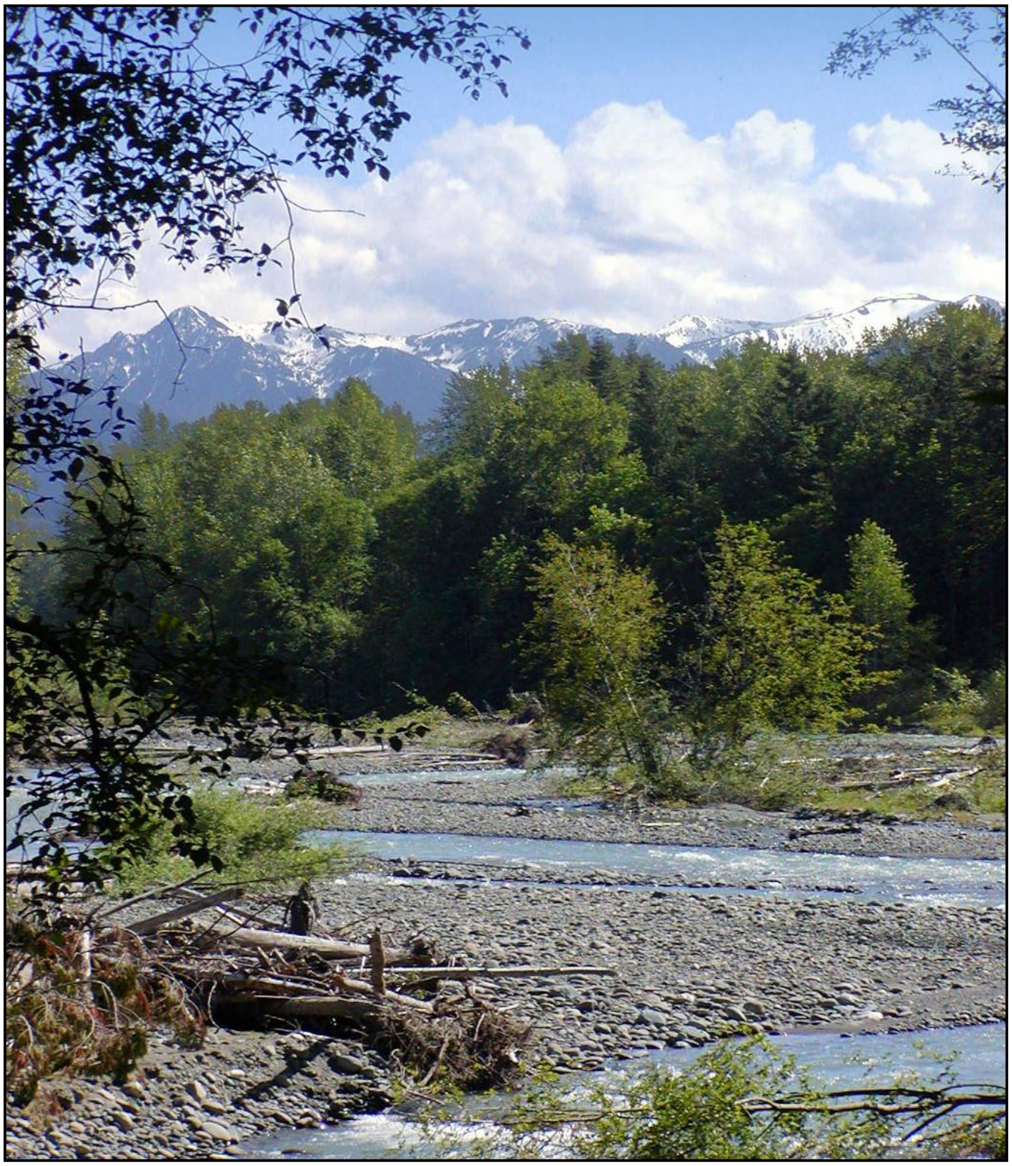
Dungeness River
Targeted Watershed Initiative



FINAL REPORT

For E.P.A. Targeted Watershed Grant
WS-97098101-0

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FIGURES

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NAME OF PROJECT
Dungeness River Targeted Watershed Initiative (WS-97098101-0)

PROJECT SUMMARY
The 200 square-mile Dungeness Watershed is located on the Olympic Peninsula of northern Puget Sound in Washington State (Figure 1). The Dungeness River originates in the steep mountains of Olympic National Park and flows 32 miles through wilderness, forest and the Sequim Valley before reaching Dungeness Bay, partially within the boundary of Dungeness National Wildlife Refuge. The Watershed provides for over 200 fish and wildlife species, and is an important stop for migratory waterfowl. The River supports seven Puget Sound salmonid species, and the Bay is renowned for bountiful crab and other shellfish. This area has steadily converted from forest to agricultural and residential land uses, and is rapidly urbanizing. Residents and visitors enjoy a variety of recreational activities in a mild, sunny climate within the rain-shadow of the mountains. An extensive irrigation system, which diverts river water for lawns, livestock, crops and hobby farms, adds to the pastoral setting of the valley. The Jamestown S'Klallam Tribe, historically dependent on the watershed's cultural and natural resources, retains treaty rights to fish, hunt and gather shellfish here.

Figure 1. Dungeness Watershed on the Olympic Peninsula, Washington.

For over two decades, community members in the Dungeness Valley have joined efforts to restore and protect ecosystem functions in the Dungeness River Watershed. A great deal of restorative work has occurred via collaborative partnerships among federal and local agencies, landowners, and others. However, impaired water quality, shellfish harvest closures and dwindling salmon runs have persisted. Floodplain development and associated failing septic systems, low instream flows, and pollution from residential and agricultural stormwater runoff contribute to these problems.

Recipients of an Environmental Protection Agency (EPA) Watershed Initiative Grant, now called the Targeted Watershed Grant (TWG), the Jamestown S'Klallam Tribe and local partners set out to examine some of the linked threats present in the watershed. The overall project was based on strategies within the *Elwha-Dungeness Watershed Plan for Water Resources Inventory Area 18* (Elwha-Dungeness Planning Unit, 2005) (Watershed Plan) and was designed to look more closely at pollutant sources, demonstrate Best Management Practices, and boost public outreach efforts related to the watershed problems. The following specific tasks were selected for the project:

Task 1: a Microbial Source Tracking Study (MST), to more precisely define pollutant sources;

Task 2: innovative Best Management Practice (BMP) demonstrations (and market-based incentives for BMP implementation) related to water quality treatment, septic maintenance, stormwater management, and irrigation water management; and

Task 3: an Effectiveness Monitoring Study, to evaluate the BMP demonstrations and help determine short-term goal (achieved within grant timeline) success.

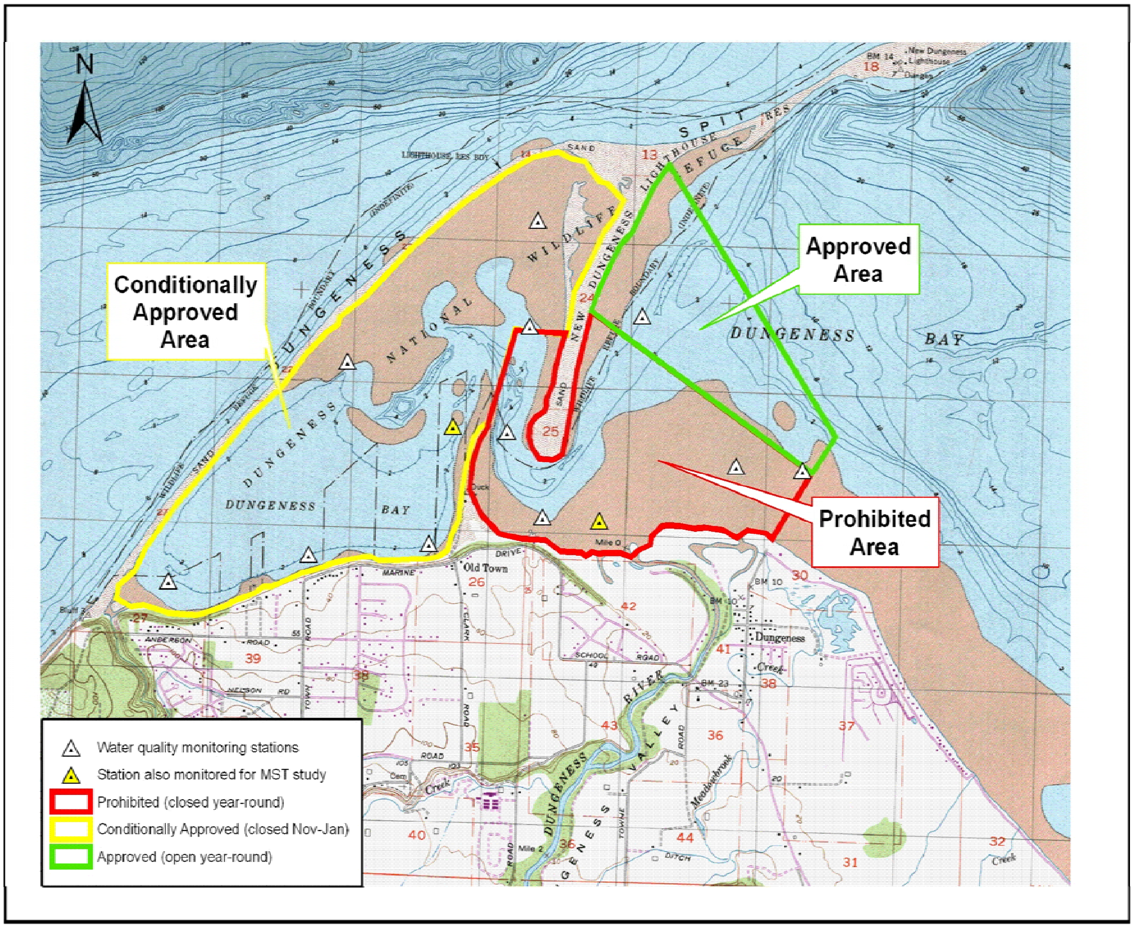
Additionally, we outlined and followed a public outreach plan to provide information to adults and children on bacterial pollution and prevention, inform residents about where to obtain remediation services, create ways to reach new audiences, and update locals and other interested parties about project progress.

WATERSHED THREATS AND RESTORATION EFFORTS

The natural ecosystem processes of the Dungeness River and Bay have been impaired by human-related activities within the Watershed. Land use changes and physical alterations, such as floodplain development, riparian vegetation removal and an extensive irrigation system, are factors in stormwater pollution, low in-stream flows, bacterial contamination and overall degraded aquatic habitat. Failing septic systems, poor animal keeping practices and inadequate management of stormwater runoff have caused elevated bacterial levels in the River, Bay and irrigation ditches. These impacts have resulted in human health risk and four salmonid species listed as threatened under the Endangered Species Act (ESA). Like many Puget Sound basins, the Dungeness is 303(d)-listed (1996) for fecal coliform bacteria and impaired in-stream flows. Many of the other streams in the Watershed are also listed for these and other parameters. The bacteria listings resulted in closures of Dungeness Bay to tribal and non-tribal shellfish harvests beginning in 2000 (Sargeant 2004) (Figure 2). Economic and recreational uses of the River and Bay have also been inhibited.

The Dungeness River Management Team (DRMT), the watershed council established by the Jamestown S'Klallam Tribe and Clallam County in 1995, spent five years completing the East WRIA 18 portion of the Dungeness-Elwha Watershed Plan, which was adopted by Clallam County Board of Commissioners in 2005. The Plan draws from many previous planning efforts and focuses on four interrelated watershed issues: Water Quality, Water Quantity, Habitat and In-stream Flows.

Figure 2. Dungeness Bay shellfish closure areas.



The Dungeness Targeted Watershed project was originally based on two focused strategies that were folded into the 2005 Watershed Plan. The first, *Clean Water Strategy for Addressing Fecal Coliform* (Hempleman and Streeter, 2004) (Clean Water Strategy), stemmed from two Total Maximum Daily Load (TMDL) studies by Washington Department of Ecology (Sargeant, 2002 and Sargeant, 2004). The Clean Water Strategy coordinates actions to address non-point source pollution throughout the watershed. The second effort, a *Comprehensive Irrigation District Management Plan* (HDR, 2003, revised 2006), was an incentive-based approach for the irrigation community to manage their system in light of both the Endangered Species and Clean Water Acts.

Considering the status of the two strategies in 2003/2004, initiating the tasks described in our *Dungeness Targeted Watershed Initiative Work Plan* (Jamestown S'Klallam Tribe, 2004) was the natural next step. Updates on these strategies since that time are provided below.

<u>Clean Water Strategy (Strategy) Status</u>:
When the TWG project began, the Clean Water Strategy and its associated implementation plan were being finalized and reviewed by the Clean Water Work Group, a committee comprised of federal, state, local and tribal organizations, and watershed residents. The Work Group's main focus is on water quality planning and implementation of the Strategy. Because many of the TWG tasks relate to actions from the Strategy, the Work Group was called on for feedback over the course of the project and provided essential volunteer help with various phases of the project.

Many of the tasks in our TWG Work Plan (e.g. MST, Training and Septic Cost-Share Program, Stormwater Demonstrations, Irrigation Ditch Piping Demonstration, etc.) are identified in the Strategy as high priority projects for watershed-wide water quality improvements. A report on the status of the Detailed Implementation Plan for the Strategy was recently updated by the County and the Work Group, taking into account the accomplishments from the TWG and other grant projects, as well as present and future needs (Maier, 2008).

CIDMP Status:
The CIDMP, a pilot project under an innovative planning process developed for irrigation activities in Washington State, was also being finalized at the time the TWG was awarded. Negotiations were underway between the local Sequim-Dungeness Valley Water Users Association and the governmental agencies charged with implementing the Clean Water and Endangered Species Acts. The corresponding plan offered numerous measures by which stream flows, water quality conditions, and prospects for recovery of listed species could be improved. Water conservation and water quality protection via piping open irrigation ditches, concurrent with public outreach and stormwater-related projects, are some of the measures detailed in this incentive-based plan. Although the plan remains in draft form today, due to further negotiations needed related to water conservation (per NOAA Fisheries), it has been used as a reference guide for planning local water conservation and water quality projects.

TWG project tasks were selected according to specific criteria, and due to certain shared goals with the 2005 Watershed Plan. The tasks, project selection criteria, and goals are listed in Table 1 below:

Table 1: Project tasks, selection criteria and goals.

Project Tasks
Task 1: Microbial Source Tracking (MST) Study
Task 2: Innovative BMP Demonstrations *Task (2a): Myco-remediation Demonstration* *Task (2b): Homeowner Sewage Management BMP Education and Training* *Task (2c): Stormwater BMP Demonstrations* *Task (2d): Irrigation Ditch Piping Demonstration*
Task 3: Effectiveness Monitoring Study
Public Outreach
Project Selection Criteria
• Degree to which project embraces an innovative restoration approach
• Potential for project success and cost-effectiveness
• Ability for project to address more than one priority watershed issue simultaneously
Long-term Goals
• Increased use of BMPs associated with improving water quality
• Improved water quality in the Dungeness Watershed and Bay to meet shellfish harvest- and freshwater-standards and to meet restoration targets
• Stormwater impact mitigation
• Improved in-stream flows for ESA-listed fish
• Removal of the Dungeness River from the 303(d) list (for both fecal coliform and low in-stream flows)
Short-term Goals (expected to be achieved within grant timeline)
• Species-specific pollutant source identification (addressed by Task 1)
• Application of innovative BMPs (addressed by Tasks 2(a-d)
• Reduction in number of faulty septic systems (addressed by Task 2(b))
• Improved irrigation efficiency and public/private system coordination (addressed by Task 2(d))
• Enhanced public awareness of pollutant sources (addressed by all Tasks)
• Enhanced public awareness of pollutant prevention techniques (addressed by Tasks 2(a-d), 3, 4)

PROJECT TASKS

The overall project examined sources of watershed pollution and demonstrated or studied techniques to prevent or reduce their impacts while improving aquatic habitat and informing the public. The implemented tasks are described in detail below.

