Kitsap County Health District
Upper Hood Canal Pollution Identification and Correction Project
Final Report

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Pollution Identification and Correction Program
December 31, 2008

Funded by Washington State Department of Ecology, Centennial Clean Water Funds
and the Kitsap County Surface and Storm Water Management Program

WASHINGTON STATE DEPARTMENT OF ECOLOGY

KITSAP COUNTY SSWM Surface and Storm Water Management

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This project would not have been possible without grant funding from Washington State Department of Ecology Centennial Clean Water Fund, and matching funds from Kitsap County's Surface and Stormwater Management (SSWM) Program. SSWM's core purpose is to address non-point pollution, which has been identified as the primary source of pollution in Kitsap County's surface waters. SSWM funds a variety of activities oriented toward non-point pollution control, flood reduction, and fish passage improvement. SSWM provides a stable funding source for Health District pollution identification and correction activities.

FINAL REPORT
DECEMBER 31, 2008

EXECUTIVE SUMMARY

In 2003, Washington State Department of Health Shellfish Programs (WSDOH) established shellfish closure zones at the mouths of Kinman Creek, Lofall Creek, and Jump Off Joe Creek along Kitsap County's Upper Hood Canal shoreline. Kitsap County Health District (Kitsap Health) initiated preliminary investigations along these creeks and found elevated fecal coliform (FC) levels, indicating FC pollution sources.

Fecal pollution sources typically include failing onsite sewage systems (OSS) and inadequate animal waste management. Fecal pollution is a public health concern because disease-causing organisms are present in fecal waste. Fecal waste, which contains nitrogen and phosphorus, can also deplete oxygen in surface waters as it degrades.

Kitsap Health conducted an early action pollution identification and correction (PIC) project during 2005-2006 in the Upper Hood Canal watershed from Warrenville (Ioka Way, Silverdale) south to the Kitsap-Mason County line (see Figure 1, Study Segments 1-9). Funding was provided by Puget Sound Action Team and the United States Environmental Protection Agency. Matching funds were provided by Kitsap County Surface and Stormwater Management Program (SSWM). A final report was submitted January 23, 2006.

This report details work conducted for the Washington State Department of Ecology Centennial Clean Water Fund (CCWF) 2006 grant to complete the investigation of Kitsap County's Upper Hood Canal shoreline (see Figure 1, Study Segments 10-17). The project builds on work conducted during the Hood Canal 2005-2006 project, extending the project area north to Salisbury Point, north of the Hood Canal Bridge, and assessing shoreline discharges during the dry weather season (May – October), in addition to the wet weather season.

The goals of the Upper Hood Canal Pollution Identification and Correction Project are:

- Protect designated beneficial uses in Upper Hood Canal from pollutants discharged from failing OSS and animal waste. Prevent degradation of Hood Canal.
- Locate approximately seventy-nine (79) OSS in the project area, identify their components, and characterize performance.
- Reduce fecal pollution into Hood Canal along Kitsap County's shoreline from failing OSS and animal waste.
- Provide water quality data to determine if there is a correlation between FC and nutrient levels in freshwater discharges to the marine shoreline.
- Provide water quality data to determine if FC source correction also results in nutrient reduction.

- Educate Upper Hood Canal residents about fecal pollution and actions they can take to reduce bacterial and nutrient contributions to Hood Canal.

To accomplish these goals, the following objectives were completed:

- Conducted FC source identification (shoreline surveys) along Kitsap County's developed shoreline during dry and wet seasons.
- Identified and investigated FC hotspots.
- Conducted property surveys and investigations in FC hotspots. Provided owners and residents with site-specific suggestions to avoid premature OSS failures and how to keep bacteria and nutrients out of Hood Canal.
- Enforced correction of failing OSS pursuant to state and local OSS regulations.
- Sampled a subset of Hood Canal shoreline discharges to continue correlation study of FC and nitrate+nitrite nitrogen levels.
- Sampled FC and nutrients in drainages with identified FC sources and nearby control drainages before and after OSS correction to determine FC and nutrient reductions.
- Presented project methods and results for public and peer workshops.

The conclusions of the Upper Hood Canal Water Pollution Identification and Correction Project are:

Kitsap's Upper Hood Canal shoreline does not have a serious OSS failure problem based on project results. This is supported by Kitsap Health's trend monitoring data for the water year ending September 2008. Nine (9) of the eleven(11) marine water monitoring stations in the project area meet both parts of Washington State's water quality standard for FC.

- Kitsap Health conducted thorough FC pollution source identification along Kitsap County's developed Hood Canal shoreline during the dry and wet season between 2005 and 2008.
- Properties were selected for survey based on their proximity to confirmed shoreline hotspots, WSDOH recommendation, public sewage complaints, and non-conforming monitoring and maintenance reports.
- Thirty-one FC pollution sources related to failing OSS were identified and were either corrected or vacated. This represents 4% of the properties in the project area, at the low end of the OSS failure range found in other PIC project areas. These results confirm the lack of a serious OSS failure problem along the shoreline.

Primary reasons for OSS failure in this project were age of the system and proximity to surface water.

- twenty-four (24) of the thirty-one (31) failing OSS were more than twenty years old; and
- twenty (20) had a non-conforming setback less than 100 feet from surface waters (65%).

Shoreline surveys were an effective method of finding OSS failures in this project.

- Sixteen (16) of the thirty-one (31) OSS failures (52%) found in Hood Canal since 2005 were found through shoreline surveys.
- Twenty-two (22) percent of the shoreline survey FC hotspots found in Hood Canal were found to have OSS failure sources.

Public and professional outreach programs are another effective means of finding OSS failures. Stormwater utilities, like Kitsap County Surface and Stormwater Management Program fund outreach programs that build public trust, thereby encouraging public sewage complaints and contractor referrals.

- Seven (7) OSS failures were found through public sewage complaints (23%) and
- four (4) through outreach to OSS contractors (13%).

The Lofall area has a serious FC pollution problem. Densely developed hillside areas cause stormwater challenges for the shoreline OSS below. OSS age and proximity to surface water will be an ongoing challenge for Lofall OSS. Fifteen (15) of the thirty-one (31) properties in the area were dye tested (48%) and two (2) OSS failures were found. The remaining properties are being investigated under the Jump Off Joe PIC.

Preliminary pilot nutrient study results show no correlation between FC and nitrate+nitrite nitrogen in shoreline discharges sampled for this project. Shoreline discharges with failing OSS showed elevated nitrate+nitrite nitrogen, ammonia nitrogen or ortho-phosphate concentrations compared to control discharges before OSS correction. Failing OSS may contribute nitrogen in the form of nitrate+nitrite or ammonia nitrogen, and ortho-phosphate depending upon the mechanism of the failing OSS. Nitrate+nitrite nitrogen levels were well within drinking water standards. Further investigation is needed.

PIC projects would not exist without Kitsap County's Surface and Stormwater Monitoring Program funding of program development and updates, staff training, project investigation and preparation, and grant project development and preparation. CCWF grants provide programs like PIC the essential resources to clean-up FC pollution problem areas.

Based upon the conclusions of the Upper Hood Canal Pollution Identification and Correction Project, Kitsap Health recommends the following:

- Complete correction of the four (4) remaining OSS failures as weather permits.
- Conduct dry season shoreline survey of approximately two (2) miles of Hood Canal shoreline in the Nelita and Tekiu area and follow-up on FC hotspots.
- Investigate ten (10) FC hotspots found through shoreline surveys.
- Investigate the two (2) properties that denied access, using enforcement tools, if necessary.

- Dye test the remaining nine (9) properties in the Lofall Creek drainage, the remaining four (4) properties in the Ferry Street tributary to Lofall Creek, the remaining three (3) properties in the LSD01 drainage, and the Holly property identified by WSDOH. Use enforcement tools, if necessary.
- Complete BACI for four (4) sites and other applicable sites.
- Research approximately seven hundred sixty (760) properties in the project area and develop an OSS spreadsheet with permit and maintenance status, age, and proximity to shoreline.
- Utilize available Jump Off Joe Creek Water Quality Project CCWF funding to complete the above-identified tasks.
- Publish a Hood Canal PIC report in a professional technical journal following Jump Off Joe PIC project completion.
- Share project results with WSDOH's shoreline survey program to remove closure zones from areas established around OSS failure zones. Share project results with other organizations working in the area, including the University of Washington and the Hood Canal Dissolved Oxygen Project.
- Research funding sources for future nutrient studies.
- Continue to explore ways to work in partnership with other agencies to more effectively meet goals.
- Research and test assessment methods to determine public education and outreach effectiveness and shoreline resident/visitor water quality information needs.
- Research potential methods to better build public trust, in order to increase participation rates, by actively working to provide accurate and representative data upon which to base regulation and legislation.
- Continue to support development of fact-based and consistent Hood Canal-wide messages and sharing information and effective methods with other jurisdictions.

KITSAP COUNTY UPPER HOOD CANAL POLLUTION IDENTIFICATION AND CORRECTION PROJECT FINAL REPORT DECEMBER 31, 2008

1.0 INTRODUCTION

In 2003, Washington State Department of Health Shellfish Programs (WSDOH) established shellfish closure zones at the mouths of Kinman Creek, Lofall Creek, and Jump Off Joe Creek along Kitsap County's Upper Hood Canal shoreline. Kitsap County Health District (Kitsap Health) initiated preliminary investigations along these creeks and found elevated fecal coliform (FC) levels, indicating FC pollution sources.

Fecal pollution sources typically include failing onsite sewage systems (OSS) and inadequate animal waste management. Fecal pollution is a public health concern because disease-causing organisms are present in fecal waste. Fecal waste, which contains nitrogen and phosphorus, can also deplete oxygen in surface waters as it degrades.

