Henderson Inlet Watershed
Fecal Coliform Bacteria
Total Maximum Daily Load

Water Quality Implementation Plan

July 2008

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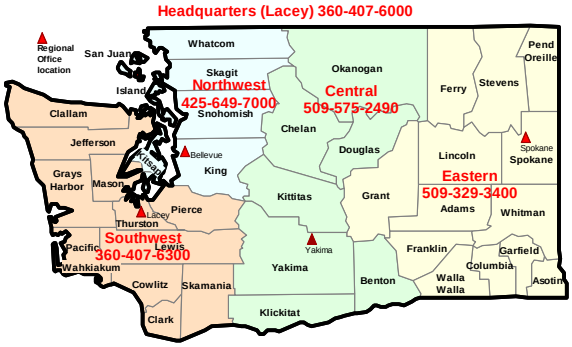

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Henderson Inlet Watershed Fecal Coliform Water Quality Implementation Plan

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Total Maximum Daily Load (TMDL)

Developed by
Henderson Inlet Watershed Technical Advisory Group

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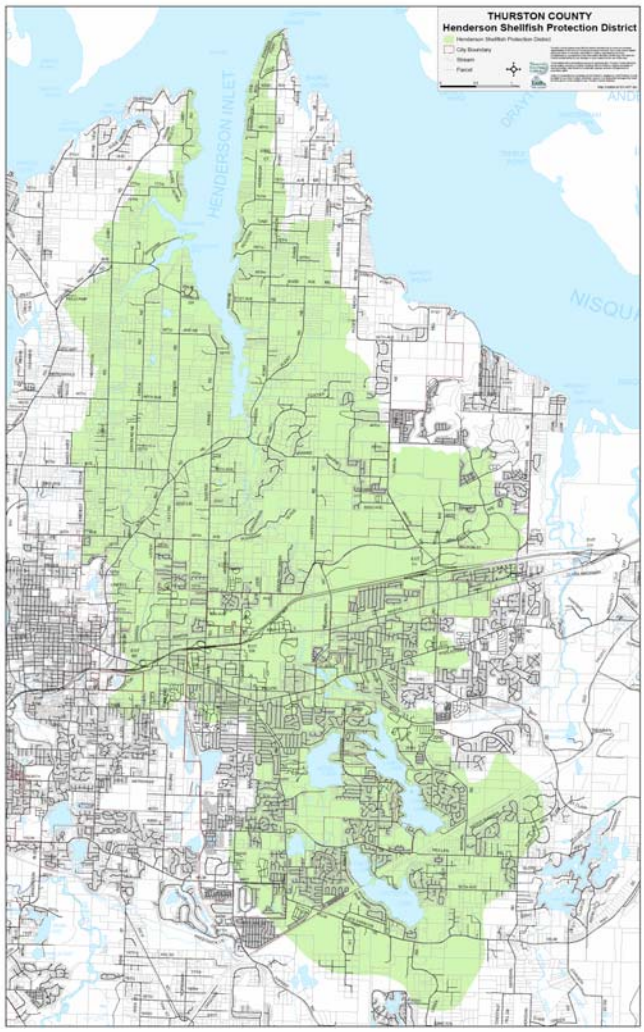
Executive Summary

The federal Clean Water Act requires states to maintain a list of water bodies that fail to meet water quality standards. In Washington, that list is called the 303(d) List, which is part of Washington's Water Quality Assessment or. The Clean Water Act also requires states to see that these "impaired" water bodies are restored to healthy water quality. The water cleanup process that's typically used is the total maximum daily load (or TMDL) process.

The cleanup process begins with a water quality study to identify and evaluate sources of pollution. It includes analysis to determine how much pollution from those sources needs to be reduced in order to restore healthy water quality. Study findings are then used as a guide to help develop a cleanup plan and put it into action.



Henderson Inlet is one of five inlets that form the southern end of Puget Sound. Woodland and Woodard Creeks are the largest tributaries in the 30,000 acre watershed, draining 80 percent of the basin. The other major streams in the watershed, Dobbs Creek (East Creek), Meyer Creek (Snug Creek), and Sleepy Creek (Libby Creek), drain small areas of the Dickerson Point and Johnson Point peninsulas (Thurston County PHSS and WWM, 1995).

Ecology conducted a water quality study in Henderson Inlet watershed during 2002-2005. The water quality study, *Henderson Inlet Watershed Fecal Coliform Bacteria, Dissolved Oxygen, pH and Temperature Total Maximum Daily Load* (Sargeant, 2006) evaluated reported water quality impairments.

Issues with dissolved oxygen and pH in freshwater were largely found to be related to natural causes such as discharge from ground water or wetlands. However, some dissolved oxygen issues appear to be related to too many nutrients from human causes (nitrogen and phosphorus) entering the water bodies. Since low dissolved oxygen is a growing concern in a number of south Puget Sound areas, including Henderson Inlet, the study report and this cleanup plan make recommendations for reducing nutrients in the watershed. Hydrologic analysis was not able to explain why the water is too warm in parts of Woodland Creek.

Fecal coliform bacteria concentrations were found to be too high throughout the watershed. The TMDL study report set goals (also called "load allocations") for reducing bacteria at important locations. The following tables, which list those locations, will help to prioritize cleanup actions in the areas where, and when reduction is most needed.

Bacteria reduction needed for Woodland Creek tributaries and stormwater**.**

*RM refers to river mile. Distance is measured from the mouth.

Site	Critical season	Geometric mean	90th percentile	FC reduction needed to meet standards	Limiting criterion	Target value fc/100 mL
Stormwater discharge at Woodland RM 3.7	Storm event	446	8370	99%	90th percentile	100
College Creek at RM 0.4	Storm event	161	694	86%	90th percentile	100
WSDOT stormwater discharge at Woodland RM 3.1	Storm event	31	624	84%	90th percentile	100
Stormwater pipe from Interstate 5 at Woodland RM 3.1	Storm event	539	659	91%	Geometric Mean	50
Stormwater pipe at Woodland RM 2.6	Storm event	617	1920	95%	90th percentile	100
Palm Creek at Woodland RM 1.95	Storm event	54	246	59%	90th percentile	100
Fox Creek at Woodland RM 1.9	Storm event	41	451	78%	90th percentile	100
Quail Creek at Woodland RM 1.1	Storm event	212	2510	96%	90th percentile	100
Woodland Creek at RM 0.2	Storm event	102	552	92%	90th percentile	43
Woodland Creek at RM 2.6	Dry season	87	108	43%	Geometric Mean	50
Eagle Creek at Woodland RM 2.25	Dry season	204	2180	95%	90th percentile	100
Jorgenson Creek at Woodland RM 1.2	Dry season	412	904	89%	90th percentile	100
Woodland Creek at RM 0.2	Dry season	192	271	93%	Geometric Mean	14

Bacteria reductions needed for Woodard Creek tributaries and stormwater.

Site	Critical season	90th percentile	FC reduction needed to meet standards	Limiting criterion	Target value fc/100 mL
Stormwater discharge to Taylor wetland	Storm event	4590	98%	90th percentile	100
Woodard Creek at RM 6.9	Storm event	415	76%	90th percentile	100
Woodard Creek at RM 0.0	Storm event	450	90%	90th percentile	43

Bacteria reductions needed for Henderson Inlet tributaries.

Site	Critical season	Geometric mean	90th percentile	FC reduction needed to meet standards	Limiting criterion	Target value fc/100 mL
Meyer Creek	Storm event	109	741	87%	90th percentile	100
Sleepy Creek	Storm event	90	835	88%	90th percentile	100
Dobbs Creek	Storm event	299	2420	96%	90th percentile	100
Goose Creek	Storm event	54	773	87%	90th percentile	100

The goal of the cleanup is to achieve water quality standards. These reduction goals provide a guideline for prioritizing cleanup activities. The most likely human-related sources are highest priority for cleanup actions. These include septic systems, pet waste, and livestock management practices. Stormwater mobilizes contamination from these sources and carries it into waterways. Stormwater management is a significant problem in the watershed, and will be a major focus of cleanup efforts.

Cleanup actions will include a combination of:

- Improved management of stormwater discharges.
- Implementation of an on-site septic system operations and maintenance program.
- Source investigation including septic surveys, water quality monitoring, and visual surveys of land use and management practices.
- Technical assistance to landowners.
- Informational workshops and other outreach aimed at encouraging landowners to improve land use practices.
- Oversight of sources with discharge permits.
- Enforcement.
- Water quality monitoring to guide cleanup; assess effectiveness of cleanup actions; monitor progress towards water quality goals; and, ultimately, demonstrate compliance with water quality standards.
- On-going evaluation, by the technical advisory group, of the effectiveness of cleanup actions with changes to the cleanup strategy as needed.

Sources of bacteria are mostly small and scattered throughout the watershed. While each of these individual sources alone may contribute only a little pollution, together they create a significant bacteria load. It will take small changes by many individual landowners to restore water quality in Henderson Inlet watershed.

The goal of the technical advisory group is for the water bodies in Henderson Inlet Watershed to meet water quality standards by 2018, with a 75 percent reduction by 2015.

Introduction

Creeks in the Henderson Inlet watershed support a variety of aesthetic, recreational, commercial, and educational opportunities. Henderson Inlet itself also supports substantial commercial and recreational shellfish harvest as well as other aquatic life. Freshwater areas of the watershed provide salmon habitat, especially below Interstate 5.

Figure 1 shows the area in Henderson Inlet watershed. Ecology began a water cleanup process (also called a TMDL, or total maximum daily load) in this watershed (Table 1) to:

- Reduce health risks to people who play and fish in the water or consume shellfish harvested from the water.
- Restore and sustain commercial and recreational shellfish harvest.
- Restore and protect habitat for aquatic life.

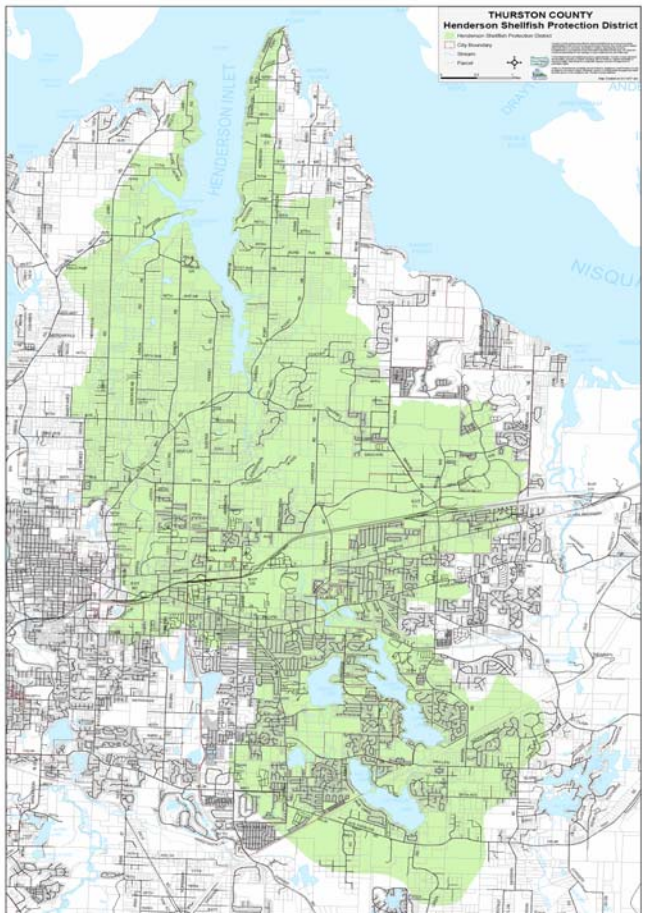


Figure 1: Henderson Inlet watershed

Table 1: Henderson Inlet and tributaries that do not meet water quality standards

Water Body	Parameter
Marine Water	
Henderson Inlet	Dissolved Oxygen, Fecal Coliform
Henderson Inlet	Fecal Coliform
Freshwater	
Dobbs Creek	Fecal Coliform, pH
Sleepy Creek	Dissolved Oxygen, Fecal Coliform, pH
Woodard Creek	Dissolved Oxygen, Fecal Coliform, pH
Woodland Creek	Dissolved Oxygen, Fecal Coliform, Temperature
Meyer (Snug) Creek	Fecal coliform bacteria, pH
Goose Creek	Fecal coliform bacteria

With the help of local governments, Ecology conducted a water quality study in the Henderson Inlet watershed during 2002-2005. The study evaluated fecal coliform bacteria, temperature, dissolved oxygen and pH.

Fecal coliform bacteria are found in the feces of warm blooded animals like humans, pets, livestock, birds and other wildlife. If fecal coliform bacteria are present in the water, other bacteria and viruses (pathogens) found in feces are likely also present. People playing, swimming or fishing may be exposed to pathogens through small cuts or by accidentally swallowing water. Health effects can be as mild as an unexplained rash or upset stomach, or very serious such as hepatitis. Eating contaminated shellfish can also cause illness.

The water quality study report, *Henderson Inlet Watershed Fecal Coliform Bacteria, Dissolved Oxygen, pH, and Temperature Total Maximum Daily Load Study* (Sargeant, 2006) established reduction goals only for fecal coliform. Those goals (called TMDL allocations) and related recommendations address both "nonpoint" sources (many small sources, spread throughout an area) and "point" sources (primarily discharge from stormwater pipes or ditches). The study report is available on line at http://www.ecy.wa.gov/biblio/0603012.html.

Actions to reach cleanup goals will first target human-related sources that can be controlled: septic systems, pet waste and livestock-keeping practices. Stormwater, while not itself a source of bacteria, contributes to bacteria problems by carrying pollution into waterways, even from some distance away. The water quality study found several stormwater outfalls carrying significant bacteria loads. Improved management of stormwater runoff is the highest priority for reducing bacteria concentrations in the watershed.

Wildlife, too, can contribute bacteria. Wildlife is generally considered part of the "natural background." However, there may be management opportunities to reduce bacteria where human activities encourage unusual numbers of wildlife, for instance, waste management in commercial areas, or feeding waterfowl along shorelines.

In the early 2000s, elevated bacteria concentrations in Henderson Inlet resulted in restrictions on shellfish harvest. As part of the response, Thurston County commissioners formed a shellfish protection districts' citizen advisory group. That group developed a *Shellfish Protection Districts Implementation Work Plan* (available online at http://www.co.thurston.wa.us/shellfish/), which recommends long-term strategies necessary to protect shellfish harvest in Henderson Inlet. While their recommendations focus specifically on Henderson Inlet, and the TMDL study is concerned with reducing bacteria throughout the watershed, the two processes identified very similar needs. Some of the advisory committee's recommendations were incorporated into this plan. In addition to bacteria, the water quality study confirmed some problems with pH, temperature, and dissolved oxygen. While some of these issues were determined to be a

result of natural causes, the report makes recommendations for addressing human contributions. Those recommendations are included in the *What Will Be Done* section of this implementation (cleanup) plan. No specific reduction goals were established for these parameters.

Many factors support improving water quality in Henderson watershed:

- There is relatively strong public support of good environmental quality and restoration of the recreational and economic benefits of Henderson Inlet.
- The cities of Lacey and Olympia, Thurston County, and others have strong water quality programs.
- Since the beginning of the water quality study, local governments have initiated several major cleanup actions that deal with identified high-priority bacteria sources (see *What Will Be Done*, in this report).
- New federal stormwater regulations went into effect, as this plan was being developed, that will have long-term effects on improving stormwater management and water quality.

On the other hand, there are some real challenges to improving water quality. This area is growing quickly. More septic systems, domestic animals, and yard care products increase potential threats to water quality. More impervious surface means more pollutant-loaded stormwater quickly entering area water bodies. At the same time, natural controls on pollution, like streamside vegetation which filters and absorbs runoff, are often degraded with development. These factors increase pressure on the natural system of the watershed and increase the difficulty of improving water quality.