Task 1. Microbial Source Tracking (MST) Study

Note: Some of the content herein is modified or excerpted from the Task 1 final report, *Microbial Source Tracking in the Dungeness Watershed* (Woodruff et al., 2009a). The full report can be accessed from the following link on the Dungeness River Audubon Center's website: http://www.dungenessrivercenter.org/DungenessWatershedResearch.html.

It has been well-established that nonpoint fecal pollution is a problem in the Dungeness Watershed and this type of pollution is exceedingly difficult to track to source of origin. Thus, we were eager to begin a Dungeness MST study as part of the TWG. We partnered with Battelle (Pacific Northwest Division) Marine Sciences Laboratory in Sequim, Washington, whose researchers conducted two independent, sequential phases of the MST study between 2006 and 2008 to determine the predominant bacterial sources of pollution at various times and in various locations of the Watershed. The first phase was funded by TWG (EPA) and used a genetic "fingerprinting" (ribotyping) approach. The second phase was funded by Washington Department of Ecology through a Centennial Clean Water Fund Grant obtained by the Tribe, and it used a *Bacteroides* target-specific PCR (polymerase chain reaction) approach.

MST Study, Phase 1 – Ribotyping Method

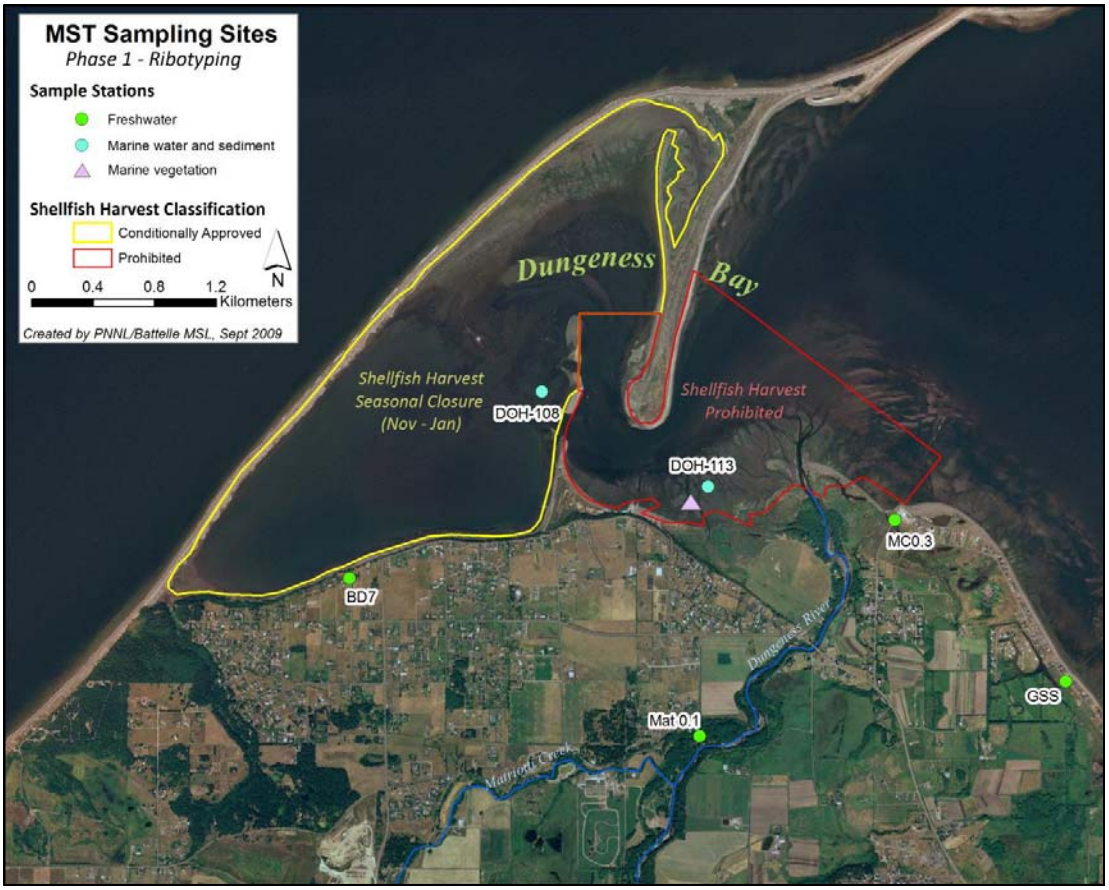
The ribotyping method used in Phase 1 is based on the premise that the DNA fingerprint of the *E. coli* bacteria living within the gut or intestine of a particular specie of animal, although genetically similar to other species, has certain unique differences in the DNA sequence that can be used to match to an *E. coli* bacteria from an unknown source (e.g. water or sediment sample). Hence, this method requires a large database (host reference library) of known source *E. coli* isolates that is used for comparison against unknown sources of *E. coli*. Once unknown samples (water, sediment and marine vegetation samples containing fecal coliform from unknown sources) are collected, the ribotyping method utilizes a multiple step laboratory analytical process to cultivate fragments of ribosomal RNA from *E. coli* from the sample. The unknown fragments are then matched to RNA fragments from *E. coli* cultivated from known fecal sources in the host reference library.

We wanted Phase 1 to address questions raised following the TMDL studies in the lower River (Sargeant, 2002) and the Bay (Sargaent, 2004). A total of six MST sample sites (Figure 3) were selected and sampled monthly over a one-year time period to characterize the predominant sources (host animals) of *E. coli* bacteria and to assess the potential for mitigation. Study design and methodology are detailed in the final report (Woodruff et. al., 2009a) and reference an EPA-approved Quality Assurance Project Plan (Battelle Marine Sciences Laboratory, 2005).

Specific objectives for Phase 1 included the following:

- Determine what bacteria sources may be controllable.
- Use results from this study for public outreach, mitigation where practical, and improvement of the design of future water-quality monitoring projects.
- Characterize the predominant sources of fecal coliform bacteria in the lower Dungeness watershed and Dungeness Bay.
- Determine the predominant sources of fecal coliform at key specific sites and examine the differences between sites.
- Determine if and/or what temporal trends may exist based on the time period sampled (one year).

Figure 3. Phase 1 MST (Ribotyping) sampling locations.



In addition to the collection of unknown samples (freshwater, marine water, marine sediment and marine vegetation samples containing fecal coliform bacteria from unknown sources), known samples (fecal samples from known sources) were collected when possible from species in the Dungeness Watershed and the greater Olympic Peninsula region. This local species inventory was added to the extensive, pre-existing host reference library at the Institute of Environmental Health (IEH) in Seattle to increase the likelihood of DNA matches between *E. coli* in unknown test samples and *E. coli* from known source types.

MST Study, Phase 2 – *Bacteroides* Target Specific PCR Method

The *Bacteroides* target-specific PCR approach used during Phase 2 is based on amplifying known DNA biomarkers from *Bacteroides* bacteria found in the gut of warm-blooded animals and matching those with *Bacteroides* DNA in water samples. This approach did not require the development of a source library as in Phase 1 or require the culture of the indicator bacteria, *E. coli*, except as a screening tool. While a number of primers have been developed, only several are readily available, and our study was limited to primers that were available to the EPA Manchester Laboratory to identify human and ruminant sources of *Bacteroides*.

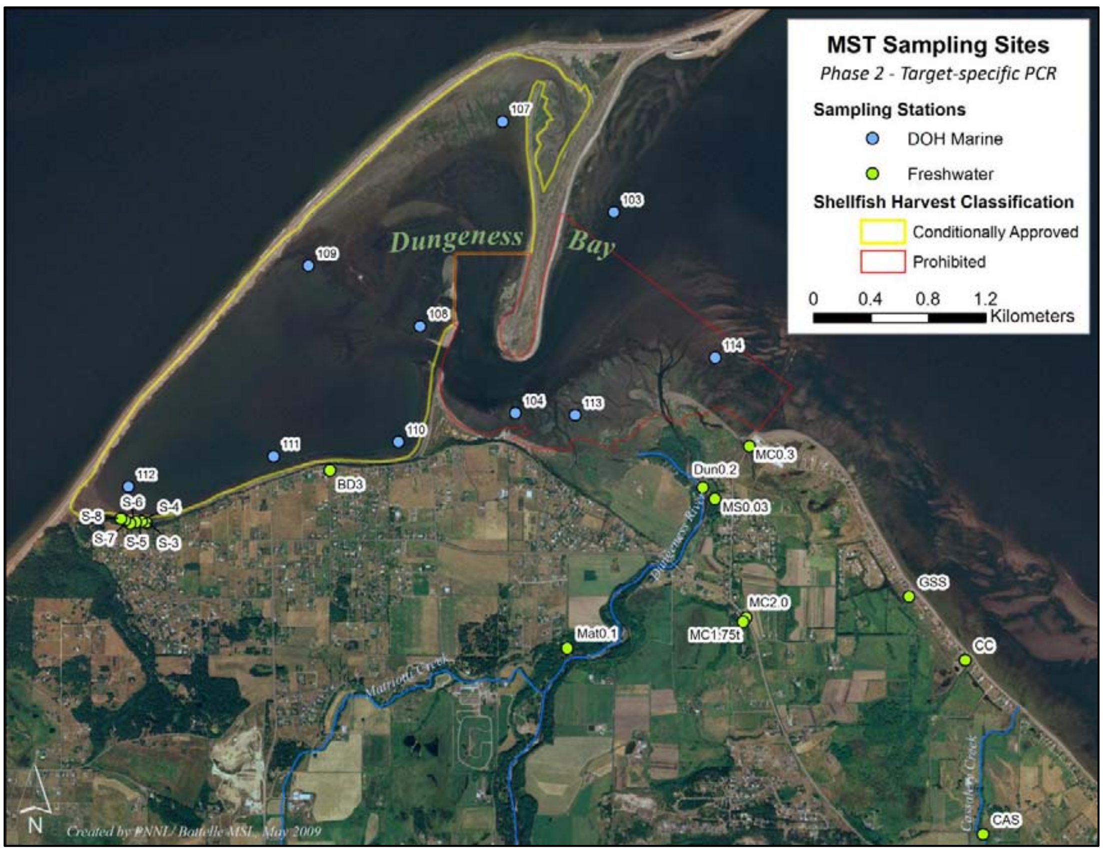
Specific objectives for Phase 2 included the following:

- Verify the presence or absence of human and ruminant sources at previous Phase 1 MST monitoring stations in the watershed.

- Determine the presence or absence of human and ruminant sources at additional selected monitoring stations in the watershed.
- Assess the spatial extent of human and /or ruminant sources in Dungeness Bay during the Shellfish Harvest Conditional Closure time period.
- Assess the presence of human and/or ruminant sources from freshwater seeps located along inner Dungeness Bay.
- Use the results of the study to target specific waste-reduction BMPs.
- Foster community education and outreach regarding sources of human fecal contamination in the Dungeness watershed.

Phase 2 was conducted approximately one and a half years after Phase 1 ended and was of shorter duration. It focused on confirming the presence/absence of human and ruminant sources at selected stations in the Dungeness watershed. Most of the stations sampled during Phase 1 were included in the Phase 2 sampling plan along with additional sites of concern or interest, based on the results of Phase 1. Phase 2 involved fewer sampling events (three), but included more sampling stations (Figure 4).

Figure 4. Phase 2 MST (*Bacteroides* Target Specific PCR) sampling locations.



Samples were collected on December 2, 2008 (10 marine stations, 6 seep stations), December 12, 2008 (10 freshwater stations), and January 6, 2009 (5 marine stations, 11 freshwater stations) and analyzed for *Bacteroides* and fecal coliform. 14 of the 27 stations were sampled on at least two of the three dates, including the Phase 1 sampling stations and a majority of the marine sites. Additionally, Total Suspended Solid samples were analyzed from each station and sampling event with the exception of several seep sites which were logistically difficult to sample. This data was collected in order to determine if there was a correlation to the fecal coliform data.

Task 2. Innovative Best Management Practice (BMP) Demonstrations

An integral component of the Dungeness TWG was installation and study of BMPs aimed at preventing and/or improving water quality in the Watershed. Guided by our Watershed Plan and strategies, we focused on four BMPs (Tasks 2a-2d), as described below.

Task (2a). Myco-remediation Demonstration

Note: Some of the content herein is modified or excerpted from the Task 2a final report, *Field Demonstration of Mycoremediation for Removal of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington* (Thomas et al., 2009). The full report can be accessed from the following link on the Dungeness River Audubon Center's website: http://www.dungenessrivercenter.org/DungenessWatershedResearch.html.

Mycoremediation is a form of bioremediation that uses conditioned native fungi, or mushrooms, and fungal mycelium that are usually applied to soil to remove and degrade contaminants. For our project, Battelle Marine Sciences Laboratory designed a mycoremediation demonstration site to incorporate two bioretention cells (plots). The site was located on residential property, adjacent to pasture land and tidal wetlands that are connected to the Strait of Juan de Fuca (Figure 5).

Figure 5. Mycoremediation Demonstration Site.

Detailed descriptions of the methodology and site construction are described in a final report (Thomas et. al. 2009). Specific objectives of the demonstration are listed below:

- Determine the technical effectiveness of a fungal-enhanced (mycoremediated) bioretention cell at reducing fecal coliform bacteria and nutrients from surface water runoff in a field setting.
- Compare the technical effectiveness of the mycoremediation bioretention cell to that of a bioretention cell without mycoremediation.
- Provide guidance on the use and effectiveness of the technique as a BMP for reducing fecal coliform bacteria and nutrients in other watersheds.
- Improve overall functional habitat value by restoring native vegetation, while remediating contaminant levels.

Both constructed plots contained native wetland plants, soils and associated microbes, while only one (the "treatment cell") received the addition of fungal-enhanced mulch. Figure 6 shows the plots being constructed.

Figure 6. Construction of Mycoremediation Demonstration Site.

Flowing surface water was directed to both the control cell and the treatment cell via a splitter box, or "D-box". This design allowed for a comparative study of the bacteria and nutrient removal effectiveness between the two plots at the field site. A schematic of the twin cells is shown in Figure 7.

After construction, three phases of the study were implemented. The first phase looked at the fecal coliform and nutrient concentrations in the source water and two outflow pipes from the control and treatment cells. Once a source of water was in place, fecal coliform and nutrient samples from this phase were analyzed on a monthly basis. A dye test was conducted during the second phase of the study in order to better understand the retention time and attenuation rate of water moving through the site. Finally, the third phase involved a spike experiment that introduced a one-time inoculation of dairy lagoon waste into the source inflow at the site. During this phase, fecal coliform and nutrient concentrations were analyzed at selected time periods from the two cells based on the results of the dye test to further assess the functionality of the system(s) at removing greater concentrations of bacteria and nutrients.

Figure 7. Schematic of Biofilitration Cells, with native plants and fungi in the Treatment cell and native plants only in the Control. Inflow water is split with equal volumes and fed to the two cells (not to scale).

