions from atmospheric deposition to Hood Canal.

Corrective Actions

This source of nitrogen is potentially significant when compared to other human-caused sources. However, specific corrective actions for this source in the Hood Canal watershed are not listed at this time because identifying and correcting the contributing sources are beyond the scope of this plan. Because air pollutants can be dispersed far from the originating source, the entire geographic area or airshed responsible for emitting the air pollution would need to be considered.

In the past 20 years, deposits of atmospheric nitrogen have increased dramatically nationwide. In general, to reduce this source of pollution, national, regional, and state policies need to include:

- More efficient use of fertilizers and improved handling of animal wastes.
- Reductions in fossil fuel combustion.

Marina and Boat Waste

Hood Canal is a popular recreational boating area. According to the Interagency Committee for Outdoor Recreation (IAC)'s *Boating Facilities Program Policy Plan,* dated November 2003, Washington residents own approximately 310,000 motorboats, sailboats, personal watercraft, kayaks, and canoes. Residents of the three counties that border Hood Canal (Mason, Jefferson, and Kitsap), own approximately 20,000 boats. Also, according to IAC, 15 boat moorages and launches are on Hood Canal (IAC, 2004).

Four pumpout facilities on or near Hood Canal: Port Ludlow marina (technically north of Hood Canal), Pleasant Harbor Marina, Twanoh State Park, and Alderbrook Inn and Resort accept the sewage from these boats, (Dona Wolfe, personal communication, 2004). Also, according to staff at Washington State Parks the Port Ludlow Marina reported receiving 12,000 gallons of boat sewage in 2002. Other pump-out facilities did not report how much they pumped during 2002. While some of the boats that use Hood Canal have marine sanitation devices, the vast majority does not. Shore-side restrooms serve most of the 15 publicly and privately owned moorages and launches.

Heavy boater use of Hood Canal generally coincides with summer season and shrimp and crab commercial and recreational seasons and fall tribal commercial salmon season. Many of the public ramps, state parks, and marinas display signs and provide literature to educate boaters about proper handling of waste. Large vessels with holding tanks typically take advantage of pumpout facilities, as needed, and many small boats use portable on-board toilets or rely on shore-side facilities. Although this practice generally handles human solid waste, the reality is that many recreational boaters in small boats dump urine directly overboard, which adds a small amount of uric acid (a nitrogenous waste) to the surface waters.

Corrective Actions

- Washington State Parks and the IAC, with input from Mason, Kitsap, and Jefferson counties and the boating population, should assess whether the number of pumpouts and shore-side facilities is adequate, whether they are being regularly maintained, and whether current state grants programs are sufficient to ensure that there are sufficient pumpouts and shore-side facilities to accommodate boaters on Hood Canal.
- Washington State Parks should work with the three counties, water quality field agents, the HCCC, and boaters to determine if additional boater education is needed to reduce the amount of boater sewage to Hood Canal.
- The Action Team should convene the Marina/Boater Task Force to assess current pollution prevention efforts (including public education, financial assistance and regulations) and discuss the need for designation of no-discharge zones, additional education or outreach, or other measures.

Solid Waste Management

The potential amount for solid waste would include landfills, illegal dumping of solid waste and application of biosolids on non-forestry lands. Biosolids application to forestry lands is addressed in the Forest Practices section.

At the March 27, 2004 PACA Technical Work Session, the technical work group identified landfills and illegal dumping as potential contributors of nutrients to Hood Canal related to solid waste management. Currently, the Hood Canal watershed has no permitted landfills. Although illegal dumping may present a solid waste and potentially a localized hazardous waste concern, the PACA workgroup did not make this source a priority as a high potential to contribute to low dissolved oxygen.

Data does not indicate this potential source is a significant contributor of nitrogen or BOD to Hood Canal. Biosolids application sites located near Webb Hill, between the Skokomish River and Shelton, have been assumed to possibly add nitrogen to Hood Canal. However, surface and groundwater flow patterns determined through the use of monitoring wells in the vicinity, indicate that water flow travels toward Oakland Bay, and not Hood Canal (Wynn Hoffman, personal communication, 2004).

Corrective Actions

No corrective actions are proposed at this time.

Another possible approach to removing plankton and improving dissolved oxygen levels:

Bivalve mollusks, such as clams, oysters and mussels are renowned efficient filter feeders that remove excess plankton and solids from coastal marine waters. Hood Canal, due to its unique oceanography, produces conditions that are ideal for natural shellfish propagation. Most of the shoreline is heavily populated with natural sets of Pacific oysters, and often rich clam resources that live below the beach surface in the same band of shoreline as the oysters. These intertidal resources represent more than a valuable natural resource to beach owners, tribal and non-tribal shellfish growers and visiting recreational harvesters—they are also efficient and cost-effective natural filters.

In other coastal areas, such as Chesapeake Bay, the loss of a prolific oyster population has resulted in a loss of this important natural filtering asset, and researchers estimate that it now takes oysters in the Chesapeake Bay more than a year to filter the volume of the bay's water, where it once took only a few days. The resulting poor water quality, over-enriched with plankton and severely depressed oxygen essentially year-round, paints a desperate situation for Chesapeake Bay.

In Hood Canal, we realize that healthy shoreline populations of shellfish can only filter a "strip" of nearshore water that is mostly "healthy" with adequate oxygen. No doubt the shellfish are filtering great quantities of water and assisting in removal of excess plankton, but they cannot extend their influence to filter large volumes of off-shore water. However, geoduck populations exist to depths exceeding 100 feet and may help to some extent.

Corrective Actions

Similar anoxic and hypoxic conditions in other parts of the world, especially the Baltic and Scandinavian countries, exist in deep fjord-like conditions that are similar to Hood Canal. Resource managers and engineers have experimented with mussel long-lines and raft structures to use the natural filtering ability of these bivalves in a three-dimensional system, extending to roughly 10 meters, to mitigate nitrogen input from upland sources (Haamer, 1996).

If allowed, strategic siting of mussel rafts, especially in the southern end of the canal where plankton production is greatest, may provide natural filtration , and also produce a valuable farmed product. The Skokomish Tribe and the Pacific Coast Shellfish Growers have expressed interest in a possible joint venture to test this theory. (Bill Dewey, personal communication, 2004; Keith Dublanica, personal communication, 2004; David Herrera, personal communication, 2004). Time doesn't allow a careful computation of the size or density of farms that would be necessary to make a difference, but discussions with tribes and industry will continue if this seems to be worthy of consideration.

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Appendix A Marine Water Quality Measures and Status of Water Quality Listings in Hood Canal

A. Marine Water Quality Measures - Marine water quality in Washington is generally characterized based on a set of 5 indicators:

- ***Dissolved Oxygen (D.O.)*** indicates the degree to which water can support aquatic life.
- ***Dissolved Inorganic Nitrogen (NO2,NO3 or - D.I.N)*** indicates where dissolved nitrogen nutrients are at limiting concentrations, indicating areas that would be susceptible to added nutrients/nitrogen from point or non-point sources, resulting in reduced water quality.
- ***Ammonia (NH4)*** is often indicative of human sources of nutrient waste.
- ***Stratification potential*** influences how readily nutrient pollutants will be diluted and mixed out or if low oxygen conditions are likely to persist.
- ***Fecal Coliform bacteria*** can indicate concentrations of human and animal waste and can be indicative of elevated nutrients.