There are also multiple demands on local governments to address these problems. Every major watershed in Thurston County is involved in a water cleanup (TMDL) process. Water quality problems are affecting shellfish harvest in several marine areas. In addition, the new federal stormwater regulations increase requirements on local jurisdictions. Local resources are challenged to deal with these multiple demands. Implementation measures will need to be prioritized on a jurisdiction-wide basis.

The technical advisory group developed this cleanup plan and will work together to put it into action, evaluate progress, and make adjustments as necessary. The group anticipates that fecal coliform concentrations can be reduced to meet water quality standards by 2018, and that 75 percent of that improvement can be achieved by 2015.

Watershed Description

Henderson Inlet Basin

Henderson Inlet is one of five inlets that form the southern end of Puget Sound. It is located between Budd Inlet on the west and Nisqually Reach on the east. The five-mile long inlet ranges from one-fourth to three-fourths miles in width, averaging about 25 feet in depth. A large portion of the lower inlet is exposed mudflats at low tide.

Woodland and Woodard Creeks are the largest tributaries in the 30,000 acre Henderson Inlet watershed, draining 80 percent of the basin. The other major streams in the watershed, Dobbs Creek (East Creek), Meyer Creek (Snug Creek), and Sleepy Creek (Libby Creek), drain small areas of the Dickerson Point and Johnson Point peninsulas (Thurston County PHSS and WWM, 1995).

Woodland Creek

Woodland Creek is the largest creek draining to Henderson Inlet (Figure 2) with an area of approximately 29.7 square miles (76.8 square kilometers). It flows through northeast Olympia and central Lacey before emptying into Henderson Inlet. Four lakes connected by extensive wetlands form a horseshoe-shaped chain which makes up the headwaters of Woodland Creek. Hicks Lake flows into Pattison Lake and then into Long Lake.

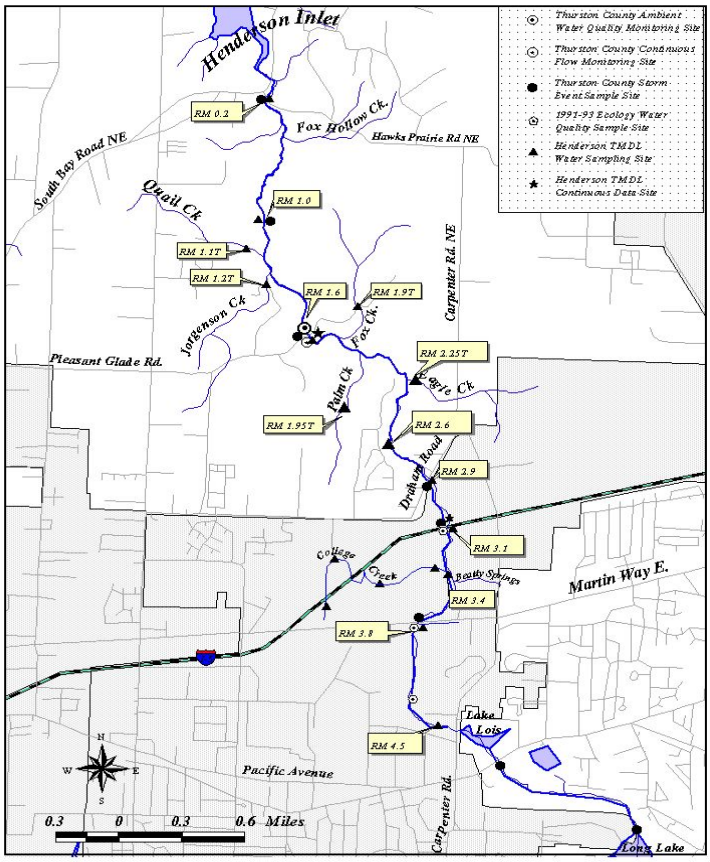


Figure 2: Woodland Creek study area

From Long Lake to Martin Way, Woodland Creek includes one mile of perennial stream flowing to Lake Lois. From Lake Lois, an intermittent channel that is often dry during the summer flows through a narrow, steep-sided ravine through second-growth forest. Downstream of Martin Way, several springs provide perennial flow to lower Woodland Creek.

The Woodland Creek basin is one of the fastest-growing areas in the county (Thurston County WWM, 1995). Ninety percent of the

Woodland Creek watershed lies within an Urban Growth Area (UGA), primarily Lacey but also Olympia (Clingman, 2001). The basin still contains substantial areas of undeveloped forests, though the dominant land use is suburban-density, residential development. Residential subdivisions are spreading rapidly in the area around the headwater lakes and near the mouth of the stream basin.

A description of Woodland and Woodard Creek basin geology, soils, hydrology, vegetation, fish habitat, and critical areas can be found in the Woodland and Woodard Creek Comprehensive Drainage Basin Plan (Thurston County WWM, 1995).

Woodard Creek

Woodard Creek, the second largest creek, is 7.5 miles in length and drains a basin of 5,090 acres (Figure 3). Ground water feeds a large wetland, known as Taylor wetland, at the headwaters of Woodard Creek just south of I-5 at the Pacific Avenue interchange. Industrial and commercial development on Fones Road surrounds the wetland at the creek's headwaters.

Large portions of high density commercial areas in Lacey and Olympia, including the South Sound Mall and Olympia Square, drain into the wetland through the Fones Road ditch. The mouth of Woodard Creek is an estuarine wetland that is currently protected as a natural area by the Washington Department of Natural Resources.

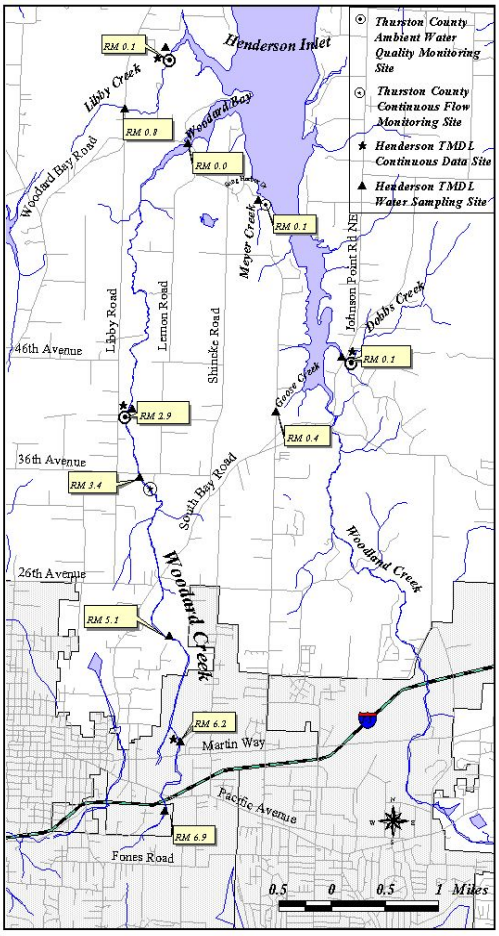


Figure 3: Woodard Creek study area

Meyer Creek

Meyer Creek is approximately one mile in length (Thurston County PHSS and WWM, 1999). The headwaters of the creek originate in a wetland at Schinke Road south of 56th Avenue. The creek flows northeast through pastureland and into Henderson Inlet at Snug Harbor, approximately one mile south of Woodard Bay. Primary land uses are rural, residential, and agricultural.

Sleepy Creek

Sleepy Creek is 1.1 miles in length, with the primary land uses rural, residential, and agricultural. This creek originates in a wetland, flows through a series of gullies and wooded ravines, and enters Henderson Inlet at Chapman Bay. Coho and chum salmon use Sleepy Creek (Thurston County WWM, 1997).

Dobbs Creek

Dobbs Creek is 1.5 miles long. The primary land uses are rural, residential, and agricultural. The creek flows through wooded terrain as well as open pastures near the headwaters (Thurston County PHSS and WWM, 1999). Pleasant Forest Campground, a large recreational vehicle park, is located along the mid-stem of the creek. Coho and chum salmon use Dobbs Creek (Thurston County WWM, 1997).

Goose Creek

Goose Creek is approximately one mile long. It empties into the southern-most portion of Henderson Inlet. The headwaters originate from a large pond off Schincke Road and the creek flows northeast through a narrow channel crossing Sleater-Kinney Road. In their 1983-84 report, Thurston County reported flows ranging from no flow to 0.6 cfs with an average flow of 0.09 cfs (Thurston County PHSS and WWM, 2001).

What Will be Done?

Implementation strategy
(summary of actions)

Bacteria

Fecal coliform bacteria come from the waste of warm-blooded animals. Cleanup will focus on improved management of bacteria sources including septic systems, pet waste, and livestock keeping.

Stormwater carries contamination from these sources into waterways. Both the *Henderson Inlet Watershed Fecal Coliform Bacteria, Dissolved Oxygen, pH and Temperature Total Maximum Daily Load* and the *Shellfish Protection Districts Implementation Workplan* identify the importance of improved management of stormwater. Improved stormwater management is the highest priority for action.

Sources of bacteria are mostly small and scattered throughout the watershed. While each of these individual sources alone may contribute only a little pollution, together they create a significant bacteria load.

Cleanup actions will include a combination of:

- Improved management of stormwater discharges.
- Implementation of the Henderson Inlet On-site Septic System Operations and Maintenance Program.
- Source investigation, including septic surveys and visual surveys of land use and management practices.
- Technical assistance and, where possible, financial assistance to landowners.
- Informational workshops and other outreach aimed at encouraging landowners to improve land use practices and management of septic systems.
- Oversight of sources with discharge permits.
- Enforcement.
- Water quality monitoring to further define sources, guide cleanup, assess effectiveness of cleanup actions, monitor progress towards water quality goals and, ultimately, demonstrate compliance with water quality standards.
- On-going evaluation, by the technical advisory group, of the effectiveness of cleanup actions, with changes to the cleanup strategy as needed.

As this plan was being developed, new stormwater regulations from the federal Clean Water Act are going into effect. The Phase II Municipal Stormwater Permit applies to the cities of Lacey and Olympia and many parts of Thurston County (as well as over 100 other cities and counties in Washington). Phase I of the stormwater regulations went into effect in 1990 and applied to seven Washington jurisdictions with large population concentrations.

The Phase II rules identify six minimum control measures to protect water quality:

1. Public education and outreach.
2. Public participation/involvement.
3. Illicit discharge detection and elimination.
4. Construction site runoff control.
5. Post-construction runoff control.
6. Pollution prevention/good housekeeping.

In addition to these programmatic requirements, Table 7 identifies specific actions to address specific stormwater sources. Those actions became requirements of the Phase II permits of local jurisdictions. Thurston County, Lacey and Olympia are well underway to addressing stormwater needs, including projects that will deal with the top two stormwater sources identified by the water quality study in the Woodland Creek drainage.

While the new Phase II requirements create opportunities for improving water quality, they also present largely unfunded requirements to local governments. Thurston County may be particularly challenged by this, as they currently have TMDL processes happening in all five major watersheds. Priorities will be evaluated on an area-wide basis.

Two important projects to help prioritize cleanup work

Thurston County conducted a characterization study of Henderson watershed. This pilot project evaluated the watershed processes (movement of water, wood, sediment, pollutants, and heat) and biological processes (aquatic integrity and habitat connectivity). The resulting information will show which wetland, riparian, and floodplain sites are best for preservation and restoration. It will identify where stormwater retrofit improvements will provide the highest ecological benefit. And it will help the county meet multiple regulatory requirements in the most cost-efficient way.

Thurston County, the city of Lacey, and LOTT Wastewater Alliance conducted another important study, the Woodland Creek Pollutant Load Reduction Project. This project identified best management practices to reduce bacteria and nutrient loading to Woodland Creek from the Long Lake outlet to river mile 1.6.

~ *The project started by gathering existing hydrologic, water quality, and land use data. Then, they used the Watershed Treatment Model to estimate pollutant loads from specific sources within each sub-basin in the project area. The resulting report and recommendations are available online at www.co.thurston.wa.us/health/ehrp/woodland.html*

The Department of Ecology awarded Thurston County a $750, 000 Stormwater Program Grant, in 2008, to upgrade the Tanglewilde neighborhood to rehabilitate the existing stormwater infrastructure.

It will address the stormwater outfall on Martin Way (RM 3.7) that carries the biggest bacterial load and some of the highest nitrogen concentrations to Woodland Creek.

The county continues to work with the community. The action plan was developed in March 2008.

The TMDL water quality study set goals for reducing bacteria at key points in the Henderson Inlet watershed.

Tables 2, 3, and 4 identify the necessary bacteria reductions. These are sometimes referred to as Load Allocations or Waste load Allocations (see Appendix A). These reductions are a guide. The goal of this water cleanup plan is to meet state water quality standards.

Table 2: Bacteria reductions needed for Woodland Creek tributaries and stormwater sources during storm events and dry season.

Woodland Creek Sites	Critical season	Geometric mean	90th percentile	FC reduction needed to meet standards	Limiting criterion	Target value fc/100 mL
Stormwater discharge at Woodland RM 3.7	Storm event	446	8370	99%	90th percentile	100
WSDOT stormwater discharge at Woodland RM 3.1	Storm event	31	624	84%	90th percentile	100
Stormwater pipe from Interstate 5 at Woodland RM 3.1	Storm event	539	659	91%	Geometric Mean	50
Stormwater pipe at Woodland RM 2.6	Storm event	617	1920	95%	90th percentile	100
Woodland Creek at RM 0.2	Storm event	102	552	92%	90th percentile	43
Tributary Sites	**Critical season**	**Geometric mean**	**90th percentile**	**FC reduction needed to meet standards**	**Limiting criterion**	**Target value fc/100 mL**
Palm Creek at Woodland RM 1.95	Storm event	54	246	59%	90th percentile	100
Fox Creek at Woodland RM 1.9	Storm event	41	451	78%	90th percentile	100
Quail Creek at Woodland RM 1.1	Storm event	212	2510	96%	90th percentile	100
College Creek at RM 0.4	Storm event	161	694	86%	90th percentile	100
Dry Season Sites	**Critical season**	**Geometric mean**	**90th percentile**	**FC reduction needed to meet standards**	**Limiting criterion**	**Target value fc/100 mL**
Woodland Creek at RM 2.6	Dry season	87	108	43%	Geometric Mean	50
Eagle Creek at Woodland RM 2.25	Dry season	204	2180	95%	90th percentile	100
Jorgenson Creek at Woodland RM 1.2	Dry season	412	904	89%	90th percentile	100
Woodland Creek at RM 0.2	Dry season	192	271	93%	Geometric Mean	14

*RM refers to river mile. Distance is measured from the mouth.

Table 3: Bacteria reductions needed for Woodard Creek tributaries and stormwater.

Site	Critical season	90th percentile	FC reduction needed to meet standards	Limiting criterion	Target value fc/100 mL
Stormwater discharge to Taylor wetland	Storm event	4590	98%	90th percentile	100
Woodard Creek at RM 6.9	Storm event	415	76%	90th percentile	100
Woodard Creek at RM 0.0	Storm event	450	90%	90th percentile	43

Table 4: Bacteria reductions needed for Henderson Inlet tributaries.

Site	Critical season	Geometric mean	90th percentile	FC reduction needed to meet standards	Limiting criterion	Target value fc/100 mL
Meyer Creek	Storm event	109	741	87%	90th percentile	100
Sleepy Creek	Storm event	90	835	88%	90th percentile	100
Dobbs Creek	Storm event	299	2420	96%	90th percentile	100
Goose Creek	Storm event	54	773	87%	90th percentile	100

Ecology and other implementing agencies believe these actions can achieve water quality standards for bacteria by 2018. Seventy-five percent of that reduction will be achieved by 2015.