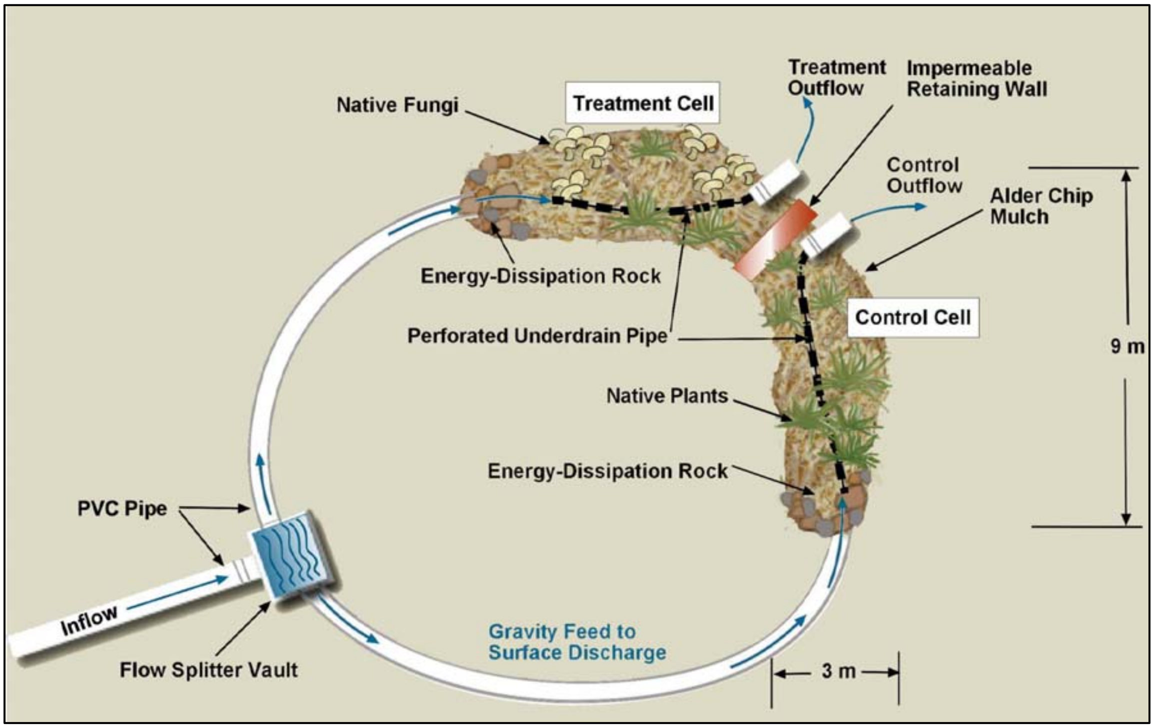


Image excerpted from Thomas et al., 2009.

Task (2b). Homeowner Sewage Management BMP Education and Training

Knowing that failing septic systems are one way bacteria enter our waterways (confirmed in the MST Study), one of the focuses of our grant was sewage management education and training. The task involved three elements: (i) education and cost-share incentives, (ii) professional septic maintenance training, and (iii) development of a market-based tool for homeowner decision-making on sewage management alternatives. These are described individually below.

(i) Education and Cost-share Incentives for Homeowners: This effort supported a Clallam County program, "Septic 101", offered to homeowners living in areas with impaired water quality (as established by TMDL and other monitoring). Septic 101 classes were led by Clallam County's Septic O&M Specialist, whose position initially was fully funded by the TWG. The classes were held approximately once per month to help homeowners understand what is needed to maintain a healthy, functional septic system. Homeowners were given records and locations of their septic systems; septic experts were on hand to present useful septic maintenance information and to answer questions; and a list of sanitary survey inspectors was provided.

As further incentive, those homeowners who attended one Septic 101 class were eligible to receive cost-share for managing their septic systems. Cost-share included reimbursement (up to a maximum amount, according to the specific cost-share item) of 50% of the expenses associated with licensed septic inspection, installation of viewing ports (risers), tank pumping and minor repairs. Depending on the extent of necessary repairs, the County waived the cost of the repair permit as part of the program. In the case of a low- to moderate-income landowner with failing septic systems, the Specialist worked with the landowner to obtain funding and facilitate repair and cleanup.

Follow-up questionnaires were mailed to participants to determine whether lifestyle improvements (e.g. laundry load spacing, proper disposal of medications, etc.) were achieved as a result of the septic system education. Results of the questionnaire were analyzed statistically, and provided in a summary report by Clallam County: *Septic 101 Homeowner Survey Results* (2009), which is located on the attached CD. The sewage management effort was also tracked in the Effectiveness Monitoring Study (Task 3) to determine if water quality improved as a result of septic repairs.

This sub-task also included dye testing of septic systems to identify or confirm suspected failures, and door-to-door surveys in areas with septics of concern (previously identified in paper surveys). Information from the surveys was put into the Clallam County Permit Plan database where septic system information (installations, repairs, failures, etc.) is tracked.

During the latter part of the grant period, an opportunity arose to offer two pilot septic system inspection trainings to homeowners in the area. The need for this type of training was especially apparent after a 2007 law began requiring homeowners to manage their systems and Clallam County Board of Health adopted the *Clallam County On-site Septic System Management Plan* (Sound Resolutions and Cascadia Consulting Group, 2007). The pilot included classroom presentation of materials, hands-on inspection training of a septic system at a field site, and a course evaluation.

(ii) <u>O&M Maintenance Agreement Facilitation and Training to Industry Professionals on Alternative Sewage Management Systems</u>: With this subtask, the County's O&M Specialist organized trainings to industry professionals on maintenance of alternative sewage management systems, as well as on state regulations related to onsite systems. Washington Onsite Sewage System Association and Washington Department of Health conducted the trainings. In the past, few local industry professionals were able to complete such trainings, due to training cost and distance to training sites. By providing the training locally, in Clallam County, several professionals were able to participate. The Specialist then worked with these professionals to develop a program for processing O&M agreements with homeowners who own septic systems with pumps.

We were fortunate that the initiation by Clallam County of an Onsite Septic System (OSS) Workgroup coincided with the TWG project timeline. Beginning in 2006, the County, Clallam Conservation District, Jamestown S'Klallam Tribe and several other parties participated in the OSS Workgroup, which ambitiously met twice per month to develop the state-required Septic System Management Plan (cited above). The plan was adopted in June 2007 and included recommendations for market-based incentives that encourage homeowners to arrange for O&M Agreements with local professionals.

(iii) <u>Market-based Incentive Guide for Homeowners</u>: One of the key messages we wanted to reach the public was that routinely inspecting and maintaining one's septic system is key in keeping septic system costs down. Homeowners acknowledge the high costs of major septic repairs or replacement, yet– with an estimated 400-600 septic systems failing in Clallam County each year (personal communication, Janine Reed, 2008) –we felt it important that homeowners be more aware that regular maintenance, at relatively low cost, can prevent such occurrences. The Tribe distributed this message in the form of a market-based incentive guide brochure mailed out to residents of the Clean Water District. A copy of this brochure, *The Key to Having a Cost Efficient Septic System: Inspection and Maintenance* (2008) is provided on the attached CD.

Task (2c). Stormwater BMP Demonstrations

This task involved planning, designing and installing stormwater management systems to demonstrate stormwater best management practices suitable for residential, roadside, and parking lot areas. The original conception of this task by the Clallam Conservation District incorporated three components: (i) retrofitting existing residential properties to manage stormwater via rain gardens; (ii) designing and demonstrating best management practices to address roadside stormwater runoff; and, (iii) incorporating Low Impact Development practices into a parking lot development. Public outreach, such as site tours, media coverage and related materials was also planned for the demonstrations.

Several circumstances resulted in location changes and modifications to the design of the original demonstrations. Nonetheless, the resultant three components fulfilled the intended task objectives: (1) increased public understanding of residential contributions to stormwater runoff, and (2) increased public understanding of appropriate BMPs available for preventing pollution from entering stormwater runoff. Each of the three activities is described below.

(i) Helen Haller Raingarden Demonstration: Clallam Conservation District led this effort to have a rain garden installed at a local school (Helen Haller Elementary) to capture the school's roof runoff, which was creating flooding problems in the school parking lot. Helen Haller fifth grade students and teachers were involved in the design and installation of the rain garden (Figure 8).

Figure 8. Ground-breaking excavation at the rain garden site, Helen Haller Elementary School, Sequim, WA.

(ii) Low Impact Development Demonstration Training with Future Builders Program: In 2006-07, the Clallam Conservation District (CCD) assisted the North Peninsula Building Association (NBPA) with training and demonstrations at that year's Future Builders home site. Future Builders is a NPBA-sponsored vocational building program for high school students, whereby students build one house per year and learn construction skills during the process.

(iii) Low Impact Development Parking Lot Demonstrations: The Tribe incorporated LID practices into the design and construction of two parking lots on Tribal-trust land. The first (Casino Lot) was constructed adjacent to the Tribe's Seven Cedars Casino, and contains several rain gardens. The second (Longhouse Lot) is located adjacent to the Tribe's new (2008) Longhouse Market, and features a Filterra bioretention system and bioswales.

Task (2d). Irrigation Ditch Piping Demonstration ("Clallam-Cline Combo")

The Clallam Conservation District managed this massive undertaking to unite the Cline Irrigation District (a special purpose public district and government entity) with the Clallam Ditch Company (a private irrigation company) for the purpose of replacing the sytems' respective main canals with one pipeline.

This project was selected in part due to its fit with the types of measures proposed by the Comprehensive Irrigation District Management Plan (HDR, 2003, revised 2006), which address both the CWA (water quality) and ESA (water quantity). Objectives of the partnership included:

- preventing contaminants carried in runoff from entering the Clallam and Cline irrigation systems;
- conserving Dungeness River water by reducing the amount of water needed to supply these irrigation systems (by making the system run more efficiently); and,
- creating as a showcase the first public-private partnership of its kind (between an irrigation district and irrigation company) in the Dungeness Valley.

Both irrigation entities deliver Dungeness River water to water users in the lower Dungeness Watershed. Because the Cline Irrigation District (District) is located to the north and downstream of the Clallam Ditch Company (Company), prior to the project the District's canals had to pass through the territory served by the Company before reaching the land it served. This meant the Company and District main canals crossed each other four times, making the overall system inefficient both in terms of water loss and economically.

These canals also had to traverse a diverse landscape of farms, rural residential development, golf courses and urban areas. The commercial and urban areas (all of which presently use on-site septic systems for sewage disposal) are concentrated in the upstream end of the irrigation delivery network, along with one moderately sized dairy farm. Before project implementation, a myriad of contaminants were able to enter the open irrigation system through this landscape – and subsequently into the Dungeness River or Bay via excess tailwater returns (the surplus water diverted in order for downstream users to be able to access their supply). Steps necessary to complete the project included approved landowner agreements, engineering specifications and designs, a bidding process for hiring contractors, and project construction.

Task 3. Effectiveness Monitoring Study

Note: Some of the content herein is modified or excerpted from the Task 3 final report, *Effectiveness Monitoring of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington* (Woodruff et al., 2009b). The full report and accompanying data can be accessed from the following link on the Dungeness River Audubon Center's website: http://www.dungenessrivercenter.org/DungenessWatershedResearch.html.

We addressed the monitoring and evaluation component of our Targeted Watershed Grant by conducting an effectiveness monitoring study. The intent was to look both at the site-specific scale, as well as the watershed level scale – to determine how well the implemented BMPs (e.g. irrigation piping, septic repairs, mycoremediation) achieved their objectives. Components of the study, which are detailed in the above cited final report, included:

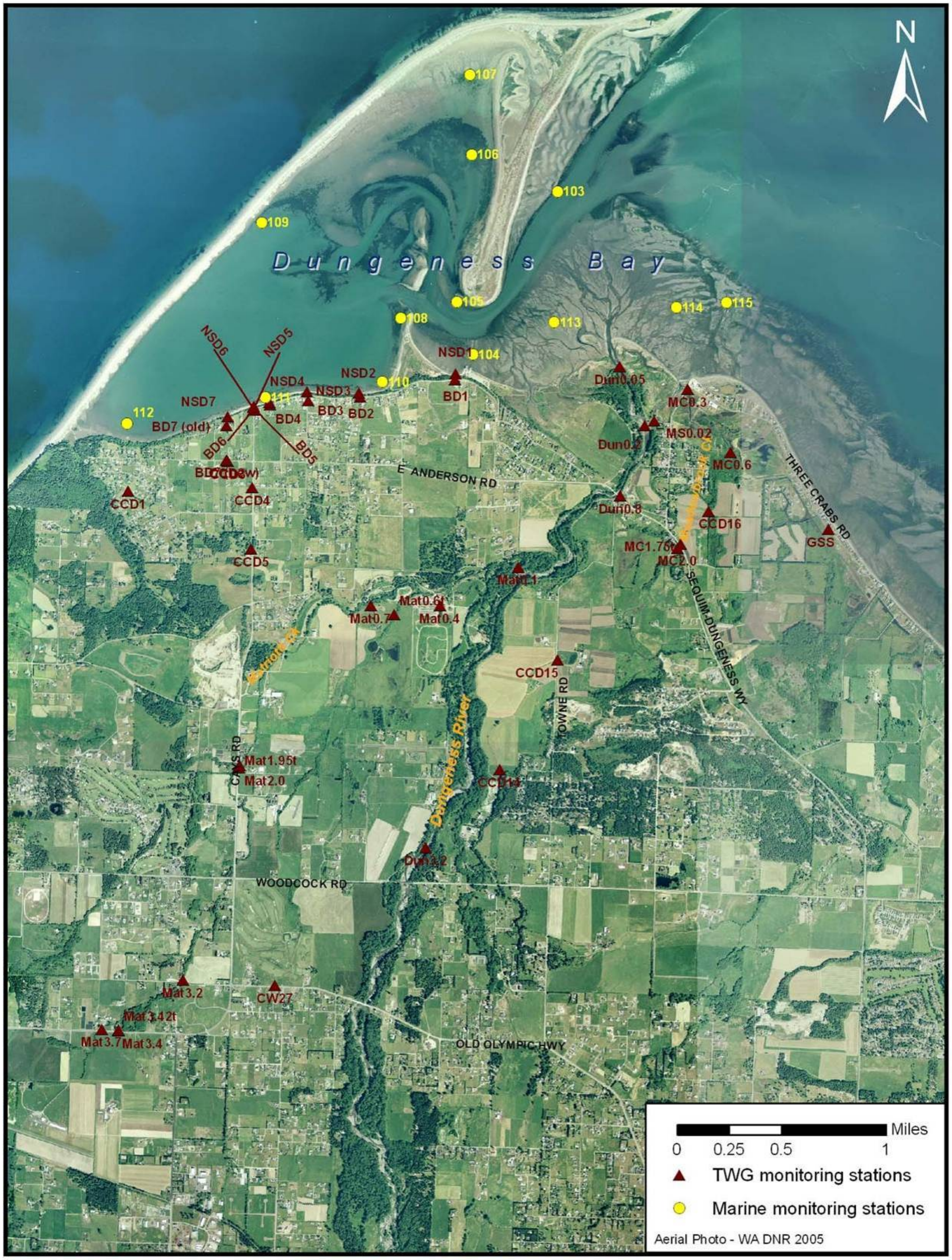
- a statistical examination of fecal coliform trends in the Dungeness watershed and Dungeness Bay between 1998 and 2008;
- a characterization of the nutrients in the watershed, conducted as part of the TWG study (2005 through 2008); and,
- evaluations of the effectiveness of irrigation piping and on-site septic system repairs as BMPs for remediating fecal coliform bacteria. (As described earlier, an evaluation of the effectiveness of mycoremediation was conducted in a separate report (Thomas et al., 2009)).