According to these indices, Hood Canal is considered to be of *'very high concern'*, showing both high natural sensitivity to nutrient inputs, and a strong probability that human activities are exacerbating water quality degradation (Ecology, Marine Water Quality Monitoring 2001).

B. Recognizing Impaired Water Quality through the Clean Water Act
Section 303 (d) of Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water — such as for drinking, recreation, [aquatic life], aquatic habitat, [shellfish utilization] and industrial use — are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years. Waters placed on the 303(d) list require the preparation of Total Maximum Daily Loads (TMDLs), a key tool in the work to clean up polluted waters. TMDLs identify the maximum amount of a pollutant to be allowed to be released into a water body so as not to impair uses of the water, and allocate that amount among various sources. In addition, even before a TMDL is completed, the inclusion of a water on the 303(d) list can reduce the amount of pollutants allowed to be released under permits issued by Ecology. The goal is to make the best possible decisions on whether each body of water is impaired by pollutants, to ensure that all impaired waters are identified and that no waters are mistakenly identified (Ecology, 2003).

1998 water quality impairment listings (303d List)
The **1998 303(d) List** was the last one submitted to and approved by EPA. This list is currently referred to in writing discharge permits, characterizing watershed conditions and focusing financial assistance funding. It also is the current basis for prioritizing TMDL studies and implementation planning. The 1998 list was based on a major change to the segmentation system used to identify impaired waters. In previous lists, whole water bodies or major sections were listed based on sampling from limited areas within the water body. In order to more accurately represent the area of a water body that data indicated was impaired, the 1998 segments were limited to the portion of the water body located in the same section (township/range/section) as the sample data location (Ecology, 2003).

However, since the 'dots' are not connected between listed segments, and since few of the total segments are sampled, it is difficult for the 303(d) list to document or account for water quality impairments occurring across larger or adjacent *water body* systems (e.g. Lynch Cove, southern Hood Canal, etc...). Since the pattern of water quality impairment in Hood Canal is likely larger than the limited set of marine grids and stream segments currently proposed for formal listings. A perspective that takes into consideration larger patterns of water quality impairment is particularly relevant in the Hood Canal system.

The impaired waters occurring on the 1998 303(d) list are mapped in Figure 8. Most of these impaired waters listings are attributed to fecal coliform contamination or degradation of aquatic habitat or temperature regimes in streams. The 1998 303(d) Listings in Hood Canal relevant to Nutrients or Dissolved Oxygen impairments consist of:

Marine Grids

- g123 Holly Cove (listing parameter - D.O.) map ID #47123FOD1
- g148 Lynch Cove (listing parameter - D.O.) map ID #47123DOF2
- g151 Lynch Cove (listing parameter - D.O.) map ID # 47122D9I8
- g160 Lynch Cove (listing parameter - D.O.) map ID# 47122D9J2

Stream Segments

- 391 Lower Skokomish (Instream Flow) map ID #BH48GW

2002/ 2004 draft water quality impairment listings *(Ecology's proposed changes to 1998 303d List - currently out for public review and comment)*

Listings relevant to Nutrients or Dissolved Oxygen consist of:

Marine Grids - Category 5/ Impaired

- Port Gamble Bay (listing parameter - D.O.)

Marine Grids - Category 2 / of Concern

- Holly Cove, station HC04 [proposed listing ID #38638] (listing parameter - D.O.) - *Ecology cites: "The measured excursions beyond criterion are a natural condition per 01/03/2003 submittal by Jim Zimny, Kitsap County."*
- Seabeck Bay nearshore adjacent to Seabeck Creek, station HC14 [proposed listing ID # 38790] (listing parameter - D.O.) - *Ecology*cites: *"The measured excursions beyod the criterion are a natural condition per the 01/03/03 submittal by Jim Zimny of Kitsap County."*
- Nearshore north of Vinland, station HC25 [proposed listing ID # 38380] (listing parameter D.O.) - Ecology cites: *"The measured excursions beyod the criterion are a natural condition per the 01/03/03 submittal by Jim Zimny of Kitsap County."*
- Hood Canal, South end of Main Channel, station HC01 [proposed listing ID # 38630] (listed parameter - D.O.) - Ecology cites: *"The measured excursions beyod the criterion are a natural condition per the 01/03/03 submittal by Jim Zimny of Kitsap County."*
- Hood Canal, Mid-Channel south side of Hood Canal Bridge, station HC32 [proposed listing ID # 38388] (listed parameter - D.O.) - Ecology cites: *"The measured excursions beyod the criterion are a natural condition per the 01/03/03 submittal by Jim Zimny of Kitsap County."*

Stream Segments - Category 5/ Impaired

- Union River segment proposed ID #38908 (listed parameter - D.O.)

- Union River segment proposed ID #38902 (listed parameter - D.O.)
- Union River segment proposed ID #38898 (listed parameter - D.O.)
- Tahuya River segment proposed ID #38890 (listed parameter - D.O.)
- Tahuya River segment proposed ID #38894 (listed parameter - D.O.)
- Big Anderson Creek segment proposed ID#38431 (listed parameter - D.O.)
- Unnamed Creek segment proposed ID #38922 (listed parameter - D.O.)

Stream Segments - Category 2/ of Concern
None identified.

Anti-degradation of Water Quality
State policy requires that discharges into a receiving water shall not further degrade the existing water quality of the *water body*. In cases where natural conditions of a receiving water are of lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria. Similarly, when receiving waters are of higher quality than the criteria assigned, the existing water quality shall be protected.

Appendix B Methodology in Nitrogen calculations

Human Sewage

Untreated human sewage contains nitrogen, mostly in the form of organic matter and ammonia (NH_4). Typical nitrogen concentration in raw household sewage ranges widely. Its concentration is generally reported to vary from 25 to 100 milligrams per liter (mg/l) (EPA 1980; Horsley & Witten, Inc. 2000; EPA 2002). The following account reflects the expert workshop focus on nutrients discharged to the Hood Canal following treatment of human sewage by individual onsite sewage disposal systems and describes the rationale used to estimate a total nitrogen loading from this source. The treatment performance of onsite sewage systems used in the watershed can be expected to vary significantly depending upon the system design, site conditions, and age. This variation is reflected in the data reported in the professional literature, thus necessitating the exercise of judgment by those experts who developed the loading estimate.

The range in the literature represents the expected nitrogen concentration for any one system measured, with the possibility of variability between the amount of water use, the age of the occupants, etc. Looked at through an entire watershed with thousands of homes, the average nitrogen concentration in untreated sewage is likely to be more in the range of 50-70 mg/L versus the larger range presented in the literature. For this analysis, we assume a range of 50-70 mg/L nitrogen concentration in untreated residential sewage.