Temperature, dissolved oxygen, and pH

Temperature

Woodland Creek does not meet water quality standards for temperature between the outfall to Lois Lake and Martin Way. There is not enough data collection and analysis to determine the cause and reduction goals for temperature. Below Martin Way, the creek meets water quality standards. The water quality study recommends maintaining or improving current shade levels to protect water quality, including marginal and low dissolved oxygen levels. Recommendations for effective shade are listed in Appendix C, Table 3.

Natural conditions are likely to be the cause of higher water temperatures in parts of Woodard Creek and Sleepy Creek, but fully-established riparian vegetation would possibly lower the water temperature in Sleepy Creek.

Dissolved Oxygen

Most dissolved oxygen issues in freshwater are related to natural causes such as discharge from ground water or wetlands. Below river mile 1.6, Woodland Creek should be able to achieve water quality standards for dissolved oxygen. The cause of low oxygen levels observed during the water quality study is unknown. The study did not evaluate dissolved oxygen levels in Henderson Inlet itself. However, the Inlet is listed as "Of Concern" on Ecology's 2004 Water Quality Assessment (i.e., the 303[d] List), and oxygen levels are depressed in several other areas

of south Puget Sound as well. Therefore, study recommendations for reducing nutrient sources to Henderson Inlet are incorporated into this cleanup plan.

ph
pH problems in several areas of the watershed were determined to be from natural causes such as groundwater in-flow and wetland discharge.

Pollution sources and organizational actions, goals, and schedules

Fecal coliform bacteria loadings from Woodland and Woodard Creeks are shown in Table 5 and 6 respectively. Considerable effort will need to be focused in these areas in order for the creeks to meet water quality standards.

Table 5: Ranked Woodland Creek average estimated fecal coliform (FC) loading during storm events (November - March) and the dry season (June - September).

Woodland Creek Site	During Storm Events (billions FC per day)	Woodland Creek Site	During Dry Season (billions FC per day)
Stormwater discharge at RM 3.7	164.3	RM 2.6 - 1.6	21.2
RM 3.8 - 3.4	36.0	RM 1.6 - 1.0	15.6
RM 2.6 - 1.6	35.5	RM 2.9 - 2.6	10.4
RM 1.0 - 0.2**	35.5	Eagle Creek	8.5
College Creek RM 0.6 - 0.4	22.9	Jorgenson Creek	8.2
Quail Creek	19.1	RM 3.4 - 3.1 *	4.3
College Creek RM 0.2 - 0.0	15.1	RM 3.1 - 2.9 *	3.9
RM 2.9 - 2.6	14.1	RM 3.45 - 3.4*	2.0
Fox Creek	13.7	Quail Creek	1.4
Upstream of College Creek RM 0.6	12.2	College Creek at mouth	1.4
Jorgenson Creek	9.8	Headwaters at RM 3.45 *	0.7
Upstream at Woodland Creek RM 4.5	5.9	Fox Creek	0.3
Eagle Creek	5.1		
RM 4.5 - 3.8	2.8		
WSDOT stormwater (both discharges)	2.2		
Palm Creek	1.4		
Stormwater discharge at RM 2.6	0.2		

* These reaches or sites meet fecal coliform bacteria standards.
** Flows used to calculate loading at RM 0.2 are based on flows at RM 1.0; no flow data are available for RM 0.2.

Table 6: Ranked Woodard Creek estimated average fecal coliform (FC) loading during storm events (November - March) and the dry season (June - September).

Woodard Creek Site	During Storm Events (billions FC per day)	Woodard Creek Site	During Dry Season (billions FC per day)
RM 5.1 - 3.4	43.1	RM 6.2 - 5.1	11.1
RM 6.2 - 5.1	22.7	RM 5.1 - 3.4	7.9
Upstream of 6.9 (Taylor wetland)	10.2	Upstream of 6.9 (Taylor wetland)	0.8
RM 3.4 - 2.9	2.6	Woodland Creek RM 6.9 - 6.8	0.6
Woodland Creek RM 6.9-6.8	0.01		

Table 7 shows specific actions and responsibilities for restoring water quality. The technical advisory group deems Priority 1 actions most important for reducing bacteria based on information from the water quality study.

Many of the Priority 1 actions are already underway. Priority 2 and 3 items either address smaller bacteria sources, or are actions that will be undertaken only if higher priority actions are unable to achieve anticipated results.

An “R” in the Priority column means “recommended action” and refers to actions for parameters other than bacteria: i.e., dissolved oxygen, pH, and temperature. While some analysis was done for these parameters during the TMDL water quality study, and attention to their management is important (especially in the case of dissolved oxygen and related nutrients), reductions are not a mandated part of the TMDL project. Some of the actions in Table 7 that address bacteria will also help improve or protect other water quality parameters.

Some of these actions are described in more detail in other sections of this plan. Appendix B contains a description of the programmatic authorities and responsibilities of the organizations involved with this cleanup.

Table 7: Cleanup Actions

*Note: See previous page for an explanation of priority ratings.

Source area	Action	Priority*	Lead	Funded?	Implementation status
Throughout Henderson Inlet watershed	Henderson Inlet Watershed Septic System Operations and Maintenance Program.	1	Thurston County	funded	This program is underway. It will operate on a three-year cycle, and will be fully implemented in 2009.
	Support low impact development (LID) area-wide.	1	Thurston County lead, local governments coordinating		This work is underway in two stages. Local jurisdictions expect to complete stormwater manuals by late 2009. LID standards will be part of this manual. Then an advisory committee will begin developing related policies which may include identification of areas where LID is allowed or mandated, possible incentive programs, etc.
	Watershed characterization to help prioritize stormwater projects for greatest benefit (see project description pg 15)	1	Thurston County	yes	Study complete. County is evaluating potential sites for retrofit.
	Investigate potential for homeless camps in wooded areas to contribute to bacteria pollution.	3			
	Investigate human activities that may be encouraging unnatural concentrations of wildlife (i.e., garbage management, feeding ducks and geese),	3			

Source area	Action	Priority*	Lead	Funded?	Implementation status
	Continue to encourage watershed residents to use water wisely.	R	City of Lacey, Thurston County, Thurston CD		On-going
	Technical and cost share assistance, and outreach to agricultural, shoreline and riparian landowners to assist them in implementing Best Management Practices (BMPs) that address water quality issues.	1	Thurston CD	Yes	This three-year project will start up in early 2008.
Woodland Creek					
Throughout Woodland Ck subbasin	Protect springs and tributaries in lower Woodland Creek from further degradation, including measures to protect streamside vegetation and ground water in hydraulic continuity.	R	City of Lacey, Thurston County		
	Implement effective shade recommendations (Appendix **) to improve dissolved oxygen levels.	R	Thurston CD	funded	TCD will launch a DOE grant beginning in January 2008, focusing on implementation of shade recommendations along shorelines and streams.
	Include nutrient attenuation or removal in stormwater treatment to limit algal growth in Woodland Creek.	R	Thurston County, City of Lacey		

Source area	Action	Priority*	Lead	Funded?	Implementation status
	Prohibit exempt wells within Lacey City limits where city water is available.	R	City of Lacey		pending
	Investigate possible widespread changes in groundwater nitrate concentrations in the Woodland Creek basin.	R			
Lake Lois to mouth of Jorgensen Ck (approximately RM 4.3 to 1.4)	Pollutant Load Reduction Project: Analysis of sources of pollution, including ground water, to stormwater and to Woodland Creek from the Long Lake outlet to river mile 1.6. Resulting information will be used to determine improvement options, which may include facility designs, pursuit of funding, and/or policy or regulation changes.	1	Thurston County, City of Lacey	funded	Final report issued March 2008.
Stormwater discharge at Martin Way (RM 3.7)	Pollutant Load Reduction Project and Watershed Characterization project will determine appropriate actions for this discharge. Follow-up monitoring will be conducted to confirm effectiveness.	1	Thurston County		

Source area	Action	Priority*	Lead	Funded?	Implementation status
College Ck and discharge to Woodland Ck	College Regional Stormwater Facility Monitor discharge, if any, for bacteria.	1	City of Lacey	funded	Construction complete October 2007. Addresses College Creek discharges upstream of RM 0.6 - the last major untreated stormwater discharge in Lacey that flows directly to Woodland Creek.
RM 3.45	Set biochemical oxygen demand (BOD) limits for Nisqually Fish Farm #2.	R	Ecology		
WSDOT discharges (2) at Woodland Ck and Interstate 5 RM 3.1	Implement pollution-prevention measures in Storm Water Management Plan to address bacteria concentrations at these state highway storm drains. Monitor to ensure state water quality standards are met.	2	WSDOT		
Woodland Ck RM 2.6-1.6, including Eagle, Palm, and Fox Creeks	Evaluate agricultural operations affecting this reach. Provide technical assistance as needed. (Other potential sources will be evaluated and addressed through the Pollutant Load Reduction Project.)	1	Thurston CD	funded	TCD will start work on this task in early 2008. Farms will be prioritized based on conditions and technical assistance will be provided to those landowners/operators that are cooperative.
	Fox Creek: Investigate low dissolved oxygen and possible sources of biochemical oxygen demand (BOD).	R	Thurston County, Thurston CD		

Source area	Action	Priority*	Lead	Funded?	Implementation status
Woodland Ck RM 1.6 to 0.2 including Quail and Jorgenson Creeks	Investigate possible sources during storm events, including stormwater ponds.	1	Thurston County		
	Investigate sources (on-site and stormwater) on Jorgenson Ck especially above Pleasant Glade Rd.	1	Thurston County		
	Water quality sampling on Quail Ck to determine if changes in agricultural practices have accomplished needed reductions.	2	Ecology		
Woodard Creek					
	Control phosphorus sources to protect or improve dissolved oxygen levels.	R	City of Olympia, Thurston CD, Thurston County		Partially addressed by the Henderson Inlet Watershed Septic System Operations and Maintenance Program and the work of Thurston CD.
	Provide stewardship education to residents in the Woodard Creek area.		Thurston CD, Thurston County	funded	This program has been active in the watershed since 2003 and is currently being expanded.
Taylor Wetland discharge	Stormwater treatment facility for Taylor wetland stormwater discharge. Monitor discharge, if any, for bacteria.	1	City of Olympia	funded	Completed. Facility appears to be well-sized to handle volume of stormwater received.

Source area	Action	Priority*	Lead	Funded?	Implementation status
RM 6.2 – 3.4 (Taylor Wetlands to 36th)	Additional investigation of potential sources is needed: Stormwater. Leaking sewer lines. Homeless camps. Agricultural.	1	Various		
	Water quality monitoring of tributaries RM 5.1 - 3.4.		Ecology		
	Possible microbial source tracking study.	3			
Meyer Creek					
	Technical assistance on livestock management.	1	Thurston CD		
Sleepy Creek					
	Technical assistance on livestock management.	1	Thurston CD		
Dobbs Creek					
	Investigate possible sources at RV park.	1	Thurston County		
	Segmented monitoring to identify source areas.	1	Ecology	yes	Begun summer 2007

Source area	Action	Priority*	Lead	Funded?	Implementation status
Henderson Inlet					
	Long-term trend monitoring of ammonia, nitrogen, and total nitrogen in Woodland Creek.	R			
	Periodically review the operation and planned expansion of Hawks Prairie Water Reclamation Facility, including monitoring data.	R	Ecology	yes	On-going
	Evaluate factors contributing to low dissolved oxygen levels, and determine load and waste load allocations so that the inlet meets water quality standards in the future.	R	Ecology		Ecology is currently conducting a dissolved oxygen study in South Puget Sound. The intent of this study is to collect data and develop models to determine the effects of nitrogen discharges on dissolved oxygen levels in South Puget Sound. If the study shows that something needs be done to protect dissolved oxygen levels in South Puget Sound, either a TMDL or some other plan of action that will result in clean water will be necessary.

Adaptive implementation

Improving water quality is a dynamic process. Following completion of this plan, implementing partners will meet regularly to monitor progress towards goals, evaluate successes, obstacles, and changing needs, and make adjustments to the cleanup strategy as needed. Table 7 will be our guide. Partners may adjust the table as actions or monitoring and changing watershed conditions indicate.

The water quality study and technical advisory group identified the actions in Table 7 as those needed to improve water quality. Priority 1 actions are underway or are considered very important because they will achieve the highest bacteria reductions when initiated. Some actions are designated Priority 2 or 3 because they will result in smaller reductions, or they will be pursued only if higher priority actions fail to achieve necessary reductions.

The Technical Advisory Group anticipates meeting water quality standards by 2018 (i.e., ten years following completion of the *Water Quality Improvement Plan).* Seventy-five percent reduction is anticipated by 2015.

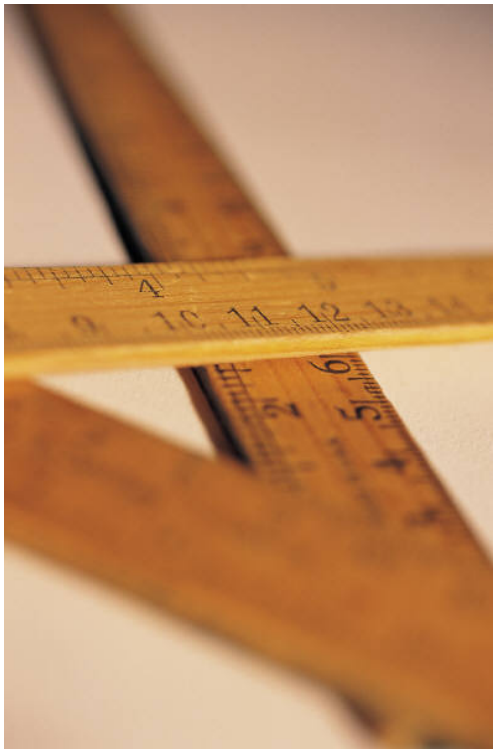
It is ultimately Ecology's responsibility to assure that cleanup is being actively pursued and water standards are achieved.

Funding Opportunities

The programs of each of the involved organizations have some base funding that will contribute to implementing and monitoring costs. But base funding is not adequate to meet the needs. The programs listed below, and possible others, are potential sources of additional funding:

- Centennial Clean Water Fund, Washington State Water Pollution Control Revolving Fund and Federal Clean Water Act Section 319 Funds, administered by Ecology.
- Public Involvement and Education funding from the Puget Sound Partnership.
- Salmon Recovery Funding Board grants and Washington Wildlife and Recreation Program grants from the Washington Interagency Committee for Outdoor Recreation.
- Thurston County's low interest loan program for on-site septic system repair and replacement. Contact Thurston County Environmental Health, 360-754-4111.
- Shellfish District Cost Share Program for agricultural best management practices, administered by Thurston Conservation District (360-754-3588).
- Cost share funding to address agricultural, riparian and shoreline best management practices that affect water quality, administered by Thurston Conservation District (360-754-3588).
- Shellfish District Cost Share Program for inspection, maintenance, and minor repairs of qualifying on-site septic systems, administered by Thurston County (360-754-4111).
- Special grants for stormwater and reclaimed water projects in the Puget Sound area are also available through Ecology. Information is available at http://www.ecy.wa.gov/programs/wq/funding/funding.html.
- Environmental Quality Incentives Program, Conservation Reserve Enhancement Program, and Wildlife Habitat Incentives Program cost-share money from the U.S. Dept. of Agriculture's Natural Resources Conservation Service. These programs are administered through the Conservation Districts as part of conservation planning.
- U.S. Dept. of Agriculture Rural Development, Home Repair Loan and Grant Programs (as authorized by Section 504 of the Housing Act of 1949, 7 CFR Part 3550; contact U.S.D.A. Service Center of Puyallup, Washington, (253-845-0553).