At the local scale, fecal coliform and nutrients (phosphate (PO_4), nitrate (NO_3), nitrite (NO_2), ammonia (NH_4), total nitrogen (TN) and total phosphorus (TP)) were monitored before and after installation of the BMPs, according to an EPA-approved Quality Assurance Project Plan (Streeter, 2005). Additional parameters (e.g. flow, temperature, pH, dissolved oxygen, turbidity) were also monitored, but the study focused on fecal coliform and nutrients. Monitoring was conducted by technicians from Clallam County, Clallam Conservation District, Jamestown S'Klallam Tribe and trained volunteers at ambient monitoring stations located upstream and downstream of the BMP sites on a monthly basis. Pre-established ambient sampling stations from the Lower Dungeness TMDL study (Sargeant, 2002) were used whenever possible for a long term data record (Figure 9). The University of Washington conducted laboratory analyses associated with the nutrient samples, and Clallam County conducted laboratory work associated with bacteria collection.

At the watershed scale, fecal coliform and nutrient data were analyzed based on geographic location within the watershed (e.g. tributaries, creeks, ditches emptying into the Bay) and in Dungeness Bay. Fecal coliform was analyzed over a ten-year time period, incorporating data collected prior to and during TWG. The nutrient analysis focused on data that was collected during both the TMDL study (1999-2000) and during this study (2006-2007). Analyses were also conducted for seasonal comparisons (wet versus dry) and for stream reach locations (lower versus middle versus upper stream reaches). Several statistical methods were used for the various analyses.

For BMP evaluations, the final study report focuses on irrigation piping and septic repairs, and whether changes were detected in water quality as a result of those two BMP demonstrations. A related study funded through a Department of Ecology Centennial Clean Water Fund grant to Clallam County (Clallam County Division of Environmental Health, 2008) focused on analysis of TWG monitoring stations and documenting progress in meeting TMDL targets. Additionally, the Washington Department of Health prepares an annual Status and Trends Summary for the marine water quality stations (e.g. Washington State Department of Health, 2008).

Figure 9. TWG fresh water monitoring stations and DOH marine monitoring stations.



Public Outreach/Education Efforts

The public outreach plan described in our Work Plan (Jamestown S'Klallam Tribe, 2004) specifically drew from the public outreach section of the Clean Water Strategy (Hempleman and Streeter, 2004):

(i) Provide information on Dungeness Bay bacterial pollution and prevention (and associated human-health risks);

(ii) Inform watershed residents on where to find local remediation services and which state/local agencies are involved in water cleanup; and,

(iii) Create innovative ways to reach new audiences and energize existing audiences.

We utilized a variety of tools to accomplish these goals, which are described in the RESULTS section.

PROJECT PARTNERS

The expertise was retained of several partners with a history of working successfully together and achieving results. Roles and responsibilities of the various partners were assigned such that implementation could be as efficient as possible, as described below.

Project Administration and Management

The Jamestown S'Klallam Tribe served as administrative lead and the fiscal agent to receive TWG funds. Watershed Planner, Shawn Hines, and Environmental Planning Manager, Hansi Hals, were the administrative contacts.

Task Management

Table 2 lists the project tasks and the respective lead task managers responsible for implementation and for routinely updating the administrative lead and/or informing of any encountered problems.

Table 2: Task descriptions and respective task managers.

Task Description		Task Manager Partner
1.	Microbial Source Tracking Study	Battelle Marine Science Laboratory *Dr. Dana Woodruff, Senior Research Scientist*
2a.	Myco-remediation Demonstration	Battelle Marine Science Laboratory *Dr. Dana Woodruff, Senior Research Scientist* *Dr. Susan Thomas, Senior Research Scientist (no longer with Battelle)*
2b.	Homeowner Sewage Management BMP Education and Training	Clallam County *Elizabeth Maier, Watershed Planner* *Janine Reed, O&M Septic Specialist* *Valerie Streeter, Watershed Planner (no longer with the County)*
2c.	Stormwater BMP Demonstrations	Jamestown S'Klallam Tribe *Hansi Hals, Environmental Planning Manager* *Lyn Muench, Environmental Planning Manager (no longer with the Tribe)* Clallam Conservation District *Joe Holtrop, District Manager*
2d.	Irrigation Ditch Piping Demonstration	Clallam Conservation District *Joe Holtrop, District Manager*
3.	Effectiveness Monitoring Study	Battelle Marine Science Laboratory *Dr. Dana Woodruff, Senior Research Scientist* Clean Water Work Group *Project partners, watershed residents and other organizations*
4.	Public Outreach (about TWG)	Jamestown S'Klallam Tribe *Hansi Hals, Environmental Planning Manager* *Lyn Muench, Environmental Planning Manager (no longer with the Tribe)*

		Shawn Hines, Watershed Planner Dungeness River Audubon Center *Bob Boekelheide, Director* *Powell Jones, Education Coordinator*

Contributed Funds

TWG partners contributed approximately 38% of the proposed total project cost as non-federal match. The spreadsheet in Table 3 details the proposed and actual match contributions for each TWG task.

Table 3: Proposed and actual partner contributed funds.

Task	***Subgrantee/ Project Partner***	***Proposed Non-Federal MATCH (Work Plan Budget)***	***Actual Non-Federal MATCH***
Task 1: MST Study	Battelle Marine Science Lab	**3,164.00**	**$ 3,674.28**
Task 2a: Mycoremediation Demonstration	Battelle Marine Science Lab		**$ 4,430.17**
Task 2b: Septic Management Education and Training	Clallam County	**89,822.00**	**$ 95,409.43**
Task 2c: Stormwater BMP Demonstrations	Stormwater Contractors *Note: This task did not receive TWG funding.*	**44,608.00**	**$ 15,526.66**
Task 2d: Irrigation BMP Demonstration	Clallam Conservation District	**350,104.35**	**$ 373,634.11**
Task 3: Effectiveness Study	Battelle Marine Science Lab		
	Clallam County	**34,425.00**	**$ 55,190.78**
	University of Washington		
	Jamestown S'Klallam Tribe		
Public Outreach	Dungeness River Audubon Center	**37,306.00**	**$ 37,528.74**
Total Contractual		**$559,429.35**	**$ 585,394.17**

Related Watershed Efforts and Leveraged Funds

The TWG project complemented on-going or new efforts and programs, such as implementing the Clean Water Strategy, water quality monitoring, salmon and instream flow recovery planning, and public outreach. More specifically, three TWG partners were awarded Centennial Clean Water grants from Washington State Department of Ecology for projects aimed at improving water quality in the Dungeness Watershed, and numerous in-kind contributions were made during the overall effort. Some of these details, arranged according to TWG task, are described below.

<u>Task 1, Microbial Source Tracking (MST) Study</u>: The Tribe was able to expand on the MST project (and some of our monitoring) as a result of receiving both TWG and Centennial grant awards. The TWG covered MST (rybotyping) monitoring through May 2007. The Tribe's Centennial funding provided additional monitoring (during December 2008 and January 2009), which used a different but

complementary MST method (*Bacteroides* Target Specific PCR) and resulted in a more comprehensive final MST report. A portion of the TWG funding provided match to and leveraged Centennial dollars which were put toward other activities such as a pet waste outreach program.

Task 2a, Mycoremediation Demonstration: Battelle contributed many hours of volunteered weekend staff time toward planting and weeding at the mycoremediation site, and Clallam Conservation District staff provided staff in-kind.

Task 2b, Homeowner Sewage Management BMP Education and Training: Although the On-Site Septic System Workgroup described above was not explicitly leveraged by TWG, the County committed to form this group and develop an OSS Management Plan in part because of the emphasis that TWG placed on septic failures. The County's O&M Specialist, who was originally entirely funded by TWG, and other TWG partners participated on the workgroup, providing an important informational link during the development of the OSS Management Plan. The County received funding from both Washington Departments of Ecology and Health to convene that workgroup and develop the Plan.

Task 2c, Stormwater BMP Demonstrations: The Tribe's LID parking lots were constructed using non-TWG funds, and several tours to these sites have been valuable public outreach opportunities. Further, as described above, the Helen Haller rain garden and the Peninsula Home Builders projects that Clallam Conservation District participated in provided non-federal match to the project and helped fulfill our goals to disseminate outreach related to stormwater runoff.

Task 2d, Irrigation Ditch Piping Demonstration: This expansive project was the first public-private partnership of its kind in the area and the largest and most complex piping project ever undertaken in the valley. As such, it involved a very elaborate funding regime with over 15 individual sources of financial support. The TWG funds were an important contribution paying for parts of Phase 1, a crucial link in the overall project. In addition, the technical advisor for this project was a retired engineer, who volunteered approximately 25 hr/wk for at least 1.5 years.

Task 3, Effectiveness Monitoring Study: The Tribe was able to expand on the effectiveness monitoring program as a result of being awarded both the TWG and Centennial grants. The TWG covered sample analysis, while the Centennial grant contributed to some of the nutrient analyses and the staff time for our lead field technician. Data from the TWG project contributed to Clallam County's TMDL compliance monitoring, ambient monitoring and source evaluation monitoring (all of which were a part of Clallam County's Centennial grant), as well as the Clallam Conservation District's recently completed study (sponsored by the District's Centennial grant) in the Three Crabs shoreline area of Sequim. Streamkeeper and trained citizen volunteers were an important contribution to the overall monitoring effort, as well.

RESULTS

As defined by EPA guidelines, project outcomes can be separated into the following defined categories:

- Monitoring: *Examples include descriptions of the data collected and what it indicates.*
- Environmental: *Examples include descriptions of water quality and habitat goals that were achieved or how much progress was made toward achieving them, descriptions of any pollutant load reductions that were achieved based upon estimations and/or modeling, and whether any waterbodies were removed from the 303(d) list or are expected to be removed in the near future.*
- Administrative: *Examples include changes in local/state rules or regulations, databases developed, sustainable or long-term support for implementing activities, or funding for watershed restoration or projection efforts.*

- Behavioral: *Examples include changes in attitudes, practices and/or behavior measured by surveys or other outreach tools and other similar measures.*
- Fiscal: *Examples include whether the projected costs were close to the actual final costs, whether all grant funds expended, any examples of fiscal management, economies of scale, public-private arrangements or other arrangements that could be useful to other watershed organizations.*

These outcome categories are addressed below with the results of the tasks to which they are relevant.

Task 1. Microbial Source Tracking (MST) Study Results

Note: Some of the content herein is modified or excerpted from the Task 1 final report, *Microbial Source Tracking in the Dungeness Watershed* (Woodruff et al., 2009a). The full report can be accessed from the following link on the Dungeness River Audubon Center's website: http://www.dungenessrivercenter.org/DungenessWatershedResearch.html.

Monitoring Outcomes

During the Phase 1 study, three types of sampling efforts took place: (1) collection of fecal source samples for incorporation into a previously established DNA library; (2) collection of environmental test samples for ribotyping analyses (e.g. freshwater, marine water, sediment, wrack); and (3) collection of water samples for fecal coliform analysis.

For source sampling, a total of 105 samples from 42 local species were collected. A total of 472 environmental samples were collected, and 1164 *E. coli* isolates were ribotyped from those samples. Of the 1164 isolates typed, 92.6% matched known source species in the IEH source library, which included 5.1% matched directly to the local source library. The remaining 7.4% of the isolates, some of which were sourced to multiple species, are referred to as *unknown* in our study.

There were 37 source types that were identified overall during the study, shown below in Table 4 with number of isolates rybotyped at each monitoring station.

Table 4. Source types identified, with number of isolates at each station.

Source Types	Total No. of Isolates	Freshwater				Marine Water		Marine Sediment		
		MAT0.1	MC0.3	GSS	BD-7	St 113-water	St 108-water	St 113-sed	St 108-sed.	wrack
avian	228	34	26	39	24	48	21	12	22	2
bear	10	6	1		1	1		1		
beaver	16	1	4	11						
bison	7	1		1					5	
bovine	34	13	6	3	5	5	1		1	
burro	1						1			
canine	18	3	2	3	6	3	1			
chicken	3			3						
crow	2		1				1			
deer	33	7	2	8	3	3	2	3	3	2
deer/elk	15					3	2	10		
dog	50	12	8	8	9	4	3			6
elk	32	3	12	2		5	2	3	5	
equine	2			1				1		
feline	18		3	8	2	5				

goat	11	1	4		1	1	1		3	
goose	1					1				
gull	146	23	30	19	13	22	20	5	14	
horse	20	5	2	3			6	1	3	
human-derived	83	16	15	5	19	8	9		11	
llama	4	2	1	1						
marine mammal	16	2				7	6		1	
otter	8	3		2	1		2			
oyster	6						1		5	
pig	1	1								
porcine	3	1			1	1				
prairie dog	2				1		1			
rabbit	3	1	1		1					
raccoon	107	19	21	14	21	8	5	9	10	
rodent	73	22	13	7	8	7	8	6	2	
sheep	2		2							
swine	1			1						
unknown	85	10	22	21	6	10	5	8		4
waterfowl	113	15	21	30	3	15	7	13	9	
yak	9	4	2	3						

Based on the proportion of total isolates typed for this study[1], the predominant sources identified were, in ranked decreasing order: avian (19.6%), gull (12.5%), waterfowl (9.7%), raccoon (9.2%), unknown (7.3%), human-derived (7.1%), rodent (6.3%) and dog (4.3%).

The data were further organized into *functional groups* to assess overall contributions of comparable sources (Table 5). According to functional groups, the highest occurring proportion of isolates was birds (42%), followed by wild mammals (26%). Domestic animal, human-derived, farm animal, and unknown sources had similar proportions, about 7% each. The Game Farm proportion of isolates was 2.5%. These data reveal that sources considered as controllable (i.e. farm animals, domestic animals, Game Farm animals, human) amount to roughly one fourth of the isolates typed for this study. If raccoon are moved into that group, the amount attributed to controlled sources increases to one third.

Table 5. List of source types assigned to functional groups.

Birds	Wild Mammals	Farm Animals	Domestic Animals	Game Farm Animals	Human	Other	Unknown
avian crow goose gull	beaver deer deer/elk elk	bovine chicken equine horse	canine dog feline cat	bear bison burro prairie dog	human septage sewage	oyster	unidentified or transient (matched multiple sources)

[1] The scope of this study allowed for the collection of five grab samples at each sampling station per sampling event. For each sampling event, there was a target goal of ribotyping a minimum of 2 *E. Coli* isolates from each of the five samples. Hence, it was expected that 10 isolates per sampling station would be achieved. In actuality, more than 10 isolates were achieved for most sampling events.

waterfowl	marine mammal otter rabbit raccoon rodent	llama pig porcine sheep swine goat		yak			

Human-derived sources are of particular interest in relation to public health and considering these sources may be the most easily controlled. Based on the percent of sampling events that human-derived sources were found at MST sampling stations, the Phase 1 study showed that human-derived sources were frequently found at Mat 0.1 (near mouth of Matriotti Creek), and found in half of the samples at MC0.3 (near mouth of Meadowbrook Creek) and at BD-7 (a bluff ditch). The frequency was 38% at GSS (Goldensands) and the two marine water stations.

The Phase 2 *Bacteroides* PCR approach complemented the Phase 1 ribotyping study. Although Phase 2 was of shorter duration, it identified human and ruminant sources over a larger geographic expanse in the lower Dungeness watershed. These findings highlight the importance of increasing mitigation efforts of these sources.

Behavioral Outcomes

Although earlier studies had shown that fecal contamination in the Dungeness Watershed and Estuary is most likely due to multiple sources (e.g., humans, pets, livestock, marine and terrestrial wildlife, etc.), the previous studies were unable to specify which sources are predominant. The lack of specificity in the former studies fueled skepticism among local citizens about these studies and about the utility of pollution prevention BMPs.

The science behind the MST studies in Task 1 is helping our community realize the *predominant* fecal coliform sources and focus on those sources that may be controlled (especially human, domestic animals, farm animals) by certain best management practices. Because the study results have not yet been widely distributed, this attitude change has mostly been noted from public correspondence at water-related festivals (i.e. Streamfest 2009 and Dungeness River Festival 2009) and at meetings such as the Clean Water Work Group.