After passing through an onsite sewage treatment system, ammonia nitrogen has generally been oxidized to form nitrate (NO_3) and nitrite (NO_2). As part of the treated effluent, nitrogen in these forms leaves the bottom of a typical leaching trench and percolate downward toward groundwater. Soil organisms at the bottom of the leaching trench, and in the surrounding subsoil remove some of the oxygen (denitrify) resulting in creation of gaseous nitrogen (N_2), which returns to the atmosphere. In addition, plant roots take up some nitrates and nitrites, which are incorporated into the organic matter of the plant. Studies of the treatment efficiencies of onsite sewage systems comprised of a septic tank and a leach field suggest that such systems are capable of removing between 30 and 70 percent of the input nitrogen.

Once in the groundwater, residual nitrate and nitrite is relatively “conservative”, *i.e.*, is not reduced by plant uptake or bacterial denitrification (EPA 2002). Therefore, for this assessment we assumed that the nitrate that is discharged through onsite sewage treatment systems eventually reaches Hood Canal.

Many factors influence the effectiveness of onsite sewage systems to treat nitrogen. The factors identified at the PACA Technical workshop include: whether systems are functioning properly, the type of soils, the depth to ground water, the number of systems that discharge into shallow aquifers that “re-appear” as seeps downgradient, the proximity to Hood Canal, the number of alternative vs. conventional systems. With these many factors that cannot be accurately assessed for this plan, the technical workgroup estimated that onsite sewage systems in the Hood Canal reduce nitrogen by between 30% and 70%. This range of treatment effectiveness and thus discharge to Hood Canal was used in the calculations for the overall nitrogen loading.

Based on the 2000 census, staff from the USGS calculated that there are 53,934 people in the Hood Canal watershed. The calculation for loading from onsite sewage systems includes the number of people, multiplied by the typical sewage flow produced per person for the Hood Canal region (60 gallons per capita), multiplied by an average nitrogen concentration of 50-70 mg/l-N. Finally, the total is multiplied by the reduction from onsite sewage system treatment (between 30% and 70% nitrogen reduction). By this method of estimation, between 74 and 241 tons of nitrogen per year is estimated to enter Hood Canal from onsite sewage systems.

Another method for calculating nitrogen loading from onsite sewage was also used to verify the assumptions and calculations. From EPA (2002), the nitrogen released in untreated sewage was estimated at 6 to 12 grams per person per day. Again we assumed a population of 53,934 and 30% to 70% reduction of nitrogen due to onsite sewage systems. This method provided a loading range of 39 tons to 182 tons per year.

Thus, the overall predicted range of nitrogen input to Hood Canal from onsite sewage systems is 39 to 241 tons of nitrogen.

<u>Uncertainty factors:</u>
The manner in which this calculation was completed results in the best estimate that could be completed for the PACA using available data. As noted above, there are many variables that produce uncertainty. The following list of factors should be taken into account when interpreting the data.

1. Failing or improperly treating onsite sewage disposal systems: The low end of the loading estimate would include assumptions that most all onsite sewage systems are functioning properly. The high end of the loading estimate would include higher nitrogen inputs associated with a higher proportion of onsite sewage systems that improperly treating sewage. In the past, when sanitary surveys have been conducted along the shoreline of Lower Hood Canal, Mason County found that as many as 1/3 of the onsite sewage treatment systems were failing. However, all onsite sewage systems contribute nitrogen to a lesser or greater extent. System "failure" might influence the overall loading, but not as substantially as with bacterial contamination.

At the PACA Technical Workshop, there was consensus that the potential impact from failing onsite sewage treatment systems could be a very large influence on the overall estimation of nitrogen loading from this source.

2. A high density of shoreline systems. Because the loading calculation included an assumption that nitrogen is conservative (*i.e.*, that all nitrogen leaving an onsite sewage treatment system is discharged to Hood Canal eventually), the loading estimate should

account for a high proportion of shoreline onsite sewage systems that would theoretically provide less nitrogen treatment in the soil after discharge from the system.

At the PACA Technical Workshop, there was consensus that the potential impact from shoreline onsite sewage treatment systems could be a very large influence on the overall estimation of nitrogen loading from this source.

3. Nitrogen uptake before reaching Hood Canal. In many areas, especially those areas in the Hood Canal watershed farther from surface water, treated effluent from onsite sewage treatment systems enters groundwater, only to discharge to the surface as a spring or a seep prior to entering the Hood Canal. Where that occurs, it is likely that the nitrogen is taken up by vegetation, or by stream biota.

The PACA Technical Workgroup felt that it was difficult to quantify this potential factor, and determined it would be highly variable depending on the location within the watershed.

4. Another variable that was not addressed is the population influx during the tourist season. There are no estimates available for the number of tourists, their use of onsite systems, and the number of seasonal residents. This factor could not be addressed in this assessment. Seasonal residents and tourists have the potential to have a disproportionately large impact, because the population influx corresponds seasonally with the highest impact on dissolved oxygen.

Stormwater Runoff

Stormwater runoff contains nitrogen from development, including nutrients from fertilizers. The Typical concentrations are found in Table A-1

For this plan, we used land use/land cover data for the Hood Canal watershed obtained from satellite photos taken in 2000. The land use/land cover was estimated from LandSat TM satellite images, and classified into different categories of landcover. From the classified data, we summed the total amount of Commercial, High Density Residential, Medium Density Residential and Low Density Residential landcover in the Hood Canal watershed. The summary data are found in Table A-1.

Table A-1. Total acreage of land uses that create stormwater runoff in the Hood Canal watershed.

WRIA	Commercial	High Density Residential	Medium Density Residential	Acreages/ Rural Development
14	41	165	238	628
15	2104	1276	2166	5501
16	49	154	1321	685
17	98	20	107	188

Nitrogen loading was estimated based on the land cover classification, based on literature values (EPA 1999). This method for calculating loading from stormwater runoff projects that roughly 48,000 pounds (24 tons) of nitrogen per year is discharged into Hood Canal. However, not all stormwater runoff reaches Hood Canal, all counties require the use of BMPs to treat stormwater runoff, and terrestrial and aquatic plants use nitrogen that is discharged to stormwater conveyance systems and small streams. From literature studies on stormwater treatment, we project that these factors in sum could reduce the total stormwater nitrogen inputs by 50% (CWP 2004). The final estimate for a range of nitrogen input to Hood Canal from stormwater runoff is 12-24 tons per year.

Table A-2: Estimated Nitrogen Loading (adapted from EPA 1999)

Land Use	Total Kjeldahl Nitrogen (TKN) (lbs/acre/year)	Nitrate (NO_3) (lbs/acre/year)	Total Nitrogen Export (sum of TKN + NO_3) (lbs/acre/year)
Commercial	6.7	3.1	9.8
High Density Residential	4.2	2.0	6.2
Moderate Density Residential	2.5	1.4	3.9
Low Density Residential	0.03	0.1	0.1

<u>Uncertainty factors:</u>
The manner in which this calculation was completed results in a very rough estimate for stormwater nutrient inputs into Hood Canal. However, we believe it represents the best estimate that could be completed for the PACA plan using available data. There are many variables that produce a significant amount of uncertainty. The following list of factors should be taken into account when interpreting the data.