Measuring Progress toward Goals



Monitoring plan

The TMDL water quality study recommended monitoring at the following stations:

Woodland Creek

Wet, Storm-event Season (November - March)

- Stormwater discharge at RM 3.7T
- College Creek at RM 0.4
- WSDOT stormwater discharge at RM 3.1T
- Palm Creek (mouth)
- Fox Creek (near mouth)
- Quail Creek (mouth)
- Woodland Creek at RM 0.2

Dry Season (June - September)

- Eagle Creek (mouth)
- Jorgenson Creek (mouth)
- Woodland Creek at RM 0.2

Woodard Creek

- Woodard Creek at RM 2.9

While not part of the TMDL monitoring, it is also recommended that the stormwater pond outfall to Taylor wetland and Woodard Creek, at RM 6.9, be monitored during the wet season to determine the effectiveness of stormwater treatment upstream of Woodard RM 6.9.

Henderson Tributaries

- Meyer Creek (mouth)
- Sleepy Creek (mouth)
- Dobbs Creek (mouth)
- Goose Creek (mouth)

Henderson Inlet

DOH stations

To determine the effectiveness of cleanup actions on dissolved oxygen, monitoring is recommended at the following stations:

Woodland Creek

Dry Season (June – September)

- Woodland Creek at RM 1.6
- Fox Creek

Woodard Creek

Low-flow Period (August and September)

- Woodard Creek at RM 2.9

While resources do not allow for ongoing monitoring at all of these stations, they will be selectively monitored as cleanup progresses. The technical advisory group will determine who is responsible for monitoring and will direct the priority of locations. The Department of Health samples monthly in Henderson Inlet as part of their regulatory responsibilities for commercial shellfish harvest.

Monitoring will be needed to further identify sources and source areas. This monitoring will include in-stream monitoring as well as field surveys and possibly other forms of investigation (e.g., microbial source tracking). Various entities will participate in this monitoring. Several of these monitoring needs are described in Table 7, some are underway, and additional needs will likely be identified as implementation progresses.

In addition, monitoring is important to assure that implementation actions are maintained. Entities with enforcement authority will be responsible for following up on any enforcement actions. Stormwater permit holders will be responsible for meeting the requirements of their permits. Those conducting restoration projects or installing BMPs will be responsible for monitoring plant survival rates and maintenance of improvements, structures and fencing.

Compliance monitoring will be needed when the technical advisory group believes that water quality standards have been achieved.

Reasonable Assurances

Water cleanup plans are required to show "reasonable assurances" of restoring water quality. The goal of this plan is for the waters of the basin to meet the state's water quality standards. Outreach, technical and financial assistance, permit administration, infrastructure construction and improvements, additional research and monitoring, and enforcement will all be used to ensure that the goals of this water clean up plan are met.

There is considerable interest and local involvement in resolving the water quality problems in Henderson watershed. Ecology believes that the following activities demonstrate strong local commitment to this cleanup effort. They address some of the key issues and add to the assurance that healthy bacteria levels will be achieved in the Henderson Inlet watershed. These activities also support reductions in nutrient levels. This assumes that the activities described below are continued and maintained:

- In the fall of 2005, the Thurston County Board of Health took an essential step for reducing pollution from septic systems by adopting the Henderson Inlet Watershed Septic System Operations and Maintenance Program. This program assures maintenance of septic systems in this watershed, with special attention on systems with a higher risk of polluting.

- Thurston County, working with the city of Lacey, has a grant through Ecology to do a more in-depth analysis of sources of pollution to Woodland Creek, including ground water. They are evaluating unincorporated, urbanized areas that were developed with on-site septic systems at a density far in excess of that allowed under current regulations. Several of the stormwater systems do not make any provision for water quality protection. One of the areas is suspected of being a major source of bacteria to the problematic Martin Way stormwater discharge to Woodland Creek.

  The Woodland Creek project is evaluating current conditions, developing an estimated "budget" of pollutant loading in each subbasin from major sources, and projecting pollution load increases or reductions, assuming various infrastructure improvement and pollution control scenarios. This information will be used to support implementation of the most feasible and effective water quality improvement options, which may include facility designs, pursuit of funding, and/or policy or regulation changes.

- Since the water quality data for this project were collected in 2002-03, the city of Olympia constructed a major stormwater facility adjacent to Taylor wetlands, just south of the Interstate 5. The facility appears to be suitably sized to handle the volume of stormwater it receives. The city will monitor bacteria concentrations in stormwater discharging, if any, to Taylor Wetlands.

- The city of Lacey recently completed a regional stormwater treatment for College Ditch, the last untreated stormwater discharge in the city that flows directly to Woodland Creek.

They will monitor discharge, if any, for bacteria.

- In 2005, the Thurston County Board of Commissioners created advisory committees to develop recommendations to allow/promote LID. Staff responded to challenges to the county's update of the Critical Area Ordinance, so this effort is currently awaiting staff resources to complete the county drainage manual, an important building block of LID standards.

- The city of Lacey is conducting ongoing work to protect and restore the riparian buffer of Woodland Creek. They are planting stream banks on public land, and have grants available to help landowners who want to improve their own stream banks.

- The Thurston Conservation District provides free technical assistance to landowners on land use issues including pet waste, use of native plants in various situations, and manure management. In Henderson Inlet watershed they expanded from their more traditional, livestock-oriented role to include information for a more residential audience. Much of their work focuses on marine and freshwater riparian areas. In some cases, they are also able to help with the cost of practices that improve and protect water quality, such as fencing and riparian plantings.

- Washington Department of Transportation (WSDOT), Thurston County, and the cities of Lacey and Olympia are covered by stormwater municipal National Pollution Discharge Elimination System (NPDES) permits. Stormwater discharges within the permitted area, roughly half of Henderson watershed, are subject to permit requirements. Actions related to stormwater that are identified in this plan will be incorporated into their permits during the next permit cycle.

- The Henderson Inlet Shellfish Protection District citizen advisory group continues to meet and oversee implementation of their work plan, and to coordinate with county staff on major land use initiatives.

- There are a number of on-going and effective outreach activities that support this cleanup effort. Some highlights are:
  - ~ Both the city of Lacey and Thurston County have active Stream Teams, involving citizens in benthic invertebrate monitoring and riparian restoration projects.
  - ~ South Sound Global Rivers Environmental Education Network (GREEN) actively involves students in water quality monitoring and education.
  - ~ Thurston County regularly conducts septic system education as part of its operations and maintenance program.
  - ~ The Thurston Conservation District is helping build awareness about the importance of marine and freshwater riparian areas, and how to restore and maintain them.
  - ~ The county and Conservation District are working together on a watershed pledge project.

- ~ At the request of residents, the city of Olympia has installed Stop and Scoop stations on Woodard Creek, including signs, pet waste collection baggies, and an information rack.
- ~ Thurston County installed pet waste stations at two community parks along Woodland Creek, plus signs at seven homeowner green spaces on Henderson Inlet, with pet waste stations in all but one.
- ~ The city of Lacey installed pet waste stations in all public parks in Henderson Inlet watershed, plus signs and pet waste stations at seven residential neighborhoods in the watershed.
- ~ The Pacific Sound Restoration Fund conducts outreach on pet waste, as well as general water quality education and community outreach at their Henderson Inlet community shellfish farm.
- ~ Every two months, Washington State University (WSU) convenes the Environmental Education Technical Advisory Committee, which serves to coordinate and foster collaborative efforts for the educational activities of the non-profits, jurisdictions and agencies serving the region.

While it is the goal of all participants in the Henderson Inlet watershed water quality improvement process to achieve clean water through voluntary control actions, Ecology, Thurston County, and the cities of Lacey and Olympia have regulatory authority to initiate enforcement actions to achieve compliance with state water quality standards.

Summary of Public Involvement Methods

Members of the technical advisory group have worked together on this project since the beginning. Thurston County and the city of Lacey participated in design of the water quality study and helped with the field work. All members contributed to completing the water quality study report and the water quality implementation report. We have worked together to develop this water quality implementation plan.

Members of the technical advisory group:

- City of Lacey
- City of Olympia
- Puget Sound Action Team
- Puget Sound Restoration Fund
- Thurston Conservation District
- Thurston County
- Squaxin Tribe
- WA Dept. of Ecology
- WA Dept of Health
- WA Dept of Transportation

Ecology conducted a public review of the *Draft Henderson Inlet Watershed Fecal Coliform Bacteria, Dissolved Oxygen, and pH Total Maximum Daily Load, Water Quality Improvement Report, Implementation Strategy* during August 2006. A display ad was published in The Olympian on July 31, 2006 and notice was posted on Ecology's public involvement internet calendar. During the comment period, Ecology posted the draft report and supporting documentation on Ecology's TMDL website and placed documents in local libraries for public review.

Outreach to the community in general includes:

- Ecology briefed the Shellfish Protection District citizens' advisory group of progress and findings. Ecology also presented information on the TMDL study at public meetings sponsored by the Shellfish Protection District Stakeholder Groups.

- Handouts describing the TMDL process were available at the county's public meetings for the Woodland Creek Pollutant Load Reduction Project.

- Ecology published a notice of the comment period in the Olympian on May 16, 2008. The notice included an offer for Ecology staff to meet with interested groups to discuss or present the cleanup plan.

- Ecology published the draft plan online, and made hard copies available for public review at Lacey and Olympia Timberline Libraries.

- Ecology conducted a 30-day comment period on the draft water quality implementation plan that ended on June 16, 2008.

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www.epa.gov/owow/tmdl/overviewfs.html

Appendices

Appendix A. What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act requirements

The Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, each state is required to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards include definitions of uses of the water which will protect shellfish harvest and drinking water supplies, for example, as well as measurements called criteria (usually numbers) to make those uses possible.

Every two years, states are required to prepare a list of water bodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list. To develop the list, Ecology compiles its own water quality data along with data submitted by local state and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before the data are used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides water bodies into one of five categories:

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data available.

Category 4 – Polluted waters that do not require a TMDL because:
- 4a. – Has a TMDL approved and it's being implemented.
- 4b. – Has a pollution control plan in place that should solve the problem.
- 4c. – Impaired by a non-pollutant such as low water flow, dams, culverts.

Category 5 – Polluted waters that require a TMDL –the 303(d) list.

TMDL process overview

The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for each of the water bodies on the 303(d) list. The TMDL identifies pollution problems in the watershed and then specifies how much the pollutant(s) need to be reduced or eliminated to achieve clean water. Then Ecology works with the local community to develop an overall approach to control the pollution, called the Implementation Strategy, and a monitoring plan to assess how well the cleanup strategy is working. Once the TMDL has been approved by EPA, a *Water Quality Implementation Plan* must be developed within one year. This plan identifies specific tasks, responsible parties and a schedule for achieving clean water.

Elements required in a TMDL

The goal of a TMDL is to ensure that the impaired water will meet water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of pollutant(s) that can be discharged to the water body and still meet standards. This amount is called the loading capacity and the TMDL will assign that load among the various sources.

If the pollutant comes from a discrete source (referred to as a point source) such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a wasteload allocation. If that pollutant comes from a set of diffuse sources (referred to as a nonpoint source) such as general urban, residential, or farm runoff, the cumulative share is called a load allocation.

The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth is sometimes included as well. The sum of the wasteload and load allocations, the margin of safety and any reserve capacity must be equal to or less than the loading capacity.

Identifying the contaminant loading capacity for a water body is an important step in developing a TMDL. EPA defines the loading capacity as "the greatest amount of loading that a water body can receive without violating water quality standards" (EPA, 2001). The loading capacity provides a reference for calculating the amount that a pollutant must be reduced to bring a water body into compliance with standards. It consists of two portions, load allocation and wasteload allocation.

By definition, a TMDL is the sum of these allocations, which must not exceed the loading capacity.

TMDL = Loading Capacity = sum of all Wasteload Allocations + sum of all Load Allocations + Margin of Safety

What Part of the Process Are We In?

The Environmental Protection Agency approved *The Henderson Inlet Watershed Fecal Coliform Bacteria, Dissolved Oxygen, and pH Total Maximum Daily Load: Water Quality Improvement Report Implementation Strategy* in January 2007. The technical advisory group began developing the Water Quality Improvement Plan in late 2006. The plan is expected to be finalized in winter of 2007-08.

Appendix B: Organizations' Roles and Responsibilities

This section describes the regulatory authorities, responsibilities, and programs of the groups that will participate in the cleanup of Henderson Inlet watershed. Specific activities for this cleanup are detailed in Table 7

City of Lacey

The city of Lacey's population in 2007 was 35,870. Residential wastewater disposal within the city is a mix of on-site septic systems and sewer connections to LOTT wastewater treatment facilities. Thurston County has jurisdiction over on-site septic systems, both within and outside city limits. Lacey operates the wastewater utility for sewer conveyance to LOTT facilities.

Lacey has development standards that apply to new developments within city limits. In the Urban Growth Area (UGA), development must adhere to city development standards for water and sewer if the development is to be connected to the city's systems. Thurston County has jurisdiction over all other development in the UGA, including stormwater management, but takes comments from city staff who review the development plans. However, the county has final authority in unincorporated areas.

Title 14, Chapter 33 of the Lacey Municipal Code establishes 200' buffers for Woodland Creek within Lacey city limits. New development within Lacey must meet the 1994 Drainage Design and Erosion Control Manual for Lacey. It is part of the city of Lacey's 2005 Development Guidelines and Public Works Standards. Lacey is in the process of updating to a stormwater manual that is technically equivalent to Ecology's 2005 Stormwater Management Manual for western Washington. Implementation of the updated manual should begin in 2009. In addition, Title 14, Chapter 3 (Zero Effect Drainage Discharge) of the municipal code allows for low impact development within the city limits. Lacey is also participating in a region-wide effort to develop low impact development standards and guidelines.

Lacey is covered by the NPDES Phase II Stormwater Permit, which Ecology issued in February 2007. The majority of Lacey's stormwater drains to the Woodland Creek basin. In fall 2007 Lacey completed a regional stormwater treatment facility that now treats stormwater discharges from Lacey which used to flow directly into College Creek, a tributary of Woodland Creek.

Lacey conducts a number of stormwater-related outreach programs. They have a storm pond education program and a stormwater facility inspection program for privately-owned stormwater facilities. Lacey's Stream Team volunteer program includes storm drain stenciling and other pollution prevention education. They are also part of the region-wide pet waste pollution prevention program, which includes brochures, signs, and pet waste stations that are offered to homeowners associations and placed at city-owned facilities.

Lacey is involved in ongoing protection and restoration of the riparian buffer of Woodland Creek. They have "Plant Grants" available for creek side private property owners who want to establish native, riparian buffers. The grants include helping the landowner develop a planting plan, help with labor, and providing plants up to a certain cost. Lacey is also working to plant public land along the creek. Woodland Creek Community Park has been a focus of this effort, where repeated replantings have been challenged by poor soils, vandalism, and wildlife. Lacey

has also purchased a new site near Draham Road, where they are working to reestablish the buffer.

Lacey's ambient monitoring program, started in 2000, provides water quality data for baseline and trend analysis. These data are compared to water quality conditions now and may be used to predict conditions in the near future. Lacey personnel monitor monthly at Woodland Creek at Draham Road, Eagle Creek, and, when flow conditions allow, at Woodland Creek at Martin Way and the outlet of Lake Lois. Measurements include flow, temperature, pH, dissolved oxygen, conductivity, fecal coliform bacteria, and nitrate-nitrogen. Temperature is monitored on Woodland Creek at the Community Park. They completed a habitat assessment of Woodland Creek in 2003, as part of the effort to improve creek conditions for the salmon run. Since 2003, they have conducted observational flow monitoring on the stretch of Woodland Creek between Lake Lois and the springs below Martin Way. This monitoring will continue. The Lacey Stream Team conducts benthic macroinvertebrate monitoring annually at four sites: Woodland Creek at Draham Road, Woodland Creek at Pleasant Glade Road, Fox Creek, and Palm Creek. This data is included in Regional Water Quality Reports produced by Thurston County Environmental Health Division.