Fiscal Outcomes

All grant funds budgeted to this task were expended. Considering the task scope, its linkage to the Task 3 Effectiveness Monitoring Study, and that two funding sources (EPA and Ecology) were utilized, the sampling effort had to be well-coordinated. For example, all sampling (MST, and routine fecal coliform sampling for Task 3) was coordinated to occur on the same day, to enhance data analysis comparisons and also for maximized time and funding efficiencies.

It was decided that *E. coli* quantitative analysis sampling would benefit the project by assuring that each sample collected for ribotyping would have a fecal coliform and *E.coli* sample associated with it. Laboratory analysis of this *E. coli* sampling was assigned to the Centennial grant (Ecology), while MST, fresh- and marine-water sampling was paid for by TWG. The Phase 2 MST approach was also funded by Ecology. The flexibility of both funding agencies (EPA and Ecology), in allowing for timeline adjustments and combined results, afforded a more comprehensive study with an expanded geographic study area.

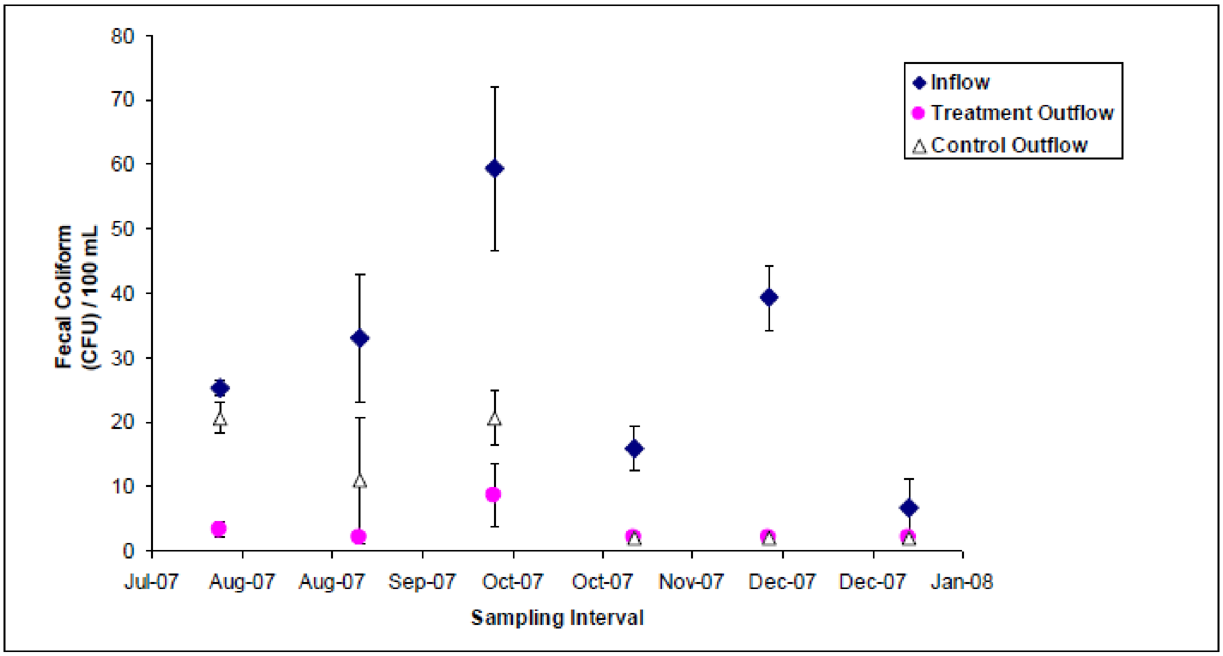
Task (2a). Myco-remediation Demonstration Results

Note: Some of the content herein is modified or excerpted from the Task 2a final report, *Field Demonstration of Mycoremediation for Removal of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington* (Thomas et al., 2009). The full report can be accessed from the following link on the Dungeness River Audubon Center's website: http://www.dungenessrivercenter.org/DungenessWatershedResearch.html.

Monitoring / Environmental Outcomes

Fecal coliform monitoring, based on concentration, showed an overall reduction of 66% in the control cell (bioremediation only) and 90% in the treatment cell (bioremediation and mycoremediation). The treatment cell was 24% more effective than the control cell (Figure 10).

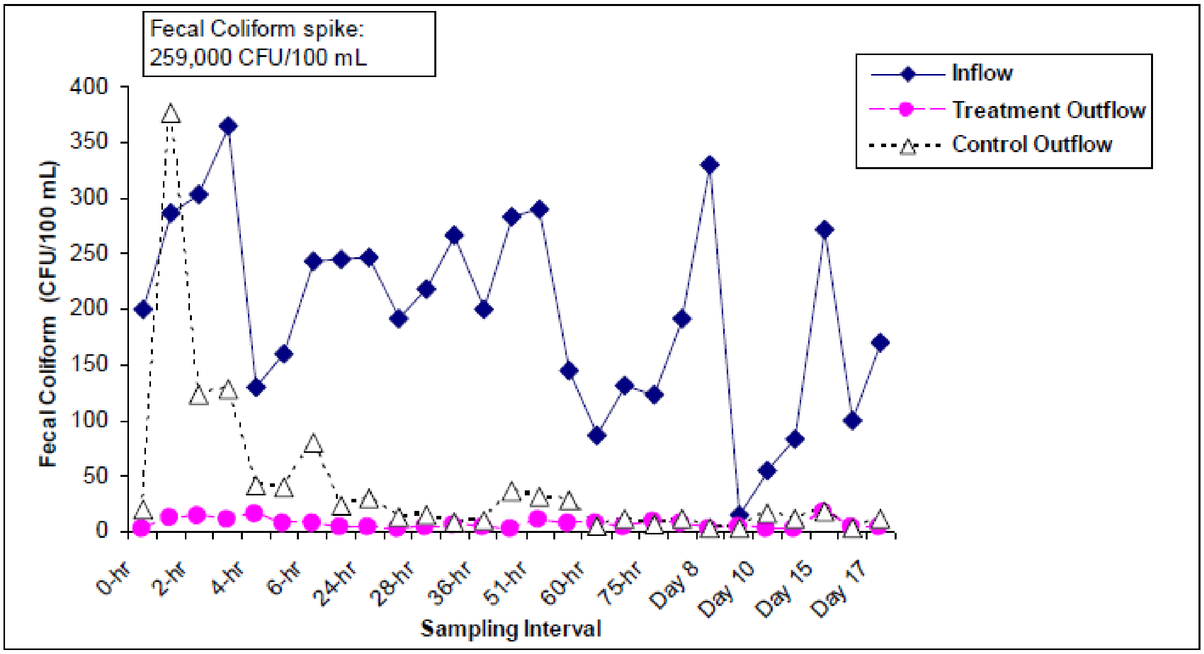
Figure 10. Fecal Coliform Concentration (CFU/100 ml) over 6-Month Time Period (mean +/- standard deviation).



Nutrients were more difficult to evaluate, as the data showed varying trends of export or removal through time. For example, the TN removal efficiencies ranged from -423% (TN export) to 75% removal, and TP removal was consistently exported from both cells. It was concluded that although mycoremediation treatment is applicable to other contaminants such as nutrients, the design features for our particular study were more suitable to the removal of fecal coliform bacteria than to nutrients.

During the 17-day spiked experiment, highly concentrated dairy lagoon waste was spiked into the system, to see how the cells functioned with larger concentrations of fecal coliform (an initial spike of 259,000 CFU/100 ml, with 194,250 CFU gradually added over 15 minutes) and nutrients. After the inflow concentrations reached a steady state at 29 hours, the treatment outflow was on average 5 CFU/100 ml and the control outflow was 13 CFU/100 ml, representing a 97% fecal coliform reduction in the mycoremediation treatment cell and 92% reduction in the control cell. Further, for the first 28 hours, concentrations in the control outflow were significantly higher than those in the treatment outflow; i.e. the treatment cell began showing reductions much sooner than the control (Figure 11). The data also suggest that bioretention cells can reduce fecal coliform bacteria under a range of concentrations and that mycoremediation treatment enhances or increases that reduction. However, based on these experiments, we do not know what the upper threshold of fecal coliform concentration is, beyond which the system would not function effectively to reduce fecal coliform.

Figure 11. Spiked Experiment Fecal Coliform Results. (Note: x-axis is not proportional.)



Fiscal Outcomes

All grant funds budgeted to this task were expended. Because this was a research/demonstration project, our budget included site construction, research and consultant costs. Redistributed funding from the County TWG budget paid for the spiked experiment, which supplemented the results on mycoremediation effectiveness.

Except for the unanticipated costs related to the water-distribution-pipe repair and fence installation, projected costs were close to expected costs for the particular scope and physical size of the project. An expanded scope, to remediate for a specific contaminant for example, may require additional funding depending on the appropriate site design needed (e.g. the creation of functional aerobic and anaerobic layer to transform nutrients to less available forms would be an added cost).

For remediation of bacteria, the demonstration showed that the chosen site design was highly effective and can be relatively economical. If this method were to be used at an actual bacterial remediation site, funding would need to cover the following key components: the delivery and application of fungal mulch, piping to the site from an existing water supply, native plantings (if they are not already on site), and any associated labor. For this demonstration, at a site that was constructed and requiring new native plantings, $12,600 was spent on the fungal mulch and $2,000 on native plants for two plots that were each three meters wide by nine meters long.

Task (2b). Homeowner Sewage Management BMP Education, Cost-share & Training Results

Monitoring Outcomes

Clallam County monitored progress on this task by tracking the number of related actions accomplished, as listed below:

- 53 Septic 101 courses were held, with a total of 1,234 participants;
- 598 Septic 101 follow-up questionnaires were mailed out to assess homeowner changes made as a result of participating; 358 questionnaires filled out and returned to County (60% return rate);
- 53 septic repairs were completed, including 8 repairs from the SOC list and 45 repairs in SOC neighborhoods (i.e. along shorelines, rivers, creeks or road ditches which at least had the potential of impacting Dungeness Bay); an additional 20 repairs were completed that were from the SOC or neighboring list;
- 9 septic repairs (out of the 53 SOC or neighboring SOC list) were from direct septic discharges to water bodies or to a ditch draining to a water body were identified;
- 3 septic repairs (out of the 53 SOC or neighboring SOC list) were identified as a result of one of the 9 dye tests completed;
- 145 sanitary surveys were completed by septic system designers and 108 Septic of Concern surveys were completed by County;
- 13 trainings on alternative sewage management systems were offered to 248 professionals; 161 O&M agreements with septic homeowners were processed.

Administrative Outcomes

Two state laws took effect during the TWG timeframe requiring counties to (1) establish Marine Recovery Areas (MRA) where bacteria or nitrogen are negatively impacting water quality, and (2) requiring homeowners to inspect and maintain their septic systems. In response, Clallam County formed an Onsite Septic System Work Group, whereby stakeholders were invited to help develop a plan to carry out the laws locally. Several TWG partners and many other community members participated in the Work Group, which met twice per month in 2006 and 2007. In June 2007, Clallam County Board of Health adopted the Clallam County On-Site Septic System (OSS) Management Plan (2007), which gives guidelines for homeowners in complying with the new laws.

The County's septic system specialist reported increased participation in the cost-share incentive program and increased cooperation in implementing septic system maintenance and repairs when the laws went into effect and the OSS Plan was adopted. Examples of requirements included in the County's 2008 Revised Onsite Sewage System Code (based on recommendations in the OSS Plan) include septic inspections at the time of sale of a property, annual inspections for restaurants and all alternative septic systems, inspections for conventional gravity systems every three years, and "maintenance provider" certification requirements.

Behavioral / Educational Outcomes

The Septic 101 workshops (Figure 12) provided by Clallam County were very effective at encouraging lifestyle changes that help septic systems function properly, based on surveys completed by workshop participants. Survey results revealed that lifestyle improvements were made to all of the household activities considered as detrimental to maintaining high functioning septic systems. For example, with knowledge gained from the workshops, participants discontinued disposing medications down drains, began spacing out use of washing machines, and discontinued use of septic additives.

Septic 101 attendees overwhelmingly commended the Septic 101 course offering and provided considerable positive feedback. Even so, participation in the cost-share program remained lower than

Figure 12. Homeowners participating at a Septic 101 Workshop.

expected during most of the grant period. Many homeowners expressed a fear of finding septic failures or of being required to make costly repairs. Septic owners were either unwilling to spend money on septic system repairs or funding was not available for many low income property owners. In response, Clallam County began emphasizing to homeowners the importance of septic system maintenance, not only for public health reasons, but also because routine inspections and maintenance can provide extensive cost savings and increase property values. These messages were a focus in the Septic 101 workshops, as well as in a market-based incentive guide brochure, *The Key to Having a Cost Efficient Septic System: Inspection and Maintenance* (2008). The brochure was mailed out to over 3,500 residents of the Clean Water District and are further available at Clallam County and Jamestown S'Klallam Tribe.

The two pilot septic system inspection trainings offered to homeowners toward the end of the grant period resulted in 42 individuals trained and certified by the County to inspect their own septic systems. The pilot included classroom presentation of materials, hands-on inspection training of a septic system at a field site (Figure 13), a course evaluation and testing/certification. These pilot trainings appealed to homeowners because, per guidelines in the OSS Management Plan, the trainings qualified them to inspect their own septic systems, eliminating the need to hire an inspector.

Figure 13. Pilot Septic System Inspection Training for Homeowners.

Fiscal Outcomes

Some funding for this task was redistributed to other tasks within the overall TWG project. For example, part-way through the project period, Clallam County Department of Environmental Health was able to fund the O&M Specialist (salary/benefits/indirect) out of the County's general fund. This allowed the remaining funds for the O&M Specialist to be transferred to the Task 3 Effectiveness Monitoring Study, which had been underfunded. Additionally, when it became apparent that septic homeowners would be more apt to participate in septic cost-share programs after receiving technical training, some of the cost-share funds were redirected to fund a highly sought-after homeowner septic inspection training program, which was very successful. Further, a small amount of unexpended funds (related to the septic system cost-share program) was returned to the Tribe at the close of the partner contract and was redistributed to cover the unanticipated tribal staff time contributed to finalizing the three project report grant deliverables for Task 1, Task 2a and Task 3.

One of the activities accomplished through the OSS Work Group process to develop the OSS Plan was an assessment of the costs associated with implementation of an O&M program for Clallam County. The valuation, which Clallam County Environmental Health Services (EHS) expects to refine as it develops a funding mechanism during Phase I of the implementation, is described in the OSS Plan (2007):

> … Clallam County EHS estimates that annual costs to implement this plan will total approximately $300,000, [to fund] two environmental health specialists, two permit technicians and program support….
>
> [Additionally,] necessary database, web and application development is estimated to cost $25,000 to $50,000. Determining the current parcel location as needed for about 1000 cases is estimated to cost $35,000 to $70,000, based on an estimate of 1 hour per case and a cost of $35 to $70 per hour. Finding and describing the necessary data for [septic systems] not in the current permit system is estimated to cost $1,533,000 for the whole county and $991,200 in the Marine Recovery Area. This cost is based on an estimate of an average of 6 hours of field and office work per site visit at $70 per hour. Ongoing tasks, which would largely be part of the new permit technicians' duties, have not been priced. These would include filling out the necessary system information for the [septic system] or programming Permit Plan to filter data submitted over the web.

According to Clallam County EHS estimates, the cost for performing regular maintenance for the property owner will average between $200-$300 per year, depending on the complexity of the system and whether the system has been adequately maintained in the past. This includes an estimated average inspection costs of $163 per year and an estimated average pumping cost of $110, per year (based on an average cost of $330 per three-year pumping schedule). There may be additional costs associated with county fees, a previous lack of pumping, and/or the need for minor septic repairs or equipment malfunction. The homeowner septic guide brochure (described above and available on the attached CD) summarizes these annual costs and was an effective way to point out that basic septic system maintenance is affordable compared to average annual sewer system charges, and compared to the potentially exorbitant costs associated with septic system failures due to lack of routine inspections and maintenance.