Kitsap Health conducted an early action pollution identification and correction (PIC) project during 2005-2006 in the Upper Hood Canal watershed from Warrenville (Ioka Way, Silverdale) south to the Kitsap-Mason County line (see Figure 1, Study Segments 1-9). Funding was provided by Puget Sound Action Team and the United States Environmental Protection Agency. Matching funds were provided by Kitsap County Surface and Stormwater Management Program (SSWM). A final report was submitted January 23, 2006.

This report details work conducted for the Washington State Department of Ecology Centennial Clean Water Fund (CCWF) 2006 grant to complete the investigation of Kitsap County's Upper Hood Canal shoreline (see Figure 1, Study Segments 10-17). The project builds on work conducted during the Hood Canal 2005-2006 project, extending the project area north to Salisbury Point, north of the Hood Canal Bridge, and assessing shoreline discharges during the dry weather season (May – October), in addition to the wet weather season.

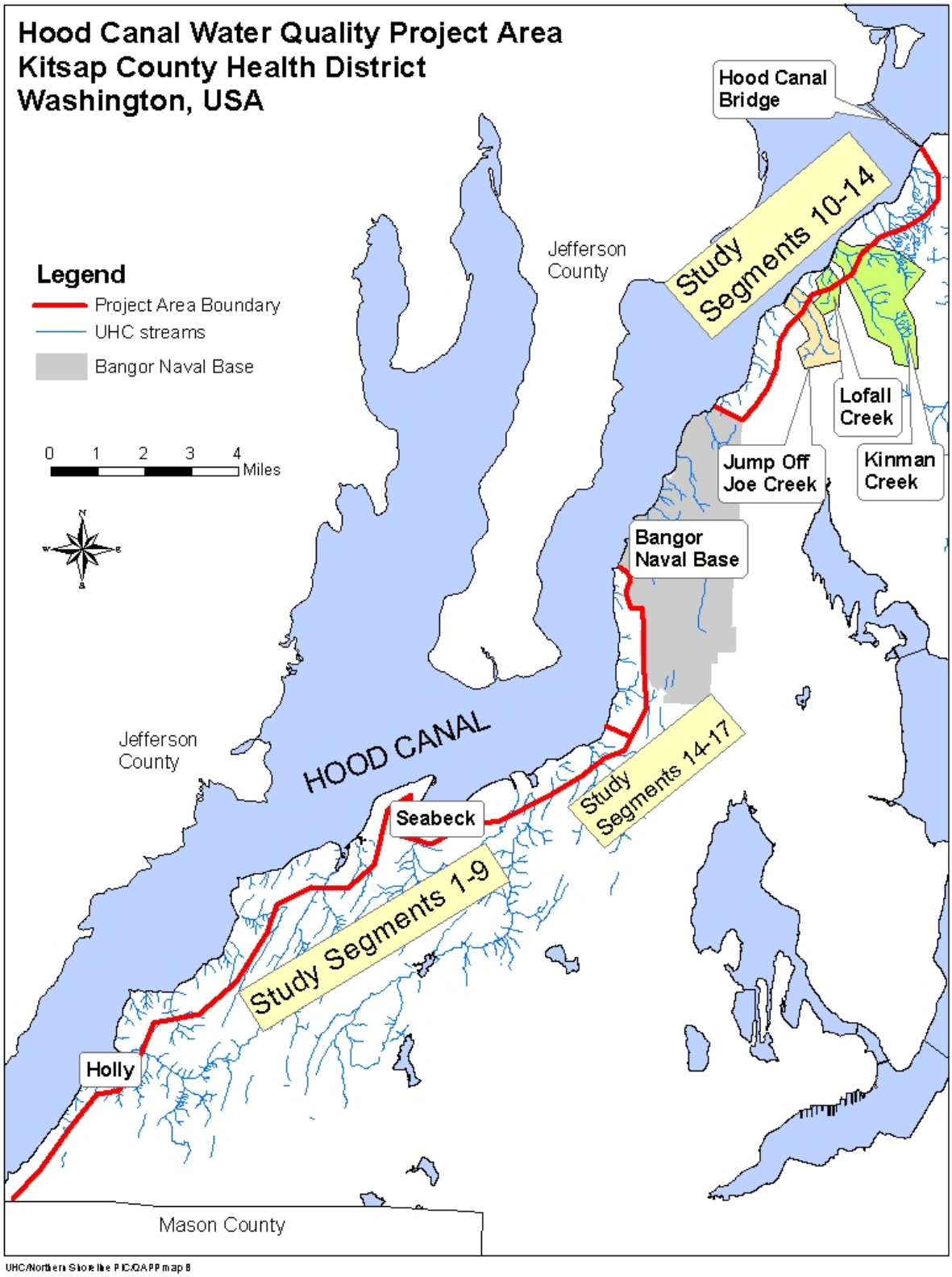
Kitsap was awarded CCWF funding for the Jump Off Joe Creek Watershed Pollution and Identification Project (Jump Off Joe PIC) in 2008, which is expected to be completed in 2011.

2.0 PROJECT AREA DESCRIPTION

The Hood Canal is bordered on the east by Kitsap County, on the west by Jefferson County, and on the south by Mason County. The northern project area boundary is Salisbury Point Park, north of the Hood Canal Bridge. The southern boundary is the Kitsap/Mason County border, south of Holly. The project area includes approximately thirty-three (33) miles of developed shoreline and three miles of undeveloped shoreline.

Upland properties in the Lofall Creek and Kinman Creek watersheds that may be contributing fecal pollution to the mouths of Lofall and Kinman Creeks were also included. Three hundred (300) upland properties in the Jump Off Joe watershed are included in the Jump Off Joe PIC project area. Figure 1 shows a map of the Upper Hood Canal watershed and project area.

Figure 1. Kitsap County Health District Upper Hood Canal Project Area



3.0 GOALS AND OBJECTIVES

The goals of the Upper Hood Canal Pollution Identification and Correction Project are to:

- Protect designated beneficial uses in Upper Hood Canal from pollutants discharged from failing OSS and animal waste. Prevent degradation of Hood Canal.
- Locate approximately seventy-nine (79) OSS in the project area, identify their components, and characterize performance.
- Reduce fecal pollution into Hood Canal along Kitsap County's shoreline from failing OSS and animal waste.
- Provide water quality data to determine if there is a correlation between FC and nutrient levels in freshwater discharges to the marine shoreline.
- Provide water quality data to determine if FC source correction also results in nutrient reduction.
- Educate Upper Hood Canal residents about fecal pollution and actions they can take to reduce bacterial and nutrient contributions to Hood Canal.

To accomplish these goals, the following objectives were completed:

- Conducted FC source identification (shoreline surveys) along Kitsap County's developed shoreline during dry and wet seasons.
- Identified and investigated FC hotspots.
- Conducted property surveys and investigations in FC hotspots. Provided owners and residents with site-specific suggestions to avoid premature OSS failures and how to keep bacteria and nutrients out of Hood Canal.
- Enforced correction of failing OSS pursuant to state and local OSS regulations.
- Sampled a subset of Hood Canal shoreline discharges to continue correlation study of FC and nitrate+nitrite nitrogen levels.
- Sampled FC and nutrients in drainages with identified FC sources and nearby control drainages before and after OSS correction to determine FC and nutrient reductions.
- Presented project methods and results for public and peer workshops.

4.0 PROJECT DESIGN AND METHODS

All work was conducted according to the methods contained in the "Manual of Protocol: Fecal Coliform Bacteria Pollution Identification and Correction" (Health District, 2003). The project design consisted of the following components:

4.1 SHORELINE SURVEY

The shoreline was divided into two segments: an approximately eighteen (18) mile section north of Ioka Drive in Silverdale; and an approximately fifteen (15) mile section south. Ioka Drive in Silverdale was selected as the north boundary of the 2005-2006 project, based on WSDOH's shoreline assessment.

All accessible discharges in each shoreline segment, including curtain drains, bulkhead drains, drainage culverts, overland flows, and significant beach flows from nearshore properties were

sampled for FC. Samples were collected at low tide to target the discharge of fresh groundwater versus the drainage of residual marine water. Detailed field notes, photographs and global positioning system waypoints were collected in support of samples. Confirmation samples were collected in drainages with FC results at or above the threshold of 200 FC/100ml. FC hotspots were investigated for potential FC sources.

4.2 PROPERTY SURVEYS

Properties were selected for survey based on their proximity to confirmed shoreline hotspots. FC investigations of the Lofall Creek shoreline hotspot indicated that the majority of the creek's drainage basin had elevated FC levels and all Lofall Creek watershed parcels were selected for survey. Other properties were added based on WSDOH recommendations, public sewage complaints and non-conforming monitoring and maintenance reports.

A total of eighty-six (86) properties were selected to survey in the project area:

- twelve (12) were FC hotspots found from shoreline surveys;
- one (1) was identified by WSDOH shoreline surveys;
- eleven (11) were public sewage complaints;
- six (6) were OSS repair plan submissions;
- one (1) was located at a shoreline survey access point;
- one (1) was found through a non-conforming monitoring and maintenance report;
- three (3) were found through visual observation;
- forty-eight (48) are located in the Lofall Creek drainage; and
- three (3) are located in the Kinman Creek drainage.

The PIC survey consisted of an OSS record search, homeowner/resident interview, field inspection, and water samples and dye test when necessary. The purpose of the survey was to identify all potential sources of FC contamination (including failing OSS and inadequate animal waste management) and potential sources of nutrient contamination (including yard waste and fertilizer). The survey included a strong educational component to proactively educate property owners about how to properly operate and maintain their OSS and to identify any non-conforming conditions that could cause premature OSS failure. Property owners were given copies of OSS records, information about how to reduce bacterial and nutrient pollution sources to Hood Canal from their property, and information about the Shorebank Septic Loan program.