1. The land use/land cover data were obtained from an interpretation of LandSat TM data. Landsat data have a "pixel" size of 30 meters. This means that the smallest unit that could be classified as a landcover was roughly a 100 foot circle. A more detailed analysis being conducted by the HCCC with a pixel size of 5 meters will be completed by mid-2004.

Because of the nature of rural development, the land cover classifications for development are probably biased low—meaning that if the estimates are wrong, they are probably underestimating the various developed land classifications. The bias for underestimating development is consistent with the data for WRIA 14, which includes a portion of the Belfair UGA.

2. Another uncertainty in the loading estimate from stormwater is because staff are not fully aware of the "transmission routes" for stormwater. As road networks are developed, stormwater is transmitted more efficiently downstream. Because of the largely rural nature of the Hood Canal watershed, there are not a lot of data that allow for the analysis of how effectively stormwater is being transmitted directly to Hood Canal.

3. In general, estimating nitrogen based on landcover is at best a coarse-level analysis. Individual landscaping practices, pet waste handling, stormwater conveyance patterns, and other factors will affect the projections.

Salmon Carcass disposal

We made a rough estimate of salmon carcass nitrogen input into the marine waters of Hood Canal as follows. First, we assumed that treaty rights allow for Tribal fisherman to catch 450,000 chum annually (Personal communication, Keith Dublanica, David Herrera and Guy Miller, Skokomish Tribe fisheries and natural resources departments). However, this level of chum harvest is not often reached (Ted Labbe, personal communication, 2004). Therefore, we assume:

1) Between 200,000 and 300,000 total fish caught in an average season
2) Approximately 2/3 of the total, or 133,000-200,000 fish, are disposed of overboard and deposit in water beneath the thermocline
3) The average weight of fish is 8 pounds, so between 1.06 million and 1.6 million pounds of fish decompose adding nitrogen into the water column
4) The amount of nitrogen in an average fish is 3% by weight *
5) Therefore the nitrogen released amounts to 32,000-48,000 pounds or 16-24 tons.

* source: Cederholm et al., 2001

Assumptions and limitations

We assumed a range of chums caught by tribal fishermen from 200,000-300,000 fish. Some of these dead carcasses drift into shallow water or onto the upper shoreline with the tide, and do not contribute to the dissolved oxygen problem. We assume 1/3 of the totals do not contribute, and 2/3 sink to the bottom in water depths or 30 feet or more (into the hypoxic water). As fish decompose, two important processes occur: one is more immediate and relates to the protein and oil in their flesh which demands oxygen; the other relates to total breakdown into basic elements including nitrogen, and may take several months. Although these dead fish undoubtedly use up oxygen as they rot, the exact amount of nitrogen leached into the Hood Canal and the BOD equivalent is difficult to compute, since much of the fish's flesh is converted into other living biomass by detritus feeders, such as crab and shrimp. We also realize the fishery takes place after the severe September and October conditions of extreme low DO, but the effect of one to one and a half million pounds of fish in the Great Bend vicinity of the Canal is significant, and represents a source we can address through working with the Skokomish Tribe..

Agricultural Waste and Practices

There was general agreement in the PACA technical workgroup that nitrogen originating from livestock waste reaches the Hood Canal waters through runoff and leaching.

In 1998, the United Stated Geological Survey conducted a water quality assessment of the Puget Sound Basin focusing on nutrient transport in rivers from 1980 through 1993 (Embrey and Inkpen, 1998). Of the four river basins that were assessed that empty into the Hood Canal, the Skokomish, Hamma Hamma, Duckabush, and the Dosewallips, only the Skokomish was found to contribute nitrogen from animal manure. The report estimated that from1980 to 1993 approximately 0.11 tons of total nitrogen loading per square mile per year resulted from animal waste.

The Olympic National Park and Olympic National Forest occupy much of the Skokomish Watershed with only 61,468 acres lying outside the Park and Forest boundaries (Kirby, personal communication, 2004). A total of 2,007 acres are enrolled in agriculture lands and are mainly concentrated in the Skokomish Valley (Kirby, personal communication, 2004). A livestock inventory conducted in winter 2004 showed that there are 1,110 cows, 75 horses, 14 llamas, 2 sheep and 68 goats (Kirby, personal communication, 2004).

The Mason Conservation District conducted a livestock inventory in the lower Hood Canal watershed (excludes the Skokomish watershed). Generally, only small agricultural or livestock farms operate in the area (Kirby, personal communication, 2004, Sweet *et al*, 2002). The inventory reported 118 cows and 127 horses (Mason CD, 1997).

Table A-3 shows the number of cattle and horses in the Skokomish and Lower Hood Canal watersheds, the estimated total waste per livestock category, and the estimated amount of nitrogen that reaches Hood Canal via runoff and leaching. The nitrogen loading from horse and cattle waste was calculated by determining the total number of livestock per area and the relative contribution of nitrogen per livestock category. For this study we used ranges of 3% runoff for well managed farms, 20% using national average for runoff from farms, and 80% runoff for farms that have poor animal waste management (NRC, 1993 and Howarth *et al.* 1996, 2002 as cited in CENR 2003).

The Mason Conservation District reported that approximately half of the farms fall into the poor animal waste category. For the remaining farms we calculated a range of 3% and 20% runoff. Mason Conservation District reported that the average weight per cattle in this area is 1000 pounds and the average weight per horse in this area is 1000 pounds. The total percent loading estimates were calculated using a United States Department of Agriculture estimate of nitrogen content in excreted manure per 1000 pounds of horse and cattle (USDA, 1992).

Assuming that half of the livestock come from poorly managed farms (Kirby, personal communication, 2004) yields a nitrogen load of 35,112 pounds or 17.6 tons. Assuming that the other half of the farms are in the range of well to average management (Kirby, personal communication, 2004) yields a nitrogen load of 0.7 tons to 4.4 tons. Thus, the total nitrogen load is in the range of approximately 18 tons to 22 tons.

Uncertainty

The PACA technical workgroup acknowledged that there is great variability due to seasonality. For example, while there is a range of how long individuals keep cattle on their property, on average cattle are only kept for 6 months out of the year before they are sent to feed lots outside the Hood Canal watershed (Kirby, personal communication, 2004). Agricultural practices including how crowded the cattle and their relation to or distance from water bodies are also greatly variable. Large cattle operations have a greater impact. Flooding or heavy rainfall on improperly stored manure, for example, will increase how much nitrogen enters Hood Canal.

The estimates calculated in this section were based on percentage of poor to well managed farms. These assumptions should be revisited at a later date with more specific information on farm management practices, which would lead to more precise estimates of nitrogen loading

Table A-3. Nitrogen loading estimate from Cattle and Horse waste in the Skokomish and Union Watersheds.