City of Olympia

The city of Olympia's Storm and Surface Water Utility is responsible for stormwater management, water quality, and aquatic habitat in the city. Their program includes eight core services: development review, technical assistance/code enforcement, public education and involvement, environmental planning and policy development, capital facilities planning, and monitoring, research and evaluation.

Portions of Woodard and Woodland Creek watershed are located within the city Of Olympia's jurisdiction and its urban growth area (UGA). Approximately 1,246 ac (28 percent) of Woodard basin are in the city limits, and 884 ac (18 percent) are in the UGA. Approximately 155 ac (0.8 percent) in Woodland basin are in the city, and 29 ac (0.2 percent) are in the UGA.

The city of Olympia (with Thurston County) monitors the ambient water quality and benthic macroinvertebrates in each of its streams. Water quality data are available online, www.geodata.org/swater/ , and macroinvertebrate data are published in the Stream Team newsletter. The city of Olympia regularly works with Thurston County on water quality issues throughout the city. The city also actively investigates the sources of pollutants entering streams and stormwater through their Illicit Discharge Detection and Elimination Program and conducts outreach to businesses and residents.

Environmental Protection Agency (EPA)

EPA is responsible for seeing that the federal Clean Water Act is implemented. EPA must approve TMDL. They also provide grant funding for water quality projects.

Henderson Inlet Shellfish Protection District citizen advisory group

In December 2001, the Board of Thurston County Commissioners created shellfish protection districts for Henderson Inlet and the Nisqually Reach because shellfish resources were declining there . The following spring, the commissioners appointed a stakeholder group for each shellfish protection district. The groups developed recommendations to restore water quality in Henderson Inlet and Nisqually Reach. Recommendations submitted to the county commissioners in 2003 included improvements in management of on-site septic systems, stormwater management, agricultural practices, land use, and wildlife.

The Henderson and Nisqually Shellfish Protection District stakeholders groups recommended that the two groups be combined and work on an implementation work plan began. That plan is available at http://www.co.thurston.wa.us/shellfish/.

In December 2003, the combined shellfish protection district stakeholder group became the core members of a larger citizen advisory committee to help develop a risk-based operation and maintenance program for on-site septic systems in the Henderson Watershed. The program was started in response to degrading water quality in Henderson Inlet and to the results of a Henderson Inlet DNA-typing study which showed that human waste is contributing to the problem. In the fall of 2005, the Thurston County Board of Health passed the Septic System Operation and Maintenance Proposal for Henderson Inlet Watershed.

The group continues to meet and oversee implementation of their work plan and issues affecting bacteria in Henderson Inlet. Their work, along with the *Henderson Watershed Total Maximum Daily Load Study*, will provide the foundation of the detailed cleanup plan for Henderson Inlet.

Natural Resources Conservation Service (NRCS)

The NRCS works in partnership with Pierce and Thurston Conservation Districts to improve water quality and conservation. Resources are targeted to address water quality priorities identified through local processes including watershed planning, Department of Health surveys, and TMDLs. The NRCS administers all of the programs in the 2002 Farm Bill, including:

- Conservation of Private Grazing Land Initiative.
- Conservation Reserve Program.
- Conservation Security Program.
- Conservation Technical Assistance.
- Environmental Quality Incentives Program.
- Emergency Watershed Protection Program.
- Farm and Ranch Lands Protection Program.
- Grassland Reserve Program.
- Plant Material Program.
- Resource Conservation and Development Program.
- Snow Survey and Water Supply Forecasts Program.

- Soil Survey Programs.
- Technical Service Providers.
- Wetlands Reserve Program.
- Wildlife Habitat Incentives Program.

These programs are available to landowners in both Pierce and Thurston counties. Several of the programs provide cost-share incentives to landowners who commit to implementing certain conservation practices. For more information on Farm Bill programs, go to:

www.wa.nrcs.usda.gov/programs/index.html.

In addition to these programmatic resources, the NRCS provides staff time and technical expertise to support restoration efforts.

Puget Sound Restoration Fund

Puget Sound Restoration Fund (PSRF) is a nonprofit organization founded in 1997 and dedicated exclusively to achieving restoration of habitat and native species in Puget Sound. As a project-oriented, non-activist organization, PSRF has pioneered new approaches to the restoration of prime shellfish growing areas, launched regional efforts to restore marine species of historic and ecological significance and collaborates with diverse tribal, government, and private partners to restore local places that support real resources.

PSRF co-manages a community shellfish farm on Henderson Inlet in partnership with the Pacific Coast Shellfish Growers Association on property owned by Washington State University. The farm serves as a marine education facility, hosting shoreline tours for hundreds of school children every year, as well as providing hands-on connections between citizens and shellfish resources during community harvest events. It also provides a focal point for environmental education about pet waste and other sources of bacterial contamination.

In 2003, Governor Locke honored Geoff Menzies, manager of PSRF's Drayton Harbor Community Oyster Farm, and Betsy Peabody, executive director of PSRF, as "local heroes" for their efforts in restoring Puget Sound shellfish growing areas. In August 2005, PSRF's native oyster restoration project was one of 30 projects from around the nation showcased at the White House Conference on Cooperative Conservation as premier examples of cooperative conservation. In October 2005, the state Department of Ecology awarded PSRF with an Environmental Excellence Award – the state's highest for environmental stewardship - for efforts to connect people's actions to clean water in Henderson Inlet and elsewhere in Puget Sound.

Thurston Conservation District

Thurston Conservation District under authority of Ch. 89.08 RCW, Conservation Districts, provides education and technical assistance to residents, develops conservation plans for farms, and assists with design and installation of best management practices. When developing conservation plans, the district uses guidance and specifications from the U.S. Natural Resources

Conservation Service. Farmers who receive a Notice of Correction from Ecology will normally be referred to Thurston Conservation District for assistance.

Thurston Conservation District is funded by a county-wide district assessment, in accordance with Chapter 89.08.400 RCW. The district assessment excludes properties within the city limits of Yelm, Tenino, and Rainier, as those cities were formed before 1948 and chose to be excluded, per the RCW. Currently, 28 percent of the district's tax assessment is dedicated to project work in the Shellfish Protection District. The district regularly receives funding from the Conservation Commission, and grants funding from Ecology, the Salmon Recovery Funding Board, and others.

In addition to conservation planning, technical and cost-share assistance to landowners, the Conservation District has a yearly native plant sale and provides a majority of the funding for South Sound GREEN, a student-based volunteer monitoring and education program.

They also coordinate the Shellfish Pledge Program, an incentive-based program that is geared toward both urban and rural landowners.

Thurston County

Thurston County has maintained a county-wide ambient surface water monitoring program for over 15 years. The program tracks flow, macroinvertebrates, and ambient water quality. At any given time, the program includes approximately 20 sites on major and priority streams and rivers, with site selection being somewhat adaptive based on issues, needs, and funding. In the north part of Thurston County, the program is funded by the stormwater utility.

The Thurston County Storm and Surface Water Utility was created in 1985 to help curb flooding and pollution problems caused by stormwater runoff. It is funded by fees from residents who own property in unincorporated Thurston County within the utility rate boundary. The utility reduces pollution and flooding damage through a combination of capital facilities, public-education, facility operations and maintenance, and drainage and erosion control standards for new development. Some areas of Thurston County are covered under the Phase II NPDES stormwater permit, issued in February 2007.

During 1999-2000, Thurston County used Ecology grant funds to conduct a microbial source tracking study to discern pollutant source types in Henderson Inlet and Woodland Creek. The results of this study have helped the county prioritize water quality work and will help in the ongoing cleanup effort. The study is available online at:

http://www.co.thurston.wa.us/shellfish/publicationsmedia.htm.

The county also participated in water quality monitoring as part of the Henderson TMDL water quality study.

The county regulates land use in unincorporated areas through a Critical Areas Ordinance (Ch. 18E.60.050), in accordance with Washington State's Growth Management Act, Ch. 36.70A. They are currently updating the ordinance. The update proposes wider buffer requirements along

all classes of streams, as well along marine shorelines. The county has created a low impact development steering committee to investigate whether low impact development regulations and standards should be developed. Minimum on-site requirements are established by Washington Department of Health (DOH) in Chapter 246-272A WAC, and the county has established further standards under Article IV of the Thurston County Sanitary Code. County compliance staff deals with on-site failures, usually in response to complaints. In addition, the county health department conducts on-site investigations. These investigations are usually grant-funded, and conducted in response to known problems with specific geographic focus. Thurston County maintains a loan fund for repairing failing or failed on-site septic systems, or correcting a failing or failed on-site system (with connection to municipal sewer service where available). They will administer the Septic System Operations and Maintenance Program.

Under Article VI, 4.2, of Thurston County Sanitary Code domestic animal waste must be prevented from washing into surface water and cannot be applied at rates exceeding agronomic rates. In addition, pet waste cannot be intentionally dumped in ways that will affect surface or storm water.

Washington Department of Ecology (Ecology)

Washington State Department of Ecology has responsibility under the federal Clean Water Act to establish water quality standards, coordinate water cleanup projects (TMDLs), and enforce water quality regulations under the Water Pollution Control Act (Chapter 90.48 RCW). In addition to this regulatory role, Ecology gives grants and loans to local governments, tribes, conservation districts, and citizens groups for water quality projects. Projects that support water cleanup plans for TMDLs are a high priority for funding.

When non-dairy agricultural problems occur, farmers are typically referred to conservation districts for technical assistance, after Ecology confirms that surface water pollution is the result of poor farm management practices. If necessary, Ecology can require specific actions such as implementation of an approved farm plan to correct the problem, using the authority of Ch. 90.48 RCW.

Ecology administers stormwater municipal NPDES Phase I and II permits, including a permit for the Department of Transportation.

Washington Department of Health (DOH)

The Department of Health (DOH), under authority of Ch. 43.70 RCW, monitors marine water quality in commercial shellfish growing areas of the state, including Henderson Inlet. In the past, DOH has downgraded commercial shellfish classification in areas of Henderson Inlet because fecal coliform levels were higher than public health-based water quality standards. Currently, one sampling station is under threatened status and there are several stations of concern due to elevated bacteria levels. DOH continues to monitor water quality in the Inlet at least twelve times per year.

Washington State Department of Transportation (WSDOT)

WSDOT is responsible for managing stormwater from state highways and implements their Storm Water Management Plan which describes a range of best management practices. These practices are applied to new development, and are retrofitted to existing facilities as needed.

Washington State University (WSU) Extension

WSU water quality programs in Thurston and Mason counties use practical approaches to provide better protection of water resources. Primary program efforts include:

- The WSU Water Resources Real Estate Professional Education program provides information to associates, brokers, developers, and appraisers about water resource issues. The purpose is to help these real estate professionals and their clients make sound decisions about landscape development. Local experts provide information about local issues and related best available science, as well as how water resources can be protected through technical assistance or through legal action. Courses can be used as credit for professional license re-certification. In the past year (identify the year) a total of 220 participants were involved.

- The Native Plant Salvage Project is directly affiliated with WSU Extension, however, funding is provided by local jurisdictions, grants, state, and federal agencies. The program educates residents and developers about retaining vegetation to reduce stormwater, increase groundwater recharge, provide filtration and reduce pesticide use. The program has involved over 1200 individuals in its educational programs during the past year and has 250 volunteers.

  Every other month, (or Six times a year,) WSU convenes the Environmental Education Technical Advisory Committee, which coordinates and fosters collaboration of the educational activities of the non-profits, jurisdictions, and agencies serving the region.

Appendix C. Woodland Creek Temperature Recommendations for Reach between Beatty Springs and Henderson Inlet

Introduction

Originally, the Woodland Creek Temperature TMDL analysis included a model of the existing and potential riparian vegetation in order to set shade load allocations so that the system would meet temperature standards. In Upper Woodland Creek (from the outlet of Long Lake to just downstream of Martin Way), the amount of achievable shade alone is predicted to be insufficient to meet temperature standards. The upper segment of Woodland Creek experiences low and no flow conditions during a majority of the year. In addition, stream flow in these portions of the creek is derived from a series of shallow lakes which frequently reach temperatures of 24°C during the summer months.

The analysis did not investigate the influence of hydrology, including the interaction of groundwater or the impacts of groundwater withdrawals, on stream flow dynamics and stream temperatures in Woodland Creek. It did not include a model to predict the natural/background temperature condition of the system. Therefore, before a TMDL for temperature can be established for Woodland Creek, a background/natural temperature condition for the upper portion of Woodland Creek, from Long Lake to Beatty Springs must be determined. Then the temperature TMDL, including Load Allocations and Wasteload Allocations, can be established.

Lower Woodland Creek, between Beatty Springs and the mouth, meets the Class AA temperature standard of 16°C. The data listed in the Henderson Inlet TMDL clearly demonstrates that water temperatures in lower Woodland Creek are stabilized by inflow from the numerous springs and groundwater-fed tributaries and a well-established riparian zone along most reaches. However, in order to continue meeting water quality standards in the future, effective shade recommendations were developed. Finally, wasteload allocations were established for the Nisqually Trout Farm and for all existing and future stormwater sources of pollution which enter this reach of Woodland Creek.

Applicable Water Quality Criteria

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

Woodland Creek and tributaries are designated Class AA (extraordinary) as defined by the Water Quality Standards for Surface Waters of the State of Washington (Hicks, 2000; Chapters 173-201A-030 and 173-201A-120 WAC).

The water quality standards establish beneficial uses of waters and incorporate specific numeric and narrative criteria for parameters such as water temperature. These criteria are intended to define the level of protection necessary to support characteristic uses (Rashin and Graber, 1992). The characteristic uses of the waters in this specific area are:

- *Recreation:* fishing and swimming.
- *Fish and Shellfish:* anadromous salmonid species in the basin including chinook salmon, chum salmon, coho salmon, and steelhead trout.
- *Water Supply & Stock Watering:* agriculture extracts water for irrigation and stock watering.
- *Wildlife Habitat:* Riparian areas are used by a variety of wildlife species which are dependent on the habitat.

The water quality standards establish values for temperature to protect these characteristic uses. The intent of the water quality standards is that human alterations of the watershed, or direct discharges to the water body, shall not cause the established criterion for any parameter to be exceeded. This study found that the Woodland Creek basin has been significantly altered by human activity (e.g., forest clearing for agriculture, timber harvest and development, clearing and degradation of riparian zones, changes in the historic flow regime, and decreases in groundwater recharge). This altered state, combined with what may be natural conditions in the system, has caused temperatures greater than the current temperature criterion of 16.0°C for this Class AA water body at many locations.

Under these conditions, the temperature criterion in the water quality standards for Class AA waters are in effect:

"Numeric water quality criteria for Class AA freshwater streams state that temperature shall not exceed 16.0℃ due to human activities. When natural conditions exceed 16.0℃, no temperature increases will be allowed which will raise the receiving water temperature greater than 0.3℃".

"If natural conditions are below 16.0℃, incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8℃ or bring the stream temperature above 16.0℃ at any time (Chapter 173-201A-030 WAC)".

The July 2003 proposed temperature standards do not use the Class AA and A distinction but depend on whether streams are or could be salmonid or trout core-rearing or non-core-rearing water bodies. However, streams that were previously identified as Class AA are designated as salmonid or trout spawning, core rearing, and migration streams, and must not exceed a seven-day average maximum temperature threshold of 16°C. (The previous standard also used 16°C, but as the instantaneous maximum temperature – this information makes the previous sentence confusing. Is it necessary here?). Streams that were previously identified as Class A are designated as salmonid or trout spawning, non-core rearing, and migration and must not exceed a

seven-day average maximum temperature threshold of 17.5°C. This project evaluates the ability to meet the standards in effect at the time the report is written.