Based upon the results of each survey, each OSS was categorized as Failing, Suspect, Non-Conforming, or No Apparent Problems (see Appendix A for rating category criteria.) Failing OSS were corrected pursuant to state and local OSS regulations.

4.3 PUBLIC EDUCATION AND OUTREACH

One focus of this project was to provide property owners and residents with information to recognize and reduce fecal pollution and nutrient contributions to Hood Canal from their properties.

OSS contractors working in the project area were also given project information and information about the Shorebank Septic Loan program, resulting in several repair plan submissions in the area.

Kitsap Health has actively participated in the Hood Canal Watershed Education Network (HCWEN) since 2005. This group meets regularly with frequency ranging from monthly to quarterly, depending on the activity level, to coordinate educational messages for a "Hood Canal-wide" approach. Kitsap Health has also provided presentations, materials and training for other jurisdictions, in order to share information and effective methods and reduce project lead times.

4.4 PILOT NUTRIENT STUDY

In 2005-2006, Kitsap Health conducted a pilot FC/nitrate+nitrite nitrogen nutrient study, selecting the shoreline segment south of Big Beef Creek and north of the Seabeck Marina due to the high concentration of homes and small lot sizes. Fifty-one (51) distinct drainages were sampled during three (3) events for FC and nitrate+nitrite nitrogen. No correlation between FC and nitrate+nitrate nitrogen was found in the three (3) sampling events. Concentrations of nitrate+nitrite nitrogen were significantly reduced during moderate and heavy rainfall events as compared to the dry weather sampling event.

This project added to the study data by conducting similar work in the Holly shoreline community and nearby undeveloped shoreline per United States Geologic Survey (USGS) peer review of 2005 work.

This project also built on Kitsap Health's 2005-2006 before and after FC source correction investigation (BACI). The BACI collected FC, nitrate+nitrite nitrogen, ammonia nitrogen, and ortho-phosphate samples from FC contaminated drainages and similar nearby control drainages before and after FC source correction. Flows were measured by the bucket and stop watch method, where possible. Salinity was also measured as suggested per USGS in peer review of the 2005-2006 project.

Shoreline discharges from seven (7) selected failing OSS had elevated nitrate+nitrite nitrogen, ammonia nitrogen or ortho-phosphate as compared to shoreline discharges where OSS were working properly. Failing OSS may contribute nitrogen in the form of nitrate+nitrite or ammonia nitrogen, depending upon the mechanism of the failing OSS.

Math Handyman, Kitsap Health Water Quality's contract statistician, helped design the study and analyzed all nutrient data collected since 2005 for statistical significance. The Water Quality's trend monitoring program uses a 95% confidence level for statistical analysis. This project chose to also report the less restrictive 90% confidence level due to the comparatively small number of samples collected.

5.0 RESULTS AND DISCUSSION

5.1 SHORELINE SURVEY AND INVESTIGATION

Shoreline Survey

Shoreline discharge samples were collected on twenty-seven (27) different days between February 4, 2007 and September 28, 2008. A total of five hundred three (503) FC samples were collected from two hundred seventy-five (275) individual drainages and sixty-seven (67) confirmation samples were collected. Twenty FC hotspots were confirmed and eight (8) OSS failures were found: five (5) during wet season (November – April) shoreline surveys and three (3) during dry season surveys. This shows the importance of wet and dry season shoreline surveys. Some failing OSS can only be identified in the wet season because they are caused by surface or ground water intrusion. Some failing OSS can only be found in the dry season because they are caused by hydraulic overload during the busy vacation season or are heavily diluted in the wet season.

Wet Season (November through April)

Kitsap Health surveyed twenty-three (23) miles of the developed Hood Canal shoreline for this project during the wet season, beginning in February 2007. This work was conducted from Salisbury Point (just north of the Hood Canal Bridge) south to Ioka Way in Silverdale. The small Holly development in the south section was surveyed twice, once with three miles of nearby undeveloped shoreline for the nutrient study.

This work, in conjunction with 2005-2006 project work, completes wet season shoreline assessment of Kitsap's Hood Canal shoreline from the Hood Canal Bridge to the Kitsap/Mason County line.

A total of two hundred thirty-five (235) FC samples were collected on twelve (12) different days. Ten (10) discharges exceeded the 200 FC/100ml investigation threshold, seven of these were confirmed. Four (4) FC hotspots were tracked back to four (4) failing OSS.

The other three (3) drainages were Lofall Creek, LSD01 (a 12" outfall immediately south of the Lofall ferry dock), and a large drainage from the Vinland community north of Bangor Submarine Base. These drainages flow year-round and the developments nearby are more than 70 years old. All were investigated and found to have high levels of fecal pollution. Follow-up investigation and correction continues through the Jump Off Joe PIC.

Dry Season (May through October)

Kitsap Health conducted a shoreline survey of thirty-one (31) miles of developed Hood Canal shoreline for this project during the dry season from Salisbury Point south to the Kitsap/Mason County line (excluding Naval Base Kitsap Bangor

A total of two hundred sixty-eight (268) FC samples were collected over fifteen (15) days. Twenty-six (26) discharges exceeded the 200 FC/100ml investigation threshold, and confirmation samples were collected. Thirteen (13) FC hotspots were confirmed. Eleven (11) of the hotspots were investigated and three (3) OSS failures were found: one (1) has been corrected and two (2) are in the correction process.

Seven (7) properties need further investigation and three (3) are being investigated through the Jump Off Joe PIC (Lakeness, LF01, Jump Off Joe Mouth).

This work completes dry season assessment of Kitsap's Hood Canal shoreline with exception of approximately two miles that includes the small communities of Nelita and Tekiu.

Investigations

The Lofall area was developed with small lots on a wet hillside. The Kinman house was built in 1884 by the caretaker of Kitsap Memorial Park, when Washington was still a territory. Many of the OSS have exceeded the average 30-year lifespan. Drainage systems in the area are layered on very old systems and stormwater patches have been added to address flooding.

Kitsap Health began investigation at the FC hotspots found at the mouth of Lofall Creek (LF01) and the 12" outfall immediately south of Lofall Ferry Dock (LSD01). These are located within ½ mile of each other: the creek to the north of the Lofall ferry dock and LSD01 immediately south. Due to heavy brush and many underground culverts, it was difficult to determine the complicated path of Lofall Creek and LSD01. Three (3) houses in the area border both drainages and it is unclear where underground drainages may flow.

Lofall Creek

One hundred and thirty-eight (138) FC samples were collected from Lofall Creek segments during investigations in this old and complex drainage basin. Summary results are presented in Table 1 and data in Appendix B.

Monitoring results indicate that the majority of the creek's drainage basin had elevated FC levels. As a result, Kitsap Health determined that all parcels along the mainstem of Lofall Creek from the well site to the mouth need to be surveyed and dye tested. This includes fourteen (14) residences, and possibly three (3) others that border LSD01. Twelve (12) of the fourteen (14) were surveyed and two (2) property owners have not responded. Five (5) dye tests have been conducted, with one still in progress. Two (2) OSS failures were found and corrected. Eight (8) properties had "No Apparent Problems" and two (2) had "No Records". Complete Lofall survey results are presented in Table 2.

Stormwater was tracked through the Twelve Trees Commercial development upstream and the outfall along Pioneer Road was investigated and found to have very low FC levels. Samples collected at the downstream Pioneer Road culvert were found to be very foamy with very low FC levels. Optical brightener testing was negative. Detergent field kit testing was negative. The suds were tracked to a failing OSS immediately upstream, which has been vacated. The residence had low wastewater flow and the failure was located in a large wetland stream.

Table 1
Lofall Creek Water Quality Summary
July 2007 – October 6, 2008

Station	# of Samples	Range	FC GMV[2]	% Samples >100 FC/100 ml.	Meets Standard[1]?
Units			*FC/50ml*	*%*	
WQ Standard[1]	*NA*	*NA*	*Max. 50*	*Max. 10%*	
Lofall Creek Mouth (LF01)	45	23 - ≥1600	**381**	**67%**	**NO**
Ferry Street Tributary (Ferry sw)	47	<2 - ≥1600	**47**	**30%**	**NO**
Lofall Creek @ Wesley (LF02)	46	23 - ≥1600	**335**	**61%**	**NO**

[1]Chapter 173-201A WAC for Class A Fresh Waters.

[2] Fecal Coliform Geometric Mean Value

Violations of Water Quality Standard are shaded and in bold.

swwq8bdc1\os_wq\common\pic\upperhood\upperhood2006\enforcement\impactdata\lofallcreeksummarytable.xls

Ferry Street tributary to Lofall Creek

Ferry Street catch basins were investigated due to suds found in the Lofall Creek tributary at Ferry Street. Optical brightener testing was negative. Investigations delineated nine (9) residences in this segment. Six (6) surveys were conducted. Five (5) of the residences were dye tested with negative results, one (1) twice (in winter and in summer). No failures have been found to date.

Of the six (6) surveyed, one (1) had "No Apparent Problems" and five (5) were "Non Conforming" because they are in close proximity to roadside ditches and drainage culverts.

12" Outfall Immediately South of Lofall Dock (LSD01)

LSD01 was investigated and found to be an FC hotspot. Kitsap Health investigated the drainage and collected upstream samples, finding no FC problems at the upstream Beham Road culvert. Eight (8) residences are located in the FC problem segment, three (3) of which may also drain to Lofall Creek.

Seven (7) surveys were conducted and one (1) property owner denied Kitsap Health access to sample or dye test due to long term stormwater frustrations and agreed to a dye test after all others in the drainage are dye tested. Five (5) OSS in this segment were dye tested, one (1) twice (in winter and in summer). No failures have been found to date.

Of the seven (7) surveyed, three (3) parcels had "No Apparent Problems", two (2) had "No Records", and two (2) were "Non-Conforming". The "Non-Conforming" ratings resulted from a deficient monitoring and maintenance report in one case and an unpermitted repair in the other.