Task (2c). Stormwater BMP Demonstrations Results

(i) Helen Haller Raingarden Demonstration:

Environmental / Educational Outcomes

Site construction occurred in 2006 and entailed excavation of a small depression, adding five yards each of amended soil and compost, and planting native vegetation. A pipe was mounted to the school building to drain stormwater from the school roof to the raingarden, and a simple fence was installed around the planted area.

The raingarden has eliminated the flooding problems in the school parking lot. Helen Haller fifth grade students and teachers were involved in the design and installation of the rain garden. Although this design was installed at a local elementary school, it is an appropriate model for a residential rain garden in the Sequim area of the Dungeness Watershed. Figure 14 below shows the site flourishing in 2008.

Figure 14. Helen Haller Rain Garden, post construction.

Fiscal Outcomes

TWG funding was not expended on this task. This task provided in-kind match to the overall project in the form of Clallam Conservation District staff time and construction (including donated excavation services by Jamestown Excavating) and materials donated to Clallam Conservation District.

(ii) Low Impact Development Demonstration Training with Future Builers Program:

Environmental / Educational Outcomes

CCD's contribution to the Future Builder's Program included teaching students about Low Impact Development (LID) and demonstrating the use of a rain garden in managing stormwater on the 2006-07 home site (Figure 15). Additionally, CCD offered several natural landscaping workshops at the Dungeness River Audubon Center that were all open to the public.

Figure 15. Incorporation of LID at the 2006-07 Future Builders Home Site.

Fiscal Outcomes

TWG funding was not expended on this task. This task provided in-kind match to the overall project in the form of Clallam Conservation District staff time.

(iii) Low Impact Development Parking Lot Demonstrations:

Environmental / Educational Outcomes

The Tribe incorporated LID practices into the design and construction of two parking lots on tribal-trust land. The first (Casino Lot) was constructed adjacent to the Tribe's Seven Cedars Casino, and contains several rain gardens. The second (Longhouse Lot) is located adjacent to the Tribe's new (2008) Longhouse Market, and features a Filterra bioretention system and bioswales. Several tours, including some associated with LID workshops (Figure 16), have been conducted at both sites and highlighted in the local newspapers. A brochure was also developed for distribution during educational tours.

Figure 16. Tour of Longhouse Market LID and Filterra Bioretention System during LID Workshop, 2008.

Administrative Outcomes

The Longhouse Lot is located on Tribal-trust property, so federal environmental rules and Tribal regulations apply. The Tribe's recently completed Tribal Environmental Protection Ordinance adopts by reference most of the Clallam County Environmental Protection rules. However, the Tribe chose to adhere to the more stringent 2005 Washington Department of Ecology stormwater standards (rather than the 1992 guidelines which the County references). A detailed monitoring system has been set up to assess if the best management practices (LID) for stormwater perform as expected.

Fiscal Outcomes
TWG funding was not expended on this task.

Task (2d). Irrigation Ditch Piping Demonstration Results

The TWG contributed to the piping of several significant sections of the overall "Clallam-Cline-Combo" project, including elimination of tailwater (any water, including irrigation water, rain or stormwater, remaining in the ditch after water has been delivered to the final water user on a given ditch system) (HDR, 2006) into Dungeness Bay and a section in the southern portion of the system (white boundaries in Figures 17 and 18). The overall project resulted in replacement of approximately 17 miles of open irrigation canals and laterals with about 16 miles of pipelines and the installation of several flow monitoring devices. According to the Sequim-Dungeness Valley Water Users Association's Water Conservation Plan (1999), estimates these enclosed ditches provide a combined instream water savings of at least six cubic feet per second (and around 0.82 cfs for the TWG-specific sections). Further, the contaminant load existing in tailwater (needed at the end of open irrigation ditches so that water users above have access) was entirely removed for ditches that were piped and capped. However, as illuminated during the Effectiveness Monitoring Study, in some places a stormwater conveyance ditch had to be reconstructed above or next to the irrigation piping (per Clallam County Road Department regulations) in order to convey stormwater. These and other roadside ditches appear to be a continued problem.

In addition to in-stream flow and water quality benefits, the project allows for a more efficiently managed irrigation system, with the elimination of unnecessary routes, reduced need for electric pumps to apply irrigation water, and less required ditch maintenance.

Monitoring Outcomes

Fecal coliform bacteria monitoring and flow monitoring have occurred at several ditch sites within these irrigation systems for many years. The Clallam Conservation District prioritizes piping projects, in part, according to those which have the highest potential for water quality and water quantity benefits. Flow and bacteria sampling continued monthly during the project, and where possible after the project, along with the other effectiveness monitoring. Effectiveness monitoring of piping projects can not be accomplished by customary methods (sampling a location before and after the project), as piped sampling sites are no longer accessible and tailwaters are eliminated post-construction. A different approach to fecal coliform effectiveness monitoring of the piping project is discussed with the Task 3, Effectiveness Monitoring Study Results. As for water conservation, water savings were estimated based on studies conducted for the *Dungeness River Agricultural Water Users Comprehensive Water Conservation Plan* (Montgomery Water Group, 1999). It is expected that in the long-term, the new flow monitoring devices (paid for by non-TWG funding) and existing flow gages will help water users and other interested parties to monitor more closely the amount of water being diverted for these irrigation systems.

Environmental Outcomes

Continued piping of irrigation ditches is a recommended action in the Dungeness Bay and Dungeness River/Matriotti TMDL studies. Several tailwater ditches were eliminated as a result of the project, removing the potential for conveyance of pollutants at the downstream end of the irrigation system. In

Figure 17. Clallam-Cline-Combo Ditch Project (Northern Extent).

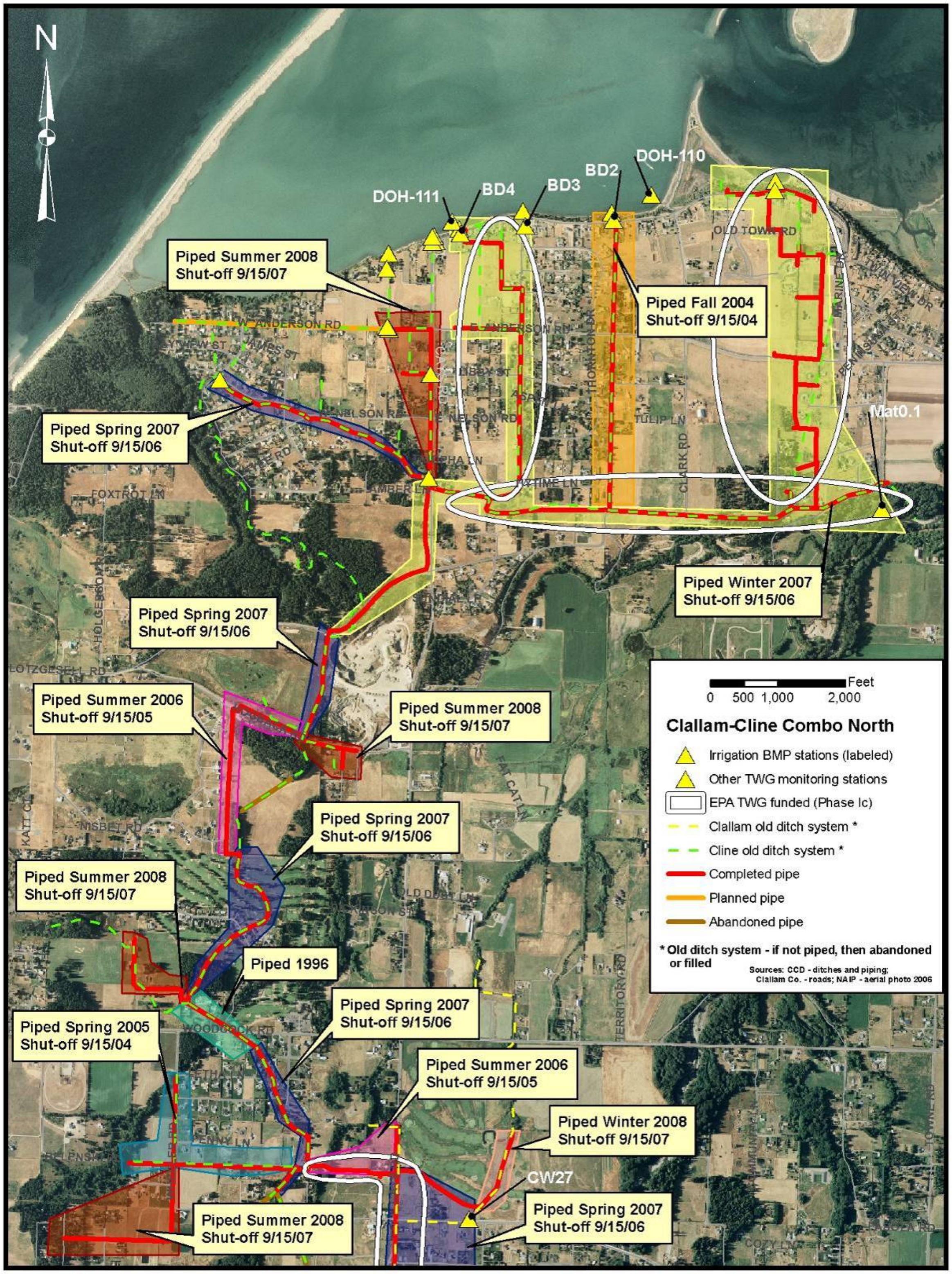
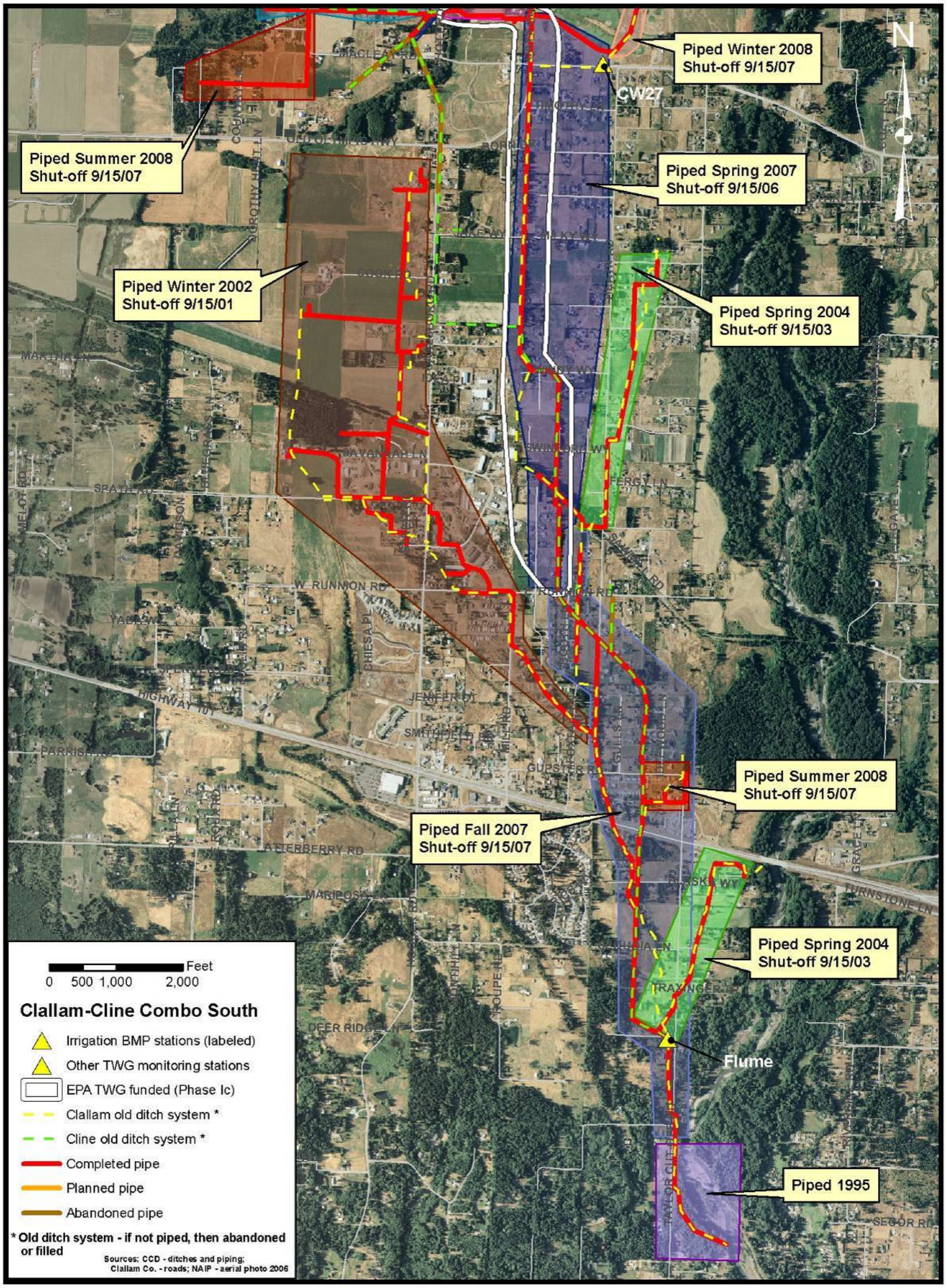


Figure 18. Clallam-Cline-Combo Ditch Project (Southern Extent).



relation to water conservation, the project implemented recommendations in the Water Conservation Plan (1999), the Comprehensive Irrigation District Management Plan (HDR, 2003, revised 2006), and the Elwha-Dungeness Watershed Plan (2005). With expansion of the overall project to include a third irrigation entity (Dungeness Irrigation Group), our Work Plan's estimated 3.25 cfs water savings was surpassed. Per Water Conservation Plan estimates, the expanded project equates to reduced diversions from the Dungeness River of 6.0 cfs. Further, the three irrigation entities negotiated with Washington Department of Ecology to officially transfer 6.0 cfs of their irrigation water right to instream flows, providing assurances that the saved water remains instream.

Fiscal Outcomes

All grant funds budgeted for this task were expended. Because this extensive project required multiple funding sponsors with various grant periods and matching requirements, and because the project had to work around the irrigation season, implementation and fiscal management had to be creative and well-organized. Clallam Conservation District maintained extensive fiscal tracking tools (sample spreadsheets available upon request) and worked hand-in-hand with irrigator representatives to assure irrigation schedules could be adequately maintained during construction of the various task phases.

Task 3. Effectiveness Monitoring Study

Note: Most of the content herein is modified or excerpted from the Task 3 final report, *Fecal Coliform Bacteria and Nutrient Assessment in the Dungeness Watershed, Washington* (Woodruff et al., 2009b). The full report and accompanying data can be accessed from the following link on the Dungeness River Audubon Center's website: http://www.dungenessrivercenter.org/DungenessWatershedResearch.html.

Monitoring / Environmental Outcomes

The overall results of this study have not shown an improvement in surface water quality with respect to fecal coliform bacteria in the Dungeness Watershed or Bay within the last 10 years. However, water quality conditions have not declined within the Watershed either. This is notable considering the steadily increasing population, a greater use of onsite sewage treatment systems, and the shift in land use resulting in increased impervious surfaces. The apparent "steady state" condition of water quality may be due in some part to best management practices and outreach programs implemented while development proceeded.