Temperature is a water quality concern because most aquatic organisms, including salmonids, are "cold-blooded" and are strongly influenced by higher water temperature (Schuett-Hames et al. 1999). Temperature is a concern in Woodland Creek because coho use it as a migration corridor and as spawning and rearing habitat. However, since 89 percent of the coho found in Woodland Creek are hatchery fish (Squaxin Island Tribe, 2001), the potential impacts are somewhat less damaging. Elevated temperature and altered flow regime, resulting from various land use activities, such as agriculture, and urban development in the area, limit the available spawning and rearing habitat for coho salmon and other anadromous salmonids.

Ecology 2002 Temperature Monitoring

Water and air temperatures in the Woodland Creek watershed were monitored continuously during the summer and fall of 2002. The Quality Assurance Project Plan (Zalewsky, 2002) describes the data collection program and methods.

Eleven mainstem and three tributary monitoring stations were established within the study area (Figure 1). Figure 2 summarizes the maximum daily temperatures in Woodland Creek and tributaries on the hottest day of 2002 at each station. Figure 3 summarizes the maximum 7-day averages of daily maximum temperatures in Woodland Creek and tributaries during 2002. As expected, stream temperature regimes within the upper portion of Woodland Creek from Martin Way to the outlet of Long Lake are markedly different than those in the lower section of the Creek downstream of Beatty Spring.

Lower Woodland Creek

All mainstem and tributary stations located within the lower portion of Woodland Creek, between Beatty Springs and the mouth, met the Class AA temperature standard of 16°C (Figure 4). The only exception to this was Fox Creek, where daily maximum temperatures over 16°C but below 17°C were recorded. Maximum daily stream temperatures in Fox Creek exceeded the Class AA standard of 16°C (highest value was 16.8°C) on nine of the 108 days sampled, however this station was located just downstream of a wetland area and water temperatures appear to experience the natural heating typically associated with these conditions.

The data clearly demonstrate that water temperatures in lower Woodland Creek are stabilized by inflow from the numerous springs and groundwater-fed tributaries. The average outflow temperature of Beatty Spring between May and September was 11.7°C. Flow from Beatty Spring during this same time period averages 49 percent of the measured flow at the mouth of Woodland Creek. Maximum stream temperatures in Eagle Creek and Jorgensen Creek, at 14.1°C and 11.9°C respectively, were well below the Class AA criteria. In situ temperature measurements in Quail Creek and other springs and seeps within this reach averaged 10 to 14°C.

Station WC01, located at Hawks Prairie Road exhibited the highest stream temperatures during the study period. Closer examination of the data revealed that the temperature sensor at this station was placed at a location which went dry at low tide. Consequently, air temperature, not

water temperature, was being measured. Further, since this station is tidally impacted, the temperature regime is controlled to a large extent by the inflow of marine water. Effective shade recommendations for this station were not made because of the marine influence and the sensor location.

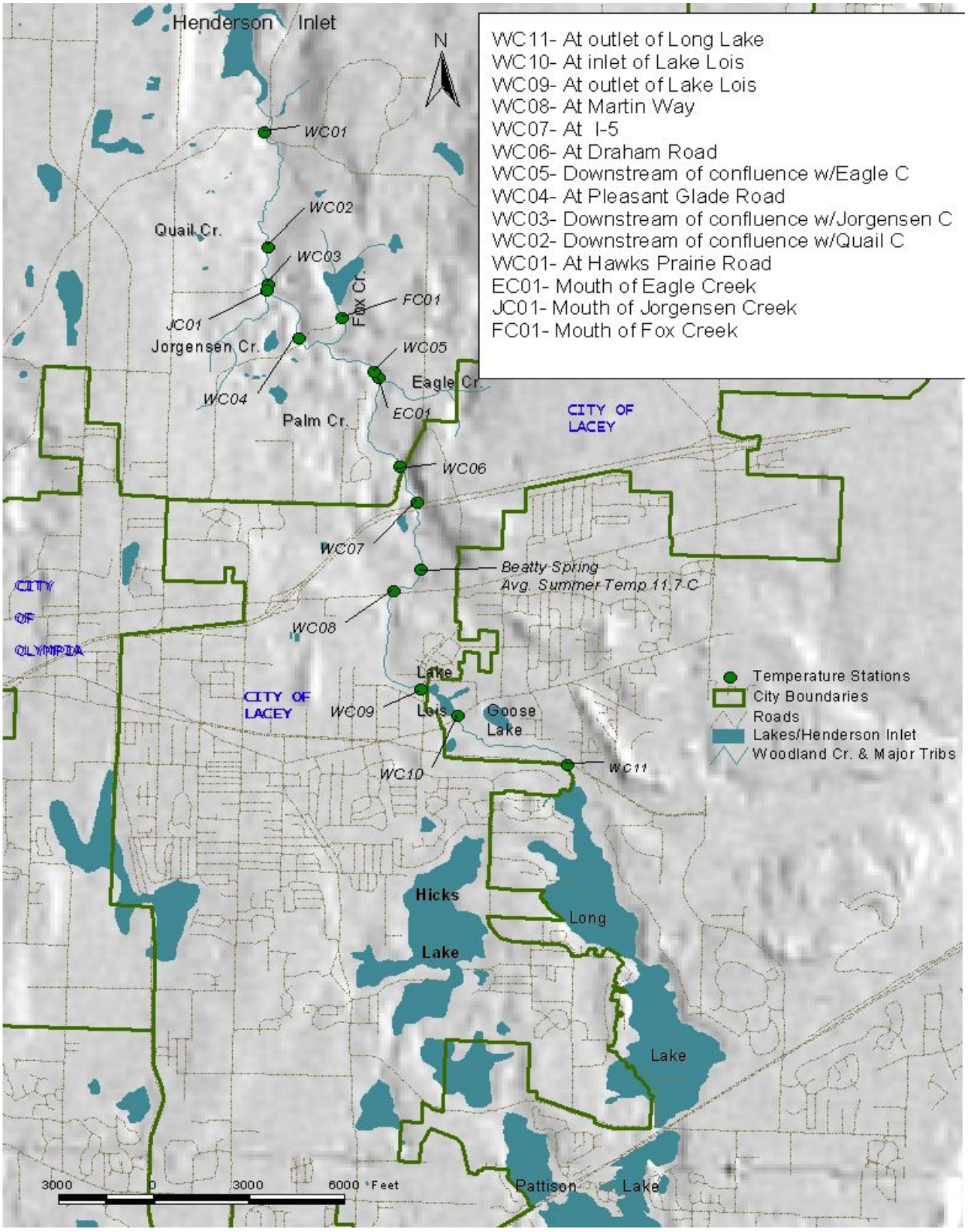

Figure 1. Ecology 2002 Temperature Monitoring Sites in the Woodland Creek watershed.

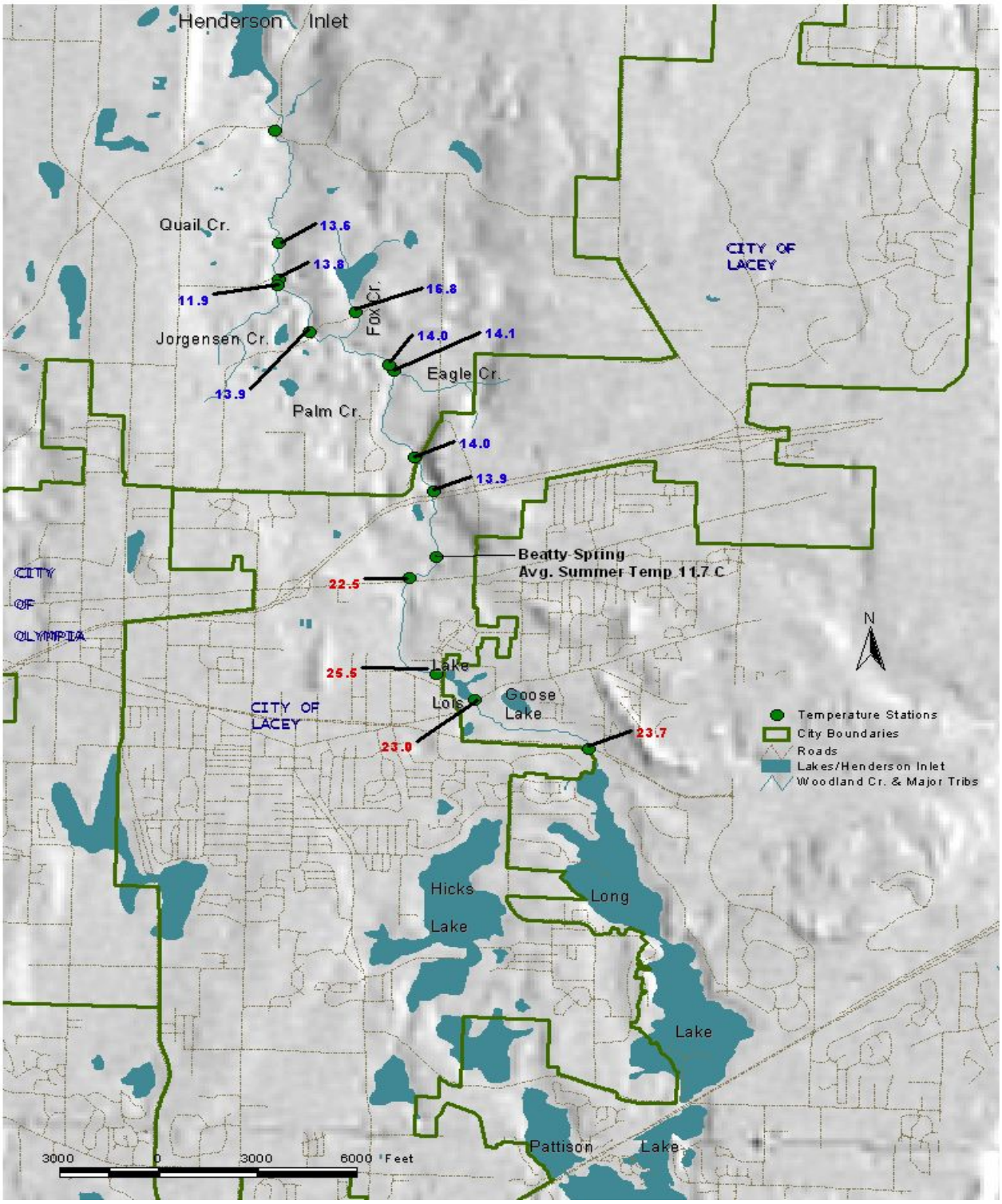

Figure 2. Maximum daily temperatures in Woodland Creek and tributaries in 2002 on the hottest day of the year at each station. Exceedences of the numeric temperature criterion of 16°C are shown in red.

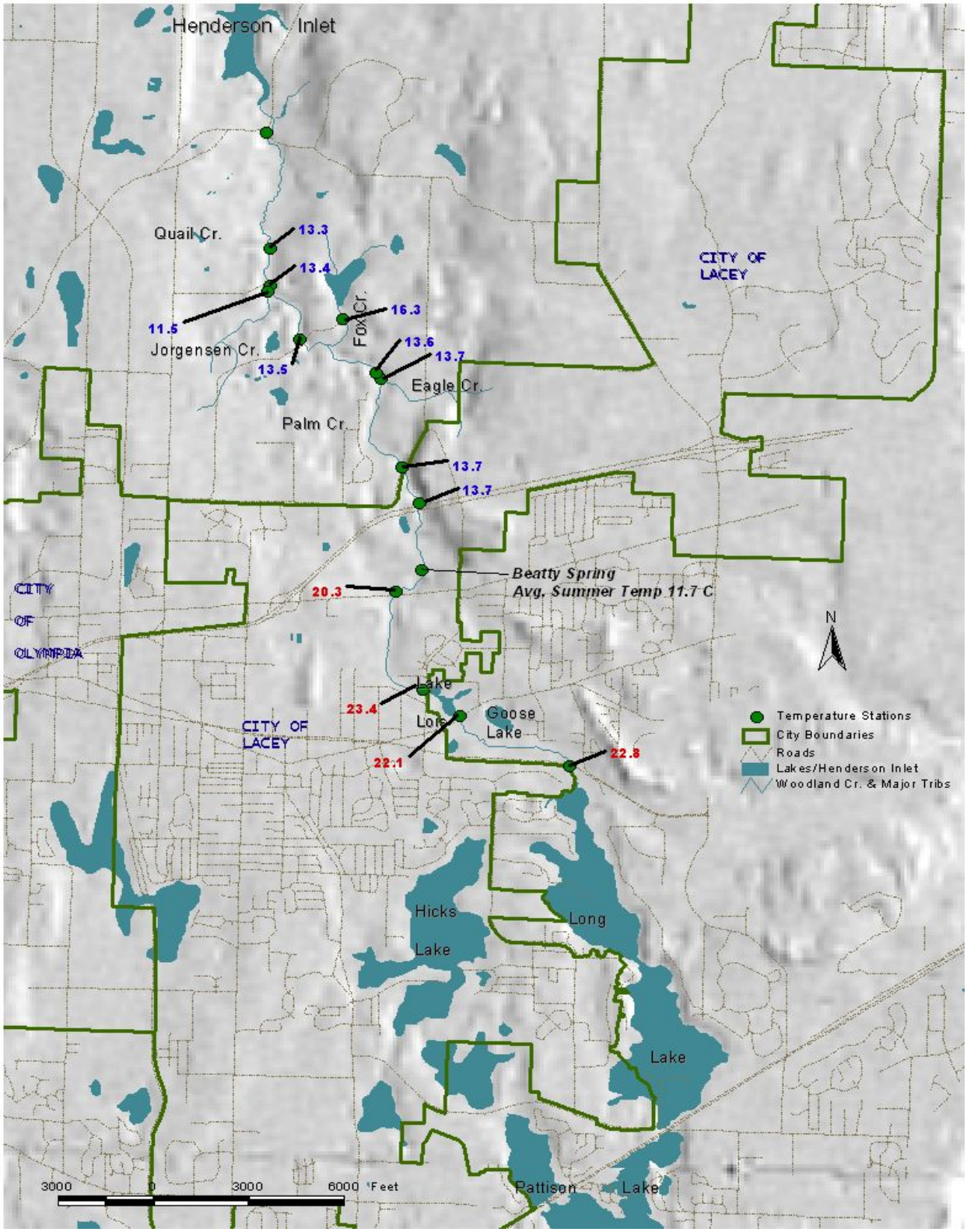

Figure 3. Maximum 7-day averages of daily maximum temperatures in Woodland Creek and tributaries in 2002.