Livestock Type	No. of livestock	Avg. weight (lbs.)	N prod. lbs/d/1000# of livestock	Total N per day	lbs. of N per yr (horses) 6 mo. (cattle)[5]	3% runoff (well managed farms)	20% runoff (average)	80% runoff (poorly managed farms)
Beef Cattle	1228	1000	0.3	368	66,976	2,009	13,395	53,581
Horse	202	1000	0.28	57	20,805	624	4,161	16,644
Total					87,781	2,633	17,556	70,225

Sources: (Howarth *et al.,* 1996 as cited in CENR, 2003**;** Kirby, 2004; Mason CD, 1997; NRC, 1993; USDA, 1992).

Table A-4. Estimated nitrogen loading to Hood Canal from forest fertilization.

	Year	Number of acres fertilized	Pounds of Urea pellets per acre	Pounds active N per acre	Total tons N	1% entering streams (tons)	10% entering streams (tons)
Simpson	2003	500	440	200	50	0.5	5
Simpson	2002	600	440	200	60	0.6	6
USFS	2001	1275	440	200	128	1.3	13
Simpson	1996	2000	440	200	200	2	20

Sources: (Anderson, 2000; Carlson, 2004; Cline, 1973; Greggs, 2004).

[5] Cattle only remain in the Skokomish and Union watersheds for and average of six months out of the year before they are sent to feed lots elsewhere (Kirby, personal communication, 2004).

Forest Practices

Researchers have found that fertilization of forests can result in the export of some proportion of fertilizer to surface waters through runoff and leaching (Anderson, 2000; Cline, 1973; EPA, 1990). Once the fertilizers reach surface waters, nitrogen can be quickly transported downstream depending on the rate of flow of the forest streams and how quickly aquatic plants consume the excess nitrogen. For this plan, we estimated the amount of nitrogen input to Hood Canal from forest fertilization based on a previous study in the Tahuya River watershed (Cline, 1973) and another study in the western Cascade mountains (Anderson, 2000).

In the Tahuya River study between 0.45 % and 1 % nitrogen was detected at downstream sites (Cline, 1973). In the western Cascade study the amount of applied nitrogen lost to forest streams was generally less than 10%, but could be larger (up to 27%) under certain soil and moisture conditions (Anderson, 2000). Based on these studies (Cline, 1973, Anderson, 2000), we used a range of 1% to10% loss of total applied nitrogen to estimate potential runoff and leaching to Hood Canal. We acknowledge that these studies were conducted prior to the adoption of the most current and more stringent Washington State forest practices rules and that these estimates could be high depending on how well current forest practice rules are followed, such as maintaining required buffer widths around streams. Physical factors that could accelerate or decelerate runoff and leaching include the slope of the land, soil permeability, soil water saturation, and rainfall (Cline, 1973).

In 2003, approximately 500 acres were fertilized. Applying a 1 % and a 10 % runoff estimate, yields a range of 0.5 and 5 tons of nitrogen that may have entered Hood Canal.

Uncertainty

The PACA technical workgroup acknowledged that there is a great deal of uncertainty about how much nitrogen originating from forest fertilization enters Hood Canal. The actual amount would depend on how and when the fertilizer is applied. For example, if fertilizer is applied closer to surface waters and on steep slopes, fertilizer runoff greatly increases. Upland fertilizer application may impact Hood Canal less than fertilizer application closer to the shores. As seen in Table A-4, the amount of fertilized acreage varies a great deal from year to year. Thus, the total nitrogen loading from forest fertilization into Hood Canal is expected to vary each year.

Appendix C PACA Work Session Meeting Summaries

Work Session 1. February 27, 2004 Session in Belfair Public Library

Focus Question: What human-related activities contribute to low dissolved oxygen levels in Hood Canal?

Changes in Aquatic Bio-Diversity	Hydraulic & Hydrological Modification	Commercial Fishing Practices	Human Sewage	Ag Wastes & Practices	Point Sources	Storm Water Impacts
Increase seal/ seagull populations	Hydrologic Modification	Salmon carcass disposal in nearshore	Human sewage sources	Farm animal waste	Release of effluents	Improperly treated storm water runoff
Changes in animal abundances/ occurrences	Hydro alteration – development	Carcass dumping – Marine	Septics add nutrients	Agriculture manure	Permitted (NPDES) discharges (*i.e.* Alderbrook)	Development & related storm water runoff
Sea life harvesting	Diversion of water from HC watershed	Sediment disturbance – geoduck harvesting practices	Recreation waste	Aerosol fallout from manure spraying?	Fish hatchery waste – nutrient laden food, etc.	Charity car washes/car lots and residential
	Low DO Skok estuary borrow pits				Shellfish plants rinse water	Low DO water from storm vaults
	HC Bridge UW study – circulation issues				Aquaculture	
	Hydro alteration – dams					
	Skokomish River Flooding					

<u>Focus Question</u>: What human-related activities contribute to low dissolved oxygen levels in Hood Canal? (Continued)

Marina & Boat Wastes	Solid Waste Management	Land Use Development Standards	Aquatic Habitat Alterations	Forest Practices	Individual Landscaping Practices	Ag & Commercial Fertilizing Practices
Marina & boat wastes	Pet waste	Land use patterns & changes	Displacement or removal of aquatic plants	Changes in forest type Conifer to alder	Residential lawn fertilizers	Fertilizer runoff
Fisherperson "poop" (pleasure boaters)	Fertilization (unintentional or as by-product	Increasing land development	Loss of shoreline/ estuary functions	Logging/timber practices	Yard waste dumping at beach or streams	Agriculture fertilizer
Boat/marina waste	Illegal dumping	Lack of standards for low DO area	Removal of wetlands	Alder conversion of forests	Lawn/garden clipping dump	Lawn/turf fertilizer use (e.g. golf course)
	Landfills	Effects of increased rural population density in HC	LWD removal in streams	Commercial forest fertilizers		
		Older high density development effects on HC	Eel grass/ nearshore impact – changing commercial fishing methods	Pesticide & herbicide use		
		Lack of consistent & thorough water quality monitoring				

Focus Question: What existing studies, information, or data do we have available that quantifies human-related activities that contribute to low dissolved oxygen levels in Hood Canal?