TABLE 2
SUMMARY OF LOFALL OSS SURVEY RESULTS
2007 - 2008

	Total Properties	Did Not Participate	Denied Access	Failing	Suspect	Non-Conforming	No Records	No Apparent Problems
Lofall Creek	14	2	0	2	0	0	2	8
Ferry Street	9	3	0	0	0	5	0	1
LSD01	8	0	1	0	0	2	2	3

Other Investigations
Ninety-five (95) FC samples and one (1) total coliform drinking water sample were collected in support of property investigations in the Lofall area (Anchor Court, Hilltop, Lofall Court, Lofall Road, and Kitsap Memorial State Park) and in Miami Beach (south of Seabeck).

5.2 PROPERTY SURVEYS

Properties were selected for survey based on their proximity to confirmed shoreline hotspots, WSDOH recommendation, public sewage complaints, and non-conforming monitoring and maintenance reports.

Surveys were conducted between January 10, 2007 and December 10, 2008. Seventy-three (73) survey inspections of the eighty-six (86) total properties were completed (84%), and one (1) owner denied access (1%). Inspectors had more difficulty gaining survey and dye test access in comparison to 2003 and 2004 work. Many new drainage pipes and structures are buried in the ground or beach, preventing sample collection.

Nineteen (19**)** failing OSS were found during this project, or 26% of the properties surveyed. A total of thirty-one (31) failing OSS were found and corrected between 2005 and 2008. Of these, thirteen (13) were in the northern project area and eighteen (18) in the southern area. The thirty-three (33) mile project area has approximately seven hundred sixty (760) shoreline properties, with four hundred twenty (420) in the northern area and three-hundred forty (340) in the southern.

Our results indicate that only 4% of the project area OSS were FC sources to the shoreline. This is on the low end of the range of failure rates (3% to 16%) found in other areas of Kitsap County surveyed over the past fifteen (15) years.

Property survey OSS results are presented in Table 3.

Table 3
Upper Hood Canal Pollution Identification and Correction Project
OSS Survey Results Summary
2006 – 2008

	Participating Properties	Failing	Suspect	Non-Conforming	No Records	No Apparent Problems
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Shoreline	58 (78%)	15 (79%)	3 (75%)	12 (75%)	9 (82%)	19 (79%)
Upland	16 (22%)	4 (21%)	1 (25%)	4 (25%)	2 (18%)	5 (21%)
Total	74	19 (26%)	4 (5%)	16 (22%)	11 (15%)	24 (32%)

n=number

5.2.1 Analysis of Failures

Fifteen (15) of the nineteen (79%) failing OSS were located adjacent to surface waters (<100 feet) and four (4) of nineteen (21%) were located 100 feet or more from surface waters. Eight (8) of the failing OSS (42%) discharged directly to Hood Canal, one was a travel trailer discharge that was disconnected.

The age of the OSS and homeowner maintenance of the OSS have been the most prevalent causes of failure in previous PIC surveys. Other factors related to OSS failure include:

- Close proximity of the OSS to surface water;
- Poor soil types and shallow depth to water table/impervious layer;
- Inadequate or lack of maintenance of the OSS;
- Number of previous repairs (failure history); and
- Grey water discharge.

The age of the OSS and proximity to surface water were the primary reasons for OSS failure in this project:

- twenty-four (24) of the thirty-one (31) failing OSS were more than twenty years old (77%); and
- twenty (20) of the thirty-one (31) failing OSS had a non-conforming setback of less than 100 feet from surface waters (65%).

Analysis of factors relating to failing OSS (some failing OSS had more than one factor) shows that:

- Fifteen (15) of the nineteen (79%) failing OSS were 20 years old or older;
- One (1) of the nineteen (5%) failing OSS had failed and was previously repaired;
- Fifteen (15) of the nineteen (79%) failing OSS were located less than 100 feet from surface waters (one (1) in the tidal zone and one (1) in a wetland);
- One (1) of the nineteen (5%) failing OSS was a greywater discharge;
- One (1) of the nineteen (5%) was a travel trailer discharge to the shoreline;
- Three (3) of the nineteen (16%) were short circuiting into drains;
- Three (3) of the nineteen (16%) were linked to system abuse through hydraulic overload. Two were recovered, one of which had a sticky toilet flapper.

5.2.2 Types of OSS Repairs and Maintenance Requirements

Fourteen (14) of the failing OSS have been repaired, one (1) was vacated, and four (4) are in progress. Of the fourteen (14) repaired, one (1) repair was accomplished by routing greywater into the septic tank with a follow-up dye test, one (1) leaky toilet was repaired, one (1) system was backfilled and dye tested, Washington State Department of Fish and Wildlife removed mountain beavers from one (1) failing drainfield, one (1) was repaired with a gravity OSS, two (2) were repaired with pump to gravity OSS, and seven (7) were repaired with alternative OSS. Of the four (4) properties in progress, one (1) is awaiting installation of a new septic tank, one (1) has been ordered to remove a travel trailer discharge , one (1) was repaired and failed again,

and one (1) has temporarily installed pre-treatment and is pumping to an upland gravity drainfield while finalizing the easement for the new OSS.

Kitsap County Board of Health Ordinance 2008-11 "Onsite Sewage System and General Sewage Sanitation Regulations" requires ongoing monitoring and maintenance of OSS. Standard gravity OSS require septic tank inspection every three years and alternative OSS require ongoing monitoring and maintenance performed by a Health District certified maintenance specialist. This will help ensure optimal OSS operation for the future.

5.3 PUBLIC EDUCATION AND OUTREACH

Kitsap Health's parcel surveys are designed to educate owners and residents about OSS and how to prevent premature system failure. They were informed about the sensitive nature of the area and actions they can take to reduce bacterial and nutrient contributions to Hood Canal. Inspectors distributed copies of OSS permit records, Kitsap Health's Homeowner's Guide to Onsite Sewage Systems and the Shorebank Septic Loan Program brochure.

OSS contractors working in the project area were educated about the Hood Canal project and the Shorebank Septic Loan program, resulting in four (4) repair plan submissions in the area.

Four (4) public presentations were conducted for this project:

- Kitsap Health was invited to present at the 2007 Puget Sound Georgia Basin research conference in Vancouver BC in April 2007. The supporting paper, "Pollution Identification and Correction: A Public Health Approach to Low Dissolved Oxygen in Hood Canal", was published on-line under 2007 Proceedings at http://www.engr.washington.edu/epp/psgb/ and on the Health District website at http://www.kitsapcountyhealth.com/environmenta_health/water_quality/docs/hoodcanal_lowoxygen.pdf.
- Project methods and results were presented at the Washington Environmental Protection Agency Bacteriological Conference in Tacoma on March 26 and 27, 2007.
- The Hood Canal Coordinating Council invited Kitsap Health to provide a project update and "How to Keep Bacteria and Nutrients Out of Hood Canal" presentation for the Community Nearshore Restoration Program at the Seabeck Christian Conference Center on November 15, 2007.
- Kitsap Health staffed an informational booth about the project at Kitsap County Natural Resources Nearshore Workshop at the Driftwood Keys Community Club on June 24, 2008.

5.4 PILOT NUTRIENT STUDY

FC and Nitrate+Nitrite Nitrogen Correlation Study
Kitsap Health continued this pilot study initiated in the 2005-2006 project. FC and nitrate+nitrite nitrogen samples were collected from shoreline discharges in an undeveloped area, as suggested by USGS, and from the nearby Holly development.

On February 26, 2008 and March 11, 2008, fifty-one (51) FC and nitrate+nitrite nitrogen samples were collected and discharge flows were measured, when possible. Most of the shoreline

discharges were estimated due to the difficulty measuring flow on low-gradient or well-drained beaches or from leaky pipes.

Nineteen (19) sample sets were collected from undeveloped shorelines. Only three (3) sample sites were found in one (1) mile of undeveloped shoreline north of Holly and sixteen (16) sites were found in the two (2) miles south of Holly. Thirty-one (31) sample sets were collected from twenty-two (22) sites in Holly.

Kitsap Health's contract statistician, Math Handyman, found no correlation between nitrate+nitrite nitrogen and fecal coliform in any of the developed or undeveloped shorelines sampled between 2005 and 2008. Nitrate+nitrite nitrogen levels were very low (see Appendix C) and were diluted during rain conditions.

Before and After Correction Investigation (BACI)

FC, nitrate+nitrite nitrogen, ammonia nitrogen, and ortho-phosphate samples were collected from FC contaminated drainages and similar control drainages before and after FC source correction. Salinity was measured and flows were measured, where possible, or they were estimated.

Fifty-six (56) sample sets were collected on twelve (12) days between March 6, 2007 and February 21, 2008. Samples were collected after OSS correction at seven (7) locations in support of data collected at the sites before correction under the 2005-2006 project. Samples were collected at four (4) locations before OSS correction in fall 2008.

Shoreline discharges with failing OSS showed elevated nitrate+nitrite nitrogen, ammonia nitrogen or ortho-phosphate concentrations compared to control discharges before OSS correction. Failing OSS may contribute nitrogen in the form of nitrate+nitrite or ammonia nitrogen, and ortho-phosphate depending upon the mechanism of the failing OSS.

- Site 4-75 had elevated ammonia nitrogen levels, indicating incomplete nitrification of the septic tank effluent. This was likely due to hydraulic overload, plugged drainfield, and close proximity (within 50 feet) to the shoreline.
- Site 5-5 septic tank inspection showed no sign of groundwater intrusion, as confirmed by low ammonia nitrogen levels. High FC and nitrate+nitrite nitrogen levels were measured, confirming a short circuit between a broken well overflow and incompletely treated drainfield effluent.
- Site 8-10 was a direct discharge with very high FC levels due to limited vertical separation and horizontal setback to the shoreline (less than 20 feet). Ammonia nitrogen levels were also very high because the septic tank was undersized, resulting in incomplete nitrification of the sewage effluent and high ortho-phosphate levels.