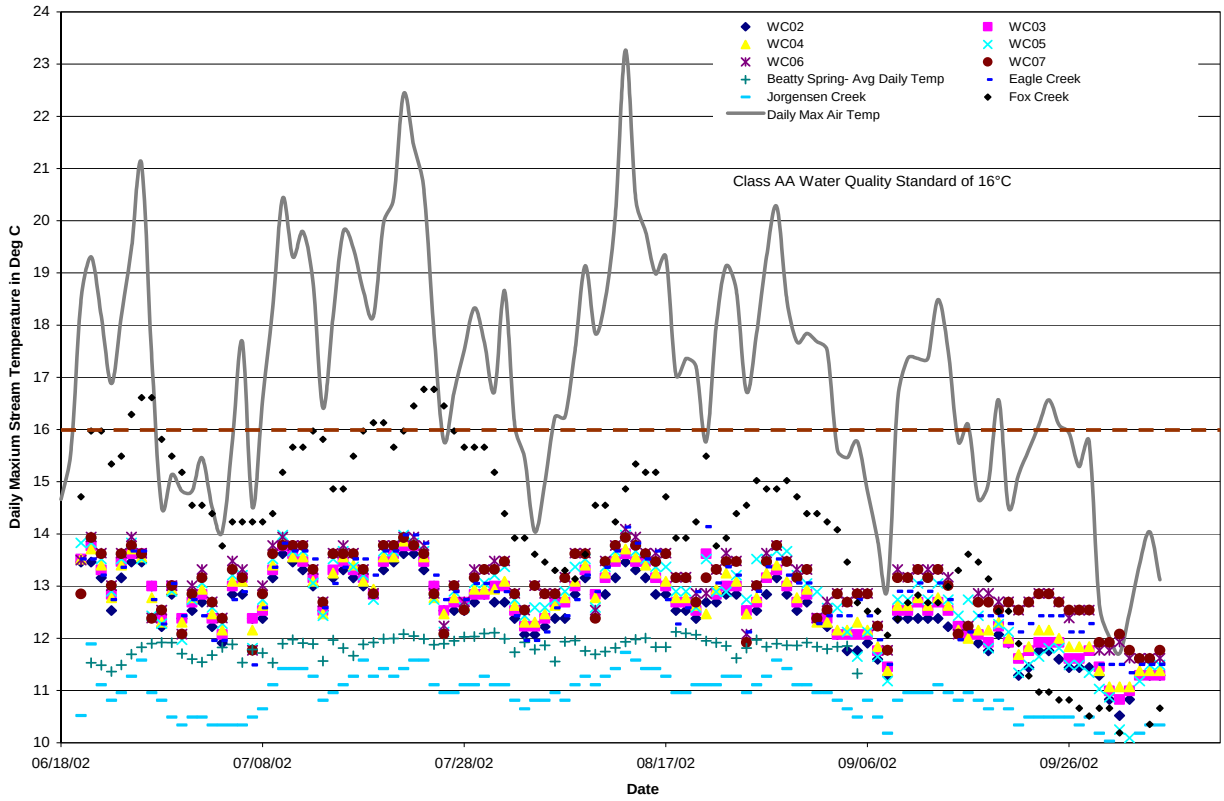

Figure 4. Stream Temperature Profiles in Lower Woodland Creek.

Effective Shade Technical Analysis

The technical analysis for temperature in Woodland Creek focuses primarily on documentation of the current temperature and flow regime, and on effective shade. Effective shade is defined as the fraction of the potential solar shortwave radiation that is blocked by vegetation and topography before it reaches the stream surface. Effective shade is a function of several landscape and stream geometric relationships. Some of the factors that influence effective shade include the following:

- Latitude and longitude.
- Time of year.
- Stream aspect and width.
- Vegetation buffer height, width, overhang, and canopy density.
- Topographic shade angles.

Riparian height, width, and density describe the physical barriers between the stream and sun that can attenuate and scatter incoming solar radiation (i.e., produce shade). The sun's position has a vertical component (i.e., altitude) and a horizontal component (i.e., azimuth) that are both functions of time/date (i.e., solar declination) and the earth's rotation (i.e., hour angle). While the interaction of these shade variables may seem complex, the math that describes them is relatively straightforward geometry, much of which was developed decades ago by the solar energy industry.

Percent effective shade is perhaps the most straightforward stream parameter to monitor or calculate and is easily translated into quantifiable water quality management and recovery objectives. Using solar tables or mathematical simulations, the potential daily solar load can be quantified. The measured solar load at the stream surface can easily be measured with hemispherical photography or estimated using mathematical shade simulation computer programs (Boyd, 1996).

Effective shade was calculated for Woodland Creek using the Shade Model developed by the Oregon Department of Environmental Quality (ODEQ, 2000) and modified by Ecology (2003). Effective shade calculations were verified with field data. Table 1 illustrates the accuracy of the effective shade calculations compared to hand-held densiometer measurements.

Table 1. Comparison of calculated and measured effective shade.

Station	Average Calculated Effective Shade (%) using Shade Model	Average Effective Shade (%) Calculated from Densiometer Measurements	Percent Difference
WC08	97.2	100	1.8
WC06	87.3	93	6.1
WC05	87.8	93	5.6
WC04	86.2	84	2.6
WC03	79.3	74	7.2
WC02	73.6	76	3.2
		AVERAGE % DIFFERENCE	**6.8**

At one time, forests of Western hemlock, Western red cedar, and Douglas fir covered approximately two-thirds of the watershed area (Thurston County, 1993). Much of the original forest was cut in the late nineteenth century, and much of the resulting second growth Douglas fir was cut again in the past 50 years.

Riparian vegetation characteristics, including height and density, were used to estimate current effective shade along the mainstem of Woodland Creek. Vegetation polygons were estimated from the most recent orthophotos[1] within 300 ft (91 m) of the centerline of Woodland Creek. Vegetation species, height, and canopy cover categories were assigned to each polygon, based on visual interpretation and field observations during the habitat surveys. Polygon attributes were verified or refined in the field using observations of vegetation type and a laser range finder for vegetation height at all accessible locations. Densiometer readings were also taken at two to three cross-sections upstream of each temperature monitoring location.

Riparian vegetation size and density was sampled at 162-foot intervals (50 m intervals) along the mainstem of Woodland Creek using the TTools Extension for ArcView that was developed by ODEQ (2001). At each stream transect location, the vegetation grid was sampled orthogonal to the stream at 14 ft (4.6 m) wide riparian zone intervals starting at the wetted edge and

[1] Woodland Creek riparian zone orthophotos were available from Thurston County, WA. The 2001 imagery covered the entire Woodland Creek riparian zone, from the mouth to Hicks, Pattison, and Long Lakes.

progressing to 135 ft (41 m) from each side of the stream. Other spatial data calculated at each transect location include stream aspect, as well as topographic shade angles to the west, south, and east. Stream widths were determined from field measurements taken during Ecology stream surveys.

Effective shade was calculated for two scenarios of vegetation:

- Current riparian vegetation based on field and spatial data for height and canopy density.
- Maximum effective shade from fully established 100-yr old riparian vegetation. Vegetation heights for riparian vegetation were obtained using soil site index (SI) information, which was taken from the Soil Survey of Thurston County, WA (USDA 1990) (Table 2). SI is a measure of the potential productivity of a site and is based primarily on soil conditions. SI for a soil is typically given for 50 and 100 years and describes, among other things, the dominant tree species, and heights of the dominant tree species found on that site.

Table 2. Vegetation characteristics for riparian soil types in Woodland Creek (USDA, 1990).

	Distance downstream	Common Tree	Soil	100-yr SI (m)	100-yr SI (m)	Height (m) of
Landmarks	**from headwaters in m**	**Species**	**Type**	**Red Alder**	**Douglas Fir**	**tallest trees**
Beatty Springs (3500 m)	3200-3950	Douglas fir, Red Alder	Schneider very gravelly loam		46	46
	3950-4704	Douglas fir, Red Alder	Hoogdal silt loam		51	51
	4704-5856	Douglas fir, Red Alder	Giles silt loam		53	53
	5856-7707	Red alder, W. Red cedar	Bellingham silty clay loam	37		37
Henderson Inlet	7707-9009	Salt tolerant grasses	Hidraquents, tidal	na	na	na

Figure 5 presents predicted effective shade along Woodland Creek from just downstream of Martin Way near Beatty Spring to Henderson Inlet near Hawks Prairie Road. Lower Woodland Creek is fairly heavily vegetated with second and third- growth forests and dense stands of alder and maple within the riparian zone. Riparian openings do exist and are located primarily within residential areas. Current effective shade ranges from 33 to 94 percent and indicates areas where vegetation has been cleared and where topographic shading has an influence on the stream channel. Future riparian vegetation differs little in species type and height compared to current vegetation. Canopy densities within this reach were adjusted from 80 percent to 85 percent to reflect a greater canopy closure, which was assumed to develop with time.

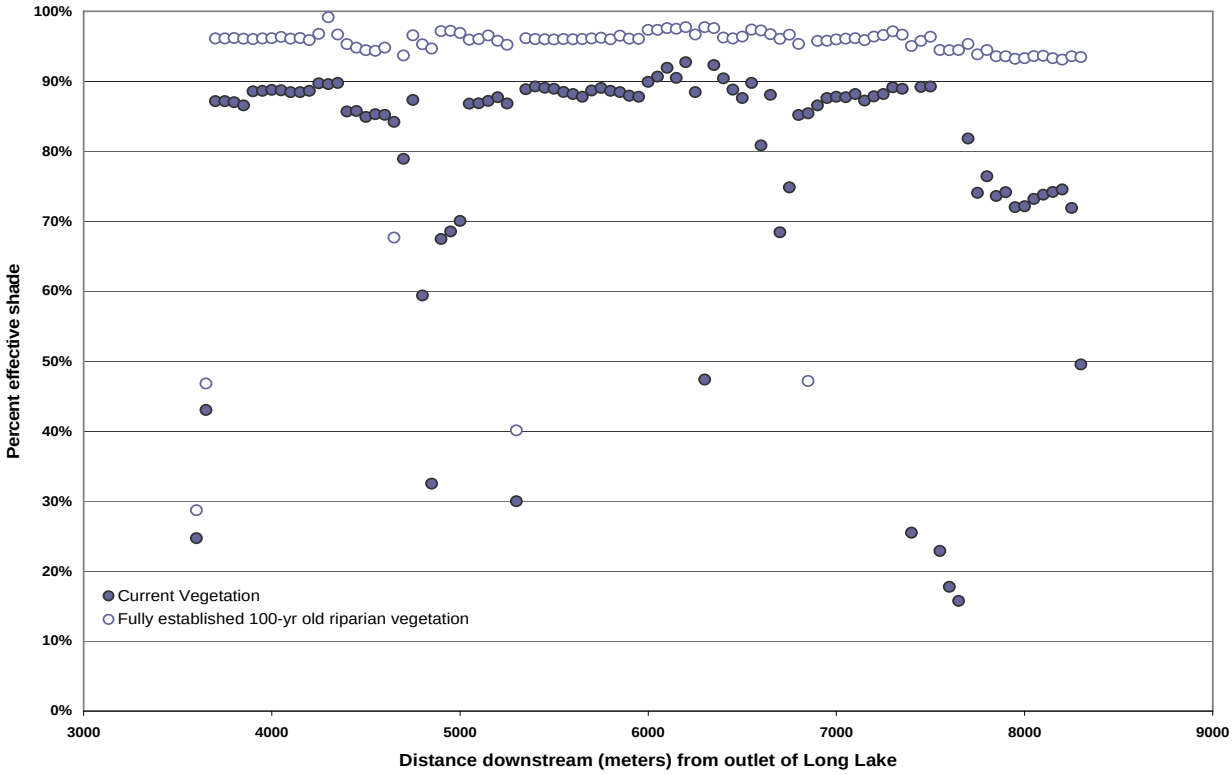

Figure 5. Current and future condition riparian effective shade for Woodland Creek from just downstream of Beatty Spring to the zone of tidal influenced vegetation near Hawks Prairie Road.

Effective Shade Recommendations

The canopy is very important as a means of intercepting sunlight and reducing the energy that is transferred to the surface of the stream. The thicker and taller the canopy, the less direct solar energy reaches the water surface over the course of the day.

A secondary consequence of near stream vegetation is its effect on the riparian microclimate. Riparian corridors often produce a microclimate that surrounds the stream where cooler air temperatures, higher relative humidity, and lower wind speeds are characteristic. Riparian microclimates tend to moderate daily air temperatures by decreasing daily maximum temperatures and increasing daily minimum temperatures. Increases in relative humidity result from evapotranspiration that occurs in the riparian plant communities. Wind speed is reduced by because the riparian vegetation physically blocks air movement, to a certain extent.

Recommendations for effective shade were developed for Woodland Creek between Beatty Springs and Henderson Inlet. Targets are suggested for this reach of the creek, which meets Class AA water quality criteria, to prohibit degradation in the future. These effective shade targets are the effective shade that would result from fully established 100-year old riparian vegetation (Table 3 and Figure 6).

Table 3. Recommendations for effective shade in Woodland Creek mainstem from Martin Way to Henderson Inlet (Reach 3). NOTE: percent signs in the table below are not necessary.

River Mile (distance from mouth)	Distance in meters from outlet of Long Lake	Current condition average effective shade (percent)	Load Allocation for effective effective shade on August 1 (percent)
2.9	3600	25	29
	3650	43	47
	3700	87	96
2.75	3750	87	96
	3800	87	96
	3850	87	96
	3900	89	96
	3950	89	96
	4000	89	96
	4050	89	96
	4100	88	96
	4150	88	96
2.5	4200	89	96
	4250	90	97
	4300	90	99
	4350	90	97
	4400	86	95
	4450	86	95
	4500	85	94
	4550	85	94
2.25	4600	85	95
	4650	84	85
	4700	79	94
	4750	87	97
	4800	59	95
	4850	33	95
	4900	68	97
	4950	69	97
2.0	5000	70	97
	5050	87	96
	5100	87	96
	5150	87	97
	5200	88	96
	5250	87	95
	5300	30	40
	5350	89	96
1.75	5400	89	96
	5450	89	96
	5500	89	96
	5550	89	96
	5600	88	96
	5650	88	96
	5700	89	96
	5750	89	96
1.5	5800	89	96

Table 3. Continued. Recommendations for effective shade in Woodland Creek mainstem from Martin Way to Henderson Inlet (Reach 3).

River Mile (distance from mouth)	Distance in meters from outlet of Long Lake	Current condition average effective shade (percent)	Load Allocation for effective effective shade on August 1 (percent)
	5950	88	96
	6000	90	97
	6050	91	97
	6100	92	98
	6150	91	98
1.25	6200	93	98
	6250	88	97
	6300	47	98
	6350	92	98
	6400	90	96
	6450	89	96
	6500	88	96
	6550	90	97
1.0	6600	81	97
	6650	88	97
	6700	68	96
	6750	75	97
	6800	85	95
	6850	85	86
	6900	87	96
	6950	88	96
0.75	7000	88	96
	7050	88	96
	7100	88	96
	7150	87	96
	7200	88	96
	7250	88	97
	7300	89	97
	7350	89	97
0.5	7400	26	95
	7450	89	96
	7500	89	96
	7550	23	94
	7600	18	94
	7650	16	95
	7700	82	95
	7750	74	94
0.25	7800	76	95
	7850	74	94
	7900	74	94
	7950	72	93
	8000	72	93
	8050	73	94
	8100	74	94
	8150	74	93
0	8200	75	93