- Changes in Aquatic Biodiversity

Title or Topic:	Macrobenthic Communities and Eutrophication, Roger *I.E.* Newell & Jörg A. Ott
Source:	Ecosystems at the Land-Sea Margin: Drainage Basin to Coastal Sea, Coastal and Estuarine Studies
Date:	2000
Notes:	

Title or Topic:	For landings – WDFW/Tribes For population trends – WDFW/Tribes
Source:	In WDFW – groundfish/forage fish (Greg Bargmann) Birds: Dave Nysewander/Dave Ware Marine mammals: Steve Jefferies Other wildlife: Dave Brittel Biodiversity studies: Elizabeth Rodrick
Date:	
Notes:	

- Hydraulic and Hydrological Modification

Title or Topic:	Comprehensive Flood Hazard Management Plan
Source:	KCM
Date:	1996
Notes:	

Title or Topic:	Lots of papers by Booth, Schueler, Karr, Mallin, and others describing how development changes watershed hydrology
Source:	
Date:	
Notes:	

- Commercial Fishing Practices

Title or Topic:	Geoduck Final Environmental Impact Statement
Source:	WDFW
Date:	
Notes:	

Title or Topic:	Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity by John G. Stockner
Source:	American Fisheries Society Symposium 34:71-88, 2003 Proceedings of 2001 Nutrient Conference: Restoring Nutrients to Salmonid Ecosystems, Eugene, OR 24-26 April, 2001
Date:	AFS 2003 publication of 2001 conference
Notes:	Jaquet, Joe; Ned Pittman, Jeffrey Heinis; Steve Thompson; Nui Tatyama, and Jeff Cedarholm. Observations of Chum Salmon Consumption by Wildlife and Changes in Water Chemistry at Kennedy Creek – 1997-2000 (Mary Lou Mills has a copy)

Title or Topic:	Commercial Salmon Harvests (fish tickets)

Source:	WDFW – Tribes (co-managers)
Date:	On-going
Notes:	Estimates of commercial salmon harvest (percent dumped in nearshore/canal maybe included)

Title or Topic:	Marine Derived Nutrients from Salmon Carcasses
Source:	Book produced by WDNR and WDFW, Jeff Cedarholm (WDFW contact: David Johnson)
Date:	
Notes:	About interactions of wildlife and use of salmon carcasses

Title or Topic:	Seafood Waste Management Study
Source:	Pacific Seafood Processors Association
Date:	June 1983
Notes:	Seafood "composting" in the nearshore, processing waste and effluent

- Human Sewage

Title or Topic:	Human sewage
Source:	Kitsap County Health District
Date:	1996-2003
Notes:	FC trad data and conventional parameters (temperature, do, ph, turbidity) for Upper Hood Canal Watershed. 2001-2002 Report provided. 2002-2003 report coming.

Title or Topic:	Innovative Systems in the La Pine National Demonstration Project
Source:	Oregon DEQ, Authors Barbara Rich, Dan Haldeman, Todd Cleveland, Jill Johnson, Rod Werck, Roger Everett
Date:	Not available
Notes:	Evaluates different sewage treatment systems in terms of performance, denitrification Email for Barbara Rich = BarbaraR@co.deschutes.or.us

Title or Topic:	Human sewage
Source:	Kitsap County Health District
Date:	1995
Notes:	Upper Hood Canal Water Quality Assessment – FC, conventional and nutrients for stream and marine

Title or Topic:	Lower Hood Canal Pollution Identification
Source:	Mason County Health
Date:	2001
Notes:	Centennial Clean Water Grant G0000357

Title or Topic:	Human Sewage
Source:	Kitsap County Health District
Date:	2001
Notes:	Final Report – Port Gamble Bay/Gamblewood Sanitary Survey Project (Impacts of failing OSS and animal waste on surface water. Many other reports available too.

Title or Topic:	List of approved system and products as established in Chapter 246-272 WAC on site sewage system
Source:	DOH waste water
Date:	2003 - 2004
Notes:	Lists of OSSS systems approved for use removal rates

Title or Topic:	Methodology to Predict Nitrogen Loading from OSSS
Source:	Tom Long, 8th NW On-Site Wastewater Treatment Short Course and Equipment Exhibition
Date:	Sept. 18-19

Notes:	Nitrogen loading rates from vanous OSSS types and soils

Title or Topic:	Lower Union River Water Quality Assessment
Source:	Mason Conversation District HCSEG
Date:	2003 - ongoing
Notes:	• Fecal dates in lower Union River watershed • Toxin data also

Title or Topic:	Unpublished data on bacteria and nutrients in Belfair Creek
Source:	Ecology (Dave Garland)
Date:	2003-2004
Notes:	Data shows bacteria due to on-site system failure and also correlates nitrogen with bacteria loading.

Title or Topic:	Skokomish Fecal Coliform TMDL Submitted. Also detailed Implementation Plan
Source:	Ecology
Date:	Submittal – 1992, -1993
Notes:	Info available via Publications at www.ecy.wa.gov

Title or Topic:	Union River Fecal Coliform Water Cleanup Detailed Implementation Plan
Source:	Ecology - Dave Garland (425) 645-7021
Date:	August 2003
Notes:	Report documents implementation cleanup actions for bacteria in Union River

Title or Topic:	Union River Fecal Coliform TMDL Study Report
Source:	Ecology – Dave Garland
Date:	June 2002
Notes:	Report documents seasonal variation and loading of bacteria in Union River Watershed

- Ag Wastes & Practices

Title or Topic:	LUR Farm inventory and LHC
Source:	Mason Conservation
Date:	Updated 2004
Notes:	

Title or Topic:	Skok Farm Inventory
Source:	Mason Conservation District
Date:	2004
Notes:	

Title or Topic:	Skok Final Report
Source:	Mason Conservation
Date:	09/2003
Notes:	Includes all BMP's implemented - # farms - ? Feet fence

Title or Topic:	Nutrient Transport in the Major Rivers and Streams of the Puget Sound Basin, WA
Source:	USGS
Date:	March 1998
Notes:	Non-point (animal manures, agriculture fertilizers, atmos deposition) Point (WW treatment plant)

Title or Topic:	Skokomish Fecal Coliform TMDL Submittal. Also detailed implementation plan
Source:	Ecology

Date:	Submitted – 1992? DIP – 1993
Notes:	Info available via Ecology publications @ www.ecy.wa.gov

- Individual Landscaping Practices

Title or Topic:	Water Pollution Facts
Source:	Kitsap SSWM & PSAT
Date:	
Notes:	20 Facts and actions to prevent water contamination (including lawn and garden chemicals) Fact sheet and implementation actions for WQ problems, including nutrients

Title or Topic:	Low dissolved oxygen in HC- problem and what to do
Source:	Teri King's draft brochure
Date:	2004
Notes:	Draft Sea Grant brochure covers landscape chemicals and clippings

Title or Topic:	Potential source
Source:	Lawn Jockey (www.lawnjockey.com)
Date:	
Notes:	Web source for residential lawn practices – ecofriendly/recyclish

- Point Sources

Title or Topic:	NPDES Permits for WRIA 14, 15, 16, 17
Source:	ECY – Teri King has CD of them
Date:	2004
Notes:	

Title or Topic:	Municipal and industrial permits (have discharge monitoring reports DMRs for effluent discharges)
Source:	Ecology
Date:	
Notes:	Permits not now including nitrogen monitoring, could be amended to include nitrogen control and monitoring

Title or Topic:	Ecology – issued aquaculture net pen permits could include nutrient control and monitoring
Source:	
Date:	
Notes:	

- Storm Water Impacts

Title or Topic:	Skokomish Centennial Grant #G9500169
Source:	
Date:	
Notes:	