Fecal Coliform Trends

Freshwater fecal coliform (FC) data from more than 2000 samples collected between 1998 and 2008 were analyzed for trends over time and by geographic area. The samples were collected from over 55 stations along the Dungeness River, its tributaries, nearby creeks and irrigation ditches. The samples collected during this time period had natural high variability with respect to concentration, sometimes differing by several orders of magnitude. In order to examine the possible sources of variability within the data, regression models were used to partition potential sources (tributary, month, season, and year) that could be linked to the variation. Based on these models, there was no significant increase or decrease in the annual mean FC concentration during the time period examined. The year 2000 had the highest geometric mean concentration. There was a distinct seasonal pattern noted, with the dry season (April through September) having significantly higher FC concentration than the wet season (October through March). There was also a decrease in FC concentration with increasing distance from the mouth of the river or any given tributary or creek. The Dungeness River had the lowest median concentration of bacteria of all freshwater bodies examined (i.e. Dungeness River, Matriotti Creek, Meadowbrook Creek, Meadowbrook Slough, Bell Creek, and Johnson creek), ranging between 2 and 12 CFU/100 ml. Of the Dungeness tributaries, Matriotti Creek had the highest median concentration, ranging between 31 and 103 CFU/100 ml. Irrigation ditches were significantly higher than the Dungeness River as well.

Fecal coliform data from adjacent marine waters was also analyzed between 1998 and 2008. Over 1,200 FC observations from 13 stations within Dungeness Bay were monitored monthly by the Washington State Department of Health as part of the National Shellfish Sanitation Program. Similar to the freshwater data, there was no significant increase or decrease in FC for the time period examined, although 2002 had the highest geometric mean concentration of all years and individual station trends did exist. Again, there was a distinct seasonal trend; however the pattern was the opposite of that observed at the freshwater stations, with significantly higher FC concentrations found during the wet season in marine waters compared to the dry season.

The evaluation of effectiveness for mitigating FC in the Dungeness watershed focused primarily on concentration data, rather than data based on in-stream loading (i.e. concentration times flow). Flow information was collected from a number of TWG monitoring stations, however it was not consistently available, and an in-depth analysis of loading was impractical.

Nutrient Trends

Nutrient samples were collected from selected freshwater stations during routine FC monitoring as part of the TWG study (2005 through 2008). Over 830 nutrient observations were analyzed, including phosphate (PO_4), nitrate (NO_3), nitrite (NO_2), ammonia (NH_4), total nitrogen (TN) and total phosphorus (TP). For a general reference, nutrient data was compared to historic data (nitrate and phosphate) collected at another location in the upper Dungeness River between 1959 and 1970. For the most part, recent nutrient levels in the lower Dungeness watershed were not very different than historic values, although a direct site comparison could not be made. There were, however, several trends in the data that warrant further investigation.

Ammonia concentrations were slightly elevated at all Dungeness tributaries and Bell Creek compared to those detected in the River or Johnson Creek. In addition, ammonia levels were an order of magnitude higher at Golden Sands Slough, another freshwater station close to the Bay. Ammonia is generally found in areas with low oxygen availability (i.e. groundwater) and is rapidly oxidized to nitrate in contact with surface waters. Its presence in surface waters, even at low levels, could indicate close proximity to potential sources such as septic systems or agricultural runoff. There were minimal seasonal changes noted in ammonia concentrations, another possible indication of septic system influence since septic system input generally varies less by season than other anthropogenic nutrient sources incorporated into seasonal runoff. Total inorganic nitrogen (TIN) was higher in Matriotti Creek, Bell Creek, Golden Sands Slough and the irrigation ditches compared to other water bodies and stations. TIN is an indicator of a number of possible anthropogenic inputs. Overall, the TIN data was higher during the wet season compared to the dry season, a possible indication of anthropogenic runoff. PO_4 and TP concentrations showed a similar trend of elevated concentrations in Bell Creek, Golden Sands Slough and the irrigation ditches, with higher concentrations during the wet seasons compared to the dry season.

There was no significant correlation between nutrients (NH_4, NO_3, NO_2, TIN, TN, PO_4, and TP), freshwater FC concentrations, and daily rainfall determined for the days of sample collection. The lack of a statistically significant correlation may be indicative of varying sources of FC and nutrients; however, analysis of rainfall patterns over a longer duration might demonstrate a correlation.

Irrigation Piping and Septic Repair Effectiveness

Two BMP demonstrations conducted during the TWG study (irrigation piping and septic repairs) were analyzed on a site specific scale to determine their effectiveness at removal of FC bacteria and/or nutrients. To the extent possible, water samples were collected upstream and downstream of each BMP activity, as well as before and after implementation of a BMP. Piping irrigation ditches is considered a

BMP for water conservation by preventing conveyance losses. Since the water conveyance system is enclosed in a pipe, the possibility of contaminants entering the system is greatly reduced, and if the pipeline is closed at the end, there is no spilling of excess tailwater at the downstream end of the irrigation system.

Monitoring for the effectiveness of irrigation piping could not be conducted by standard methods in the sense that downstream samples could not be collected in most cases since the source water was eliminated. Median concentrations from the two upstream stations were 10 and 128 CFU/100 ml. At one downstream location, the tailwater from a bluff ditch station (IRR-3) that emptied into the Bay was monitored after piping was complete because regulations required that a stormwater conveyance ditch be reconstructed above the pipe to continue to convey runoff. After piping, the FC concentration in the stormwater runoff conveyance was not significantly different than before the piping. Further analysis examined the impact of piping on tailwater discharge into Dungeness Bay, comparing data before and after the piping at three marine monitoring sites located near the freshwater bluff ditch sites. One marine station, DOH-110 was significantly different before and after piping. However, the geometric mean at this site before piping was 7 CFU/100 ml and after the piping was 4 CFU/100 ml. While this was statistically significant, it has little meaning from a water quality improvement standpoint.
A number of benefits of irrigation piping can clearly be demonstrated such as water conservation, reduced ditch maintenance and efficient water delivery; however, the empirical evidence of reduction in FC was not clearly apparent from this study. In the case where an irrigation ditch was piped to eliminate tailwater, but the piped ditch closely coupled the path of a stormwater runoff conveyance into the Bay, the benefits were reduced. However, the potential source of contamination to this ditch is from a much smaller geographic area than prior to piping when several miles of open irrigation ditch led to this discharge location.

Effectiveness monitoring of a second BMP activity, septic system repairs, was examined as part of the TWG study. Nine direct discharge septic repairs (out of a total of 53 TWG repairs) were completed and analyzed for FC bacteria and nutrient removal. Samples were collected upstream and downstream of each septic repair where possible, as well as before and after the repair. In all cases, the nearest routine monitoring station, either upstream and/or downstream of a repair, was used for analysis. In general, for almost all septic repairs there was no significant difference between upstream and downstream FC levels based on the closest TWG monitoring site. In addition, there was no significant difference before and after a septic repair at those monitoring sites. Nutrients were examined in the same way; however, in most cases there was not enough nutrient data to allow an evaluation of the repair effectiveness. Of the three repairs that could be evaluated, one repair showed a significant reduction in nitrite between the upstream and downstream station, before and after the repair. In this case the sample locations were relatively close to the repair, whereas results from other septic repair locations were confounded by a greater distance between the monitoring sites and the location of the repair.

While the benefit of implementing septic system repairs is clear, the monitoring method used to detect repair effectiveness, in hindsight, was not sensitive enough to detect a change at the site specific or local scale. Closest established monitoring stations were used, regardless of the location of the repair, rather than establishing monitoring stations in close proximity to repair locations. Hence, a statistical decrease in FC contamination as a result of septic system repairs was not observed, in part because the monitoring sites were located too far away from the repair to detect a difference. This coupled with the high natural variability in FC concentrations resulted in no statistically significant findings. The nutrient results from one case where a significant decrease was detected indicate that monitoring stations placed in closer proximity to the repair or source in question would have a better chance of detecting a significant difference. This type of monitoring could be used for detecting failing septic systems or evaluating repair effectiveness, if monitoring locations were selected specifically for that purpose.

Administrative Outcomes
The study provided an opportunity, for the first time, to explore surface water quality data in the Dungeness Watershed from a broader perspective than has generally been possible in the past from smaller, specifically targeted projects. For this study, datasets from past, recent, and ongoing programs in the Dungeness watershed and Dungeness Bay were combined into a "master database" to evaluate overall trends from the past decade, and to consolidate all parameters into a single data file. Part of this effort included quality assurance checks on the entire dataset. The intent is to follow the format of and build upon the master database to maintain consistent water quality data record keeping for any future analyses.

Recommendations in the final report for this task include evaluating results in the broader context of other types of studies previously conducted in the watershed, and re-assessing and potentially modifying fecal coliform and nutrient monitoring strategies with short-term and long-term sample design plans. These recommendations will be topics of further discussion at future Clean Water Work Group and related meetings.

Fiscal Outcomes
All funds budgeted for this task were expended. The budget proposal in our Work Plan (2004) significantly underestimated the total cost for this comprehensive and involved task. When considering the immense amount and types of data, the various analyses incorporated, and the unanticipated but necessary reorganization of the database associated with effective monitoring, an updated budget would have been more inclusive. An agreed-upon final report outline during the Work Plan stage may have helped better prepare us in budget and timing estimations. Without this retrospective, and because the data and projects were so expansive, it was difficult to gauge the amount of work needed, and the level of detail practical within the project scope.

Owing to the flexibility of the grant, we were able to extend our original grant period and make adjustments to the overall grant budget. For example, we transferred funds from Task 2b to this task when it became possible for the County to utilize an alternate county funding source to support the septic management and training effort. Similarly, unexpended Task 2b funding, in part, made it possible for the Tribe to assist with aspects of the Effectiveness Monitoring database and final report.

Public Outreach Results
The following tools were used to accomplish the goals of our Public Outreach Plan:

- Newspaper Advertisements: We brought back *The Clean Water Herald*, formerly a Clallam County newsletter aimed at raising public awareness about local water quality issues. The TWG Clean Water Herald editions were in the form of four full-page color newspaper advertisements published in two local newspapers (Sequim Gazette and Peninsula Daily News) over the course of the project. The first two issues circulated mid-2006 and provided background and described the TWG grant and task scopes, while the last two issues circulated toward the end of the grant in 2009 and provided project results. Additionally, the local news magazine, *Living on the Peninsula*, produced a comprehensive article on water quality in the Dungeness, which highlighted the TWG project in 2006. The Clallam Conservation District and the Northwest Indian Fisheries Commission periodically updated their quarterly newsletters with progress on related tasks, and we were also able to prepare fact sheets, available on the attached CD, for public distribution on two of the TWG studies (the MST Study and the Mycoremediation Study).

- Open Public Workshops: The Dungeness River Audubon Center, one of the project partners, provided the venue for several workshops aimed at adult audiences. The Conservation District led many of these, including topics such as horse and livestock best management practices and native landscaping. Additionally, pet waste presentations were given by partners at two marine landowners workshops.

  We are especially proud of the many activity-based programs the River Center put in place (in partnership with TWG) for school-age children and teens. An annual favorite has been Watershed Weeks, where (initially 7th-grade and later) 8th-grade students learn from project partners about shellfish biology, water quality, and septic system management (Figure 19). The TWG helped fund this program, as well as water monitoring field trip programs for 4th- and 5th-graders, water quality field stewardship programs for 6th-graders, and a field program for 7th-graders about the history of human interactions in the Dungeness Watershed. From 2005-2007, these offerings amounted to 191 classes and 4,483 students, a testament to the high demand for programs of this caliber.

Figure 19. Watershed Week 2008 (Photo by Tiffany Royal, NWIFC).

- Outreach Display: We designed a revolving three-panel display at the Dungeness River Audubon Center to showcase the innovative TWG activities and environmental results as they occurred. The display highlights each of the TWG tasks, includes photographs, tables and charts as appropriate, and was updated several times over the course of the grant timeline – most recently in September 2009. This latest version includes project results. The display traveled to multiple outreach festivals, such as the annual Dungeness River Festival, Streamfest (Figure 20) and other events, during the course of the grant, and many of the posters on the display have be used as stand-alone "fact sheets".

- Established Websites: Pre-existing websites for the Dungeness River Management Team, Dungeness River Audubon Center and the Jamestown S'Klallam Tribe have been updated to reference the project and provide links to project reports and other outreach products.

Figure 20. CWWG display (left) and Dungeness River Audubon Center display (right) at Streamfest 2009.

- Presentations to Regional Colleagues: In order to assist with the transfer of knowledge gained from the project, several grant partners prepared and/or were invited to present project information to both local and regional colleagues during the course of the grant period and beyond, as summarized in Table 6:

Table 6: Outreach to regional colleagues.

Year 1	Clallam Conservation District provided a field trip tour of the mycoremediation demonstration site to the State Conservation Commission.
Year 2	TWG partners presented comprehensive TWG update (PowerPoint presentation) to Dungeness River Management Team on 3/15/06 and to Clallam County Board of Health on 3/21/06, providing detailed task statuses and information to key decision makers in the watershed.
	Battelle provided presentation on Mycoremediation project (Task 2a) to EPA.
	Tribe provided presentation describing Tribal water quality program, including activities related to TWG, to EPA Region 10 Tribal Leaders Conference, August 23, 2006.
	Tribe showcased the Clean Water Work Group display (which highlights our TWG projects) at Streamfest 2006 and Dungeness River Fest 2006.
Year 3	Battelle hosted a tour of mycoremediation demonstration site to Puget Sound Action Team, Department of Ecology, and Washington Department of Health.
Year 4	Tribe provided a presentation on the MST project to a Coordinated Tribal Water Quality Group meeting in January 2008.
	Tribe showcased the Clean Water Work Group display (which highlights our TWG projects) at two regional Puget Sound Partnership (PSP) meetings (January and March 2008) attended by 85-90 participants and held to discuss the PSP Action Agenda.
	Battelle provided preliminary results to 33 attendees of an April 9, 2008 Dungeness River Management Team Meeting. Audience included members of the DRMT and public.

	Battelle presented Dungeness MST Study and preliminary results as a Case Study at the annual Washington Association of District Employees (WADE) conference on June 17, 2008. Approximately 20 conference attendees were present.
	Tribe showcased the Clean Water Work Group display (which highlights our TWG projects) at Streamfest 2008 and Dungeness River Festival 2008 (estimated 3,000 in attendance at River Festival).
Year 5	Tribe presented preliminary findings (and lessons learned) of Phase 1 MST study to Water Resources Inventory Area (WRIA) 17 (Quilcene-Snow watershed) planning unit.
	Battelle presented findings of Effectiveness Monitoring Study at Clean Water Work Group meeting held September 24, 2009. A final site tour was also provided to the Group and to EPA staff.
	Tribe showcased the Clean Water Work Group display (which highlights our TWG projects) at Streamfest 2009 (estimated 400-800 in attendance) and Dungeness River Festival 2009 (estimated 3,000 in attendance).
	Tribe presented MST results at Tribal EPA 319 Workshop in California (end of September 2009).
	Battelle presented Dungeness Effectiveness Monitoring project as a case study at the Coastal and Estuarine Research Federation (CERF) 20th Biennial Conference in Portland, Oregon (November 1-5).
	Water quality partners currently (December 2009) discussing plan for future outreach and transfer of information gained from TWG.

In addition to the presentation of results to local and regional colleagues and to the overall Public Outreach Plan, some of the TWG tasks included specific public outreach components, such as the Task 2b Homeowner Sewage Management BMP Education and Training and the Task 2c Stormwater BMP Demonstrations, as described above. Related outreach products produced by this grant are listed in GRANT DELIVERABLES section.

LESSONS LEARNED AND NEXT STEPS

During the course of the grant, accomplishments and progress within each task were tracked in quarterly reports submitted to EPA. Problems encountered and solutions implemented were also documented within the quarterly reports. A copy of the final quarterly report (Jamestown S'Klallam Tribe, 2009), which incorporates all previous quarterly reports, can be found on the attached CD.