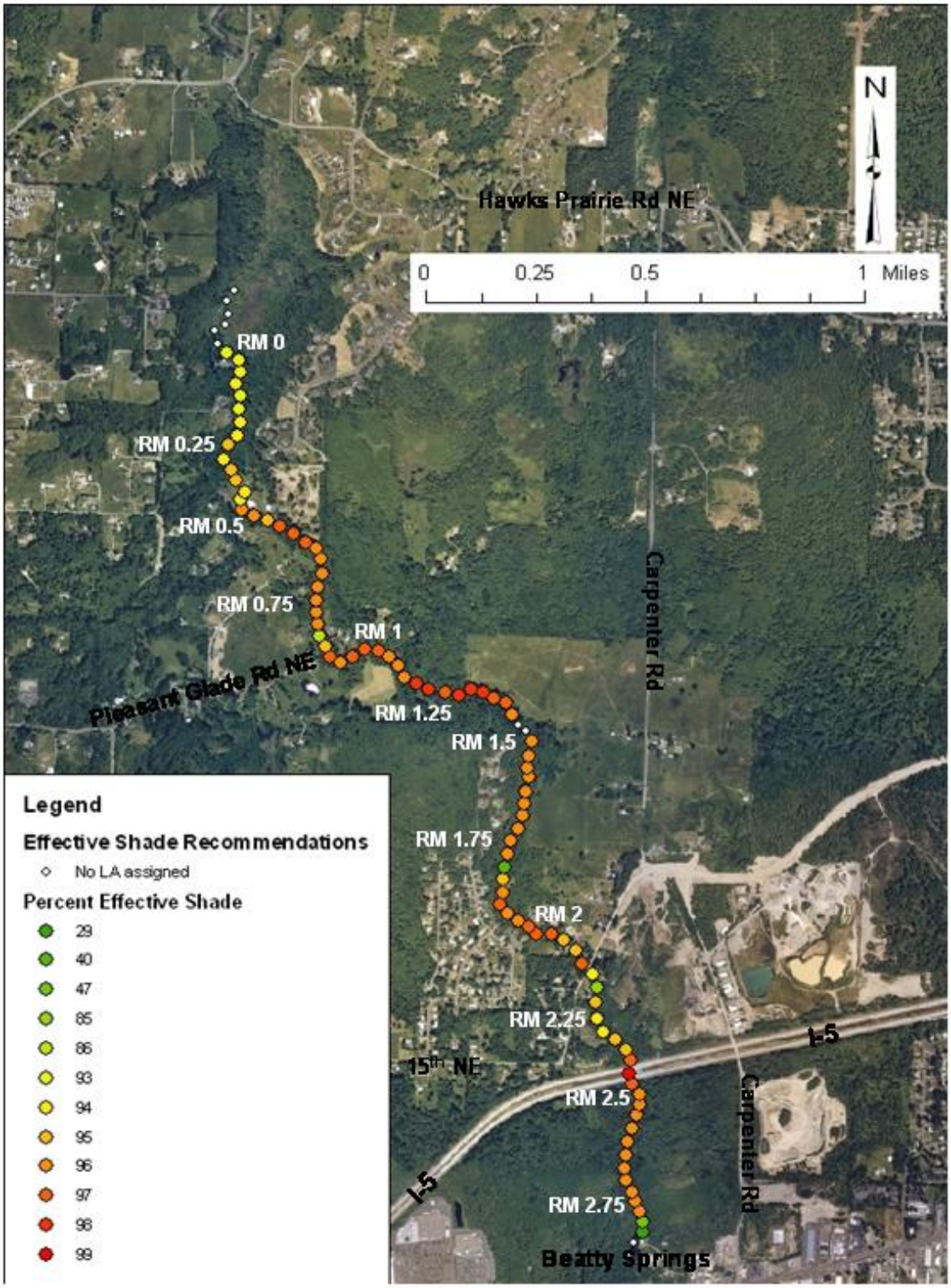

Figure 6. Effective Shade Recommendations for Woodland Creek between Beatty Springs and the creek mouth.

Nisqually Trout Farm

The Nisqually Trout Farm (Trout Farm) is located at the outlet of Beatty Springs on Woodland Creek. The Trout Farm discharges to Woodland Creek under NPDES permit number WAG131002C. The general NPDES permit for upland finfish facilities does not contain temperature limitations. Operation of the trout farm consists of pumping water from the spring into holding pens that are constantly mixed and where the water has a very low residence time. This operation does not appear to have any significant impact on the temperature of the spring water. During the summer 2003 field season, a maximum background water temperature of 14.0^{o}C was recorded and during this same period the Nisqually Trout Farm effluent did not exceed the 16.0^{o}C water quality standard. The discharge of Beatty Spring water from the hatchery is the principal source of water in Woodland Creek during the critical period. Support of beneficial uses of Woodland Creek depend on the cold water and flow provided by the spring.

Although the current operation of the fish hatchery does not contribute any thermal pollution to the system during critical conditions, a wasteload allocation was calculated to protect water quality, in case the operation of the hatchery changes in the future. Washington's surface water quality standards state that "incremental temperature increases resulting from point source activities shall not, at any time, exceed t=23/(T+5) where t represents the maximum permissible temperature increase measured at the mixing zone boundary and T is the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge." No mixing zone is authorized because the discharge is a large percentage of Woodland Creek's flow during the critical period.

The wasteload allocation for the Nisqually Trout Farm was developed based on data collected during the summer 2003. The conditions in the holding pens are assumed to be background temperatures. This maximum background temperature of 14.0^{o}C was used to calculate the allowable incremental temperature increase:

$$t = 23 / (T + 5) = 23 / (14.0 + 5) = 1.2^{o}C$$

Therefore, the wasteload allocation for the Nisqually Trout Farm is the discharge temperature that does not cause the receiving water temperature to rise greater than an increment of 1.2^{o}C or above a maximum temperature of 15.2^{o}C at any time. Under the current operating practices of the Nisqually Trout Farm, there does not appear to be reasonable potential for the current operation to cause or contribute to violation of the water quality standards or to exceed 15.2^{o}C. As a result, it is recommended that temperature monitoring of the effluent be conducted during summer months to verify the wasteload allocation is not exceeded. If monitoring demonstrates there is a reasonable potential for the temperature wasteload allocation to be exceeded, the Nisqually Trout Farm may be required to apply for an individual NPDES permit that specifies this wasteload allocation when the statewide general permit is eligible for renewal.

Stormwater Sources

Stormwater sources of thermal pollution in Woodland Creek between Beatty Springs and the mouth are assigned a wasteload allocation based on the current Water Quality standards for Class AA freshwater systems. The wasteload allocations only apply to stormwater discharges that may occur during the critical summer low flow period.

Although Woodland Creek below Beatty Springs currently meets the Class AA water quality criteria of 16.0^{o}C, the wasteload allocation for municipal stormwater discharges from new developments and redevelopments is 16.0^{o}C, to prevent degradation of water quality in this portion of Woodland Creek. This wasteload allocation complies with current water quality standards which state:

"Whenever waters are of a higher quality than the criteria assigned for said waters, the existing water quality shall be protected and…. All wastes and other materials and substances discharged into said waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment by new and existing point sources before discharge."

Best management practices (BMPs) for treating municipal stormwater runoff, which includes infiltration basins, has been applied to many of the developed areas that drain to Woodland Creek. The use of stormwater BMPs, such as stormwater infiltration, is anticipated to be adequate to protect water quality during the critical season because direct surface discharge from the basins does not typically occur during summertime rain events. Summer storm events which exceed the design for the BMPs could result in a direct surface discharge to Woodland Creek. However, these events are expected to be infrequent and are not expected to result in exceedences of the wasteload allocation.

The wasteload allocation applies during the critical summer low flow period, typically occurring from June through September. The same wasteload allocation applies to existing stormwater discharges. As stated above, Ecology may establish a compliance schedule for the municipality to install appropriate BMPs or treatment, if it is determined to be necessary to meet the wasteload allocations. Stormwater infiltration basins combined with other best management practices are anticipated to meet these wasteload allocations.

Management Recommendations

In addition to the recommendations for effective shade and the wasteload allocations, other management activities are recommended for compliance with water quality standards. The management recommendations described below would help to prevent degradation of temperature conditions in Woodland Creek between Beatty Springs and Henderson Inlet.

- Watershed residents should continue to be encouraged to use water wisely.
- The city of Lacey and Thurston County should continue to carefully manage storm runoff from impervious surfaces in accordance with the minimum requirements and technical guidance provided by the Stormwater Management Manual of Western Washington.

- Measures should be taken to protect springs and tributaries in lower Woodland Creek from further degradation, including measures to protect riparian vegetation and groundwater in hydraulic continuity.
- Practice Low Impact Development principles for new development where applicable and supported by science.
- If alternative water sources are available, it is preferable to avoid drilling new exempt wells within the Woodland Creek basin. The city of Lacey is currently considering the possibility of prohibiting new exempt wells within Lacey city limits.

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Appendix D. Response to Comments

Ecology received three sets of comments during the comment period of May 16 t o June 16, 2008.

The following comments were received from Priscilla Terry:

Comment

Now you must figure out a way to "hardwire" the policies into the daily work of local jurisdictions, especially Thurston County. The county does not have enough expertise on its staff that would allow for understanding the interconnections of plants/soil/water in our ecosystem. Although they say they do, the proof is in the pudding, and we see too many horrible outcomes of developments that could and should have been built in a manner consistent with BMPs that have been laid out for local jurisdictions to follow.

Just two examples: Walt Cox proposed subdivision (Schinke Rd) in a wetland area that drains into creek leading to shellfish growing areas in Henderson Inlet, and Crosscreek Subdivision (Johnson Pt. Rd), which sure enough crosses Dobbs Creek which also drains directly into Henderson Inlet.

Response

It is not Department of Ecology's role to dictate the local planning and development process. Local jurisdictions have the responsibility to work within the Growth Management Act keep development controlled. We agree that growth and development have an impact on water quality and encourage you to work within the structure of the local process to make sure that local planning processes are followed. As part of the TMDL we will encourage all BMPs that keep growth in balance with water quality.

Comment

Dept. of Wildlife, Dept of Ecology and the Planning staff, Developmental Services, Roads Departments, Health Dept., etc. should develop a comprehensive matrix that demonstrates exactly how a development should be put in place in order to have the desired outcomes. Both I (degree in landscape architecture specializing in urbanizing watersheds) and my husband (PhD in soil science recently retired Weyerhaeuser Company, specializing in long term site productivity and forest ecology) would be happy to serve at no cost on a committee for this purpose

Response

Thank you for offering to assist with development decisions. Since most development responsibilities fall within the county jurisdictions, I would suggest you contact your local planning office and see where you might be able to assist in local planning decisions.

The following comments were received from Jerry Unmuth:

Comment

I really think that after all the recent studies, we can now agree that most of the fecal coliform bacteria and nitrate pollution is coming from old and failing septic systems, livestock manure, and pet waste, and that it is carried to Henderson Inlet via Woodland Creek, especially when it rains.

I feel like the Pet waste and Livestock manure problems, and even the stormwater issues are going to be the least expensive and controversial to correct, and I really believe we now have the support of the residents and the political will to make these vital corrections.

My comment is mostly about the real issue. The conversion of old and failing septic systems, many of which are probably sitting over gravel covered aquifers, or are draining into trenches 8 feet deep, or are flowing onto the surface of the ground surrounding them, to sewer. It will be expensive, but frankly, I feel like the time has come for residents of the affected area to catch up on what should have been paid for long ago.

It's time to expand, and unfortunately pay for, sanitary sewer in the Woodland Creek Pollutant Load Reduction study area, and I think we all know it.

Response

Ecology agrees that runnoff carries many pollutants to the waterways. Pet waste, livestock manure and stormwater will be addressed in the TMDL.

Regarding you main comment, in the *Woodland Creek Pollutant Reduction Plan* conducted by Thurston County, connecting priority areas to sewer and concentrating on failures is a high priority. All the concerns you have listed have planned actions in the report. The action plan was completed in March 2008.

According to the report the estimated average cost per homeowner was $31,000 with some costs in the Woodland Creek area at $46,000. This cost is too high for most average home owners. The Thurston County Board of Commissioners has listed septic repair and hookups to sewer as a high priority item. This high priority also includes asking for legislative approval for state and federal funding.

Ecology will be monitoring this process through the annual adaptive management meetings starting in 2009.

The following comments were received from the city of Lacey:

Comment

Page 16: Near the bottom of the sidebar titled "Two Important Projects…" are the "next steps" in the project, but those steps (preliminary designs, planning-level cost estimates, etc.) have already been completed and presented to the public, and an Action Plan prepared. At this point, the actual next steps are to establish who will lead the project from here forward, to initiate actual project planning, and to seek funds. Thurston County could probably provide more up-to-date information about the status of the project process.

Response

Thank you, this section has been updated

Comment

Page 18: Discussion on Temperature. Recommend editing to read, "There has not been enough <u>data collection and</u> analysis to determine the cause….."

Response

Thank you, commented noted and report has been changed.

Comment

Page 17: The Table 2 data appears to be in somewhat random order. Recommend putting in order of RM.

Response

The table has been reorganized for clarity.

Comment

Page 23: Pollutant Load Reduction Project is listed as a Priority 1 action. Does this mean the Project's Action Plan recommendations must be implemented? All of them or some of them? Please clarify.

Response

Ecology considers the items in the Pollutant Load Reduction Project as a high priority for improving water quality and will encourage recommendations to be implemented. Many of the recommendations are restricted by available funds to implement them.

Ecology will check back during the annual adaptive management meetings beginning in 2009 to see how many recommendations have been implemented and what barriers exist for those not completed. The stakeholder team will then work towards finding available funds from various funding sources.

Comment

Page 23: Pollutant Load Reduction Project Implementation Status says "final report anticipated spring 2008." The final report, titled Woodland Creek Pollutant Reduction Plan, was issued in March 2008.

Response

Thank you, the plan has been updated.

Comment

Page 24: The first item in the Action column ("treatment facility for stormwater to College Creek") is officially named the College Regional Stormwater Facility. Also, under Implementation Status , the same item should read "Construction complete, October 2007," and the same paragraph should go on to say "… the last major untreated stormwater discharge…".

Response

Thank you, the plan has been updated.

Comment

Page 24: The fourth row, under Implementation Status, it should read "…technical assistance will be provided…" (the word "be" is missing).

Response

Thank you, the plan has been updated.

Comment

Page 33: To reiterate a comment from our last review, please strike "and infiltration facility" from the last bullet. The pond is not designed to be an infiltration facility.

Response

Thank you, the plan has been updated.

Comment

The remaining comments are all referring to Page 43, Appendix B, paragraphs under the "City of Lacey" heading:

- *In the first paragraph, the first line says the population in 2005 was 33,180. In April 2007, the state Office of Financial Management officially estimated Lacey's population to be 35, 870. The next sentence should read "Residential wastewater disposal…" (the "water" is missing).*

- *In the second paragraph, the last line states that "The County and Lacey are currently co-sponsoring a grant…". Two corrections: One, the County was the grant applicant and the lead jurisdiction on the project, with Lacey participating; and two, the grant is no longer current, as it ended on March 31, 2008.*

- *In the third paragraph, the second line refers to the "2005 Lacey Stormwater Manual" but no such document exists. Lacey currently uses the 1994 Drainage Design and Erosion Control Manual for Lacey, which is part of the city of Lacey 2005 Development Guidelines and Public*

- *Works Standards. Lacey is in the process of updating to a stormwater manual that is technically equivalent to Ecology's 2005 Stormwater Management Manual for Western Washington, with implementation of the updated manual in 2009.*

- *In the fourth paragraph, the first line should be rearranged to read "Lacey is covered by the NPDES Phase II Municipal Stormwater Permit" which is the word order of the actual permit title.*

- *In the fifth paragraph, delete the second word in the first line so it reads "Lacey conducts…"*

Response

Thank you, the plan has been updated.

Appendix E. Glossary and Acronyms

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which designated uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Best Management Practices (BMPs): Physical, structural, and/or operational practices that, when used singularly or in combination, prevent or reduce pollutant discharges.

Clean Water Act (CWA): Federal Act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the CWA establishes the TMDL program.

Designated Uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Effective Shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Fecal Coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within twenty-four hours at 44.5 plus or minus 0.2 degrees Celsius. FC are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100mL).

Geometric Mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from ten to 10,000 fold over a given period. The calculation is performed by either: 1) taking the nth root of a product of n factors, or 2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Load Allocation (LA): The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading Capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of Safety (MOS): Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint Source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

Phase I Stormwater Permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

Phase II Stormwater Permit: The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

Point Source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental, or injurious to the public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate uses, or to livestock, wild animals, birds, fish, or other aquatic life.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Total Maximum Daily Load (TMDL): A distribution of a substance in a water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: 1) individual wasteload allocations (WLAs) for point sources, 2) the load allocations (LAs) for nonpoint sources, 3) the contribution of natural sources, and 4) a Margin of Safety to

allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Wasteload Allocation (WLA): The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. WLAs constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.