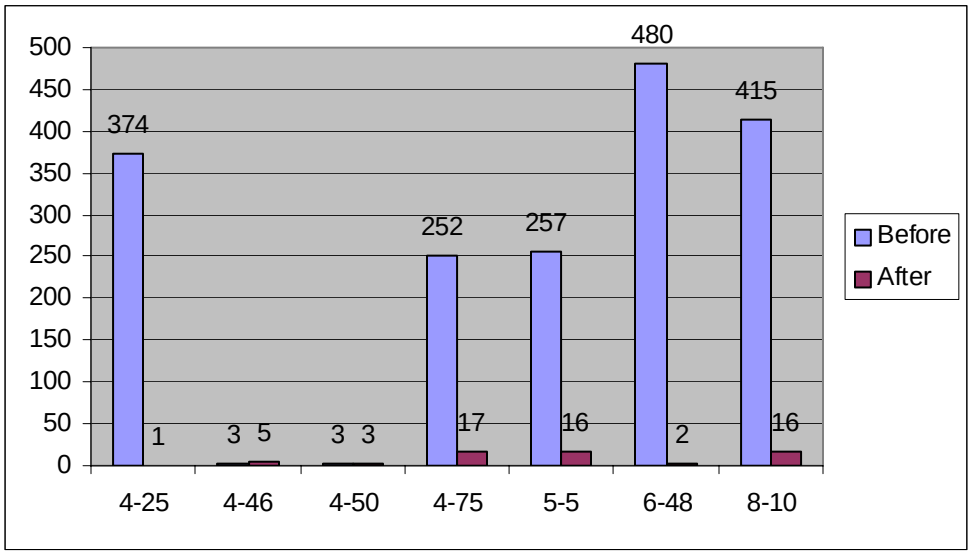
BACI results showed statistically significant nutrient reductions at the 95% confidence level after OSS correction compared to controls:

- FC reduction at one (1) of seven (7) locations (14%);
- nitrate+nitrite nitrogen reductions at two (2) locations (29%);
- ammonia nitrogen reductions at one (1) location (14%); and

- ortho-phosphate reduction at one (1) site (14%).

Table 4 shows the FC Geometric Mean Value of samples collected before and after OSS correction. Note the large FC reductions after correcting failing OSS in five (5) of the seven (7) study drainages. Sites 4-25 and 8-10 were direct discharges to the shoreline. Site 4-46 and 4-50 were greywater discharges with low fecal concentrations. Site 6-48 was a greywater discharge with a high fecal concentration.

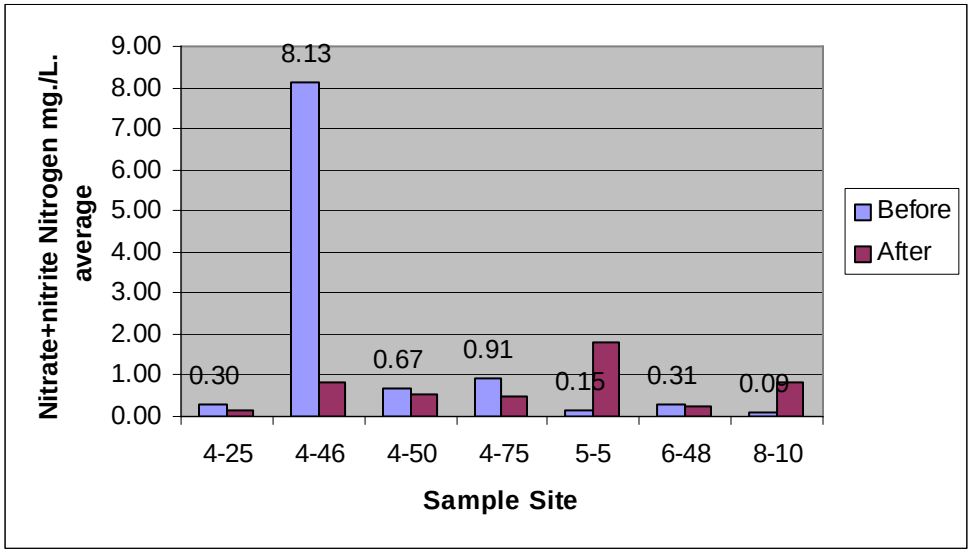
Table 4
Fecal Coliform Before and After OSS Correction



Statistically significant FC reductions were only found at one location, sample site 6-48, when compared to the nearby control drainage before and after OSS correction.

Table 5 shows average nitrate+nitrite nitrogen levels before and after OSS correction. Note the large reduction at Site 4-46 (a greywater discharge). Site 4-75 had high nitrate+nitrite nitrogen because the septic tank was converting the ammonia to nitrate+nitrite nitrogen, which was carried to the shoreline by the well overflow running through the drainfield.

Table 5
Nitrate+Nitrite Nitrogen Before and After OSS Correction

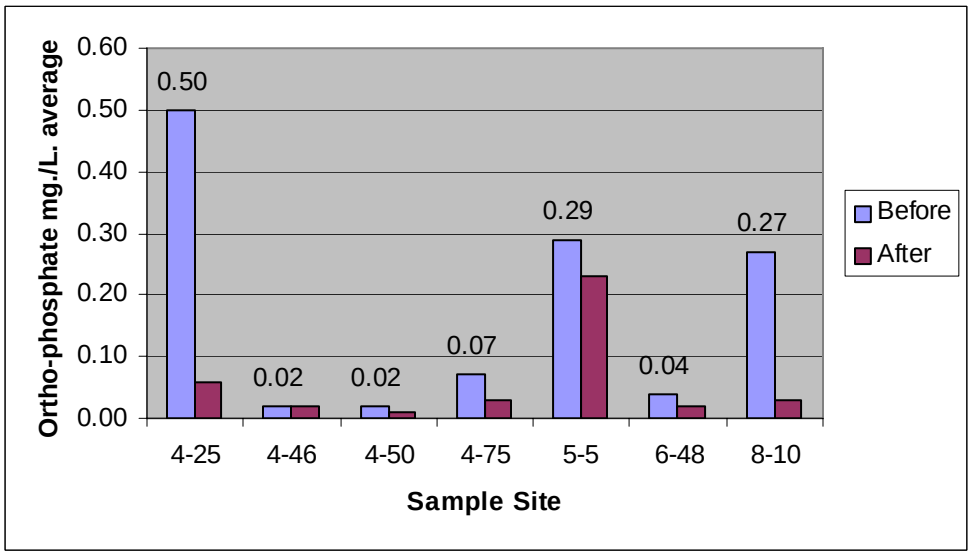


Statistically significant reductions were found at two (2) locations as compared to control drainages: sample sites 4-46 and 4-50. Site 4-25 showed significant reduction at the 90% confidence level. Site 8-10 (direct discharge) showed significant increase, likely due to extensive land clearing upgradient of the drainage after OSS correction.

The relatively low nitrate+nitrite levels found in shoreline discharges impacted by OSS failures indicate that even failing OSS do not discharge high nitrate+nitrite nitrogen levels (see Appendix B). For reference, drinking water action levels are 5 mg/L and the drinking water standard is 10 mg/L.

Table 6 shows average ortho-phosphate levels before and after OSS correction. Note the large reductions at sites 4-25 and 8-10 (direct discharges).

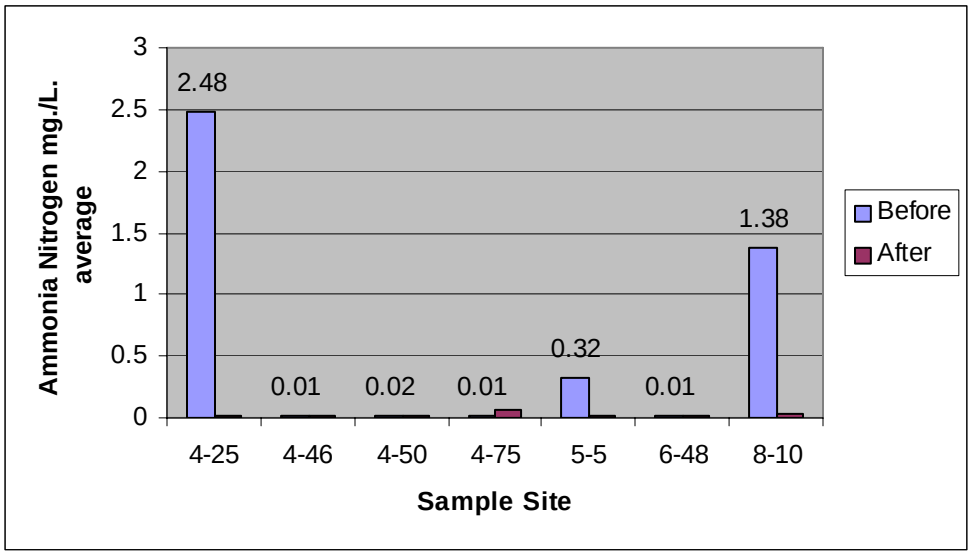
Table 6
Ortho-phosphate Before and After OSS Correction



Site 4-25 (direct discharge) showed a statistically significant reduction at the 90% confidence level compared to the control.

Table 7 shows average ammonia nitrogen levels before and after OSS correction. Note the large decreases at sites 4-25 and 8-10, both direct discharges to the shoreline.

Table 7
Ammonia Nitrogen Before and After OSS Correction



Statistically significant reductions were found at site: 5-5. Sites 4-25 and 8-10 showed significant reductions at the 90% confidence level. Elevated ammonia nitrogen levels found at site 5-5 indicate incomplete nitrification of the sewage effluent, which may be due to hydraulic overload, plugged drainfield, and 50-foot proximity to the shoreline. Elevated ortho-phosphate levels may be the result of hydraulic overload and 50-foot proximity of drainfield to the shoreline.