Task 1. Microbial Source Tracking (MST) Study

Overall, the ribotyping and PCR methods were successful in determining qualitatively the predominant sources of fecal contamination in the lower Dungeness Watershed and Bay. Challenging aspects of the project included extensive delays by the subcontractor (Institute for Environmental Health) providing the ribotyping analyses and ensuring that the public interprets the overall results appropriately (qualitatively versus quantitatively). Because there are statistical results, there is a tendency to associate them with actual bacterial amounts. Therefore, all outreach should explicitly explain that results are based only on the amount of *sampled* bacteria.

An added benefit to the project was the study period extension granted by EPA., which allowed us to incorporate a second source tracking approach and results, and made for a more comprehensive study. While the Dungeness MST study results should not be extrapolated to other geographic regions, information from the use of these source tracking tools and the overall approach can be applied to other watersheds. Results from the studies have already been used in outreach materials to the public and will be helpful during the design of mitigation strategies for sources that can be controlled, and may provide the basis for future monitoring efforts.

Task 2. Innovative BMP Demonstrations

Task (2a). Myco-remediation Demonstration

We were pleased with the overall results of this demonstration. However, there are a host of challenges that go along with studies located in a field setting. Apart from the more common delays associated with site selection and permitting, unanticipated delays associated with this field study included repairs needed for the water distribution pipe and fence installation and repair to prevent wildlife intrusion at the study site. Further, the field site location did not afford the stringent controls that would have provided additional information, such as mass balance evaluations of inputs and outputs (for further detail regarding this, see Thomas et al., 2009).

Although the evaluation of fecal coliform bacteria reductions showed obvious reduction trends, nutrient results were not as straightforward and included varying trends of export (i.e., higher concentration in the outflow relative to the inflow) or removal through time. Nutrient results exemplified the complexities associated with nutrient pathways (i.e. microbial conversion of nitrogen and phosphorus compounds to various forms that are transported through soil, water, and plants) and reaffirmed the importance of selecting design criteria that target the pollutant of interest (Hunt et al. 2006). For example, a bioretention area designed to remove phosphorus should include a soil media mix with a low P-index to enhance phosphorus uptake in the soils, rather than export. If nitrogen species are targeted, then design features should include a soil media mix with a high organic content and features that allow for submerged or anaerobic zones to allow denitrification processes to take place. Mycorrhizal fungi and native plant additions are also an important component of nutrient pathways, and could be included as design features to enhance plant uptake of nutrients and in targeted cases certain contaminants.

As listed in the final study report (Thomas et al., 2009), beneficial aspects of the mycoremediation treatment include:

- technology based on natural systems
- only native fungal species used; can locally source all materials (plants and fungi)
- minimal handling and low maintenance
- visible improvement to a site
- non-toxic byproducts; no secondary waste streams produced
- protects local water quality
- mobile and flexible; no structures, no minimum batch size
- economical
- effective at reducing fecal coliform and nutrients (when properly designed)
- applicable to a variety of other contaminants (e.g. PAHs, PCBs, metals)

Task (2b). Homeowner Sewage Management BMP Education and Training

Although the Septic 101 workshops were extremely successful, had high participation and received substantial positive feedback, participation in the cost-share program remained lower than expected during most of the grant period. Many homeowners expressed a fear of finding septic failures or of being required to make costly repairs. Septic owners were either unwilling to spend money on septic system repairs or funding was not available for many low income property owners. In response, Clallam County began emphasizing to homeowners the importance of septic system maintenance, not only for public health reasons, but also because routine inspections and maintenance can provide extensive cost savings and increase property values.

A key observation made about the cost-share program was that homeowner participation in the program increased when state laws requiring routine inspections went into effect and the OSS Plan was adopted.

The requirements also generated interest by homeowners in being trained to conduct their own septic inspections. The County provided pilot trainings toward the end of the TWG period and is in the process of developing a broader program to teach homeowners how to operate, monitor, and maintain their septic systems safely and effectively and to enable homeowners to perform the routine OSS inspections now required by state health regulations.

Task (2c). Stormwater BMP Demonstrations

The most challenging aspect of the demonstrations was locating appropriate project sites after the original sites became unattainable. The Helen Haller school raingarden project proved to be a fitting substitute for the homeowner stormwater BMPs. Although this raingarden was constructed on a school site, its size and design is an appropriate model that can be applied in residential areas.

The LID demonstrations on the Tribe's property came with several obstacles to overcome, which related to earlier land uses at the sites. For example, pre-purchase environmental testing at the Longhouse parking lot site revealed contamination from underground gas storage tanks. After the Tribe removed the tanks, it was discovered that the soil surrounding the tanks had been contaminated. Soil clean-up was followed by ongoing monitoring of groundwater to insure the site had been cleaned up satisfactorily. A series of extensive groundwater tests showed no further contamination, and the State Department of Ecology agreed that all clean-up was completed in a letter received by the Tribe in February 2007.

Although the originally proposed demonstrations were moved outside of the watershed (yet within the County) and never requested EPA funding, we felt it was important to carry out the originally proposed objectives – particularly in providing public awareness about stormwater BMPs. Public outreach was achieved for the Helen Haller project by involving school teachers and students in the project design and construction. The alternate projects for the LID demonstrations have provided locations for informative public tours and stormwater workshops.

Task (2d). Irrigation Ditch Piping Demonstration

Completely enclosing two irrigation systems with sixteen miles worth of pipe was a monumental task, both on the ground and in managing the various funding contributions, which included TWG. Because the various funding sources had different project periods and most work could not be conducted during the irrigation season, the sequencing of the various sections to be piped had to be planned creatively. Aside from certain technical issues arising at different times during construction, and the need to address (through public outreach) citizen's concerns and perceptions about removing the scenic qualities of the open ditches, the overall project is considered successful, particularly at water conservation (reducing the amount of water needed for irrigation diversions) and efficient water delivery.

From a water quality perspective, the goal of eliminating several tailwater ditches that empty into Dungeness Bay was successfully achieved. However, in some areas where piping has occurred, a stormwater conveyance ditch had to be reconstructed above or next to the irrigation piping (per Clallam County Road Department regulations) to continue to convey storm runoff water. In these cases, the benefits were reduced. This highlights the need to modify strategies related to storm water runoff collection, and may be a topic of discussion at one of the County's Stormwater Monitoring Advisory Committee meetings. This committee was established as a part of the County's recently awarded EPA West Coast Estuaries Initiative grant, the main goals of which are to develop a Comprehensive Stormwater Management Plan and to adopt *clearing and grading* and *stormwater ordinances*.

The next steps in the ditch piping effort have already begun, with Clallam Conservation District coordinating the piping of a third irrigation system that shares its river diversion point with the completed Clallam-Cline systems.

Task 3. Effectiveness Monitoring Study

Note: Some of the content herein is modified or excerpted from the Task 3 final report, *Fecal Coliform Bacteria and Nutrient Assessment in the Dungeness Watershed, Washington* (Woodruff et al., 2009b). The full report and accompanying data can be accessed from the following link on the Dungeness River Audubon Center's website: http://www.dungenessrivercenter.org/DungenessWatershedResearch.html.

The effectiveness monitoring study provided an opportunity for the first time to explore surface water quality data in the Dungeness Watershed from a broader perspective than has generally been possible in the past from smaller, specifically targeted projects. Although such an extensive data set (including information from past, recent and ongoing water quality programs) is beneficial in terms of providing a long-term data record with semi-consistent sampling locations, evaluating the data for trends and BMP effectiveness proved to be complicated. For example, the sampling locations, most of which were established previously either as part of one of the TMDL studies or due to suspected water quality problems in the vicinity, did not necessarily allow for a statistically robust examination of overall water quality patterns across the landscape, and they were not optimally located to evaluate BMP effectiveness. In the case of septic repairs, although previously established stations were chosen to be as close to the repairs as possible, the stations apparently were not close enough to show a statistical decrease in fecal coliform contamination. This, coupled with the high natural variability in fecal coliform concentrations, resulted in no statistically significant findings. Nutrient results from one case where a significant decrease was detected indicate that monitoring stations placed in closer proximity to the repair or source in question would have a better chance of detecting a significant difference. If feasible, this type of monitoring could be used for detecting failing septic systems or evaluating repair effectiveness.

Furthermore, there were limiting factors with the sampling approach use, namely: property access, seasonal availability of running water (e.g. irrigation ditches), and budget constraints. Any trends noted in the data should be viewed with these constraints in mind. Other key recommendations included in the final report (Woodruff et al., 2009b) are as follows:

- *Evaluate Results in Broader Context*: Evaluate the FC and nutrient results from the effectiveness monitoring study in the broader context of other types of studies that have been conducted in the Dungeness watershed (e.g. TMDL's, Dungeness Bay Circulation Study, Microbial Source Tracking) as well as ongoing studies (e.g. TMDL effectiveness monitoring) in order to develop an improved framework for moving forward with modifications to the existing water quality monitoring strategies (see next three bullets).
- *Fecal Coliform Water Quality Monitoring Strategy Modifications*: Re-assess and modify the overall fecal coliform water quality monitoring strategy for the Dungeness Watershed and develop sample designs for: (1) a statistically balanced, long–term dataset that will allow evaluation of landscape-scale watershed changes, (2) continued acquisition of evaluative data as site specific questions arise, and (3) storm water runoff collection and analysis. Incorporate data collection of both concentration and loading information as equally important components.
- *Nutrient Water Quality Monitoring Strategy Modifications*: Incorporate nutrient sampling into site specific and long-term sampling designs in the Watershed. This is an important water quality parameter that can provide additional insight regarding ground water conveyance and surface water runoff contaminants (e.g. human and animal waste, fertilizers, industrial pollutants).
- *On-Site Septic System Water Quality Monitoring Strategy Modifications*: Continue to refine tools to detect on-site septic system failures and evaluate septic system repairs. Evaluate a modification of

the effectiveness monitoring approach that incorporates monitoring stations located in closer proximity (upstream and downstream) of a targeted site, and incorporate both fecal coliform and nutrient collection (ammonia and nitrate) into the monitoring design.

These recommendations will be the topic of upcoming Clean Water Work Group and technical group meetings.

GRANT DELIVERABLES

Items that were produced by the project and that are provided in the attached CD include:

- Final grant quarterly project report (incorporating all previous quarterly reports)
- Final reports for Task 1 Microbial Source Tracking study, Task 2a Mycoremediation Demonstration, Task 3 Effectiveness Monitoring Study
- Fact Sheet for Task 1 Microbial Source Tracking study
- Fact Sheet for Task 2a Mycoremediation Demonstration
- Septic 101 Homeowner Survey Report (by Clallam County) for Task 2b
- Results of Homeowner Septic Training Evaluations (by Clallam County) for Task 2b
- Market based incentive guide brochure, *The Key to Having a Cost Efficient Septic System: Inspection and Maintenance*, for Task 2b
- Four newspaper advertisements describing the tasks and providing updates, for Public Outreach
- Clean Water Work Group TWG display posters (shrunk), for Public Outreach
- Photographs of Task 1 MST marine sampling, Task 2a Mycoremediation Demonstration, Task 2b Septic Education and Management, Task 2d Clallam-Cline Ditch Piping Demonstration

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REFERENCES

Battelle Marine Sciences Laboratory, 2005. *Quality Assurance Project Plan. EPA Targeted Watershed Grants Program, Dungeness River and Estuary, Task 1 – Microbial Source Tracking*. Prepared for the Jamestown S'Klallam Tribe and EPA Region 10, Seattle, WA.

Clallam County Division of Environmental Health. 2008. *Final Project Report for Centennial Grant #G0500025 "Clallam County Monitoring"*. Prepared for Washington State Department of Ecology by Clallam County Health and Human Services Department. Port Angeles, WA.

Elwha-Dungeness Planning Unit. 2005. *Elwha-Dungeness Watershed Plan, Water Resource Inventory Area 18 (WRIA 18) and Sequim Bay in West WRIA 17*. Published by Clallam County. Sequim, WA.

HDR. 2006. *Comprehensive Irrigation District Management Plan*. Prepared for the Dungeness River Agricultural Water Users Association by HDR Engineering, Inc.

Jamestown S'Klallam Tribe, 2004. *Dungeness Targeted Watershed Initiative Work Plan*. Sequim, WA.

Jamestown S'Klallam Tribe. 2009. *Dungeness River Watershed Targeted Grants Program, Final Progress Report*. Sequim, WA.

Maier, L. 2008. *Report on implementation of the Dungeness Bay/Matriotti Creek Clean Water Strategy and Detailed Implementation Plan*. Prepared by Clallam County Division of Natural Resources for Washington State Department of Health. Sequim, WA.

Montgomery Water Group. 1999. *Dungeness River Agricultural Water Users Comprehensive Water Conservation Plan*. Vols. 1-2. Includes SEPA Checklist and Subconsultants' Reports. Sequim, WA.

Reed, J. 2008. Personal communication. Clallam County Division of Environmental Health. Port Angeles, WA.

Reed, J, 2009. *Septic 101 Homeowner Survey* Results. Prepared by Clallam County Division of Environmental Health for Jamestown S'Klallam Tribe. Sequim, WA.

Sargeant, D. 2002. *Dungeness River and Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study*. Environmental Assessment Program, Washington State Department of Ecology. Olympia, WA. Publication Number 02-03-014.

Sargeant, D. 2004. *Dungeness Bay Fecal Coliform Bacteria Total Maximum Daily Load Study*. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. Publication Number 04-03-012.

Sound Resolutions and Cascadia Consulting Group, Inc. 2007. *Clallam County On-site Septic System Management Plan*. Prepared for Clallam County Environmental Health Services. Port Angeles, WA. http://www.clallam.net/assets/applets/OSSApprovedManagementPlanNoMapsJuly07.pdf

Hempleman, C. and Streeter, V. 2004. *Clean Water Strategy for addressing Bacteria Pollution in Dungeness Bay and Watershed and Water Cleanup – Detailed implementation Plan*. Prepared by Clallam

County Division of Natural Resources and Washington State Department of Ecology, Publication Number 03-10-059. Port Angeles, WA.

Streeter V. 2005. *Quality Assurance Project Plan: Bacterial/Nutrient/Flow Effectiveness Monitoring in the Clean Water District*. Prepared for U.S. Environmental Protection Agency and Washington State Department of Ecology by Clallam County Health and Human Services Department, Port Angeles, WA. Thomas, SA, LM Aston, DL Woodruff, VI Cullinan. 2009. *Field Demonstration of Mycoremediation for Removal of FC Bacteria and Nutrients in the Dungeness Watershed, Washington*. Report Number PNWD-4054-1. Prepared by Battelle Pacific Northwest Division for the Jamestown S'Klallam Tribe. Sequim, WA. http://dungenessrivercenter.org/documents/FinalMycoremediationReport.pdf

Washington State Department of Health. 2008. *Status and Trends Summary: Fecal Coliform Pollution in Dungeness Bay through 2008*. DOH Office of Shellfish and Water Protection. Olympia, WA.

Woodruff , D.L., N.K. Sather, V.I. Cullinan and S.L. Sargeant. 2009a. *Microbial Source Tracking in the Dungeness Watershed, Washington*. Report Number PNWD-4054-2. Prepared by Battelle Pacific Northwest Division for the Jamestown S'Klallam Tribe, Sequim WA. http://dungenessrivercenter.org/documents/FinalMycoremediationReport.pdf

Woodruff , D.L., V.I. Cullinan and J.M. Brandenberger. 2009b. *Effectiveness Monitoring of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington*. Report Number PNWD-4054-3. Prepared by Battelle Pacific Northwest Division for the Jamestown S'Klallam Tribe, Sequim WA. http://dungenessrivercenter.org/documents/FinalMonitoringEffectivenessStudy.pdf