Title or Topic:	Estimate of Nonpoint Pollutant Loading and Treatment Costs
Source:	Coastal Nonpoint Source Control Program, Management Measures Technical Guidance, USEPA
Date:	~1998
Notes:	Michael Rylko for source copy

Title or Topic:	Stormwater/Impervious Surfaces (Puget Sound)
Source:	Dr. Chris May
Date:	1990's?
Notes:	Impacts to stream systems from stormwater/impervious surfaces

- Marina and Boat Wastes

Title or Topic:	Ecology issued boatyard permits could include nutrient control and monitoring
Source:	
Date:	
Notes:	

Title or Topic:	Marina and Boat Waste
Source:	Kitsap County Health District
Date:	1992
Notes:	Study to determine marina impacts on FC concentrations in surface water and other studied used to develop regulations

Title or Topic:	20 Water Pollution Facts – including boat waste
Source:	Kitsap SSWM
Date:	
Notes:	Implementation actions associated with 20 WQ Facts and Issues

Title or Topic:	Low dissolved oxygen in Hood Canal Problem and What You Can Do
Source:	Teri King (Sea Grant Brochure)
Date:	2004
Notes:	Draft UW Sea Grant brochure covers boat maintenance and fishing practices

- Solid Waste Management

Title or Topic:	Pet Waste Grant
Source:	DOE/ Mason Conservation
Date:	2004
Notes:	

Title or Topic:	Pet Waste – Kitsap Peninsula
Source:	Chris May
Date:	2002-2003
Notes:	Excellent review and inputs

Title or Topic:	Pet Waste is Natural, But...
Source:	Kitsap Co. Surface Water Management
Date:	2004
Notes:	Implementation actions for pet waste management

- Land Use Development Standards

Title or Topic:	Puget Sound Land Use Cover Data
Source:	UW Urban Ecology Lab (contact: Marina Alberti)
Date:	
Notes:	New, covers all of Puget Sound. More limited historical (to 1991 or so) data for Central Puget Sound

Title or Topic:	Impervious Surface and Road Density as Highly Correlated Metrics for Predicting the Transport of Pollutants
Source:	Marina Albert et al
Date:	Not yet released (Stuart Glasoe for status)
Notes:	

Title or Topic:	CTED citations of Best Available Science
Source:	CTED
Date:	~2003
Notes:	May or may not have nutrient specific info but has information on different pollution sources, habitat impacts, mitigation measures

- Aquatic Habitat Alterations

Title or Topic:	Alteration of Hood Canal Nearshore Environments
Source:	PNP TC/ Hirschy, R
Date:	2003
Notes:	Hood Canal is broken into segments and docks, bulkheads, and development is quanitified

Title or Topic:	Limiting Factors Analysis (WRIAs 15, 16, 17)
Source:	Washington State Conservation Commission
Date:	2003
Notes:	Quantification of nearshore habitat loss/conversion (saltmarsh, fill, etc)

Title or Topic:	SSHIAP Database
Source:	PNPTC/WDFW
Date:	On-going
Notes:	Information on hydro-modifications and land use changes related to aquatic habitat

- Forest Practices

Title or Topic:	Forest Fertilizer Fertilizing Douglas Fir Forests
Source:	General Tech Report PNW – 83, see page 7
Date:	01-1979
Notes:	UW has fertilizer coop study also. Didn't have time to find USFS, WADNR, Simpson

Title or Topic:	TFW Fertilizer Study
Source:	TFW Archive, DNR should have, Skok has a copy
Date:	Early 1990's
Notes:	Directed stream sampling of aerial fertilization of forest lands

- Ag/Commercial Fertilizing Practices

Title or Topic:	Water Quality Assessment Nutrient Transport in Rivers (Embrey and Inkpen)
Source:	USGS Report 97-4270
Date:	(1998) data from 1980-1993
Notes:	Includes some Hood Canal tributaries

Title or Topic:	Human Alteration of the Global Nitrogen Cycle: Causes and Consequences
Source:	Issues in Ecology Authors: Bitousek, Aber, Howanth, Likens, Matson, Schindler, Schlesinger, Tilman
Date:	8/23/03 (?)
Notes:	Yes, I know it's broad but it's excellent! Although this is global, it provides clear solid information (factual) on human causes of alteration of the N cycle, by type of causes & quantity of change. Great

	references for further review.

- Overarching Studies

Title or Topic:	The Nature of Hood Canal
Source:	Washington Sea Grant Conference Proceedings
Date:	1998
Notes:	dissolved oxygen talks, storm water, sewage, animal, siltation, salmon, shellfish, hydraulics, etc.

Title or Topic:	1) Lower hood Canal Watershed Characterization Report, 1993 1) West Shore Hood Canal Watershed Characterization Report – 1996 or 1997 2) Lower Hood Canal Watershed Implementation Plan - 1996
Source:	1) Puget Sound River Basin Team 2) Mason County
Date:	
Notes:	Teri King

Work Session 2. March 5, 2004 at the Hoodsport Public Library

Human Sewage Approach

Basic Assumptions:

Nitrogen discharges from on-site sewage systems can reach marine waters. Nitrate is relatively "conservative" in groundwater. All nitrates that reach Hood Canal can be used to support algal growth, which has been implicated as a cause of low DO.

- Shoreline systems – large
- Failing systems – large
- Uptake by plants (discharge to streams) – highly variable ???
- More alternative systems – v. small

Working Steps:

Estimate the number of homes in the Hood Canal watershed based on 2000 Census data. Factoring out Alderbrook will give the number of homes discharging treated sewage into Hood Canal. Based on the census, we will determine the residency status (permanent vs. vacation homes). We will also use a rough estimate of the number of conventional systems, number of alternative systems, and number of improperly treating and failing systems. Use best estimated septic discharge concentration values for the various systems and calculate nitrogen and BOD loading from all systems.

Notes:
Failing – 0% treatment – N & BOD
~80 mg/L average
30% to 70% treatment

Data Needs:

Census data in GIS format, number of homes connected to sewage treatment plants, rough proportion of types of septic systems, estimates of numbers of failing systems, data that defines nitrogen outputs from septic systems (various types)

Data Sources:

- US Census Bureau
- Mason County Environmental Health database of septic systems
- Methodology to Predict Nitrogen Loading from On-site Sewage Treatment Systems (Tom Long)
- Misc. papers on nutrient removal by septic systems
- Kitsap County water quality data
- Mason County water quality data
- Mason Conservation District water quality data
- DOE water quality data
- Assessor's data of waterfront parcels

Stormwater Approach

Basic Assumptions:

The types and concentrations of pollutants[1] in storm water in Hood Canal are similar to other areas in Puget Sound with similar land cover and use. Storm water discharge (volume) depends on the location, type, and amount of land cover in a watershed and rainfall. There appear to be limited use of storm water treatment facilities within the Hood Canal. However, BMPs may lower efficiencies at nutrient removal.