6.0 CONCLUSIONS

The goals of the Upper Hood Canal Water Pollution Identification and Correction Project have been achieved:

Kitsap's Upper Hood Canal shoreline does not have a serious OSS failure problem based on project results. This is supported by Kitsap Health's trend monitoring data for the water year ending September 2008. Nine (9) of the eleven(11) marine water monitoring stations in the project area meet both parts of Washington State's water quality standard for FC.

- Kitsap Health conducted thorough FC pollution source identification along Kitsap County's developed Hood Canal shoreline during the dry and wet season between 2005 and 2008.
- Properties were selected for survey based on their proximity to confirmed shoreline hotspots, WSDOH recommendation, public sewage complaints, and non-conforming monitoring and maintenance reports.
- Thirty-one FC pollution sources related to failing OSS were identified and were either corrected or vacated. This represents 4% of the properties in the project area, at the low

end of the OSS failure range found in other PIC project areas. These results confirm the lack of a serious OSS failure problem along the shoreline.

Primary reasons for OSS failure in this project were age of the system and proximity to surface water.

- twenty-four (24) of the thirty-one (31) failing OSS were more than twenty years old; and
- twenty (20) had a non-conforming setback less than 100 feet from surface waters (65%).

Shoreline surveys were an effective method of finding OSS failures in this project.

- Sixteen (16) of the thirty-one (31) OSS failures (52%) found in Hood Canal since 2005 were found through shoreline surveys.
- Twenty-two (22) percent of the shoreline survey FC hotspots found in Hood Canal were found to have OSS failure sources.

Public and professional outreach programs are another effective means of finding OSS failures. Stormwater utilities, like Kitsap County Surface and Stormwater Management Program fund outreach programs that build public trust, thereby encouraging public sewage complaints and contractor referrals.

- Seven (7) OSS failures were found through public sewage complaints (23%) and
- four (4) through outreach to OSS contractors (13%).

The Lofall area has a serious FC pollution problem. Densely developed hillside areas cause stormwater challenges for the shoreline OSS below. OSS age and proximity to surface water will be an ongoing challenge for Lofall OSS. Fifteen (15) of the thirty-one (31) properties in the area were dye tested (48%) and two (2) OSS failures were found. The remaining properties are being investigated under the Jump Off Joe PIC.

Preliminary pilot nutrient study results show no correlation between FC and nitrate+nitrite nitrogen in shoreline discharges sampled for this project. Shoreline discharges with failing OSS showed elevated nitrate+nitrite nitrogen, ammonia nitrogen or ortho-phosphate concentrations compared to control discharges before OSS correction. Failing OSS may contribute nitrogen in the form of nitrate+nitrite or ammonia nitrogen, and ortho-phosphate depending upon the mechanism of the failing OSS. Nitrate+nitrite nitrogen levels were well within drinking water standards. Further investigation is needed.

PIC projects would not exist without Kitsap County's Surface and Stormwater Monitoring Program funding of program development and updates, staff training, project investigation and preparation, and grant project development and preparation. CCWF grants provide programs like PIC the essential resources to clean-up FC pollution problem areas.

7.0 RECOMMENDATIONS

Based upon the conclusions of the Upper Hood Canal Pollution Identification and Correction Project, Kitsap Health recommends the following:

- Complete correction of the four (4) remaining OSS failures as weather permits.

- Conduct dry season shoreline survey of approximately two (2) miles of Hood Canal shoreline in the Nelita and Tekiu area and follow-up on FC hotspots.
- Investigate ten (10) FC hotspots found through shoreline surveys.
- Investigate the two (2) properties that denied access, using enforcement tools, if necessary.
- Dye test the remaining nine (9) properties in the Lofall Creek drainage, the remaining four (4) properties in the Ferry Street tributary to Lofall Creek, the remaining three (3) properties in the LSD01 drainage, and the Holly property identified by WSDOH. Use enforcement tools, if necessary.
- Complete BACI for four (4) sites and other applicable sites.
- Research approximately seven hundred sixty (760) properties in the project area and develop an OSS spreadsheet with permit and maintenance status, age, and proximity to shoreline.
- Utilize available Jump Off Joe Creek Water Quality Project CCWF funding to complete the above-identified tasks.
- Publish a Hood Canal PIC report in a professional technical journal following Jump Off Joe PIC project completion.
- Share project results with WSDOH's shoreline survey program to remove closure zones from areas established around OSS failure zones. Share project results with other organizations working in the area, including the University of Washington and the Hood Canal Dissolved Oxygen Project.
- Research funding sources for future nutrient studies.
- Continue to explore ways to work in partnership with other agencies to more effectively meet goals.
- Research and test assessment methods to determine public education and outreach effectiveness and shoreline resident/visitor water quality information needs.
- Research potential methods to better build public trust, in order to increase participation rates, by actively working to provide accurate and representative data upon which to base regulation and legislation.
- Continue to support development of fact-based and consistent Hood Canal-wide messages and sharing information and effective methods with other jurisdictions.

8.0 REFERENCES

Bremerton-Kitsap County Board of Health Ordinance No. 1996-8, "Rules and Regulations Governing On-Site Sewage Systems." 1996.

Kitsap County Board of Health Ordinance No. 2008-11, "Onsite Sewage System and General Sewage Sanitation Regulations." May 1, 2008.

Kitsap County Health District, Hood Canal 2006 Shoreline Survey Quality Assurance Project Plan. November 6, 2006.

Kitsap County Health District, Manual of Protocol: Fecal Coliform Bacteria Pollution Identification and Correction Projects. November 2003.

Kitsap County Health District, Water Quality Analysis of Hood Canal Shoreline Discharges, Part 1.

Washington State Department of Health, 2004 Shoreline Survey of the Hood Canal 4 Shellfish Growing Area, Zabel-Lincoln. January 2005.

Swwqbdc1/pic/upperhood/hoodcanal2006/finalreport/hoodcanal2008finalreport3-09.doc

APPENDIX A

OSS Rating Category Criteria

APPENDIX A
CRITERIA FOR RATING OSS INSPECTION RESULTS

Rating Classification	Criteria for Meeting Classification[1]
No Apparent Problems[1]	• **Completed/signed** Sewage Disposal Permit on file at Health District, or available from owner. • No illegal repairs or alterations have been performed on OSS. • All applicable setbacks and conditions in effect at the time of permitting are in place.
No Records[1]	• No **completed/signed** Sewage Disposal Permit on file at the Health District, or in possession of the owner/occupant . • No Non-Conforming, Suspect or Failure criteria were observed .
Non-Conforming[2]	• Repairs or alterations have been performed on OSS without a permit • Additional bedrooms have been added to the home (or business) without a permit. • Non-conforming conditions exist (such as insufficient setbacks from surface waters or wells, no reserve area, vehicular traffic on drainfield).
Suspect[2]	• Drainfield area is saturated. • Collected water sample results from bulkhead drains, curtain drains, or other pipes or seeps, at or above 500 FC/100 ml. **and** negative dye-test. • Collected water sample results from bulkhead drains, curtain drains, or other pipes or seeps, less than 500 FC/100 ml. **and** positive dye-test.
Failure [2, 3]	• Sewage backing up into, or not draining out of a structure caused by slow soil absorption of septic tank effluent. • Sewage leaking from a septic tank, pump tank, holding tank, or collection system. • Surfacing sewage in a documented drainfield area. • Collected water sample result from bulkhead drains, curtain drains, or other pipes or seeps, at or above 500 FC/100 ml. **and** positive dye-test results. • Straight discharge (gray or blackwater) from any indoor plumbing is observed and documented.

[1] All of the criteria in each rating classification must be met.

[2]One of the criteria must be met.
[3] As defined in local sewage regulations.

APPENDIX B

Lofall Creek Fecal Coliform Sample Results

	STATION	DATE	TIME	Fecal Coliform/100ml
1	Lofall Creek Mouth (LF01)	7/1/2007	1303	**900**
2		7/29/2007	1142	**1601**
3		8/6/2007	1610	**900**
4		8/7/2007	804	**1601**
5		8/15/2007	1538	**1601**
6		12/10/2007	1000	**140**
7		12/11/2007	1137	**110**
8		1/14/2008	830	**220**
9		1/15/2008	1514	**80**
10		1/17/2008	1440	50
11		1/22/2008	1100	23
12		1/31/2008	849	**110**
13		2/4/2008	1550	50
14		2/11/2008	825	**130**
15		2/15/2008	1033	**240**
16		2/20/2008	1045	**80**
17		2/25/2008	945	**130**
18		3/3/2008	938	**110**
19		3/10/2008	955	**220**
20		3/26/2008	950	**300**
21		4/14/2008	937	30
22		4/21/2008	940	**300**
23		4/28/2008	950	**170**
24		5/5/2008	1056	80
25		5/14/2008	1115	**300**
26		5/19/2008	1015	**300**
27		5/28/2008	1055	**900**
28		6/4/2008	1320	**900**
29		6/11/2008	1040	**300**
30		6/16/2008	1030	34
31		6/23/2008	1110	**500**
32		7/2/2008	1215	**1600**
33		7/8/2008	1340	**500**
34		7/14/2008	1110	**1601**
35		7/21/2008	1200	**1601**
36		7/28/2008	1100	**1601**
37		8/4/2008	1015	**1601**
38		8/11/2008	1025	**1601**
39		8/18/2008	1015	**1601**
40		8/25/2008	1025	**1601**
41		9/2/2008	1025	**1601**
42		9/8/2008	1110	**1601**
43		9/17/2008	1145	**1601**
44		9/29/2008	1005	**1600**
45		10/6/2008	1000	**1601**
	GMV			**381**

1	Ferry Street Tributary to Lofall Creek (Ferry sw)	7/1/2007	1240	**900**
2		7/29/2007	1149	**130**
3		8/6/2007	1615	**220**
4		8/7/2007	808	30
5		8/15/2007	1545	**240**
6		11/26/2007	1208	13
7		12/10/2007	1040	**140**
8		12/11/2007	1145	30
9		1/3/2008	1204	**220**
10		1/14/2008	845	23
11		1/15/2008	1516	30
12		1/17/2008	1448	17
13		1/22/2008	1110	30
14		1/31/2008	900	**500**
15		2/4/2008	1555	50
16		2/11/2008	832	17
17		2/15/2008	1038	**500**
18		2/20/2008	1053	13
19		2/25/2008	955	4
20		3/3/2008	940	7
21		3/10/2008	1000	2
22		3/26/2008	955	50
23		4/14/2008	942	30
24		4/21/2008	950	8
25		4/28/2008	957	90
26		5/5/2008	1111	**900**
27		5/14/2008	1120	**500**
28		5/19/2008	1020	**300**
29		5/28/2008	1100	**110**
30		6/4/2008	1330	**1601**
31		6/11/2008	1050	70
32		6/16/2008	1035	30
33		6/23/2008	1120	**240**
34		7/2/2008	1235	1
35		7/8/2008	1410	2
36		7/14/2008	1250	30
37		7/21/2008	1215	23
38		7/28/2008	1105	14
39		8/4/2008	1025	13
40		8/11/2008	1035	2
41		8/18/2008	1020	4
42		8/25/2008	1035	**220**
43		9/2/2008	1035	50
44		9/8/2008	1130	2
45		9/17/2008	1205	**110**
46		9/29/2008	1025	**1601**
47		10/6/2008	1020	**300**
	GMV			**47**

1	Lofall Creek at Wesley (LF02)	7/29/2007	1200	**1600**
2		8/6/2007	1619	**1600**
3		8/7/2007	814	**1600**
4		8/15/2007	1550	**1601**
5		11/26/2007	1212	**1601**
6		12/10/2007	1050	**500**
7		12/11/2007	1146	50
8		1/3/2008	1210	**500**
9		1/14/2008	850	**70**
10		1/15/2008	1524	**80**
11		1/17/2008	1455	23
12		1/22/2008	1105	**70**
13		1/31/2008	855	**70**
14		2/4/2008	1600	**70**
15		2/11/2008	835	**500**
16		2/15/2008	1043	50
17		2/20/2008	1100	**80**
18		2/25/2008	1000	**80**
19		3/3/2008	942	**130**
20		3/10/2008	1005	**80**
21		3/26/2008	1000	**130**
22		4/14/2008	945	30
23		4/21/2008	952	**220**
24		4/28/2008	959	**240**
25		5/5/2008	1113	30
26		5/14/2008	1123	**170**
27		5/19/2008	1025	**220**
28		5/28/2008	1105	**300**
29		6/4/2008	1335	**300**
30		6/11/2008	1053	**500**
31		6/16/2008	1040	**80**
32		6/23/2008	1125	**130**
33		7/2/2008	1325	**1601**
34		7/8/2008	1430	**300**
35		7/14/2008	1255	**1600**
36		7/21/2008	1220	**1601**
37		7/28/2008	1110	**1601**
38		8/4/2008	1030	**1601**
39		8/11/2008	1040	**1601**
40		8/18/2008	1025	**1601**
41		8/25/2008	1040	**1601**
42		9/2/2008	1040	**1601**
43		9/8/2008	1135	**1600**
44		9/17/2008	1210	**1601**
45		9/29/2008	1030	**1601**
46		10/6/2008	1025	**1601**
	GMV			**335**

APPENDIX C

Pilot Nutrient Study Results

Kitsap County Health District
Upper Hood Canal FC/Nitrate+Nitrite Nitrogen Correlation Study
2005 - 2008

January 30, 2005		March 2, 2005		April 13, 2005		February 26, 2008		March 11, 2008	
Event 1	Event 1	Event 2	Event 2	Event 3	Event 3	Event 4	Event 4	Event 4	Event 4
Fecal Coliform FC/ 100ml	Nitrate+Nitrite Nitrogen mg/L	Fecal Coliform FC/ 100ml	Nitrate+Nitrite Nitrogen mg/L	Fecal Coliform FC/ 100ml	Nitrate+Nitrite Nitrogen mg/L	Fecal Coliform FC/ 100ml	Nitrate+Nitrite Nitrogen mg/L	Fecal Coliform FC/ 100ml	Nitrate+Nitrite Nitrogen mg/L
<2	0.10	<2	0.05	<2	0.04	4	0.10	4	0.14
2	3.64	<2	2.41	<2	2.80	4	0.14	<2	0.11
7	6.36	2	7.18	70	5.58	2	0.11	<2	0.16
<2	1.67	<2	0.69	<2	0.64	4	0.05	20	0.10
2	1.50	<2	0.36	4	0.96	280	0.06	<2	0.09
<2	0.58	<2	0.38	<2	0.33	<2	0.21	<2	0.06
<2	0.97	2	0.81	140	0.95	<2	0.27	<2	0.09
<2	1.50	<2	1.33	<2	1.68	4	0.95	7	0.09
<2	0.07	<2	0.02	<2	0.16	<20	0.32	<2	0.08
30	0.68	4	0.63	<2	0.16	30	0.21	<2	0.08
<2	0.10	<2	0.29	<2	0.03	<2	0.11	<2	0.15
2	0.04	<2	0.02	<2	0.02	2	0.20	<2	0.08
<2	3.51	<2	4.17	<2	2.57	2	0.23	<2	0.09
4	9.34	<2	9.80	<2	5.07	170	0.22	2	0.07
2	2.36	<2	2.37	<2	0.56	<2	0.27	2	0.07
27	0.66	<2	4.68	<2	2.80	<2	0.16	<2	0.08
2	5.54	<2	0.69	7	0.37	2	0.24	<2	0.14
<2	0.79	<2	0.39	8	0.02	<2	0.13	<2	0.10
2	0.53	240	0.54	11	1.32	8	0.12	<2	0.29
50	0.59	<2	0.04	11	3.31	50	0.30	<2	0.11
<2	0.08	2	0.81	2	0.24			50	0.22
<2	0.86	<2	4.17	2	0.16			23	1.55
9	6.99	<2	0.35	<2	0.08			4	0.51
<2	0.22	2	0.17	<2	0.05			4	1.59
<2	0.27	<2	0.16	2	0.62			2	0.22
<2	0.24	<2	0.15	8	0.59				
<2	0.21	2	0.41	4	0.17				
<2	0.77	<2	0.01	2	0.22				
<20	0.06	2	1.15	<2	0.57				
<2	<0.01	4	0.20	<2	0.09				
<2	1.62	2	0.26	8	3.10				
4	0.18	2	0.26	<2	0.92				
<2	0.24	2	1.19	<2	0.37				
8	0.60	<2	0.81	<2	0.41				
<2	0.34	<2	0.05	<2	0.97				
2	0.87	2	0.81	<2	0.13				
13	1.22	<2	0.23	4	0.38				
<2	0.35	<2	0.47	<2	0.51				
<2	0.84	11	0.45	110	0.78				
<2	0.39	280	1.16	<2	0.07				
2	0.98	<2	0.07	2	0.34				
<2	0.21	<2	0.28	4	0.66				
<2	0.73	<2	0.35	<2	0.65				
<2	0.55	<2	0.71	<2	0.12				
>1600	1.51	2	0.11	<2	0.02				
<2	0.07	<2	0.13	<2	0.98				
2	0.35	2	0.10	<2	0.34				
>1600	0.70	2	2.16						
<2	0.97	2	0.43						
<2	0.12								
11	0.14								
<2	0.07								
<2	0.96								
<2	0.48								

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Site HC4-25

	Control - 22						Impact - 25					
Before	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**
		FC/100ml	mg/L	mg/L	mg/L	gpm		FC/100ml	mg/L	mg/L	mg/L	gpm
	3/10/2005	1	0.21	0.01	0.08	1.00	2/13/2005	1601	NT	NT	NT	2.40
	3/22/2005	1	0.22	0.01	0.06	0.80	3/1/2005	900				2.10
							3/10/2005	80	0.29	0.95	0.23	2.00
							3/22/2005	170	0.31	4.01	0.76	1.80
	Average	1	0.22	01/00/00	0.07	0.90		374	0.30	2.48	0.50	2.08
	Date	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow gpm**	Date	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow gpm**
After		FC/100ml	mg/L	mg/L	mg/L	gpm		FC/100ml	mg/L	mg/L	mg/L	gpm
	03/06/06	1	0.12	0.01	0.01	0.44	03/06/06	1	0.18	0.01	0.02	2.80
	3/27/2006	1	0.16	0.01	0.05	0.51	3/27/2006	1	0.17	0.01	0.07	2.60
	4/13/2006	1	0.18	0.01	0.07	0.45	4/13/2006	2	0.12	0.01	0.08	2.30
	Average	1	0.15	01/00/00	0.04	0.47		1	0.16	0.01	0.06	2.57
	% reduction		-29%	0%	-38%	-48%		-100%	-48%	-100%	-89%	24%

* FC is calculated as a Geometric Mean Value

FC results: <2 is recorded as 1; ≥1600 is recorded as 1601

Kitsap County Health District
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Sites HC4-46 and HC-50