[1] Clarify nutrients of concern
[2]Proximity and connectivity to storm water drainages
[3]Forest, landscape, road, parking lots, bare, other impervious

Working Hypothesis:

Use existing land use/land cover data in the Hood Canal watersheds to calculate types, locations, and amounts of land cover use, precipitation estimates, and soil surveys in the watersheds to calculate storm water volume. Use available average storm water contaminant concentration values for land cover types to calculate nitrogen and BOD loading from storm water.

As an alternate, use loads/per (?) (e.g. lbs/yr) to calculate for each land cover type.

Use monthly precipitation to distribute annual load among months.

Data Needs:

Land use/land cover data, precipitation estimates in various parts of Hood Canal, storm water chemical concentrations for and loads

Data Sources:

- USFS watershed analyses
- Land Use/Land Cover GIS data from UW/USGS Jefferson, Kitsap and Mason counties
- EPA, Preliminary Data Summary of Urban Stormwater BMPs
- EPA, Estimate of Nonpoint Pollutant Loading and Treatment Costs
- Center for Watershed Protection, Impacts of Impervious Cover on Aquatic Ecosystems
- USGS GW/May's storm water studies for Banger
- UW civil engineering tech report on Puget Lowland streams (C. Konrad)

Note: Unless you have specific information about Bangor we suggest leaving it out.

Ag Wastes & Practices

Basic Assumptions:

That nitrogen and BOD, which includes fertilizers from agriculture and forest practices, comes from agricultural practices via surface flow and shallow subsurface flow. These nutrients and BOD end up in Hood Canal and contribute to low DO.

Working Hypothesis:

Estimate quantity of waste and fertilizer, taking into account space and time, land use, animal density, less uptake and removal that will give you total load into Hood Canal.

By looking at seasonality of animal density and chemical fertilizer application, we can control the input of N loading into Hood Canal.

Data Needs:

Livestock counts, estimates of nutrient and BOD export from farms, manure fertilizer application estimates, forest fertilizer use.

Data Sources:

- Mason County Cons. District 1995 farm inventories
- USGS Report 97-4270, Water Quality Assessment Nutrient Transport in rivers
- USGS Report (March 1998), Nutrient Transport in the Major Rivers and Streams of the Puget Sound Basin, WA
- Skokomish TMDL studies
- Union River TMDL studies
- NRCS Nutrient Management spreadsheet (S. Kirby)
- Livestock inventories (Conservation Districts) (S. Kirby)
- USFS – has forest fertilizer use info (F. Davis)
- DNR - has forest fertilizer use info
- Christmas tree farms → distributor to get average application (?)
- Simpson has forest fertilizer use info (get from Simpson via S. Kirby or F. Davis)
- Fertilizer recovers from golf courses – Alderbrook, others?

Point Sources Approach

Basic Assumptions:

Permitted discharges are monitored and reported to Ecology or EPA, and data are available allowing a calculation of the total sum of nitrogen and BOD from the discharges.

Maybe outside scope:

Any other relevant permits in addition to NPDES (Ecology & EPA), e.g.

- WSDOT grading/vegetation fertilization
- 404/10 permits (dredge material disposal)
- Landfill discharge permits?
- C(AFO)s
- Slash management permits

Working Hypothesis:

Estimate discharges for those NPDES permits that do not currently require nitrogen and BOD monitoring.

Simply add up the permitted discharges.

Prioritize PS discharger from inventory

- Type of discharge
- Total loading
- Location of discharge
- Seasonal variation
- Age/type of treatment
- Existing permit schedule
- Existing monitoring requirements

Data Needs:

Inventory of permitted discharges from NPDES permits. Some permits do not include requirement for nitrogen monitoring. Would need to estimate what those discharge amounts for nitrogen and BOD are until data are collected.

Data Sources:

- Teri King has a CD of NPDES permits; Michael Rylko may help with Bangor Sub-base loading calculations and reports of SW and any other submerged discharge info.
- Need to add federal NPDES permits to Teri's file? → Michael (need copy of CD) or Ecology Website and EPA files

Individual Landscaping Practices

Basic Assumptions:

Nutrients enter Hood Canal by way of landscaping practices, including chemical fertilizer application and yard waste dumping and composting practices. Run-off from lawns and landscaping on or near waterways would have a greater impact on nutrient loading.

Working Hypothesis:

- Lawn services – number of residents that use services/total application of fertilizer & herbicide
- Existing studies that estimate nutrient runoff (look internet – nationwide studies)
- Fertilizer records @ Alderbrook for estimating residential use
- Contact salmon friendly lawn campaign folk for estimates
- Query of how many people live on/near water
- Constance Ibsen north and south shore information on land practices (group nonprofit advisory board to county commissioners – S. Kirby has her number)
- By estimating fertilizer use and disposal practices we can determine the amount of N entering Hood Canal

Group Comments on Approaches

Human Sewage
- Seasonality...regional concentrations?
- How many systems are failing? Overloading?
- On-site systems on fill versus natural soils (percent)?

Ag Wastes & Practices
- Do data sources have uptake data by plants? Run-off from farms? (Spreadsheet)
- Mapping shows where the animals are
- We know the seasonality of farm animals – overall number of animals going down
- Most have farm plans
- Is coliform numbers a valid substitute? ~yes – quantitatively

Storm Water Impacts
- There isn't enough data from Puget Sound to strictly rely on those numbers – better to add other studies – there will be follow up by Stuart (land use categories)
- USFS has study numbers for watershed analyses → Chris will help point in right direction
- Road density could be a factor

Point Sources
- Use surrogate permits
- Michael will work with Bangor and work with Ecology to do inventory
- Pam will do some phone calls to Alderbrook

Landscaping Practices
- Loading rates in watershed protection manual has residential loading rates
- Make sure this is not double counted in storm water

Keep in mind the interconnectedness between clusters of human –related activities that contribute decreased dissolved oxygenlevels in Hood Canal

Focus Questions:

1) What three categories of human-related activities are the biggest contributors to decreased dissolved oxygen levels in Hood Canal? Red Dots

Changes in Aquatic Bio-Diversity	Hydraulic & Hydrological Modification	Commercial Fishing Practices	Human Sewage	Ag Wastes & Practices	Point Sources	Storm Water Impacts
1	3	1	15	9	5	12

Marina & Boat Wastes	Solid Waste Management	Land Use Development Standards	Aquatic Habitat Alterations	Forest Practices	Individual Landscaping Practices	Ag & Commercial Fertilizing Practices
0	2	12	0	2	4	4

2) Which three categories of human-related activities do we know the least about? Blue Dots

Changes in Aquatic Bio-Diversity	Hydraulic & Hydrological Modification	Commercial Fishing Practices	Human Sewage	Ag Wastes & Practices	Point Sources	Storm Water Impacts
9	11	9	1	0	0	4

Marina & Boat Wastes	Solid Waste Management	Land Use Development Standards	Aquatic Habitat Alterations	Forest Practices	Individual Landscaping Practices	Ag & Commercial Fertilizing Practices
5	6	2	10	7	1	4