	Control - 43							Impact - 46							Impact - 50						
Before	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**salinity**	**Flow**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Salinity**	**Flow**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**salinity**	**Flow**
		FC/100ml	mg/L	mg/L	mg/L	ppm	gpm		FC/100ml	mg/L	mg/L	mg/L	ppm	gpm		FC/100ml	mg/L	mg/L	mg/L	ppm	gpm
	1/30/2005	1	0.79				0.38	1/30/05	4	9.34				*	1/30/2005	30	0.68				2.44
	3/2/2005	1	0.69				0.09	3/2/05	1	9.8				0.09	2/14/2005	1					
	3/10/2005	1	0.83	0.01	0.02		0.12	3/10/05	4	9.86	0.02	0.01		*	3/2/2005	4	0.63				0.60
	3/22/2005	21	0.77	0.01	0.02			3/22/05	8	6.57	0.01	0.03			3/10/2005	2	0.84	0.02	0.02		0.60
								4/13/05	2	5.07	0.01	0.02			3/22/2005	1	0.52	0.01	0.02		
	Average	2	0.77	0.01	0.02		0.20		3	8.13	0.01	0.02		0.09		3	0.67	0.02	0.02		1.21
After	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**salinity**	**Flow gpm**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**		**Flow gpm**							
		FC/100ml	mg/L	mg/L	mg/L	ppm	gpm		FC/100ml	mg/L	mg/L	mg/L	ppm	gpm		FC/100ml	mg/L	mg/L	mg/L	ppm	gpm
	3/6/2007	1	0.44	0.01	0.02	0.1	0.14	3/6/2007	1	1.14	0.01	0.02	<0.1	0.10	3/6/2007	1	0.55	0.01	0.01	<0.1	0.57
	3/8/2007	80	0.08	0.01	0.02	0.1	0.66	3/8/2007	130	0.68	0.01	0.03	<0.1	0.78	3/8/2007	4	0.48	0.01	0.02	<0.1	6.37
	3/11/2008	4	0.46	0.01	0.02	0.1	0.24	3/11/07	1	0.67	0.01	0.01	<0.1	0.52	3/11/2007	4	0.60	0.01	0.01	<0.1	2.12
	Average	7	0.33	0.01	0.02	0.1	0.35		5	0.83	0.01	0.02	<0.1	0.47		3	0.54	0.01	0.01	<0.1	3.02
	% reduction	220%	-58%	0%	0%		75%		67%	-90%	-25%	0%		432%		-16%	-19%	-33%	-33%		149%

* FC is calculated as a Geometric Mean Value

FC results: <2 is recorded as 1; >1600 is recorded as 1601

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Upper Hood Canal Before and After FC Source Correction Study
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Site HC4-75

	Control - 76					Impact - 75						
Before	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**
		FC/100ml	mg/L	mg/L	mg/L	gpm		FC/100ml	mg/L	mg/L	mg/L	gpm
	1/31/2005	1	0.07			1.00	1/31/2005	1601	1.51			1.20
	3/2/2005	1	0.07			1.05	2/14/2005	900				
	3/10/2005	1	0.07	0.01	0.08	1.00	3/2/2005	280	1.16			0.84
	4/13/2005	2	0.07	0.01	0.09	0.31	3/10/2005	23	0.18	0.01	0.07	0.32
							4/13/2005	110	0.78	0.01	0.06	0.16
Average		1	0.07	0.01	0.09	0.84		252	0.91	0.01	0.07	0.63
After	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**
		FC/100ml	mg/L	mg/L	mg/L	gpm		FC/100ml	mg/L	mg/L	mg/L	gpm
	03/06/06	2	0.04	0.01	0.03	0.44	03/06/06	23	0.51	0.01	0.01	0.22
	3/27/2006	1	0.05	0.01	0.09	0.33	3/27/2006	50	0.49	0.12	0.06	0.17
	4/13/2006	1	0.14	0.01	0.09	0.33	4/13/2006	4	0.50	0.04	0.01	0.16
Average		1	0.08	0.01	0.07	0.37		17	0.50	0.06	0.03	0.18
	% reduction	6%	10%	0%	-18%	-56%		-93%	-45%	467%	-59%	-71%

* FC is calculated as a Geometric Mean Value

FC results: <2 is recorded as 1; ≥1600 is recorded as 1601

Kitsap County Health District
Upper Hood Canal Before and After FC Source Correction Study
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	Hood Canal Site 5-5													
	Control - 4							Impact - 5						
Before	**Date**	**FC**	**Nitrate + Nitrite**	**Ammonia**	**Ortho-Phosphate**	**Salinity**	**Flow**	**Date**	**FC**	**Nitrate + Nitrite**	**Ammonia**	**Ortho-Phosphate**	**Salinity**	**Flow**
		FC/100ml	**mg/L**	**mg/L**	**mg/L**	**ppm**	**gpm**		**FC/100ml**	**mg/L**	**mg/L**	**mg/L**	**ppm**	**gpm**
	2/2/2005	8						02/02/05	1601					
	5/2/2005	4	0.43	0.02	0.04			02/14/05	1600					
	05/05/05	4	0.37	0.01	0.03			4/26/2005	80	0.16	0.16	0.45		
								5/2/2005	50	0.12	0.44	0.20		
								05/05/05	110	0.17	0.35	0.22		
Average		5	0.40	0.02	0.04				257	0.15	0.32	0.29		
After	**Date**	**FC**	**Nitrate + Nitrite**	**Ammonia**	**Ortho-Phosphate**	**Salinity**	**Flow**	**Date**	**FC**	**Nitrate + Nitrite**	**Ammonia**	**Ortho-Phosphate**	**Salinity**	**Flow**
		FC/100ml	**mg/L**	**mg/L**	**mg/L**	**ppm**	**gpm**		**FC/100ml**	**mg/L**	**mg/L**	**mg/L**	**ppm**	**gpm**
	03/06/06	30	0.59	0.01	0.14	0.2	0.08	03/06/06	1	1.48	0.01	0.04	>0.1	1.56
	03/08/07	2	1.50	0.01	0.03	0.1	0.44	03/08/07	50	1.68	0.02	0.25	>0.1	0.12
	03/11/07	8	2.21	0.01	0.02	0.1	0.80	03/11/07	80	2.22	0.01	0.39	>0.1	0.41
Average		8	1.43	0.01	0.06	0.1	0.44		16	1.79	0.01	0.23	>0.1	0.70
	% reduction	55%	258%	-33%	81%				-94%	1096%	-96%	-22%		
* FC is calculated as a Geometric Mean Value														
FC results: <2 is recorded as 1; ≥1600 is recorded as 1601														

Kitsap County Health District
Upper Hood Canal Before and After FC Source Correction Study
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	Hood Canal Site 6-48											
	Control - 49						Impact - 48					
Before	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**
		FC/100ml	mg/L	mg/L	mg/L	gpm		FC/100ml	mg/L	mg/L	mg/L	gpm
	2/14/2005	1					02/14/05	1600				
	4/6/2005	2	0.04	0.01	0.06	3.74	4/6/2005	900	0.4	0.01	0.04	0.08
	05/25/05	30	0.22	0.06	0.03		05/25/05	23	0.34	0.01	0.05	
	06/07/05	70	0.18	0.05	0.03	1.90	06/07/05	1601	0.19	0.01	0.03	0.10
Average		8	0.15	0.04	0.04	2.82		480	0.31	0.01	0.04	0.09
After	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**Flow**
		FC/100ml	mg/L	mg/L	mg/L	gpm		FC/100ml	mg/L	mg/L	mg/L	gpm
	03/06/06	1	0.04	0.01	0.01	2.20	03/06/06	1	0.29	0.01	0.01	0.10
	3/27/2006	30	0.08	0.01	0.03	4.10	3/27/2006	2	0.28	0.01	0.02	0.09
	4/13/2006	50	0.07	0.02	0.03	2.60	4/13/2006	6	0.18	0.01	0.02	0.78
Average		11	0.06	0.01	0.02	2.97		2	0.25	0.01	0.02	0.32
	% reduction	42%	-57%	-67%	-42%	5%		-100%	-19%	0%	-58%	270%
* FC is calculated as a Geometric Mean Value												
FC results: <2 is recorded as 1; ≥1600 is recorded as 1601												

Kitsap County Health District
Upper Hood Canal Before and After FC Source Correction Study
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	Hood Canal Site 8-10													
	Control - 11							Impact - 10						
Before	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**salinity**	**Flow comment**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**salinity**	**Flow gpm**
	2/1/2005	1600						2/1/2005	1601					
	2/14/2005	280						2/14/2005	50					
	4/12/2005	280	0.25	0.01	0.02			4/12/2005	1601	0.03	2.24	0.48		
	4/20/2005	17	0.01	0.02	0.03			4/20/2005	50	0.20	0.24	0.06		
	4/27/2005							4/27/2008	500	0.05	0.88	0.10		
	5/4/2005	1601	0.03	0.01	0.04			5/4/2005	1601	0.08	2.16	0.44		
Average		321	0.10	0.01	0.03				415	0.09	1.38	0.27		
After	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**salinity**	**Flow comment**	**Date**	**FC**	**nitrate+nitrite**	**ammonia**	**o-phoshorus**	**salinity**	**Flow gpm**
	03/06/07	70	0.02	0.02	0.01	>0.1		3/6/2007	1	0.64	0.02	0.02	0.2	0.31
	03/08/07	30	0.07	0.02	0.02	>0.1	3.82	3/8/2007	11	0.62	0.04	0.03	0.2	1.58
	03/11/07	13	0.86	0.02	0.03	>0.1	12.74	3/11/2007	23	0.96	0.02	0.04	0.1	0.47
	07/16/07							7/16/2007						
								9/28/2008	240	1.00				
Average		30	0.32	0.02	0.02	>0.1	8.28		16	0.81	0.03	0.03	0.2	0.79
	% reduction	-91%	228%	50%	-33%				-96%	794%	-98%	-89%		
* FC is calculated as a Geometric Mean Value														
FC results: <2 is recorded as 1; ≥1600 is recorded as 1601														